TP 14936E

Aircraft Ground Icing General Research Activities During the 2008-09 Winter

Prepared for:

Transportation Development Centre

In cooperation with:

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

December 2009
Final Version 1.0

APS Aviation Inc.

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

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

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Un sommaire français se trouve avant la table des matières.

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***Final Draft 1.0 of this report was signed and provided to Transport Canada in December 2009. A Transport Canada technical and editorial review was subsequently completed, and the report was finalized in February 2026. 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, 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 evaluate weather data from previous winters that can have an impact on the format of the holdover time guidelines;
- 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 conduct endurance time tests in frost on various test or wing surfaces;
- To conduct endurance time tests on non-aluminum plates;
- To conduct endurance time tests to support the removal of the below -25°C row of the holdover time guidelines;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests to expand the current holdover guidelines to include conditions of rain and snow;
- To evaluate the effect of poor fluid application on fluid endurance times;
- To evaluate holdover times for anti-icing in a hangar;
- To review the use of the visibility table for use with holdover times;
- To conduct research at the National Research Council Canada wind tunnel to further develop and expand ice pellet allowance times;
- To conduct various aerodynamic research activities at the National Research Council Canada wind tunnel;
- To initiate research for development of ice detection capabilities for departing aircraft at the runway threshold; and
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2008-09 are documented in seven reports. The titles of the reports are as follows:

- TP 14933E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2008-09 Winter;
- TP 14934E Winter Weather Impact on Holdover Time Table Format (1995-2009);
- TP 14935E Research for Further Development of Ice Pellet Allowance Times: Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics Winter 2008-09;
- TP 14936E Aircraft Ground Icing General Research Activities During the 2008-09 Winter;

- TP 14937E Regression Coefficients and Equations Used to Develop the Winter 2009-10 Aircraft Ground Deicing Holdover Time Tables;
- TP 14938E Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions; and
- TP 14939E Exploratory Wind Tunnel Aerodynamic Research Examination of Contaminated Anti-Icing Fluid Flow-Off Characteristics Winter 2008-09.

In addition, the following interim report is being prepared:

- *Fluid Endurance Times Using Composite Surfaces.*

This report, TP 14936E, has the following objective:

- To document the exploratory research and general activities carried out during the winter of 2008-09.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Civil Aviation Group, 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: Stephanie Bendickson, Matthew Bowen, Chris Burke, Michael Chaput, John D'Avirro, Peter Dawson, Jeff Ford, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Michelle Pineau, Dany Posteraro, Marco Ruggi, Joey Tiano, David Youssef and Victoria Zoitakis.

Special thanks are extended to Angelo Boccanfuso, Yagusha Bodnar, Frank Eyre, 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.

In memory of the late Barry Myers whose wisdom and knowledge combined with his dedication and perseverance has played a fundamental role in the development of the aircraft ground deicing program. His presence will be missed by all who had the privilege of making his acquaintance.

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APS Aviation Inc. would like to recognize the significant contributions of Stephanie Bendickson, Peter Dawson, Michelle Pineau, and Victoria Zoitakis for their support in preparing this report.

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

16. Abstract

This report documents the general activities completed by APS Aviation Inc. (APS) related to aircraft ground deicing research in the winter of 2008-09. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2008-09, which are documented in separate reports. The eleven activities included in this report are described below.

1. Survey of Deicing Operations in Freezing Rain and Freezing Drizzle: Additional work was completed in 2008-09 on a survey related to takeoffs in freezing rain and freezing drizzle that APS conducted for Transport Canada (TC) in the winter of 2007-08. In 2008-09, the survey was administered to flight crews. The results are provided in this report.
2. Effect of Heat on Fluid Endurance Times: APS has conducted various tests over the years comparing fluid endurance times of Type II, III, and IV fluids applied heated to that of the same fluids applied at ambient temperature. A review of this research indicated that the current guidance for Type II and IV fluids is appropriate, but changes need to be made for Type III fluids. The recommended changes are provided in this report.
3. Holdover Times of Anti-Icing Fluids Below -25°C: APS conducted additional tests to determine if there is a significant difference in the endurance times of a Type II/IV fluid at -25°C versus at the fluid's lowest operational use temperature (LOUT). It was concluded there is no significant difference in endurance times.
4. Holdover Times in Conditions of Rain Mixed with Snow: APS conducted additional tests to identify whether the current guidelines could be modified to include mixed rain and snow conditions. The research showed light freezing rain holdover times can be used in conditions of light snow mixed with light rain.
5. Effect of Poor Application on Endurance Times: APS conducted several tests to determine if there is a significant difference in the endurance times if fluid film thickness of a Type II/III/IV fluid were to be reduced. It was concluded that if Type II/III/IV fluid is adequately applied, endurance times may be reduced.
6. Effect of Shearing of Anti-Icing Fluids on Endurance Times: APS was required to identify whether thickened anti-icing fluids are being sheared during fluid application in the field to the detriment of published Holdover Time (HOT) Guidelines. Reduced viscosity fluids can cause a substantial reduction on endurance times.
7. Holdover Times Related to Aircraft Hangar Operations: APS conducted a limited test program that showed it is not safe to start the clock at first exposure to precipitation. It is recommended the clock be started when anti-icing fluid application begins.
8. Support for the Development of Use of Ice Detection Cameras at End-of-Runway: APS assisted on the development of a research/action plan for enabling use of ice detection technology in an end-of-runway application. The 2008-09 work is documented in this report.
9. Support for Use of FAA Visibility Table with Type II/III/IV Fluids: APS completed further analysis of the relationship between snowfall intensity and visibility in the winter of 2008-09 at the request of the Federal Aviation Administration (FAA). The analysis showed that the FAA visibility table is more accurate than other reference material.
10. Holdover Time Guidelines Website: APS developed and implemented a website for the official TC 2009-10 HOT table guidelines.
11. Test Procedures, Presentations, and Fluid Manufacturer Reports: An account of the test procedures, presentations, and fluid manufacturer reports that were produced for the 2008-09 test program is included in this report.

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Deicing, endurance time, standards, SAE, holdover time, poor application, rain and snow, below -25°C, hangar operations, endurance times, ROGIDS, end-of-runway, visibility, shearing	Limited number of copies available from the Transportation Development Centre

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Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). 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. On trouvera dans la préface l'objet de ces rapports. Les travaux décrits dans le présent rapport ont été, en partie, coparrainés par la Federal Aviation Administration (FAA).

16. Résumé

Ce rapport fait état des activités générales menées par APS Aviation Inc. (APS) en matière de recherche sur le dégivrage d'aéronefs au sol au cours de l'hiver 2008-2009. Les activités dont fait état ce rapport ont été effectuées en plus des projets de recherche principaux menés pendant l'hiver 2008-2009, qui sont documentés dans des rapports distincts. Les onze activités qui font l'objet du présent rapport sont énumérées ci-dessous.

1. Sondage sur les opérations de dégivrage dans des conditions de pluie et de bruine verglaçantes : Des travaux supplémentaires ont été réalisés en 2008-2009 à partir d'un sondage mené par APS pour le compte de Transports Canada (TC), au cours de l'hiver 2007-2008, relativement aux décollages dans des conditions de pluie et de bruine verglaçantes. En 2008-2009, le sondage a été mené auprès des membres d'équipage. Les résultats sont présentés dans le présent rapport.
2. Effet de la chaleur sur les durées d'endurance des liquides : Au fil des années, APS a mené divers tests comparant les durées d'endurance des liquides de type II, III et IV appliqués chauffés à celles des mêmes produits appliqués à température ambiante. Un examen de ces recherches a indiqué que les directives actuelles relatives aux liquides de type II et IV sont adéquates, mais que des changements doivent être apportés pour les liquides de type III. Les modifications recommandées sont décrites dans le présent rapport.
3. Durées d'efficacité des liquides d'antigivrage à des températures inférieures à -25 °C : APS a mené des essais supplémentaires pour déterminer s'il y a une différence significative entre les durées d'endurance des liquides de type II et IV à -25 °C et la température minimale d'utilisation opérationnelle (LOUT) de ces mêmes produits. Il a été conclu qu'il n'y a aucune divergence significative dans les durées d'endurance.
4. Durées d'efficacité dans des conditions de pluie mêlées à de la neige : APS a mené une série d'essais supplémentaires pour déterminer si les lignes directrices actuelles peuvent être élargies en vue d'inclure les conditions de pluie et de neige mixtes. Les résultats ont indiqué que les durées d'efficacité applicables dans des conditions de pluie verglaçante faible peuvent être utilisées en présence de neige faible mêlée de pluie faible.
5. Effet d'une mauvaise application sur les durées d'endurance : APS a mené plusieurs essais pour déterminer si les durées d'endurance des liquides de type II, III et IV sont considérablement différentes lorsque l'épaisseur du liquide est réduite. Il a été conclu que lorsque ces produits sont mal appliqués, les durées d'endurance peuvent être réduites.
6. Effet du cisaillement des liquides d'antigivrage sur les durées d'endurance : APS avait reçu le mandat de déterminer si les liquides d'antigivrage épaissis subissent du cisaillement lors de leur application sur le terrain, au détriment des lignes directrices sur les durées d'efficacité publiées. Les liquides à viscosité réduite peuvent entraîner une diminution considérable des durées d'endurance.
7. Durées d'efficacité liées aux opérations en hangar d'aéronef : APS a mené un programme limité d'essais ayant démontré qu'il n'est pas sécuritaire de lancer le compteur dès la première exposition aux précipitations. On recommande plutôt de démarrer le décompte dès que commence l'application de liquide d'antigivrage.
8. Soutien à l'accroissement de l'utilisation de caméras de détection de givre en bout de piste : APS a participé à l'élaboration d'un plan de recherche ou d'action permettant l'utilisation de ces technologies en bout de piste. Les travaux effectués en 2008-2009 sont décrits au présent rapport.
9. Soutien à l'utilisation du tableau de visibilité de la FAA relativement aux liquides de type II, III et IV : À la demande de la Federal Aviation Administration (FAA), APS a achevé des analyses supplémentaires du lien entre l'intensité des chutes de neige et la visibilité au cours de l'hiver 2008-2009. L'analyse a démontré que le tableau de visibilité de la FAA est plus précis que tout autre document de référence.
10. Site Web des lignes directrices sur les durées d'efficacité : APS a conçu et mis en place un site Web présentant les lignes directrices sur les durées d'efficacité (2009-2010) officielles de Transports Canada.
11. Procédures d'essai, présentations et rapports des fabricants de liquides : Un compte rendu des procédures d'essais des présentations et des rapports aux fabricants de liquides pour le programme d'essais de 2008-2009 figure dans le présent rapport.

17. Mots clés	18. Diffusion
Dégivrage, durées d'endurance, normes, SAE, durée d'efficacité, mauvaise application, pluie et neige, températures inférieures à -25°C, opérations en hangar, durées d'endurance, ROGIDS, bout de piste, visibilité, cisaillement	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

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EXECUTIVE SUMMARY

This report documents the general activities related to aircraft ground deicing research completed by APS Aviation Inc. (APS) in the winter of 2008-09 on behalf of the Transportation Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA). The eleven activities documented in this report are described below and were carried out in addition to the main research projects completed in the winter of 2008-09, which are documented in separate reports.

Survey of Deicing Operations in Freezing Rain and Freezing Drizzle (Section 2)

Additional work was completed in 2008-09 on a survey related to takeoffs in freezing rain and freezing drizzle that APS conducted for TC in the winter of 2007-08. In 2008-09, the survey was administered to flight crews. The results of the flight crew survey are provided in this report.

Effect of Heat on Fluid Endurance Times (Section 3)

APS has conducted various tests over the years comparing fluid endurance times of Type II, III, and IV fluids applied heated to that of the same fluids applied at ambient temperature. A review of this research indicated that the current guidance for Type II and IV fluids is appropriate, but changes need to be made for Type III fluids. The recommended changes are provided in this report.

Holdover Times of Anti-Icing Fluids Below -25°C (Section 4)

APS conducted tests to determine if there is a significant difference in the endurance times of a Type II/IV fluid at -25°C and at the fluid's lowest operational use temperature (LOUT). It was concluded there is no significant difference in endurance times.

Holdover Times in Conditions of Light Snow Mixed with Light Rain (Section 5)

Until recently, TC and the FAA did not provide guidance for operations in light snow mixed with light rain, but guidance was available for European operators. APS conducted tests to identify whether the current guidelines could be modified to include mixed rain and snow conditions. The research showed light freezing rain holdover times (HOTs) can be used in conditions of light snow mixed with light rain.

Effect of Poor Application on Endurance Times (Section 6)

APS conducted several tests to determine if there is a significant difference in endurance times if Type II/III/IV fluid was poorly applied to aircraft surfaces. It was concluded that if Type II/III/IV fluid is inadequately applied, endurance times may be reduced.

Effect of Shearing of Anti-Icing Fluids on Endurance Times (Section 7)

APS was required to identify whether thickened anti-icing fluids are being sheared during fluid application in the field to the detriment of published HOT Guidelines. It was concluded that reduced fluid viscosities may stem from different causes. Reduced viscosity fluids can cause a substantial reduction on endurance times.

Holdover Times Related to Aircraft Hangar Operations (Section 8)

Several operators have asked TC for specific guidance on when to start the holdover time "clock" when anti-icing is conducted in a hangar. APS conducted a limited test program that showed it is not safe to start the clock at first exposure to precipitation. It is recommended the clock be started when anti-icing fluid application begins.

Support for the Development of Use of Ice Detection Cameras at End-of-Runway (Section 9)

The development of ice detection technology has been ongoing for a number of years. This work has been supported by TC and the FAA. In 2008-09, work focused on the development of a research/action plan for enabling the use of ice detection technology in an end-of-runway application. The 2008-09 work is documented in this report.

Support for Use of FAA Visibility Table with Type II/III/IV Fluids (Section 10)

APS completed further analysis of the relationship between snowfall intensity and visibility in the winter of 2008-09 at the request of the FAA. The FAA required support for its decision to mandate the use of the FAA visibility table with Type II, III, and IV fluids. The analysis was presented at an FAA/industry meeting in April 2009. The analysis clearly showed that the FAA visibility table was more accurate than the Federal Meteorological Handbook (FMH1) in predicting snowfall intensity based on visibility.

Holdover Time Guidelines Website (Section 11)

APS developed and implemented a website for the official TC HOT guidelines in 2003 to eliminate the safety risks associated with discrepancies occurring as a result of holdover time information being published in multiple locations. Since then, APS has updated the website annually to reflect changes made to the guidelines. The website was updated with the 2009-10 HOT guidelines in July 2009.

Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 12)

A number of test procedures, presentations, and fluid manufacturer reports were produced by APS for the 2008-09 test program. An account of these activities is included in this report.

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SOMMAIRE

Ce rapport fait état des activités générales se rapportant à la recherche sur le dégivrage d'aéronefs au sol menée par APS Aviation Inc. (APS), au cours de l'hiver 2008-2009, pour le compte du Centre de développement des transports (CDT) de Transports Canada (TC) et de la Federal Aviation Administration (FAA). Les onze activités dont fait état ce rapport sont décrites ci-dessous et ont été effectuées en plus des projets de recherche principaux menés pendant l'hiver 2008-2009, qui sont documentés dans des rapports distincts.

Sondage sur les opérations de dégivrage dans des conditions de pluie et de bruine verglaçantes (Section 2)

Des travaux supplémentaires ont été réalisés en 2008-2009 à partir d'un sondage mené par APS pour le compte de TC, au cours de l'hiver 2007-2008, relativement aux décollages dans des conditions de pluie et de bruine verglaçantes. En 2008-2009, le sondage a été mené auprès des membres d'équipage. Les résultats ainsi recueillis sont décrits dans le présent rapport.

Effet de la chaleur sur les durées d'endurance des liquides (Section 3)

Au fil des années, APS a mené divers tests comparant les durées d'endurance des liquides de type II, III et IV appliqués chauffés à celles des mêmes produits appliqués à température ambiante. Un examen de ces recherches a indiqué que les directives actuelles relatives aux liquides de type II et IV sont adéquates, mais que des changements doivent être apportés pour les liquides de type III. Les modifications recommandées sont décrites dans le présent rapport.

Durées d'efficacité des liquides d'antigivrage à des températures inférieures à -25 °C (Section 4)

APS a mené des essais pour déterminer s'il y a une différence significative entre les durées d'endurance des liquides de type II et IV à -25 °C et la température minimale d'utilisation opérationnelle (LOUT) de ces mêmes produits. Il a été conclu qu'il n'y a aucune divergence significative dans les durées d'endurance.

Durées d'efficacité dans des conditions de neige faible combinée à de la pluie faible (Section 5)

Jusqu'à récemment, TC et la FAA ne publiaient pas de lignes directrices relatives aux opérations dans des conditions de neige faible mélangée à de la pluie faible, alors que des directives étaient offertes aux exploitants européens. APS a mené une série d'essais pour déterminer si les lignes directrices actuelles peuvent être élargies en vue d'inclure les conditions de pluie et de neige mixtes. Les résultats ont indiqué que les durées d'efficacité applicables dans des conditions de pluie verglaçante faible peuvent être utilisées en présence de neige faible mêlée de pluie faible.

Effet d'une mauvaise application sur les durées d'endurance (Section 6)

APS a mené plusieurs essais pour déterminer si les durées d'endurance des liquides de type II, III et IV sont considérablement différentes en cas de mauvaise application sur les surfaces de l'aéronef. Il a été conclu que lorsque ces produits sont mal appliqués, les durées d'endurance peuvent être réduites.

Effet du cisaillement des liquides d'antigivrage sur les durées d'endurance (Section 7)

APS avait reçu le mandat de déterminer si les liquides d'antigivrage épaissis subissent du cisaillement lors de leur application sur le terrain, au détriment des lignes directrices sur les durées d'efficacité publiées. Il a été conclu que la réduction de la viscosité des liquides pouvait découler de différentes causes. Les liquides à viscosité réduite peuvent entraîner une diminution considérable des durées d'endurance.

Durées d'efficacité liées aux opérations en hangar d'aéronef (Section 8)

Plusieurs exploitants ont demandé à TC d'émettre des lignes directrices sur le moment où doit démarrer le « compteur » de durée d'efficacité lors d'opérations d'antigivrage menées en hangar. APS a mené un programme limité d'essais ayant démontré qu'il n'est pas sécuritaire de lancer le compteur dès la première exposition aux précipitations. On recommande plutôt que le décompte commence dès l'application de liquide d'antigivrage.

Soutien à l'utilisation accrue de caméras de détection de givre en bout de piste (Section 9)

Le développement des technologies de détection du givre est un phénomène en cours depuis plusieurs années. Ces travaux ont été appuyés par TC et la FAA. En 2008-2009, les efforts ont été axés sur l'élaboration d'un plan de recherche ou d'action permettant l'utilisation de ces technologies en bout de piste. Les travaux effectués en 2008-2009 sont décrits au présent rapport.

Soutien à l'utilisation du tableau de visibilité de la FAA relativement aux liquides de type II, III et IV (Section 10)

À la demande de la FAA, APS a achevé des analyses supplémentaires du lien entre l'intensité des chutes de neige et la visibilité au cours de l'hiver 2008-2009. La FAA avait besoin d'étayer sa décision de mandater l'utilisation du tableau de visibilité de la FAA relativement aux liquides de type II, III et IV. Les résultats de ces efforts ont été présentés lors d'une réunion de l'organisme américain et du secteur en avril 2009. L'analyse démontrait clairement que le tableau de visibilité de la FAA s'avérait plus précis que le Federal Meteorological Handbook (FMH1) pour ce qui est de prédire l'intensité des précipitations de neige en fonction de la visibilité.

Site Web des lignes directrices sur les durées d'efficacité (Section 11)

En 2003, APS a conçu et mis en place un site Web présentant les lignes directrices officielles de TC sur les durées d'efficacité, afin d'éliminer les risques pour la sécurité associés à la possibilité de divergences lorsque l'information sur les durées d'efficacité est publiée à plusieurs endroits. Depuis, APS a mis à jour le site Web chaque année pour refléter les changements apportés aux lignes directrices. Les lignes directrices sur les durées d'efficacité de 2009-2010 y ont été ajoutées en juillet 2009.

Procédures d'essai, présentations et rapports des fabricants de liquides (Section 12)

APS a produit un certain nombre de procédures d'essais, de présentations et de rapports aux fabricants de liquides pour le programme d'essais de 2008-2009. Le présent rapport contient une description de ces activités.

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GLOSSARY

AEA	Association of European Airlines
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
CBAAC	Commercial and Business Aviation Advisory Circular
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
FMH1	Federal Meteorological Handbook
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
MSC	Meteorological Service of Canada
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
OAT	Outside Air Temperature
PIWT	3 m x 6 m Open-Circuit Propulsion Icing Wind Tunnel
ROGIDS	Remote On-Ground Ice Detection Systems
SAE	SAE International
TC	Transport Canada
TCCA	Transport Canada Civil Aviation
TDC	Transportation Development Centre

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1. INTRODUCTION

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

Since the early 1990s, the Transportation Development Centre (TDC) of Transport Canada (TC) 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. Each of the research activities are documented in a separate individual report. The general activities are documented in this report.

1.1 General Activities Completed in 2008-09

The general activities completed in 2008-09 are listed below. Each activity is described in a separate section of this report (shown in parentheses):

a) Survey of Deicing Operations in Freezing Rain and Freezing Drizzle (Section 2);
b) Effect of Heat on Fluid Endurance Times (Section 3);
c) Holdover Times of Anti-Icing Fluids Below -25°C (Section 4);
d) Holdover Times in Conditions of Light Snow Mixed with Light Rain (Section 5);
e) Effect of Poor Application Methods on Fluid Endurance Times (Section 6);
f) Effect of Shearing of Anti-Icing Fluids on Endurance Times (Section 7);
g) Holdover Times Related to Aircraft Hangar Operations (Section 8);
h) Support for the Development of Use of Ice Detection Cameras at End-of-Runway (Section 9);

i) Support for Use of FAA Visibility Table with Type II/III/IV Fluids (Section 10);

j) Holdover Time Guidelines Website (Section 11); and

k) Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 12).

The relevant sections of the TC work statement can be found in Appendix A.

1.2 Snow Machine Activities

In the winter of 2008-09, the following research activities were planned to be conducted with the National Center for Atmospheric Research (NCAR) snow machine:

- Snow Pellet Testing (3 weeks);
- Endurance Time Testing (2 weeks);
- Heavy Snow Testing (1 week); and
- Type I Testing (1 week).

Procedures were developed for the four research activities and are included in Appendix B.

Some preliminary testing with the snow machine was started in early winter, but was stopped due to hardware problems. The snow machine was then sent to NCAR in Boulder, Colorado, for repair and software and hardware upgrade.

After completion of the upgrade, testing will be conducted at NCAR to compare the two snow machines and to check the effect of height difference between the two machines. It is anticipated that the testing will be completed and that the APS snow machine will be returned by Fall 2009.

2. SURVEY OF DEICING OPERATIONS IN FREEZING RAIN AND FREEZING DRIZZLE

2.1 Background

At the request of Transport Canada (TC), APS Aviation Inc. (APS) undertook a project in the winter of 2007-08 to canvas air operators on their current "best practices and procedures" in takeoffs in freezing drizzle and freezing rain conditions. The work was conducted under the auspices of the Takeoff in Freezing Drizzle and Freezing Rain Working Group, which has the objective of determining whether the current operational practice of takeoff during freezing drizzle and/or freezing rain conditions needs to be limited through additional regulatory intervention.

A preliminary survey was created to obtain the information from the air operators. The primary objective of the survey was to obtain information on current practices of Canadian air operators related to takeoffs in freezing drizzle and freezing rain conditions. However, TC also used the opportunity to collect information related to takeoffs in ice pellet conditions.

Three groups of potential survey participants were identified:

1) Air operators conducting 702, 703, 704, or 705 operations;
2) Air operators conducting 604 operations; and
3) Flight crews.

As the operations and knowledge bases of the three participant groups differed slightly, it was necessary to tailor the survey to each group. Therefore, three versions of the preliminary survey were created, with each version tailored to one of the three survey participant groups. The flight crew survey was also translated into French, making a total of four versions of the survey.

The surveys were administered through a web-based program. This was identified as the best way to conduct the survey anonymously, which was deemed critical to obtaining accurate results and a good response rate.

The air operators (702-705) and air operators (604) surveys were administered in June 2008. The flight crew survey was not administered until Fall 2008.

The work completed for this project over the winter of 2007-08 (including the summer of 2008) is documented in the TC report, TP 14872E, *Aircraft Ground Icing Research General Activities During the 2007-08 Winter* (1). This report includes copies of the four survey versions and summaries of the results of the air operators (702-705) and air operators (604) surveys.

2.2 Work Completed in Winter 2008-09

The flight crew survey was administered throughout the fall of 2008. Flight crew members were invited to participate in the survey through an article published in the October 2008 edition of the Aviation Safety Letter. Copies of the English and French versions of the flight crew survey were included in TP 14872E (1).

The response rate for the flight crew survey was much lower than expected, with only 18 individuals completing the survey (17 in English, 1 in French). However, the comments provided by these 18 participants provided some interesting and relevant information for the project.

A summary of the results of the flight crew survey is included in Appendix C. The results of the English and French surveys have been amalgamated in this summary. These results were provided to TC in January 2009.

2.3 Future Work

Due to the low response to the flight crew survey, administering the survey a second time has been considered. It is felt that making direct contact with flight crews, possibly through the pilot union and/or directly through airlines, would elicit a better response than the notice in the Aviation Safety Letter.

This work has been put on hold indefinitely due to limited resources being available.

3. EFFECT OF HEAT ON FLUID ENDURANCE TIMES

3.1 Background

Following the implementation of the Type I fluid endurance test protocol based on the application of heated fluid, questions arose about the use of heated Type II and IV fluids.

Some operators use heated Type II and Type IV fluids in 50/50 and 75/25 concentrations in one-step de/anti-icing. A field survey found that the applied temperature of Type II and Type IV fluids was often well above outside air temperature (OAT) due to heat transfer between truck tanks.

Type III fluid was introduced as a replacement for Type I fluid. It is generally used in a manner similar to that of Type I fluid: heated, at full strength, and as a one-step operation. Although its principal use is as a heated fluid, holdover times (HOTs) have been developed with fluid temperature at ambient. A less common method of use is as a cold anti-icing application.

Guidance material for heated fluids provided in the *FAA-Approved Deicing Program Updates* document states that there was no basis for reducing the current HOT Guideline values for heated Type II and IV fluids and that anti-icing applications of Type III fluid may be heated or unheated.

3.2 Objective

The objective of this activity was to compare endurance times of Type II, III, and IV fluids that are heated with those of the same fluids applied at ambient temperature, and to recommend specific changes to guidance material that will reflect the results.

3.3 Test Results

Test data showed that endurance times from heated applications of Type II and IV fluids were equal to or better than those from applications of fluid at ambient temperature.

Test data showed that fluid endurance times from heated Type III fluid differed from those of cold fluid applications; most were longer and some were shorter. The effect of heat was not the same in all conditions.

The results from this research are described in the Transport Canada (TC) report, TP 14874E, *Effect of Heat on Endurance Times of Anti-Icing Fluids* (Vol. 1 and Vol. 2) (2).

3.4 Conclusions from Previous Tests

The Federal Aviation Administration (FAA) guidance material related to heated applications of Type II and IV fluids is valid and need not be changed.

For Type III fluid, the following was concluded:

- The test method for Type III fluid in SAE International (SAE) Aerospace Recommended Practice (ARP) 5485 should be changed to reflect that tests should be conducted separately for heated fluid applications and for OAT fluid applications;
- The fluid manufacturer should identify whether the fluid is to be tested heated or at OAT, or both, depending on the intended method of fluid use in field operations;
- The heated fluid should be tested in accordance with the existing Type I test protocol;
- Consideration should be given to reflect the new test methods in SAE ARP5718;
- HOT Guidelines should be developed separately for the two test methods; and
- Holdover times for new Type III fluids should be published in fluid-specific tables.

3.5 Recommended Changes to SAE Standards

Proposed changes to SAE ARP5485, SAE ARP5718, and SAE ARP4737 are given in Appendix D.

4. HOLDOVER TIMES OF ANTI-ICING FLUIDS BELOW -25°C

4.1 Background

There has been a recent industry need to provide guidance material for operations with thickened fluids at outside air temperature (OAT) below -25°C. Although the lowest operational use temperature (LOUT) of a thickened Type II or Type IV fluid is generally a few degrees below -25°C (i.e., -28°C or -29°C), Holdover Time (HOT) Guidelines do not exist below -25°C. Testing is conducted for each certified fluid in simulated freezing fog conditions at -25°C; however, natural snow data collected as part of the standard HOT testing protocol contains only limited data at these colder temperatures. As a result, generic HOT values are assigned for Type II and Type IV fluids at OAT below -14°C to -25°C in snow conditions. Testing was required to investigate if the current holdover times below -14°C to -25°C could be extended to the fluid LOUT for Type II and Type IV fluids.

Preliminary testing was conducted in the winter of 2007-08 with only three fluids. Data from the winter of 2007-08 is available in TP 14872E (1). As these results were preliminary, it was recommended that additional testing with more fluids be conducted in the winter of 2008-09 to substantiate the results obtained.

4.2 Objective

The objective of these tests was to determine the differences in the endurance times of Type II/IV fluid tests at -25°C in comparison to endurance times from testing conducted at the fluid LOUT. The standard endurance time testing procedure and methodology were followed. During the winter of 2008-09, testing was conducted with six fluids in conjunction with standard HOT testing. The comparative endurance time testing was conducted using the same fluids at both -25°C and -28.5°C in freezing fog conditions.

4.3 Test Results

Six fluids were used for comparative endurance time testing. Table 4.1 demonstrates the results obtained in the winter of 2008-09 as well as the data collected during Winter 2007-08. Figure 4.1 graphically demonstrates the comparative results obtained.

Table 4.1: Endurance Time Tests – LOUT vs. -25°C

Test #	Year Tested	Commercial Fluid (Neat)	Endurance Time (min)	Rate of Precip. (g/dm²/h)	Ambient Temp. (°C)	Precipitation Type
LOUT1/LOUT1A	07-08	Fluid A-IV-EG	37*	4.5	-28.5	Freezing Fog
LOUT4/LOUT4A	07-08	Fluid A-IV-EG	36*	5.3	-25.0	Freezing Fog
LOUT2/LOUT2A	07-08	Fluid B-IV-PG	40*	4.8	-28.5	Freezing Fog
LOUT5/LOUT5A	07-08	Fluid B-IV-PG	43*	5.2	-25.0	Freezing Fog
LOUT3/LOUT3A	07-08	Fluid C-II-PG	29*	4.7	-28.5	Freezing Fog
LOUT6/LOUT6A	07-08	Fluid C-II-PG	29*	5.1	-25.0	Freezing Fog
LOUT7	08-09	Fluid D-IV-EG	30	4.9	-28.5	Freezing Fog
LOUT13	08-09	Fluid D-IV-EG	30	4.7	-25.0	Freezing Fog
LOUT8	08-09	Fluid E-IV-PG	25	4.8	-29.0	Freezing Fog
LOUT14	08-09	Fluid E-IV-PG	24	4.9	-25.0	Freezing Fog
LOUT9	08-09	Fluid F-IV-PG	26	4.7	-28.5	Freezing Fog
LOUT15	08-09	Fluid F-IV-PG	22	4.8	-25.0	Freezing Fog
LOUT10	08-09	Fluid G-IV-PG	23	5.0	-28.5	Freezing Fog
LOUT16	08-09	Fluid G-IV-PG	22	5.2	-25.0	Freezing Fog
LOUT11	08-09	Fluid H-IV-PG	39	5.3	-29.0	Freezing Fog
LOUT17	08-09	Fluid H-IV-PG	39	5.1	-25.0	Freezing Fog
LOUT12	08-09	Fluid I-II-PG	21	5.1	-28.5	Freezing Fog
LOUT18	08-09	Fluid I-II-PG	20	5.2	-25.0	Freezing Fog

* Average of results from duplicate tests.

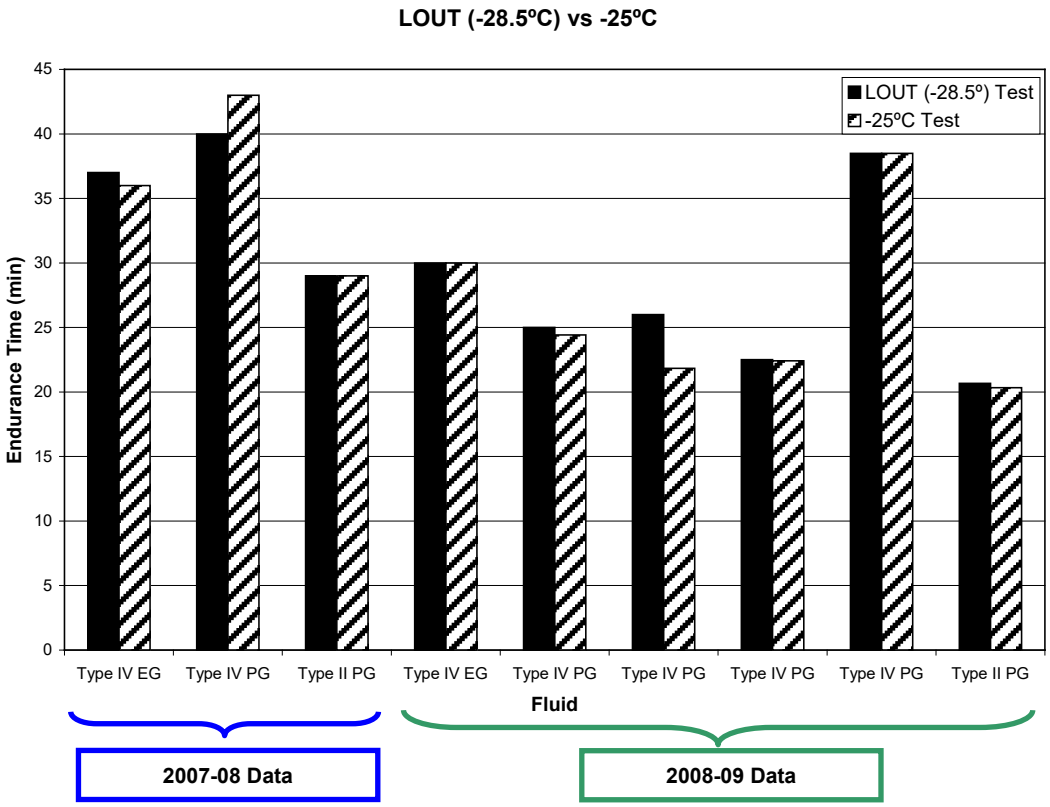

Figure 4.1: Endurance Time Tests Conducted in Winter 2007-08 and Winter 2008-09

4.4 Conclusion and Recommendations

The results obtained from the comparative endurance time testing indicated that the 3.5°C difference in test temperature (from -25°C to -28.5°C) did not have a significant effect on the fluid endurance time. Brix measurements were taken during the test to confirm the visual fluid failure, as the failure call was difficult. These results indicated that, based on the current generation of fluids (designed with a LOUT of approximately -28.5°C), the current -25°C holdover time could be extended to apply to the fluid LOUT; however, if fluid manufacturers begin to develop fluids with lower LOUTs, further testing will be required to substantiate the new LOUT holdover times. In the 2009-2010 HOT Guidelines (see Section 11 of this report), changes were made to the temperature range: the lower end temperature range was changed from "Below -14°C to -25°C" to indicate "Below -14°C to -25°C or LOUT." As a result of this change, the "Below -25°C" row was removed and a footnote was added as follows: *Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II or Type IV fluid cannot be used.*

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5. HOLDOVER TIMES IN CONDITIONS OF LIGHT SNOW MIXED WITH LIGHT RAIN

5.1 Background

As the accuracy of meteorological reporting continues to improve, especially with the likely introduction of holdover time determination systems (HOTDS), there has been an industry need for holdover time (HOT) guidelines for operations in mixed precipitation conditions. Transitional precipitation periods often include a mix of multiple precipitation types, and although these periods are generally short, on many occasions, especially at warmer temperatures, these transitional periods can last several hours. As a result, there has arisen a recent industry need for improved guidance material during these transitional periods of mixed precipitation. In addition, providing HOT guidance material for mixed precipitation conditions will further aid the development of HOT determination technology.

Transport Canada (TC) and the Federal Aviation Administration (FAA) currently do not provide guidelines for operations in light snow mixed with light rain conditions. However, some regulatory agencies and aircraft operators have guidance for dealing with such conditions. The Association of European Airlines (AEA) has recommended the use of light freezing rain holdover times for use during light "rain and snow" conditions. The purpose of these tests is to identify whether additional work is required in mixed conditions or if the current guidelines can be modified to include light snow mixed with light rain conditions.

Testing was conducted in the winter of 2007-08 to investigate if the current HOT Guidelines could be expanded to include mixed conditions (rain and snow). Comparative testing was also conducted with the same fluid in mixed rain and snow conditions and light freezing rain conditions.

These preliminary tests were conducted at the request of the FAA. This limited testing was conducted in conjunction with the standard HOT testing conducted at the National Research Council Canada (NRC) in April 2008. Results indicated that the endurance time in light "rain and snow" was on average 10-15 percent longer compared to the "light freezing rain only" test. Data from Winter 2007-08 is available in TP 14872E (1). As these results were preliminary, it was recommended that additional testing be conducted with more fluids in the winter of 2008-09.

5.2 Objective

The objective of this project was to collect additional data to determine if the current HOT Guidelines can be expanded to include mixed conditions (light snow mixed with light rain). Additional testing was conducted in conjunction with the standard HOT testing conducted at the NRC Climatic Engineering Facility (CEF) in April 2009. Two procedures were used as reference when conducting the tests (see Appendix E and Appendix F).

5.3 Test Results

Six neat fluids were used for comparative endurance time testing. Testing was conducted in both simulated mixed rain and snow (conducted at +1°C) as well as simulated light freezing rain (conducted at -3°C). The rain rate of precipitation (13 g/dm^2/h) and light freezing rain rate of precipitation (25 g/dm^2/h) were measured using the standard HOT testing protocol used for simulated freezing precipitation. The simulated snow rate of precipitation (12 g/dm^2/h) was approximated based on calibration work conducted; the dispensing apparatus showed good repeatability and could be set to achieve desired rates of precipitation. The endurance times recorded were compared. The Brix and level of adherence were monitored during the test to quantify the levels of fluid dilution and adherence during each test. Table 5.1 demonstrates the results obtained. Data collected during the winter of 2007-08 has also been included for completeness. Figure 5.1 graphically demonstrates the comparative results obtained.

5.4 Conclusions and Recommendations

For all fluids, the estimated endurance time in "light snow mixed with light rain" was always longer compared to the "light freezing rain only" test. At the estimated time of failure for both conditions, adherence was present on the plate. The condition of the fluid during the test showed characteristics like light freezing rain conditions (i.e., presence of adherence and erosion of the fluid layer). The level of adherence was generally similar, or less severe in the case of "light snow mixed with light rain"; however, adhered contamination was rougher. Light freezing rain holdover times seem a good conservative approach for light snow mixed with light rain conditions; this is in accordance with the AEA recommendation. A footnote has been included in all the Type I, II, III, and IV fluid tables of the 2009-2010 HOT Guidelines as follows:

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

Table 5.1: Light Snow Mixed with Light Rain vs. Light Freezing Rain Endurance Time Tests

Test #	Year	Commercial Fluid	Fluid Dilution	Endurance Time (min)	% Diff. in Endurance Time	Precip. Rate (g/dm²/h)	Temp. (°C)	Precipitation Type
RS1-08	2007-08	Fluid A-IV-EG	100/0	**59**	16%	25	1	S+R (12+13)
RS1-1-08	2007-08	Fluid A-IV-EG	100/0	**51**		25	-3	ZR (25)
RS2-08	2007-08	Fluid B-IV-PG	100/0	**69**	13%	25	1	S+R (12+13)
RS2-1-08	2007-08	Fluid B-IV-PG	100/0	**61**		25	-3	ZR (25)
RS1-1A	2008-09	Fluid C-IV-PG	100/0	**57**	15%	25	1	S+R (12+13)
RS7	2008-09	Fluid C-IV-PG	100/0	**49**		25	-3	ZR (25)
RS2-2A	2008-09	Fluid D-IV-PG	100/0	**54**	34%	25	1	S+R (12+13)
RS8	2008-09	Fluid D-IV-PG	100/0	**40**		25	-3	ZR (25)
RS3-3A	2008-09	Fluid E-II-PG	100/0	**36**	23%	25	1	S+R (12+13)
RS9	2008-09	Fluid E-II-PG	100/0	**29**		25	-3	ZR (25)
RS4-4A	2008-09	Fluid F-II-PG	100/0	**25**	20%	25	1	S+R (12+13)
RS10	2008-09	Fluid F-II-PG	100/0	**21**		25	-3	ZR (25)
RS5-5A	2008-09	Fluid G-III-PG	100/0	**16**	55%	25	1	S+R (12+13)
RS11	2008-09	Fluid G-III-PG	100/0	**10**		25	-3	ZR (25)
RS6-6A	2008-09	Fluid H-IV-PG	50/50	**21**	40%	25	1	S+R (12+13)
RS12	2008-09	Fluid H-IV-PG	50/50	**15**		25	-3	ZR (25)
Avg % Diff. in Fail Time					**27%**			

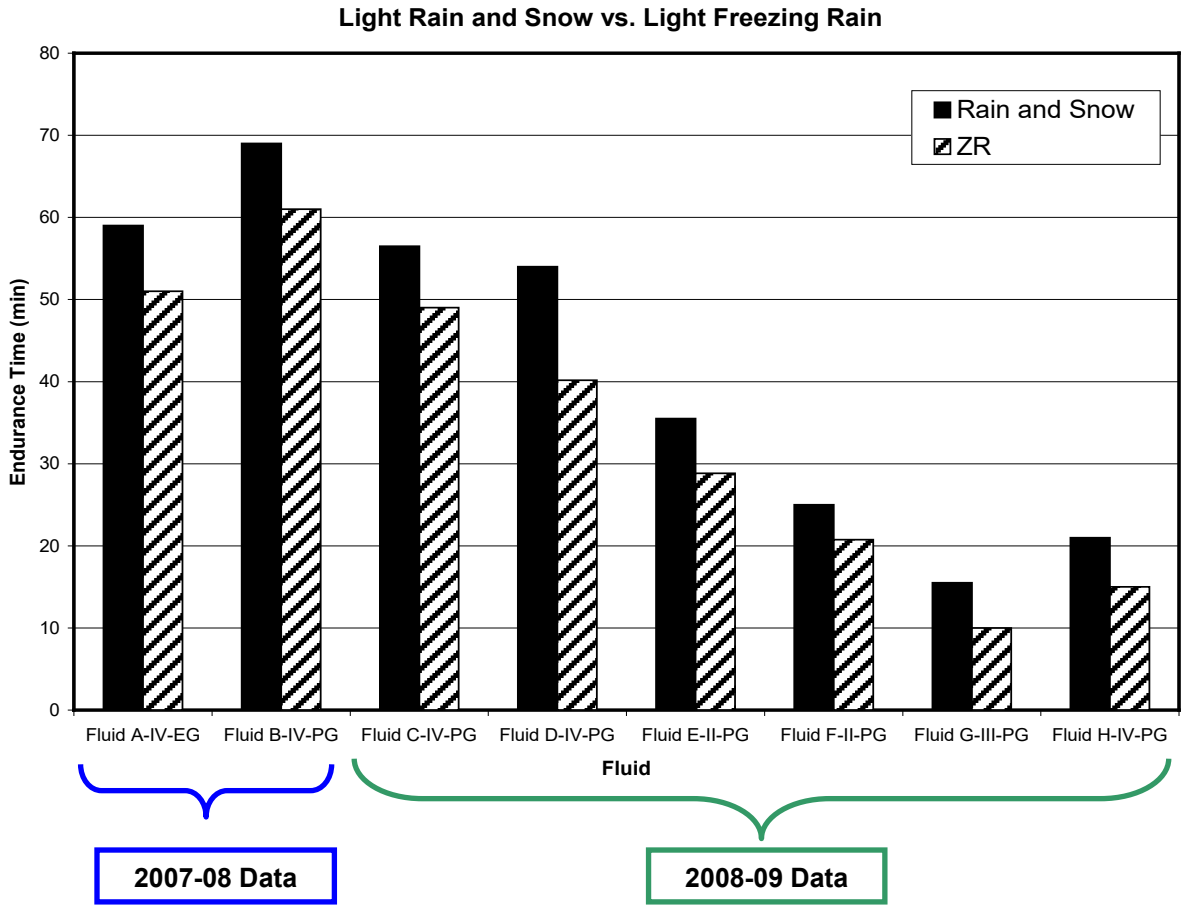


Figure 5.1: Endurance Time Tests Conducted in Winter 2007-08 and Winter 2008-09

6. EFFECT OF POOR APPLICATION METHODS ON FLUID ENDURANCE TIMES

6.1 Background

In recent years, inadequate fluid application has been an important topic of discussion throughout industry meetings. Limited data is currently available on the effects that poor application methods have on endurance times. To better understand this concern, as well as to make data readily available, a series of tests have been performed.

6.2 Objective

The overall objective of this project was to investigate the effects that poor application of fluid resulting in reduced fluid film thickness has on endurance times.

6.3 Methodology

A series of outdoor and indoor comparative tests were conducted in the winter of 2008-09. Baseline tests using the standard endurance time test procedure were conducted to compare the results using a two-step fluid application process with reduced amounts of Type II/III/IV fluid. The two-step fluid application procedure uses two fluids applied in sequence: a Type I fluid followed by a Type II/III/IV fluid. Several de/anti-icing fluids have been used to achieve this project's objective. These fluids are all lowest on-wing viscosity samples except for Octagon MaxFlo, which is a mid-production sample. The following subsections outline the outdoor and indoor procedures.

6.3.1 Outdoor Tests

APS Aviation Inc. (APS) conducted outdoor tests under natural snow conditions at the Montreal-Trudeau Airport test site facility. A procedure is included in Appendix G. A six-position test stand, shown in Figure 6.1, was used to conduct these tests. Test stand Position 1 was used for baseline purposes and Position 6 for collecting the rate of precipitation.

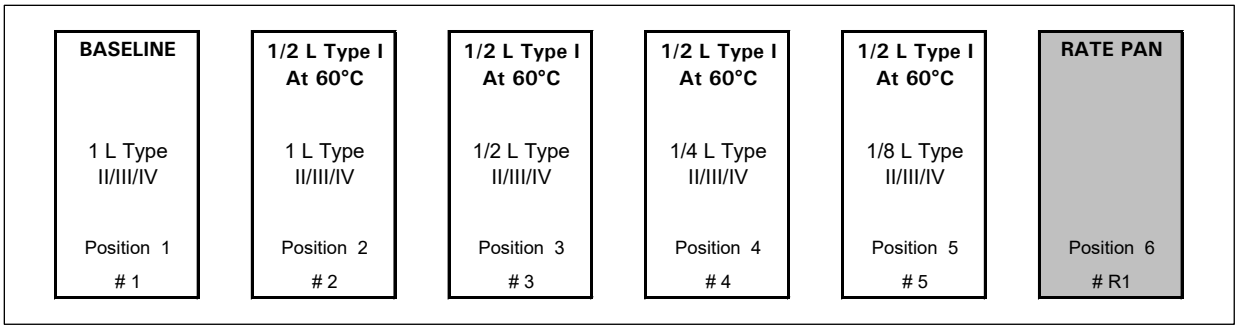


Figure 6.1: Position Test Stand Setup Outdoors

The first step of the two-step fluid application process began with the heating of Type I fluid (mixed to a 10ºC buffer) to 60ºC. Half a litre of Type I fluid was poured onto test plates two through five using a 12-hole spreader. A settling period of three minutes under precipitation elapsed before a Type II/III/IV fluid was applied. This procedure was used to simulate an operational fluid application, which follows a two-step procedure; when Type II/III/IV fluid is applied on a bare surface, the fluid does not flow as readily as when it is applied over a Type I fluid. A total of 1 L, 1/2 L, 1/4 L, and 1/8 L of Type II/III/IV fluids at outside air temperature (OAT) were hand-poured simultaneously onto the test plates according to Figure 6.1.

The same Type II/III/IV fluid was applied on Position 1 at the same time as the Type II/III/IV fluid on Positions 2, 3, 4, and 5 using the standard endurance time test procedure (1 L at OAT). This served as the baseline test.

Rate measurements were taken according to standard holdover time (HOT) testing practices. Along with rate measurements, thickness and Brix measurements were taken at 15-minute intervals, as well as at the start and end of the tests.

6.3.2 Indoor Tests

Following the preliminary work completed outdoors, the Federal Aviation Administration (FAA) recommended pursuing further testing indoors at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF). A procedure is included in Appendix E.

APS conducted indoor tests under freezing drizzle and light freezing rain conditions at the NRC CEF. The indoor test procedures were similar to those of the outdoor tests; however, only one reduced fluid quantity was tested with 1/8 L of fluid applied to the comparison test plate. In one run, 1/2 L of fluid was also tested. Precipitation rates, as well as thickness and Brix, were measured during these tests.

6.4 Test Results

Data was collected by APS under natural snow, freezing drizzle, and light freezing rain precipitation conditions during Winter 2008-09. A total of 26 comparative runs were conducted, comprising 7 outdoor runs and 19 indoor runs. A detailed log of the indoor and outdoor tests is shown in Table 6.1 and Table 6.2.

Table 6.1: Log of Outdoor Tests

Run #	Date	Fluid Name	Fluid Dilution	Type II/III/IV Quantity Poured (L)	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Endurance Time (min)	Approximate Rate (g/dm²/h)	Ambient Temp. (°C)	Precipitation Type
1	18-Feb-09	Type I + Kilfrost ABC-S	75/25	1	21:43:10	22:26:30	43.2	16	-1.1	Natural Snow
		Type I + Kilfrost ABC-S	75/25	1/2	21:43:45	22:22:00	38.2			
		Type I + Kilfrost ABC-S	75/25	1/4	21:44:00	22:16:00	32.0			
		Type I + Kilfrost ABC-S	75/25	1/8	21:44:14	22:14:30	30.2			
		Kilfrost ABC-S	75/25	1	21:43:10	22:25:00	41.5			
2	18-Feb-09	Type I + Kilfrost ABC-S	50/50	1	22:42:32	23:01:00	18.3	14	-1.0	Natural Snow
		Type I + Kilfrost ABC-S	50/50	1/2	22:42:55	23:03:30	20.4			
		Type I + Kilfrost ABC-S	50/50	1/4	22:43:07	23:02:30	19.2			
		Type I + Kilfrost ABC-S	50/50	1/8	22:43:25	23:03:00	19.4			
		Kilfrost ABC-S	50/50	1	22:42:43	23:01:00	18.2			
3	19-Feb-09	Type I + Clariant Safewing MP IV Launch	75/25	1	0:49:46	2:07:00	77.1	10	-0.7	Natural Snow
		Type I + Clariant Safewing MP IV Launch	75/25	1/2	0:50:03	2:12:00	81.6			
		Type I + Clariant Safewing MP IV Launch	75/25	1/4	0:50:24	2:13:00	82.4			
		Type I + Clariant Safewing MP IV Launch	75/25	1/8	0:50:40	1:48:00	57.2			
		Clariant Safewing MP IV Launch	75/25	1	0:49:45	2:08:00	78.2			
4	19-Feb-09	Type I + Clariant Safewing MP III 2031	100/0	1	2:31:47	3:26:30	54.4	4	-0.1	Natural Snow
		Type I + Clariant Safewing MP III 2031	100/0	1/2	2:32:07	3:27:00	54.5			
		Type I + Clariant Safewing MP III 2031	100/0	1/4	2:32:23	3:26:00	53.4			
		Type I + Clariant Safewing MP III 2031	100/0	1/8	2:32:38	3:24:30	51.5			
		Clariant Safewing MP III 2031	100/0	1	2:31:08	3:26:30	55.2			
5	19-Feb-09	Type I + ABAX Ecowing 26	100/0	1	4:26:07	5:01:30	35.2	20	-0.1	Natural Snow
		Type I + ABAX Ecowing 26	100/0	1/2	4:26:26	5:01:45	35.2			
		Type I + ABAX Ecowing 26	100/0	1/4	4:26:40	4:59:30	32.5			
		Type I + ABAX Ecowing 26	100/0	1/8	4:26:53	4:59:00	32.1			
		ABAX Ecowing 26	100/0	1	4:26:14	5:00:30	34.2			
6	22-Feb-09	Type I + Octagon MaxFlo	75/25	1	8:36:20	9:32:30	56.1	9	-4.1	Natural Snow
		Type I + Octagon MaxFlo	75/25	1/2	8:36:41	9:32:00	55.2			
		Type I + Octagon MaxFlo	75/25	1/4	8:36:59	9:31:30	54.3			
		Type I + Octagon MaxFlo	75/25	1/8	8:37:19	9:21:00	43.4			
		Octagon MaxFlo	75/25	1	8:36:18	9:31:00	54.4			
7	22-Feb-09	Type I + Lyondell ARCTIC Shield	100/0	1	12:03:06	12:58:00	54.5	12	-4.6	Natural Snow
		Type I + Lyondell ARCTIC Shield	100/0	1/2	12:03:25	13:02:00	58.4			
		Type I + Lyondell ARCTIC Shield	100/0	1/4	12:03:41	13:02:30	58.5			
		Type I + Lyondell ARCTIC Shield	100/0	1/8	12:03:59	12:58:00	54.0			
		Lyondell ARCTIC Shield	100/0	1	12:03:06	12:59:00	55.5			

Table 6.2: Log of Indoor Tests

Run #	Test #	Date	Fluid Name	Fluid Dilution	Type II/III/IV Quantity Poured (L)	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Endurance Time (min)	Actual Rate of Precip. (g/dm²/h)	Chamber Temp. (°C)	Precipitation Type
1	PA01	02-Apr-09	Type I + Kilfrost ABC-4^{sustain}	75/25	1/8	14:51:00	15:48:00	57.0	5.5	-3.3	Freezing Drizzle
	PA02		Kilfrost ABC-4^{sustain}	75/25	1	15:02:00	16:11:00	69.0	4.7	-3.2	
2	PA03	02-Apr-09	Type I + Aviation Shaanxi Hi-Tech Cleanwing II	50/50	1/8	17:31:50	18:11:00	39.2	5.2	-3.2	Freezing Drizzle
	PA04		Aviation Shaanxi Hi-Tech Cleanwing II	50/50	1	16:43:50	17:24:00	40.2	4.8	-3.1	
3	PA05	02-Apr-09	Type I + Kilfrost ABC-4^{sustain}	50/50	1/8	12:13:30	12:26:00	12.5	12.8	-3.2	Freezing Drizzle
	PA06		Kilfrost ABC-4^{sustain}	50/50	1	10:21:30	10:32:05	10.6	13.2	-3.1	
4	PA07	02-Apr-09	Type I + Kilfrost ABC-4^{sustain}	100/0	1/8	10:26:40	11:42:00	75.3	12.5	-3.1	Freezing Drizzle
	PA08		Kilfrost ABC-4^{sustain}	100/0	1	10:03:00	11:39:00	96.0	13.3	-3.1	
5	PA09	02-Apr-09	Type I + Aviation Shaanxi Hi-Tech Cleanwing II	100/0	1/8	18:37:30	19:30:00	52.5	5.7	-10.4	Freezing Drizzle
	PA10		Aviation Shaanxi Hi-Tech Cleanwing II	100/0	1	19:20:50	20:11:00	50.2	5.2	-10.5	
6	PA11	31-Mar-09	Type I + ABAX Ecowing AD-49	75/25	1/8	18:38:51	19:18:00	39.2	5.4	-10.4	Freezing Drizzle
	PA12		ABAX Ecowing AD-49	75/25	1	17:50:10	18:52:00	61.8	5.0	-10.3	
7	PA13	30-Mar-09	Type I + ABAX Ecowing AD-49	100/0	1/8	19:12:05	19:37:00	24.9	13.4	-10.3	Freezing Drizzle
	PA14		ABAX Ecowing AD-49	100/0	1	18:58:45	19:23:00	24.3	13.1	-10.3	
8	PA15	30-Mar-09	Type I + Clariant Safewing MP III Solo	75/25	1/8	20:15:00	20:36:00	21.0	13.2	-10.3	Freezing Drizzle
	PA16		Clariant Safewing MP III Solo	75/25	1	20:48:00	21:08:00	20.0	12.0	-10.3	
9	PA17	01-Apr-09	Type I + Kilfrost ABC-4^{sustain}	100/0	1/2	17:28:00	18:51:00	83.0	12.9	-3.3	Light Freezing Rain
	PA18		Type I + Kilfrost ABC-4^{sustain}	100/0	1/8	17:29:00	18:37:00	68.0	13.5	-3.3	
	PA19		Kilfrost ABC-4^{sustain}	100/0	1	16:45:10	18:15:00	89.8	13.0	-3.2	
10	PA20	01-Apr-09	Type I + Aviation Shaanxi Hi-Tech Cleanwing II	50/50	1/8	19:11:45	19:33:00	21.3	13.0	-3.2	Light Freezing Rain
	PA21		Aviation Shaanxi Hi-Tech Cleanwing II	50/50	1	16:49:10	17:10:00	20.8	13.5	-3.0	
11	PA22	01-Apr-09	Type I + Aviation Shaanxi Hi-Tech Cleanwing II	100/0	1/8	10:16:40	10:42:30	25.8	24.6	-3.2	Light Freezing Rain
	PA23		Aviation Shaanxi Hi-Tech Cleanwing II	100/0	1	8:42:50	9:07:00	24.2	24.7	-3.2	
12	PA24	01-Apr-09	Type I + ABAX Ecowing AD-49	50/50	1/8	10:49:15	11:02:40	13.4	25.0	-3.1	Light Freezing Rain
	PA25		ABAX Ecowing AD-49	50/50	1	10:05:45	10:18:00	12.3	24.8	-3.2	

6.4.1 Outdoor Test Results

Data collected from the outdoor tests did not demonstrate any significant differences in the endurance times between the baseline and the reduced fluid quantity tests, except for the tests using 1/8 L. Based on these results, 1/8 L of fluid was determined to be the quantity of fluid used during indoor tests at the NRC. A summary of the outdoor test results is shown in Table 6.3, and Figure 6.2 illustrates these results in bar graph form. It is apparent, from Figure 6.2, that a drop in the endurance times tends to begin at the 1/4 L quantity. These drop-offs in endurance time are not consistent; the inconsistencies may be related to temperature, precipitation rate, or the type/brand and dilution of fluid.

Table 6.3: Result Summary of Outdoor Tests

					Baseline	Reduced Fluid Quantity[1]			
Date	Test #	Fluid Name	Fluid Dilution	Approximate Rate (g/dm²/h)	Endurance Time 1 L (min)	Endurance Time 1 L (min)	Endurance Time 1/2 L (min)	Endurance Time 1/4 L (min)	Endurance Time 1/8 L (min)
18-Feb-09	1	Kilfrost ABC-S	75/25	16	41.5	43.2	38.2	32.0	30.2
18-Feb-09	2	Kilfrost ABC-S	50/50	14	18.2	18.3	20.4	19.2	19.4
19-Feb-09	3	Clariant Safewing MP IV Launch	75/25	10	78.2	77.1	81.6	82.4	57.2
19-Feb-09	4	Clariant Safewing MP III 2031 ECO	100/0	4	55.2	54.4	54.5	53.4	51.5
19-Feb-09	5	ABAX Ecowing 26	100/0	20	34.2	35.2	35.2	32.5	32.1
22-Feb-09	6	Octagon MaxFlo	75/25	9	54.4	56.1	55.2	54.3	43.4
22-Feb-09	7	Lyondell ARCTIC Shield	100/0	12	55.5	54.5	58.4	58.5	54.0

[1] Plates that follow a two-step fluid application process (1/2 L Type I heated to 60ºC followed by Type II/III/IV).

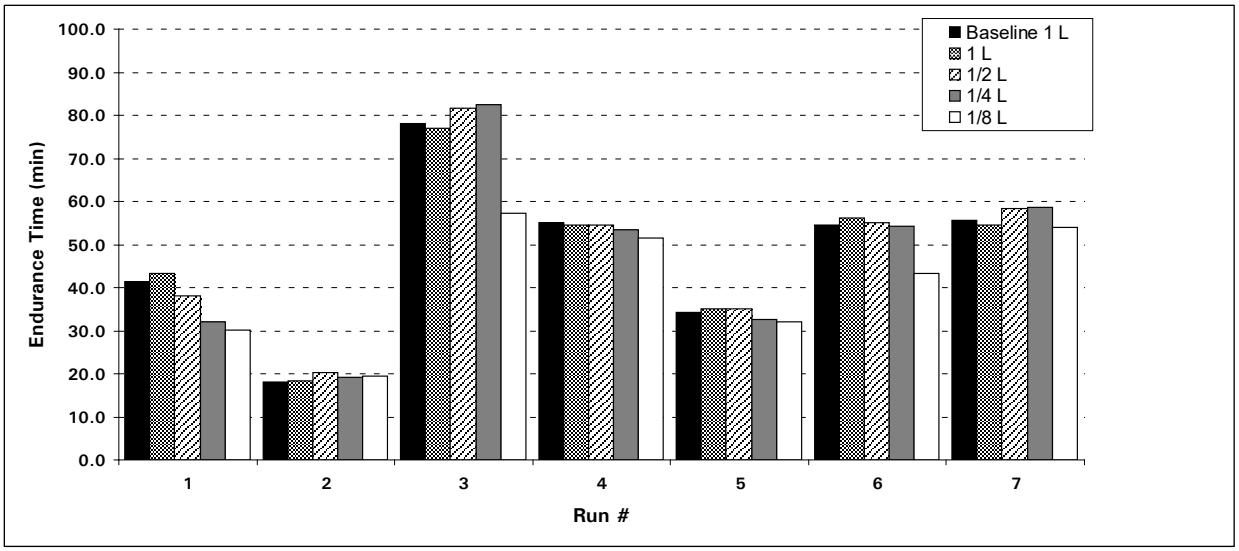


Figure 6.2: Outdoor Results

6.4.2 Indoor Test Results

Most of the indoor tests (9 of 19 cases) show no significant differences (within 10 percent) in the endurance times when fluid quantity is reduced. In 3 of the 19 cases, results demonstrate endurance times to be more than 10 percent greater than the comparative baseline tests. However, 7 of 19 cases reveal endurance times to be more than 10 percent lower. Among these cases, 5 runs show endurance times more than 20 percent lower than the comparative baseline tests. A summary of the indoor tests is shown in Table 6.4, and Figure 6.3 illustrates these results in bar graph form.

Table 6.4: Result Summary of Indoor Tests

					Baseline	Two-Step Fluid Application[1]	
Date	**Test #**	**Fluid Name**	**Fluid Dilution**	**Approximate Rate ($g/dm^2/h$)**	**Endurance Time 1 L (min)**	**Endurance Time 1/8 L (min)**	**% Difference**
02-Apr-09	PA01/PA02	Kilfrost P2282	75/25	5	69.0	57.0	17%
02-Apr-09	PA03/PA04	Xi'An Cleanwing II	50/50	5	40.2	39.2	3%
02-Apr-09	PA05/PA06	Kilfrost P2282	50/50	13	10.6	12.5	-18%
02-Apr-09	PA07/PA08	Kilfrost P2282	100/0	13	96.0	75.3	22%
31-Mar-09	PA09/PA10	Xi'An Cleanwing II	100/0	5	50.2	52.5	-5%
31-Mar-09	PA11/PA12	ABAX F394	75/25	5	61.8	39.2	37%
30-Mar-09	PA13/PA14	ABAX F394	100/0	13	24.3	24.9	-2.5%
30-Mar-09	PA15/PA16	Clariant Safewing MP III Solo	75/25	13	20.0	21.0	-5.0%
01-Apr-09	PA17/PA18/PA19	Kilfrost P2282	100/0	13	89.8	68.0	24%
						83.0 (1/2 L)	8%
01-Apr-09	PA20/PA21	Xi'An Cleanwing II	50/50	13	20.8	21.3	-2%
01-Apr-09	PA22/PA23	Xi'An Cleanwing II	100/0	25	24.2	25.8	-7%
01-Apr-09	PA24/PA25	ABAX F394	50/50	25	12.3	13.4	-9%
01-Apr-09	PA26/PA27	Kilfrost P2282	75/25	25	30.0	25.8	14%
01-Apr-09	PA28/PA29	Clariant Launch	100/0	25	41.0	32.3	21%
01-Apr-09	PA30/PA31	Octagon MaxFlo	100/0	25	29.4	31.0	-5%
30-Mar-09	PA32/PA33	ABAX F394	100/0	13	27.5	36.5	-32%
30-Mar-09	PA34/PA35	Clariant Safewing MP III Solo	75/25	13	16.0	18.5	-16%
30-Mar-09	PA36/PA37	Kilfrost P2282	100/0	25	65.5	49.8	24%
30-Mar-09	PA38/PA39	Xi'An Cleanwing II	75/25	25	19.1	18.2	5%

[1] Plates that follow a two-step fluid application process (1 L of Type I at 20°C followed by Type II/III/IV).

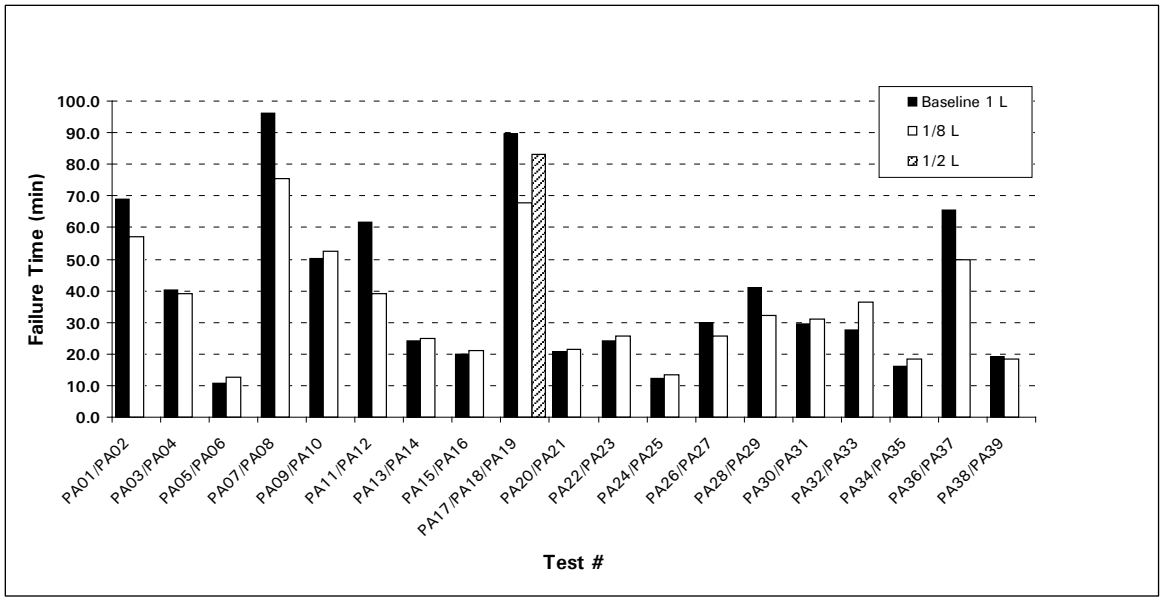


Figure 6.3: Indoor Results

6.5 Special Wind Tunnel Tests

A series of "poor application" tests were performed at the NRC 3 m x 6 m Open-Circuit Propulsion Icing Wind Tunnel (PIWT) in Winter 2008-09 to visually investigate the aerodynamic flow-off characteristics associated with inadequate anti-icing fluid application procedures. The wing section was divided in half, with 10 L of fluid applied to one side and 1 L applied to the other. Type I fluid was not used during these tests. The 10 L of fluid applied represents the regular fluid application procedure for the test, while the 1 L of fluid represents the inadequate fluid application procedure.

Test #79 of that series of tests is discussed here. Following fluid application, the test wing surface was subjected to simulated freezing rain precipitation at a rate of 25 g/dm²/h for a period of 25 minutes, after which the wind tunnel was run.

Photo 6.1 shows the appearance of the reduced quantity of fluid as compared to the normal quantity. The regular fluid application side is equivalent to approximately 7/10 L per test plate, while the inadequate application side is equivalent to approximately 1/15 L per test plate (this is about half the quantity that was applied for the plate tests described in the previous indoor test section). Visually, the fluid on the inadequate surface of the wing in Photo 6.1 might be considered to be satisfactory by a deicing operator; however, failure of the fluid on that section occurred much before the adequate application section of the wing (see Photo 6.2).

Photo 6.3 shows the wing section after the tunnel has been run. The overall approach and findings of these tests can be found in the Transport Canada (TC) report, TP 14939E, *Exploratory Wind Tunnel Aerodynamic Research Examination of Contaminated Anti-Icing Fluid Flow-Off Characteristics Winter 2008-09* (3).

6.6 Conclusions and Recommendations for Future Work

Outdoor tests reveal that reduced fluid quantity application does not significantly reduce endurance times unless the quantity applied is below 1/4 L per plate. Indoor tests performed with fluid applied at a level of 1/8 L per plate showed shorter endurance times in many cases when compared to tests using the standard endurance time protocol. These results were confirmed in the wind tunnel research that was performed during the winter of 2008-09.

In conclusion, if Type II/III/IV fluid is inadequately applied, endurance times may be reduced. The amount of fluid applied for the de/anti-icing of aircraft must be applied in sufficient quantity in order to achieve optimal protection.

Photo 6.1: After Fluid Application

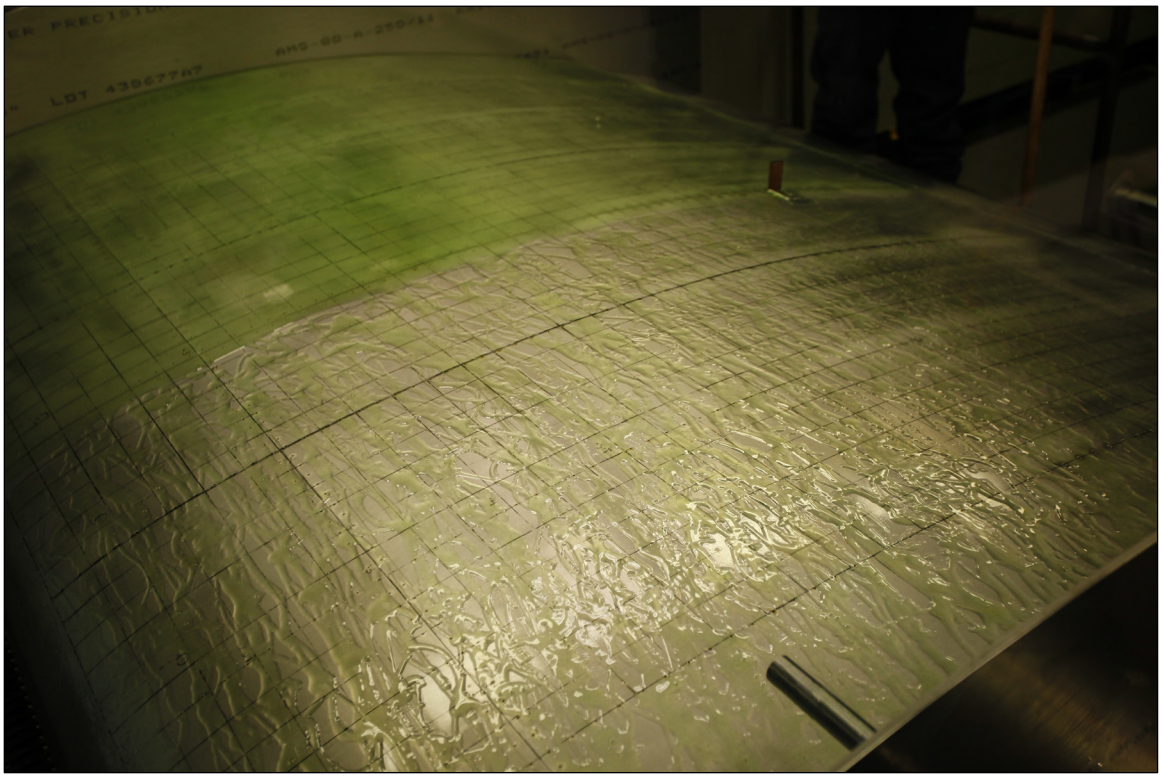


Photo 6.2: Before Takeoff Run

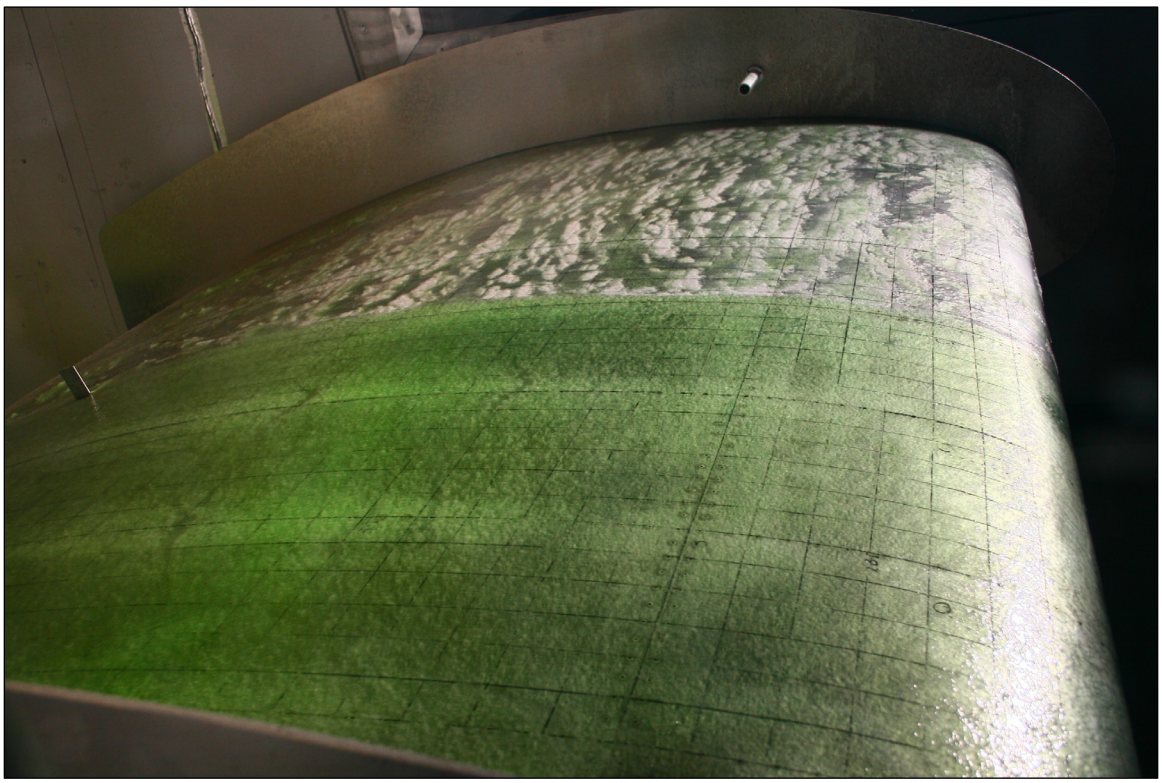
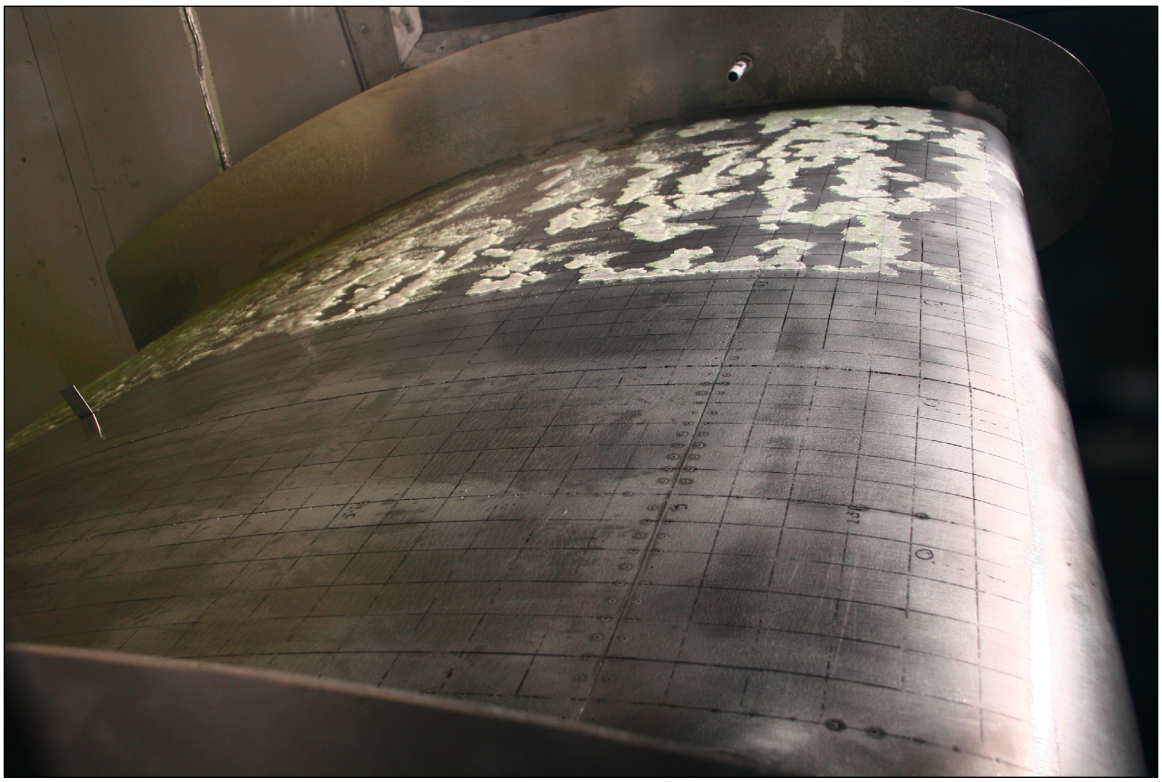


Photo 6.3: After Takeoff Run



7. EFFECT OF SHEARING OF ANTI-ICING FLUIDS ON ENDURANCE TIMES

7.1 Objective

This review investigated whether thickened anti-icing fluids are being sheared during fluid application in field operations to the detriment of published Holdover Time (HOT) Guidelines.

The review examined reports on previous studies thought to contain data and information useful for this purpose.

The analysis considered the following questions:

1. Is thickened anti-icing fluid subjected to shearing during standard field operations using recommended fluid nozzles?
2. How much is the fluid viscosity affected?
3. What is the effect of reduced fluid viscosity on fluid endurance times?
4. Does the reduction in endurance times impinge on published holdover times?

7.2 Findings

Some of the reports reviewed had addressed the specific question of shearing during fluid application. Other studies had unrelated objectives but had collected data that is useful for this examination and that could be re-analysed to that end.

The findings relative to this review for each report examined are given in Appendix H. The summary first addresses the impact of reduced viscosity on endurance times and then the question of viscosity reduction during spraying.

7.3 Summary of Findings

7.3.1 Effect of Reduced Viscosity on Fluid Endurance Times

The following five studies reported the effect of reduced viscosity on fluid endurance times:

- Transport Canada (TC) report, TP 13318E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Field Testing Program for the 1997-98 Winter* (4);
- TC report, TP 13477E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Field Testing Program for the 1998-99 Winter* (5);
- TC report, TP 14152E, *A Potential Solution for De/Anti-Icing of Commuter Aircraft* (6);
- TC report, TP 14379E, *Development of Holdover Time Guidelines for Type III Fluids* (7); and
- TC report, TP 13996E, *Influence of Application Procedure on Anti-Icing Fluid Viscosity* (8).

These reports show beyond any doubt that reduced viscosity has an immediate effect on endurance times. As shown in the report reviews, the degree of impact varies considerably by fluid brand and test condition.

One example from TP 13996E (8) can be considered:

- For Fluid C, a viscosity reduction of 7 percent led to an endurance time reduction of 12 percent; and
- For Fluid D, a viscosity reduction of 46 percent led to an endurance time reduction of 22 percent.

The effect of fluid mixing was also seen in this report, when Type IV fluid was sprayed over Type I fluid:

- For Fluid C, a viscosity reduction of 11 percent led to an endurance time reduction of 30 percent; and
- For Fluid D, a viscosity reduction of 45 percent led to an endurance time reduction of 43 percent.

7.3.1.1 Endurance Times for Degraded Type II and IV Fluids

Four studies conducted on behalf of fluid manufacturers to examine endurance times for degraded Type II and IV fluids were reviewed. The results had been formulated as holdover tables for those degraded fluids, and the changes in endurance times averaged over the tested cells are shown in Table 7.1. While the average change is not large, the results range widely, with substantial reductions in endurance times in some cells.

Table 7.1: Endurance Times for Degraded Type II and IV Fluids

Fluid	# of Tests	Reduction in Degraded Fluid Viscosity (% of Original)	Average Reduction in Degraded Fluid Endurance Time (% of Original)	Range of Reduction in Degraded Fluid Endurance Time (% of Original)
Fluid A	84	-26%	-13%	-43% to +18%
Fluid B	92	-60%	-1%	-36% to +57%
Fluid C	52	-61%	-8%	-29% to +24%
Fluid D	80	-77%	-11%	-44% to +75%

7.3.2 Shearing During Fluid Applications Using the Standard Type II/IV Nozzle

The following four studies provided information that could be used to examine whether spraying operations using the conventional nozzle reduce fluid viscosity:

- TC report, TP 13996E, *Influence of Application Procedure on Anti-Icing Fluid Viscosity* (8);
- TC report, TP 14153E, *Endurance Times of Fluids Applied with Forced Air Systems* (9);
- TC report, TP 14380E, *A Protocol for Testing Fluids Applied with Forced Air Systems* (10); and
- TC report, TP 14445E, *Evaluation of Type IV Fluids Applied Using Forced Air Assist Equipment* (11).

TP 13996E (8) documented the field tests showing that the viscosity of sprayed fluid can deviate from tank fluid viscosity by as much as 38 percent. The resultant reduction on endurance times can be as great as 22 percent.

Two tests examining forced-air assist applications (TP 14153E [9] and TP 14380E [10]) collected data on fluid viscosity from conventional nozzle applications as well as from forced-air assist applications. This data was subjected to the routine established in TP 14445E (11) to determine the seriousness of any viscosity reductions due to forced-air assist systems. This new procedure defined a method to determine if a forced-air system is acceptable for use with a specific fluid. In this method, a formula is applied to determine the lowest acceptable delivered viscosity of the specific fluid.

The results suggest that fluid applications using conventional nozzles can reduce viscosity to an extent that impinges on published holdover times for some fluids.

Additional references and information are included in Appendix H.

7.3.3 Inadequate Fluid Quantities

Previous reports did not provide any direct data or information regarding this question.

The only pertinent information might be the data collected in TP 13996E (8) concerning viscosity reductions when anti-icing fluids were sprayed over Type I fluid. In these tests, the viscosity of the mixed fluid was generally further reduced, as was the resulting endurance time. This must be a result of the mixing of the Type I and Type IV fluids. It demonstrates the importance of applying sufficient amounts of the second-step fluid to ensure that the deicing fluid is completely removed from the treated surface.

Section 6 of this report provides information and data on this subject.

7.4 Recommendations for Future Action

The reviewed reports indicate that reduced viscosity fluids can cause a substantial reduction on endurance times. Reduced viscosities may stem from different causes, including inadequate fluid storage and handling procedures. The reports indicate that viscosity reduction can also result from shearing during spray operations using conventional nozzles.

Because reduced fluid viscosity can decrease fluid endurance times to an extent that holdover times are jeopardized, it is important that operators establish and maintain strict quality control processes for fluid management. Conformance to the following requirement stated in the *FAA-Approved Deicing Program Updates, Winter 2008-2009* is essential:

> **Fluid Quality Control.**
>
> In addition, for Types II, III, and IV fluids, viscosity checks, per the fluid manufacturer's recommendations, should be performed at the beginning of the icing season and periodically throughout the winter and any time fluid contamination or damage is suspected. These viscosity checks should be performed in accordance with fluid manufacturers' recommendations and should include samples obtained through the spray nozzles of application equipment.

Quality control checks must be conducted on fluid samples from storage tanks and following spraying to verify that anti-icing fluid viscosities are higher than the viscosities identified on the brand-specific tables. Test results should be kept on record. Fluid quality control procedures should be well documented as an integral part of operator's deicing programs.

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8. HOLDOVER TIMES RELATED TO AIRCRAFT HANGAR OPERATIONS

A preliminary test program was completed in the winter of 2008-09 to examine the effect of delayed exposure to precipitation on fluid endurance time. The project was completed in response to several operators asking regulators for guidance material on holdover times (HOTs) for hangar operations.

A description of the test program and its conclusions is provided in this section. This work was also presented to the SAE International (SAE) G-12 Holdover Time Subcommittee at the May 2009 meeting in Warsaw, Poland (see presentation in Appendix I).

8.1 Background

Some operators, typically of corporate and private jets, anti-ice aircraft inside aircraft hangars. There are several reasons for anti-icing inside hangars, including avoiding central deicing facilities and avoiding the need for deicing (both of which incur delays and additional expense).

Following anti-icing, the aircraft may sit in the hangar for some time before departing the hangar and being exposed to precipitation.

Several operators have asked Transport Canada (TC) for guidance on when to start the HOT "clock" (i.e., when the available holdover time begins to be counted down) during these types of operations. Specifically, they have asked if the HOT clock can be started when the aircraft is first exposed to precipitation rather than being started when anti-icing fluid application begins.

8.2 Current Guidance Material

Federal Aviation Administration (FAA) and TC guidance material was reviewed to examine what guidance is currently provided for hangar operations and for starting the HOT clock.

No guidance specifically related to hangar operations was found in the FAA documents. However, several FAA documents contain guidance for when to start the HOT clock:

- N 8900.55 §6.a.(2)(f).1.1: Holdover times start as soon as the anti-icing step begins.
- AC135-17/AC135-16/AC120-60B: Holdover time begins when the final application of de/anti-icing fluid commences and expires when the de/anti-icing fluid applied to the aircraft loses its effectiveness.

One TC document was found to contain relevant guidance:

- TP 14052 §11.1.1 (Holdover Time Guidelines – General): The time that fluid remains effective is the time from first application of anti-icing fluid on a clean wing until such time as ice crystals form or remain in the fluid, creating a surface roughness.
- TP 14052 §10.11 (Applying Type IV Fluid in a Hangar): The period of time after Type IV 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 the frozen precipitation. The holdover time available from a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature.

  The air operator is advised to consult with the fluid manufacturer for guidance on using their fluids under these conditions. A minimum of a fluid thickness measurement may be required, dependent upon the circumstances, to ensure that the predicted fluid holdover time protection is available.

In summary, current guidance material does not state specifically when the HOT clock should start for fluids applied in hangars; however, all guidance material related to the HOT clock clearly states that the clock must be started when fluid application begins. Without any changes to guidance material, operators must start the HOT clock when anti-icing fluid application begins.

8.3 Objective

Previous research has shown that fluid thickness impacts anti-icing fluid holdover time – as thickness decreases, the holdover time also decreases. While the amount of precipitation the fluid is exposed to impacts its thickness, so too does gravity. Gravity causes fluid to flow off the aircraft, regardless of the presence of precipitation. Given this information, the current guidance material is appropriate, and the HOT clock should be started at the time of fluid application, regardless of whether exposure of the aircraft to precipitation was delayed. However, TC was interested in seeing several tests performed to confirm the application of the previous research to the aircraft hangar situation.

The objective of the project was therefore to conduct a limited number of tests to determine if the HOT clock can safely be started at the time of exposure to precipitation.

8.4 Procedure

Comparative tests were conducted outdoors in natural snow and indoors in simulated freezing precipitation. Outdoor tests were conducted at the APS Aviation Inc. (APS) test site at the Montreal-Trudeau Airport. Indoor tests were conducted at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

Separate but similar procedures were written for the outdoor and indoor tests:

- The procedure for outdoor tests is provided in *Evaluation of Endurance Time Values for Indoor (Aircraft Hangar) Anti-Icing Applications* (see Appendix J); and
- The procedure followed for indoor tests is included in *Overall Program of Tests at NRC, March-April 2009* (see Appendix E).

Each test run included a standard test and two or three hangar tests. The standard test simulated standard operational conditions. It was conducted to provide a baseline endurance time to which the hangar test endurance times could be compared. The standard test was conducted using the standard endurance time test protocol for HOT testing; therefore, the standard test endurance time provides the simulated holdover time for the test fluid in the specific environmental conditions of the test run (precipitation type, precipitation rate, and outside air temperature [OAT]).

Three types of hangar tests were conducted to examine fluid endurance times under three types of simulated hangar operational conditions.

The variables that differentiate standard operational conditions and hangar operational conditions include the following:

- Surface Temperature: Aircraft are typically at OAT in standard operations but typically at room temperature in hangar operations (as they are positioned in hangars until departure);
- Fluid Temperature: Fluid is at OAT in standard operations (as it is stored in trucks outside) but can be at room temperature (if stored in a hangar) or OAT (if stored outdoors) in hangar operations; and
- Time Between Fluid Application and Exposure to Precipitation: Exposure to precipitation is immediate in standard operations (as fluid application is done outdoors) but is delayed in hangar operations (as described in Subsection 8.1).

The test variables were set to simulate standard and hangar operations. The variables were set for the four test types as shown in Table 8.1.

Table 8.1: Test Variables

Variable	Test Type			
	Standard	Hangar 1	Hangar 2	Hangar 3
Surface Temperature	OAT	20°C	20°C	20°C
Fluid Temperature	OAT	20°C	20°C	OAT
Time Between Fluid Application and Exposure to Precipitation	0 mins	15 mins	60 mins	60 mins

Test surfaces for the hangar tests were kept indoors prior to testing to ensure they were at approximately 20°C at the beginning of the test (see Photo 8.1). The test surface for the standard test was kept in the test area to ensure it was at ambient temperature.

All test surfaces were exposed to precipitation at the same time to ensure all tests in a run were exposed to the same type and amount of precipitation. This required that fluid to be applied in advance for the hangar tests (see Photo 8.2). For Hangar 1 tests, the fluid was applied to the test surface 15 minutes prior to exposure to precipitation. For Hangar 2 and Hangar 3 tests, fluid was applied to the test surface 60 minutes prior to exposure. Photo 8.3 depicts outdoor testing.

8.5 Data

A total of 11 test runs were conducted. Tests were conducted with neat Type II, III, and IV fluids; no diluted fluids were tested. Two Type II fluids (Clariant Safewing MP II Flight and Aviation Shaanxi Cleanwing II), one Type III fluid, and three Type IV fluids (Kilfrost ABC-4^{sustain}, ABAX Ecowing AD-49, and Dow UCAR Endurance EG 106) were used for the tests. Test runs were conducted at OATs from -10°C to -1°C; under snow, light freezing rain, freezing drizzle, and in precipitation rates from 5 g/dm^2/h to 25 g/dm^2/h.

Hangar test endurance times were calculated from the start of exposure to precipitation to the time of fluid failure. A schematic showing the calculation of endurance times for each type of test is provided in Figure 8.1.

A log of tests conducted is given in Table 8.2.

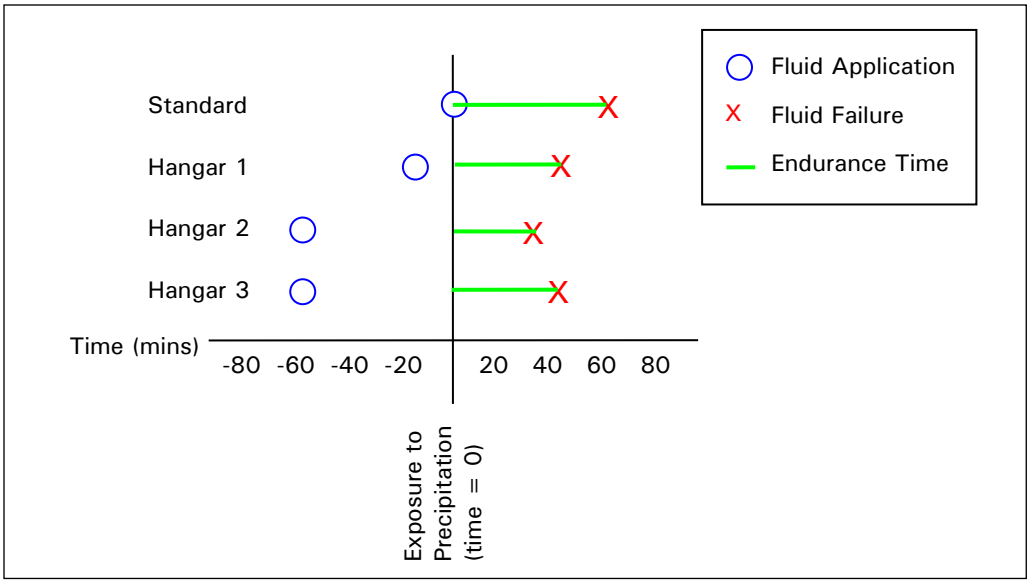

Figure 8.1: Schematic for Calculation of Endurance Time

8.6 Analysis

The test results are analysed in this subsection. A chart is provided for each test run. The standard test endurance time (which simulates holdover time) is shown as a red line on each chart. The endurance times for each of the hangar tests conducted during the run are shown as bars on the charts. Cases where the bars fall below the red line indicate tests where the endurance time of the hangar test was shorter than the standard endurance time. This indicates a safety risk; if this were a real operation, the fluid would fail before the holdover time was reached.

Of the 26 hangar tests completed, 42 percent had endurance times that were shorter than the standard test endurance times (see Table 8.3). A photo taken during Run 1 (see Photo 8.4) clearly shows the hangar tests failing sooner than the standard test.

The test result charts are provided in Figure 8.2 to Figure 8.12.

Table 8.2: Log of Tests

Run #	Date	Fluid Type	Fluid Dilution	Precipitation Type	OAT (°C)	Precip. Rate (g/dm²/h)	Standard Endurance Time[1] (mins)	Hangar Endurance Time[2],[3] (mins)		
								Hangar 1	Hangar 2	Hangar 3
1	18-Feb-09	Type IV	100%	Snow	-1	10	72 [1.7]	56 [0.6]	47 [0.4]	n/a
2	19-Feb-09	Type III	100%	Snow	-1	12	17 [0.3]	24 [0.2]	23 [0.0]	n/a
3	22-Feb-09	Type II	100%	Snow	-4	14	97 [1.3]	45 [0.4]	16 [0.1]	n/a
4	30-Mar-09	Type IV	100%	Light Freezing Rain	-10	13	76 [1.8]	45 [1.0]	37 [1.0]	41 [0.5]
5	01-Apr-09	Type II	100%	Light Freezing Rain	-3	13	36	49	46	46
6	30-Mar-09	Type IV	100%	Freezing Drizzle	-10	13	35	64	48	67
7	02-Apr-09	Type II	100%	Freezing Drizzle	-3	5	57	65	53	50
8	01-Apr-09	Type IV	100%	Light Freezing Rain	-3	25	66	n/a	51	51
9	30-Mar-09	Type IV	100%	Light Freezing Rain	-10	25	22 [1.7]	n/a	21 [0.1]	43 [1.1]
10	02-Apr-09	Type IV	100%	Freezing Drizzle	-3	13	88	n/a	51	87
11	31-Mar-09	Type IV	100%	Freezing Drizzle	-10	5	119 [1.8]	n/a	117 [0.6]	114 [0.4]

[1] Values in brackets are thickness measurements approximately at the time of exposure to precipitation.

[2] Hangar endurance times are calculated from the time of exposure to precipitation to the time of fluid failure.

[3] A "n/a" indicates the test was not conducted.

Table 8.3: Comparison of Hangar Endurance Time to Standard Endurance Time

Test Type	Total Tests	Tests Where Hangar ET Is*		
		< Standard ET	≈ Standard ET	> Standard ET
Hangar 1: • Surface @ 20°C • Fluid @ 20°C • Exposure delay 15 mins	7	3 (43%)	0 (0%)	4 (57%)
Hangar 2: • Surface @ 20°C • Fluid @ 20°C • Exposure delay 60 mins	11	5 (45%)	3 (27%)	3 (27%)
Hangar 3: • Surface @ 20°C • Fluid @ OAT • Exposure delay 60 mins	8	3 (38%)	2 (25%)	3 (38%)
All	**26**	**11 (42%)**	**5 (19%)**	**10 (38%)**

* Endurance times within 10% are considered approximately equal.

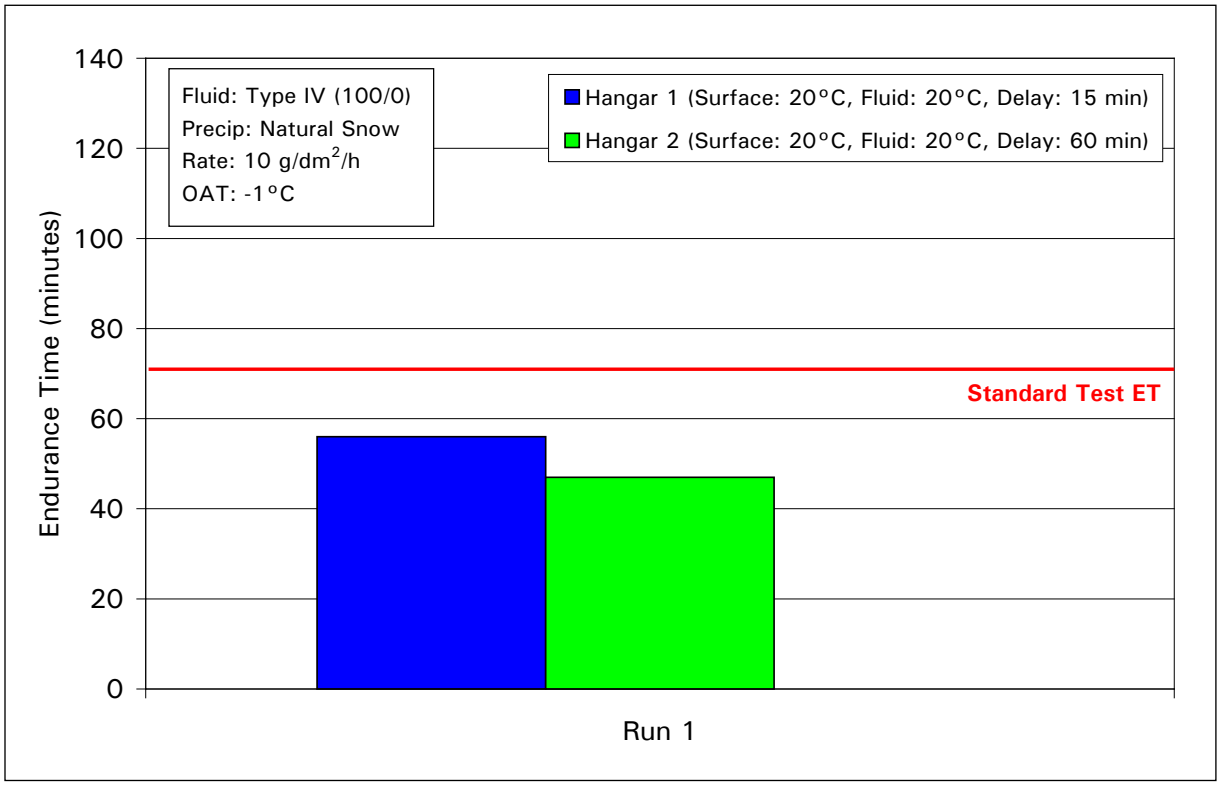

Figure 8.2: Test Results – Run 1

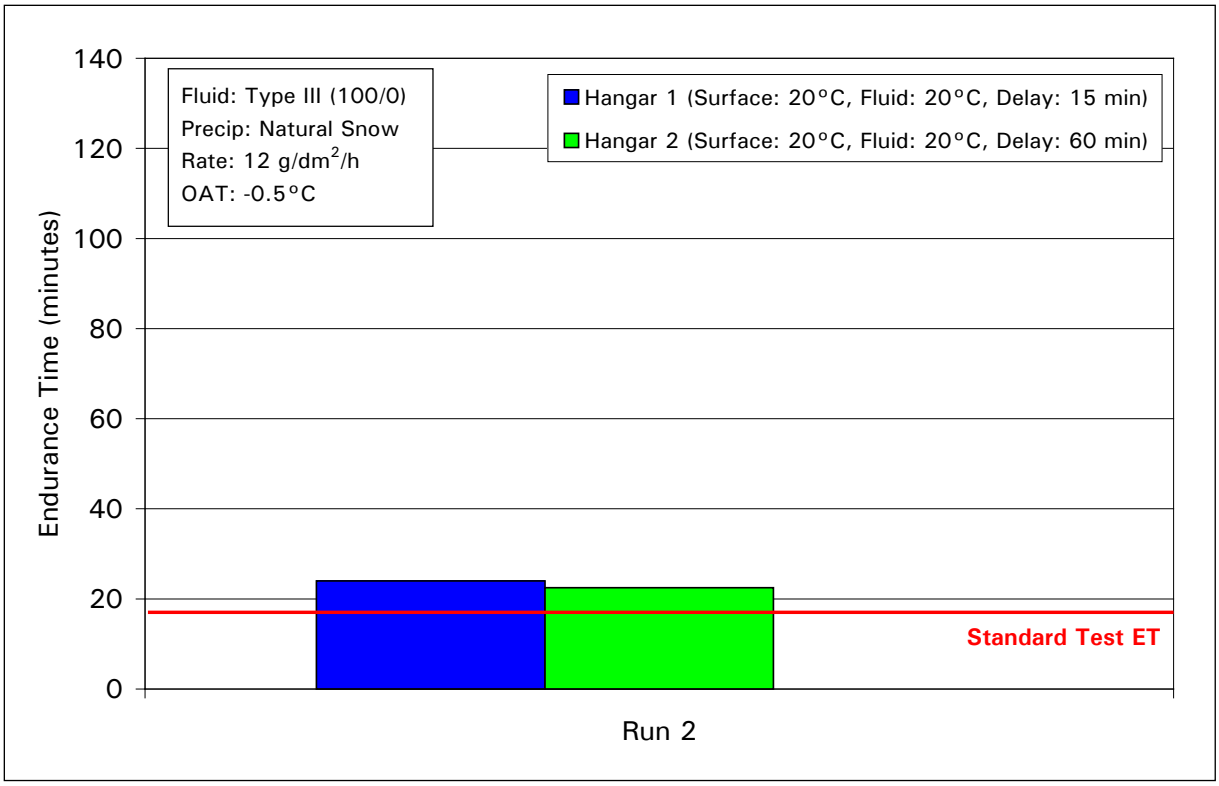

Figure 8.3: Test Results – Run 2

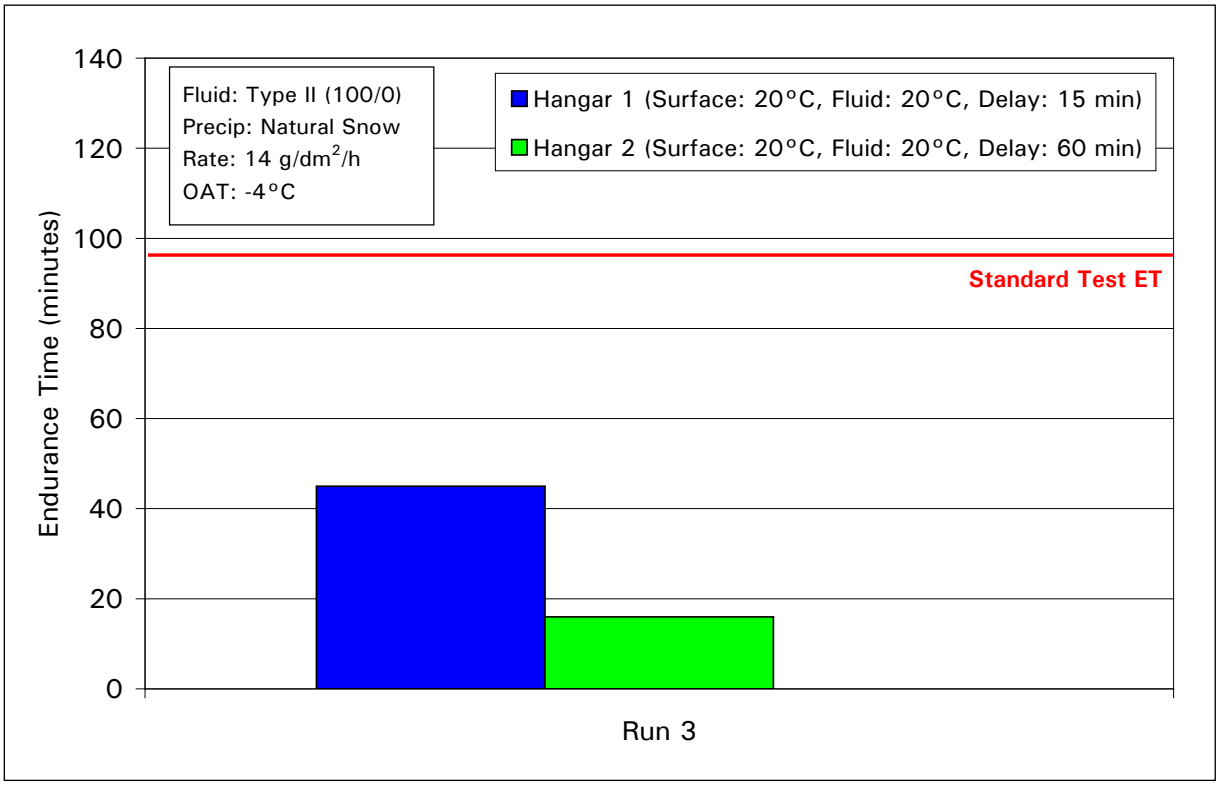

Figure 8.4: Test Results – Run 3

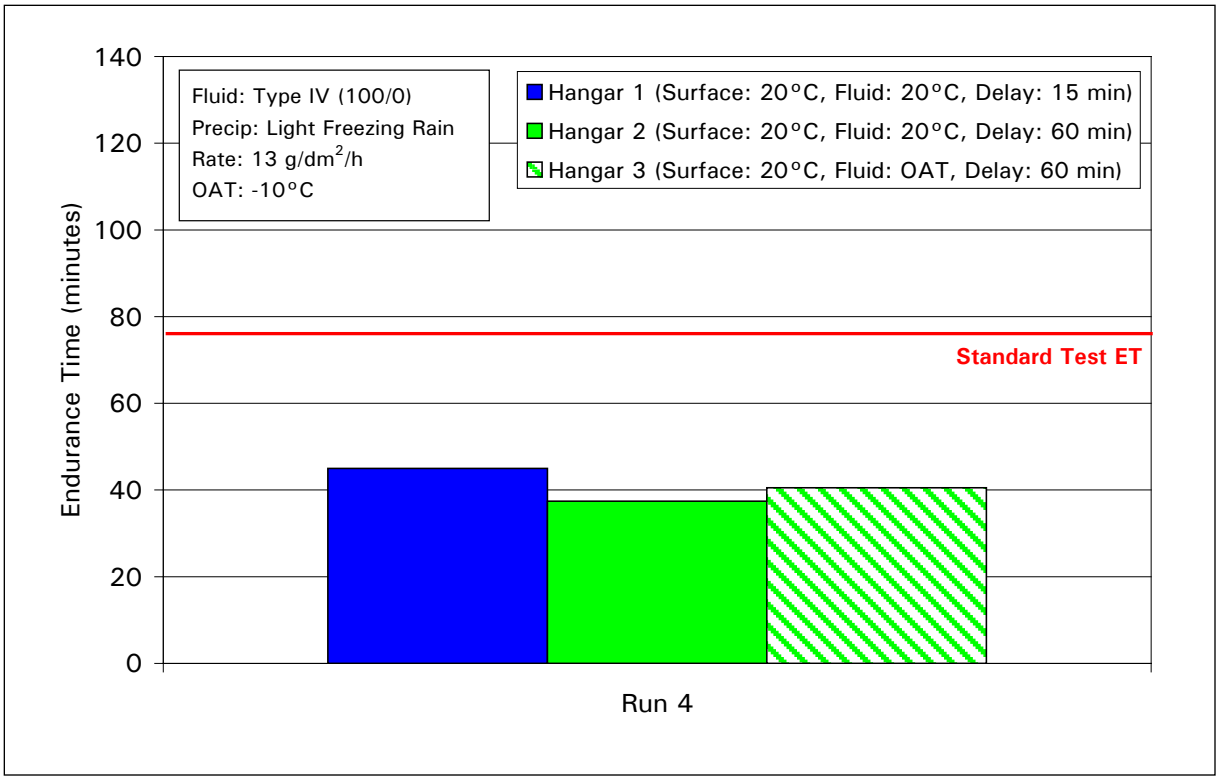

Figure 8.5: Test Results – Run 4

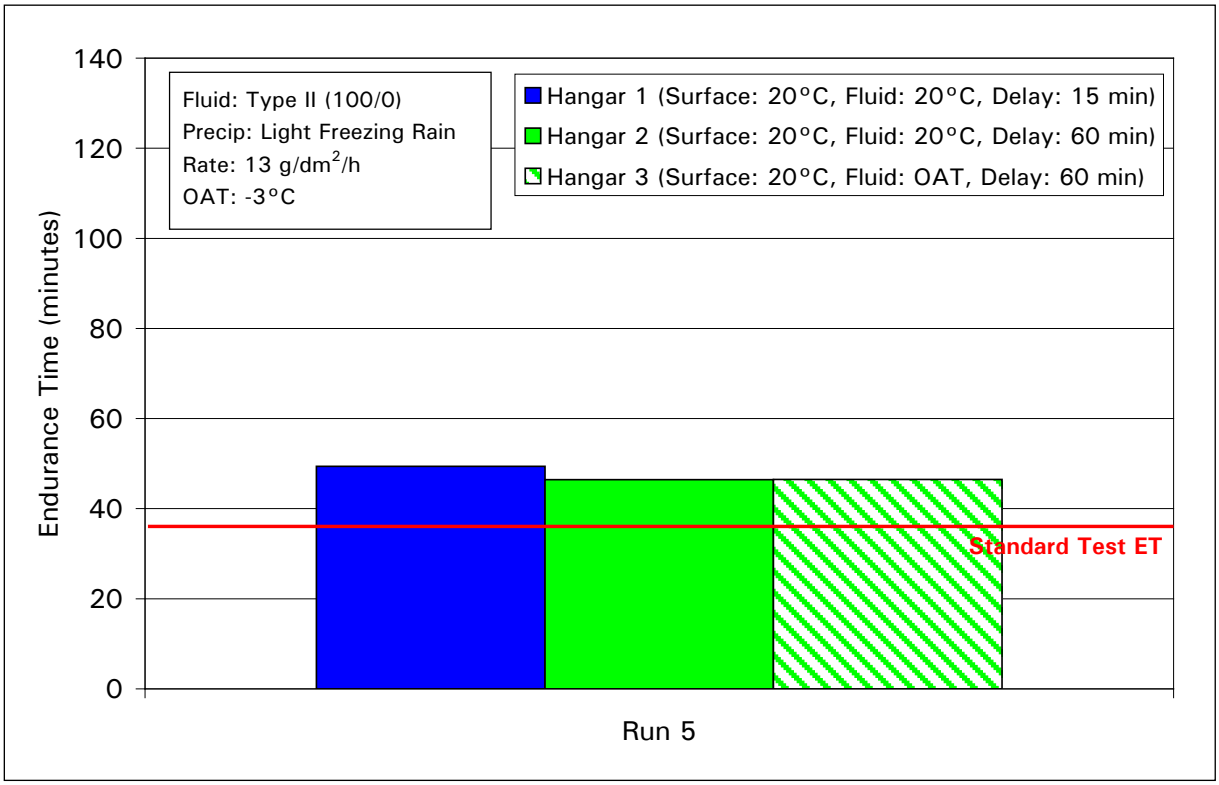

Figure 8.6: Test Results – Run 5

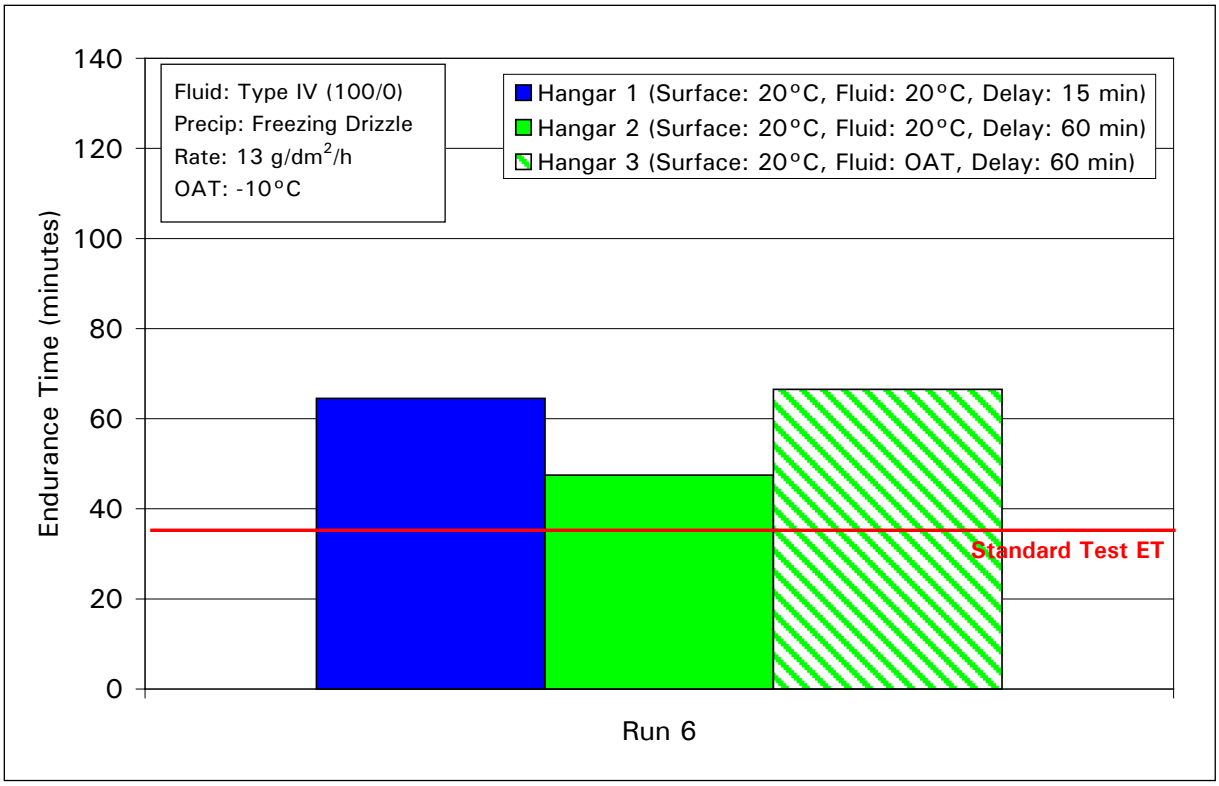

Figure 8.7: Test Results – Run 6

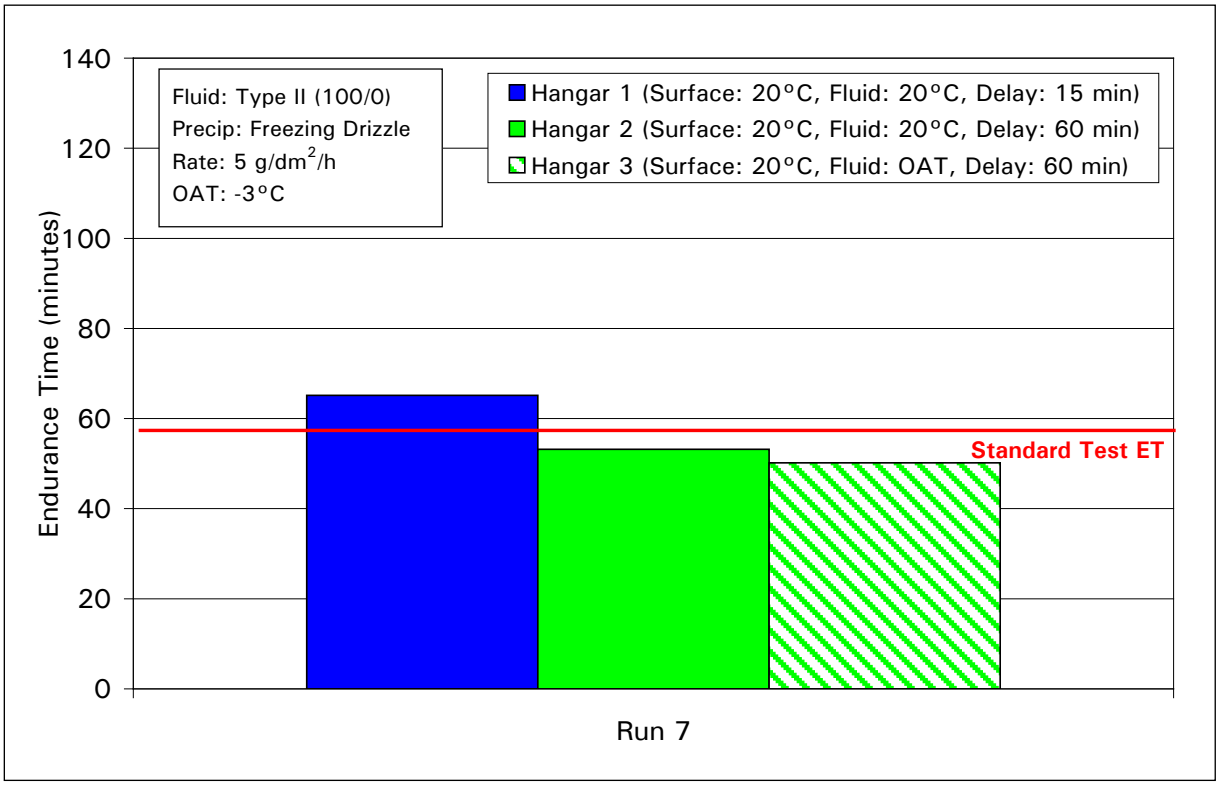

Figure 8.8: Test Results – Run 7

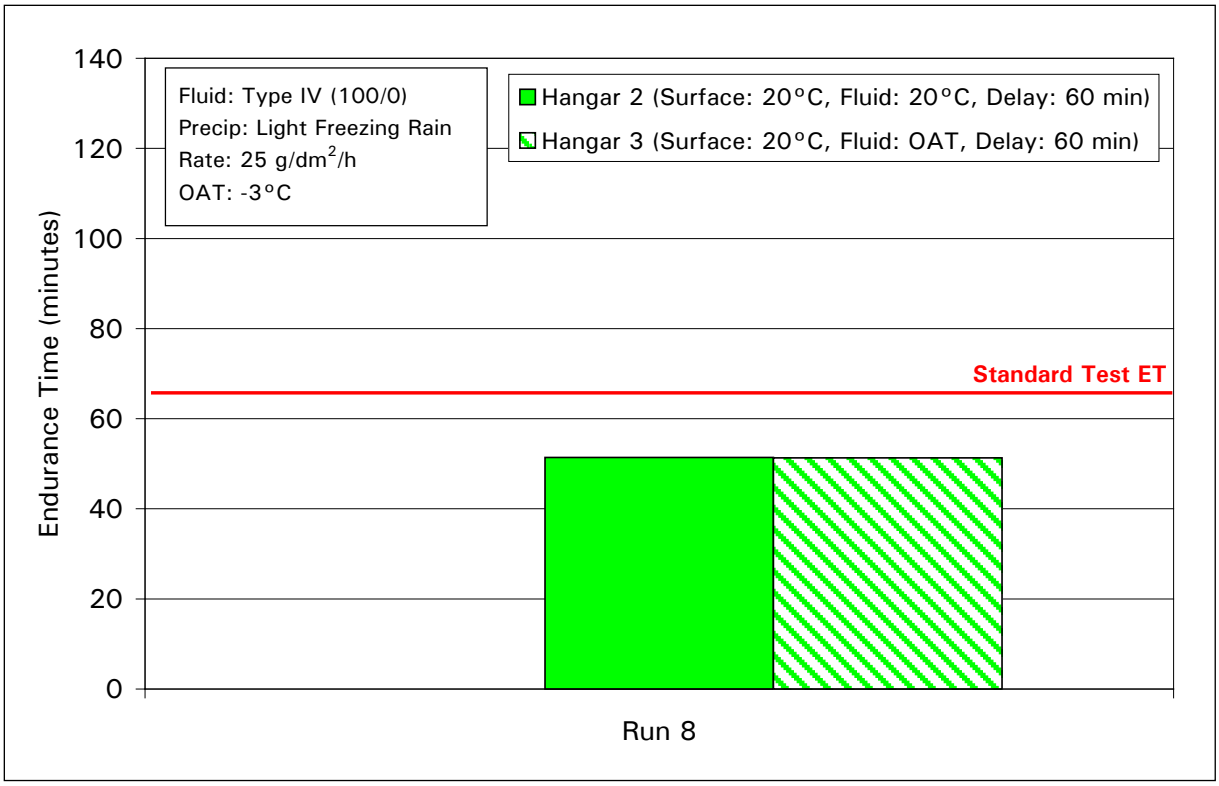

Figure 8.9: Test Results – Run 8

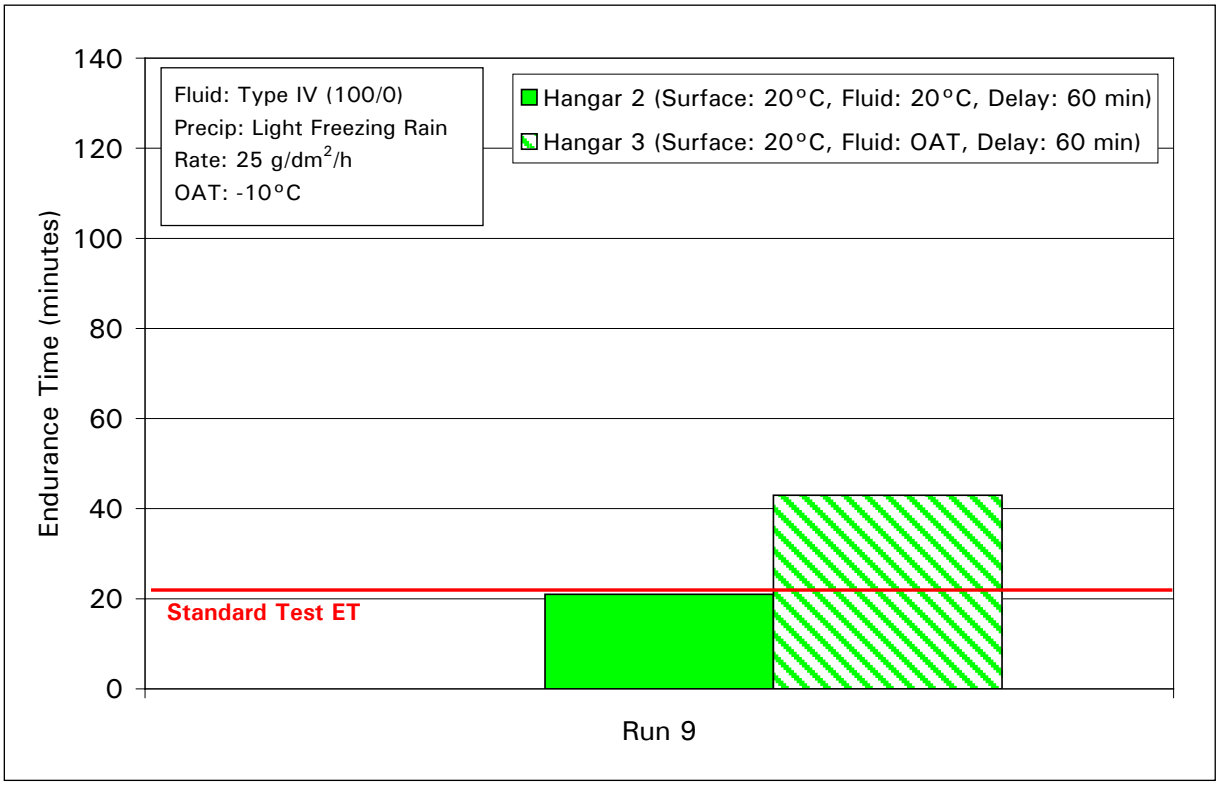

Figure 8.10: Test Results – Run 9

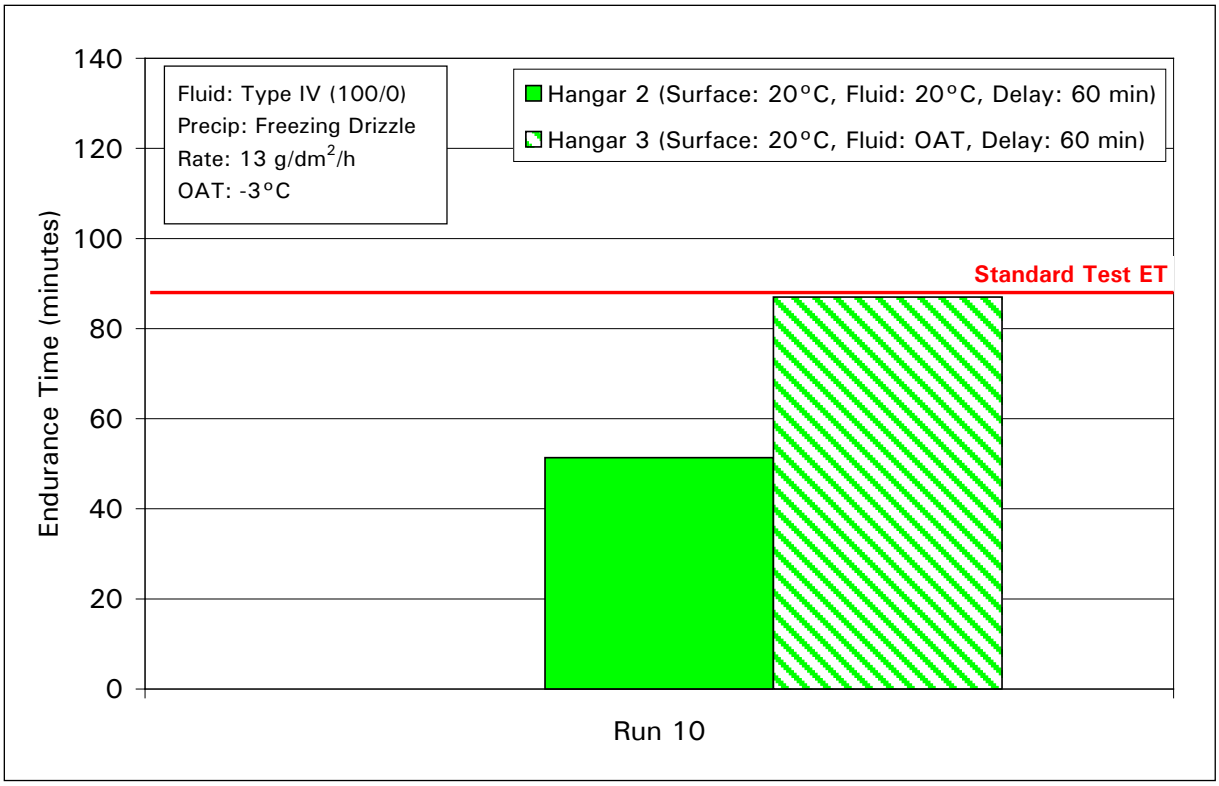

Figure 8.11: Test Results – Run 10

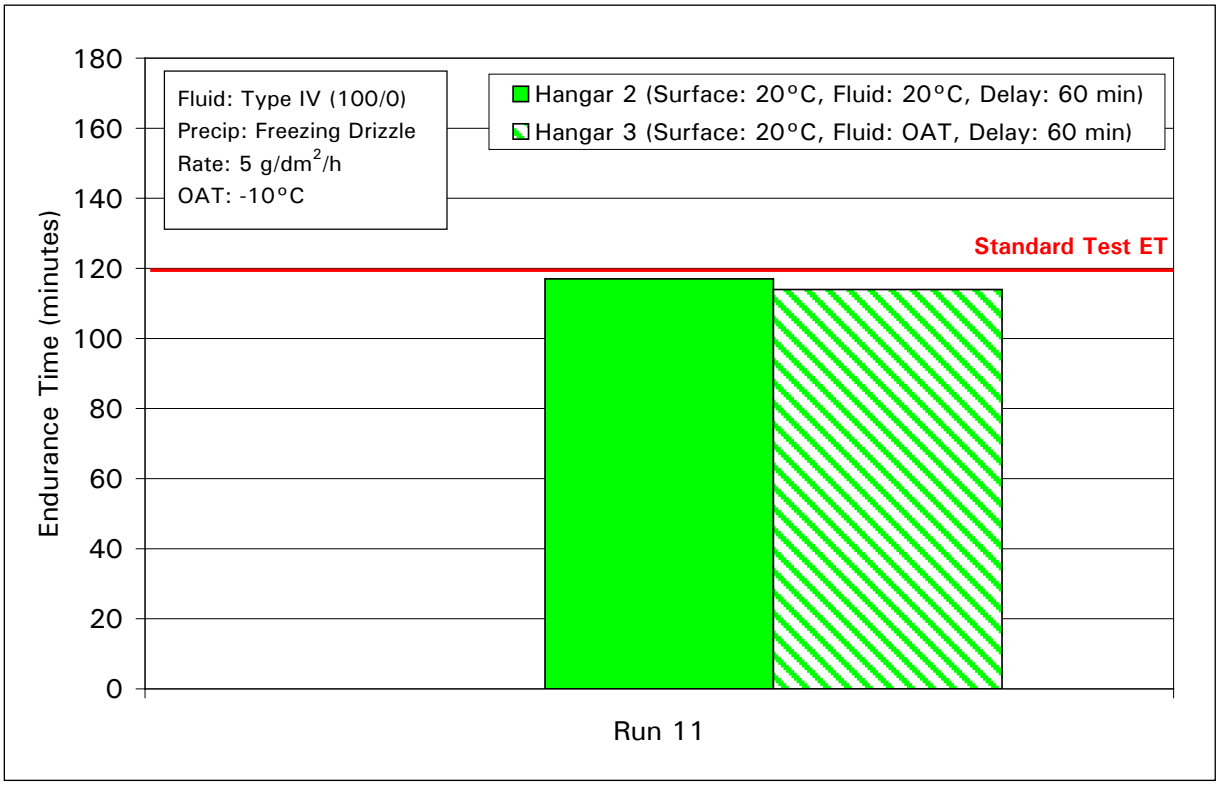

Figure 8.12: Test Results – Run 11

8.7 Observations and Conclusions

Although variability was seen in the data, the limited tests conducted indicate that when the HOT clock is started at the time of exposure for anti-icing fluids applied in hangars, the endurance time of the fluid is often shorter than the expected holdover time. This is likely due to a number of factors, including fluid thickness and fluid temperature.

Given this information, the only safe approach is to start the HOT clock when fluid application begins, not when the fluid is first exposed to precipitation.

8.8 Operational Recommendations

Based on the limited tests conducted, it is recommended that the HOT clock be started when anti-icing fluid application begins, even if fluid application takes place in a hangar and the aircraft is not immediately exposed to precipitation.

It was recommended that regulators update their guidance material to clearly indicate when the HOT clock should start for hangar operations, in accordance with the recommendation above.

TC subsequently made the following change to Subsection 10.11 of TP 14052E (previous version is shown in Subsection 8.2):

> There are operational conditions when Air Operators may choose to anti-ice their aircraft while the aircraft remains 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 Type IV 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 upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to frozen precipitation.

8.9 Recommendations for Further Research

If the industry expresses the need for early pre-flight anti-icing for operations, a series of tests could be conducted to try to establish a lower limit holdover time (or perhaps an allowance time) for fluids when applied in a hangar and subjected to a specified delay prior to being exposed to precipitation (for example, within one hour). This lower limit holdover time may be significantly lower than the current lower value in the holdover time table, and it may be expressed as a percentage value of the lower holdover time table value (i.e., 40 percent).

Photo 8.1: Test Surfaces at Room Temperature

Photo 8.2: Fluid Application Prior to Exposure to Precipitation

Photo 8.3: Outdoor Test

Photo 8.4: Run 1

9. SUPPORT FOR THE DEVELOPMENT OF USE OF ICE DETECTION CAMERAS AT END-OF-RUNWAY

Transport Canada (TC) and the Federal Aviation Administration (FAA) have supported research and development of ice detection technology for the aircraft de/anti-icing industry for many years. APS Aviation Inc. (APS) has conducted much of this work on their behalf. The work completed in support of ice detection technology in 2008-09 focused on the end-of-runway application. The 2008-09 work is documented in this section.

9.1 Previous Work

In the winter of 2004-05, APS conducted research demonstrating that, in certain circumstances, remote on-ground ice detection systems (ROGIDS) are more reliable than human visual and/or tactile detection of clear ice on an aircraft critical surface. Following this research, a working group was formed to develop a standard for using ice detectors in this capacity. The working group included representatives from TC, the FAA, APS, and industry (users and manufacturers).

Over the winters of 2005-06 and 2006-07, the working group developed a standard for the minimum operational performance requirements for ROGIDS. APS provided expert opinion and document development support during the development of the standard. The standard was published in September 2007 as SAE International (SAE) Aerospace Standard (AS) 5681.

Over the winters of 2007-08 and 2008-09, APS was part of a working group that assisted TC and the FAA in developing an Advisory Circular specifically for use of ROGIDS as a primary means for post-deicing inspection of clear ice on aircraft. APS again provided expert opinion and document development support for the Advisory Circular. The working group provided the document to TC and the FAA in December 2008. The TC Advisory Circular was published online in April 2009 at https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-602-001. The FAA is in the process of publishing a similar document.

Following the publication of the Advisory Circular for post-deicing checks for clear ice, the FAA and TC expressed interest in developing standards for a second application for this technology – the use of ice detection technology at the end of the runway.

9.2 Project Objective

The objective of this project for the winter of 2008-09 was to support the development of a research/action plan for enabling the use of ice detection technology in an end-of-runway application. In this application, ice detection technology (likely ice detection cameras) would be used to perform pre-takeoff contamination checks at the end of the runway just prior to takeoff.

9.3 Development of End-of-Runway Project Plan

Developing standards and regulations to enable the use of ice detection technology (i.e., ROGIDS) at the end of the runway is a complex task. Among the many complicating factors, perhaps the most difficult and complex is establishing fluid failure thresholds that are appropriate for ice detection technology at the end of the runway.

A new working group was established to undertake the task. The working group included representatives from TC, the FAA, APS, equipment manufacturers, and potential users. Many of the working group members had been part of previous ice detection working groups.

A preliminary meeting of the end-of-runway working group was held in conjunction with the final meeting of the post-deicing clear ice Advisory Circular working group. The meeting took place on December 4, 2008, in Ottawa. At the half-day meeting, working group members brainstormed general areas of research that would be required to establish regulatory approval for ROGIDS for an end-of-runway application.

The official project kick-off meeting was held June 10-11, 2009, in Montreal. Prior to the meeting, APS performed the following tasks:

a) Reviewed previous work completed on detection of ice on aircraft surfaces at a location close to the runway threshold;

b) Identified the limitations of current technologies and the key challenges in enabling the use of ROGIDS at the end of the runway; and

c) Prepared a proposed research/action plan.

APS gave two presentations to the working group at the beginning of the June 2009 meeting. The first presentation (a) summarized the key challenges the workgroup faced in establishing an end-of-runway application for ice detection technology and (b) presented the results of previous research relating to these challenges. The second presentation described the details of the proposed research/action plan APS had prepared. Copies of both presentations are included in Appendix I.

The remainder of the June meeting focused on discussing the proposed research/action plan and establishing a timeline for the project. The conclusion of these discussions was that the first step in enabling the use of ROGIDS at end-of-runway would be to develop a standard for the application. It was also concluded that actual research and testing was not expected to start until the winter of 2011-12. The timeline and research/action plan established at the June meeting are shown in Figure 9.1 and Figure 9.2, respectively.

The next meeting of the end-of-runway working group was held in September 2009. The focus of that meeting was to define and discuss the problem. In addition, the proposed project timeline was reviewed. A subsequent meeting of the working group is scheduled for December 2009. The focus of that meeting will be to develop content for the ROGIDS end-of-runway standard.

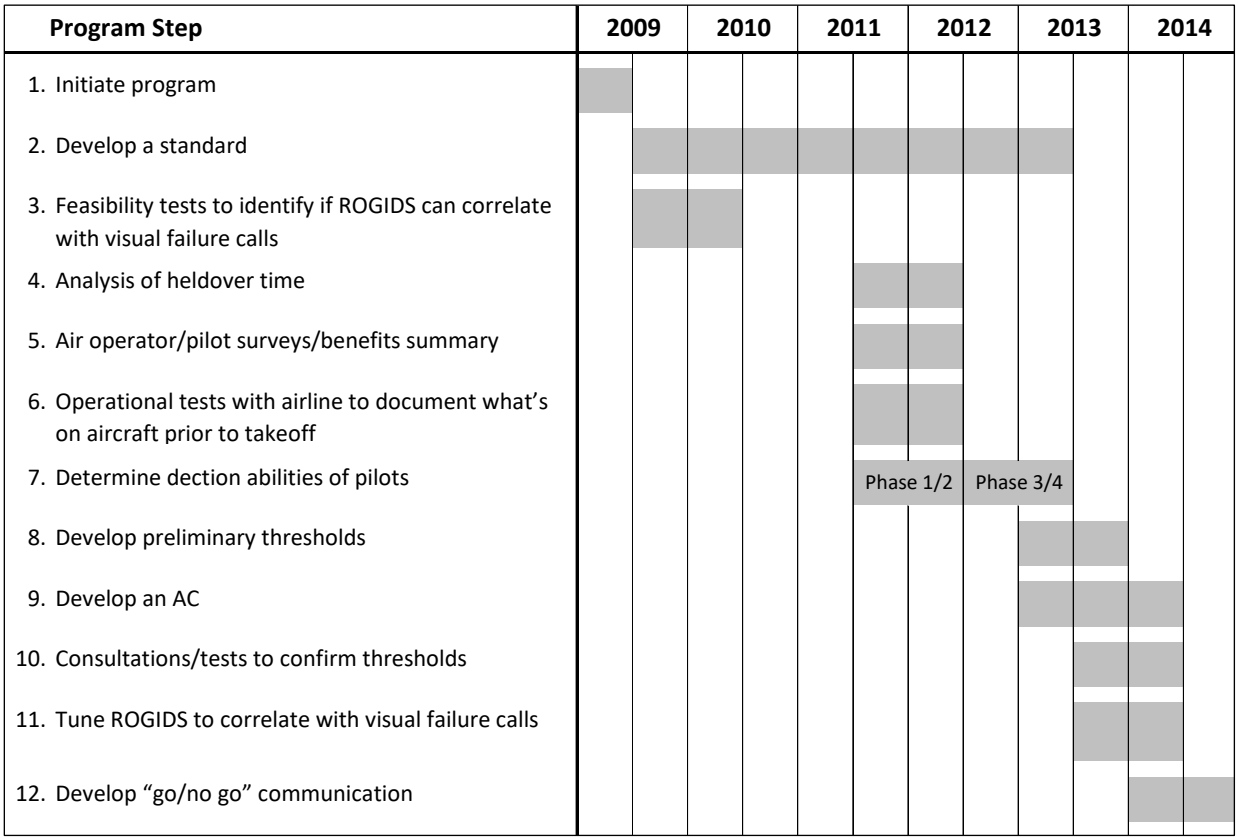

Figure 9.1: Proposed Project Timeline (June 15, 2009)

END-OF-RUNWAY ROGIDS APPLICATION: PROJECT PLAN STEPS

June 15, 2009

1. Initiate Program
   - Research review
   - Plan activities required
2. Develop a Standard
3. Feasibility tests to identify if ROGIDS can correlate with visual failure calls
   - Lab tests (could be conducted in conjunction with APS HOT testing at NRC chamber)
   - Snow tests at APS test site
   - Include "no fluid" tests
4. Analysis of "Heldover" Time
   - APS to bring historical data to next meeting
   - Obtain information from airports and/or airlines on usage of HOTs: How long are aircraft on the ground prior to departure? What % of HOT is used? How many aircraft did not go for deicing? This may or may not be done at a later date depending on sufficiency of APS historical data.
5. Air Operator/Pilot Surveys/Benefits (ON HOLD)
   a. *Pilot Survey*
      - # of turn-backs due to expired holdover times
      - # of turn-backs due to expired holdover times + pre-takeoff contamination check
      - # of turn-backs due to detection of frozen contamination during pre-takeoff check
      - # of turn-backs before HOT has expired
      - Day vs. night
      - Where are checks conducted from
      - Do pilots want these systems? Are they concerned?
      - How do pilots define fluid failure (use MC, i.e. look for gloss or shine)
   b. *Air Operator Survey*
      - Turn-backs?
   c. *Gather data on related accidents/incidents*
   d. *Report on benefits of ROGIDS for end-of-runway*

MILESTONE: DETERMINE FEASIBILITY OF PROJECT (pilot survey and ROGIDS tuning)

6. Operational Tests with Airline to Document what's on aircraft prior to takeoff
   - Objective: To prove aircraft are taking off with contamination, sensitivity analysis/threshold setting tool, using ROGIDS and? human observer from cockpit and cabin
7. Determine Visual Contamination Detection Abilities of Pilots
   - PHASE 1: Human Factors development of test plan
   - PHASE 2: Develop method for producing stable specimens for various types of failure
   - PHASE 3: Conduct preliminary tests with small group of pilots to refine procedure
   - PHASE 4: Conduct tests with large (50-100?) group of pilots
8. Develop Preliminary Thresholds
9. Develop an AC
10. Consultations and Tests to Confirm Thresholds
11. Modify ROGIDS to correlate with visual failure calls
    - Field tests
12. Develop Methodology to Communicate "Go/No Go" to Pilot

Figure 9.2: Proposed Research/Action Plan (June 15, 2009)

10. SUPPORT FOR USE OF FAA VISIBILITY TABLE WITH TYPE II/III/IV FLUIDS

In the winter of 2008-09, the Federal Aviation Administration (FAA) requested that APS Aviation Inc. (APS) conduct further analysis of the relationship between visibility and snowfall intensity in support of the FAA decision to mandate the use of its Snowfall Intensity vs. Visibility Table for Type II, III, and IV fluids.

10.1 Background

In the winter of 2002-03, APS undertook a research program to analyse the relationship between snowfall intensity and visibility. A database of visibility and precipitation rate data was constructed from rate data obtained during endurance time testing and from visibility data obtained from the Meteorological Service of Canada (MSC) weather station. The resulting data set includes 7,000 data points representing approximately 700 hours of data. The data was compared to a smaller but similar database collected by National Center for Atmospheric Research (NCAR) in Colorado, United States, and to theoretical work completed by NCAR.

As a result of this research, changes were made to the Transport Canada (TC) and FAA Snowfall Intensity vs. Visibility Tables that existed at that time. The research and resulting changes are documented in the TC report, TP 14151E, *Relationship Between Visibility and Snowfall Intensity* (15).

10.2 Use of FAA Snowfall Intensity vs. Visibility Table

In previous years, the FAA mandated that the Snowfall Intensity vs. Visibility Table had to be used with Type I fluid holdover times (HOTs), although it strongly recommended the table also be used with Type II, III, and IV fluids.

In the FAA Winter Notice for 2007-08, the FAA proposed the required use of the table for all fluid types. This recommendation was widely criticized by industry, with two key concerns arising:

1) Significant discrepancies between the FAA table and the guidelines provided in the Federal Meteorological Handbook (FMH1) indicate that the FAA table is not accurate; and
2) The industry questioned the validity of the use of catch pans inclined at a 10-degree slope in measuring snowfall intensity.

Due to the criticism, the FAA did not require the use of the table for Type II, III, and IV fluids in 2008-09, pending a more detailed review of the data supporting its use.

APS assisted with this review in the winter of 2008-09.

10.3 Analysis to Compare FAA and FMH1 Tables

At the request of the FAA, APS conducted additional analysis using the 2002-03 APS snowfall intensity vs. visibility database. The primary objective of the analysis was to use the APS database to compare the abilities of the FAA and FMH1 Snowfall Intensity vs. Visibility Tables to accurately predict snowfall intensity.

A fairly exhaustive analysis was conducted in a number of iterations, which included combining the light and very light snowfall intensity categories, re-examining the defined thresholds between snowfall intensities provided in the FAA table, conducting an analysis of frequencies, conducting an analysis of joint probabilities based on frequencies, and conducting an analysis of probability based on z-test calculations.

In the end, the analysis clearly shows that for agreement, balance, and conservative tendency in estimating snowfall intensity using visibility, the FAA table is better than the FMH1 table. Much of this improved accuracy is due to the FAA table accounting for night vs. day and temperature variations, which are not considered by the FMH1 table.

10.4 Validity of 10-Degree Slope of Catch Pans

Although no analysis was conducted, APS also addressed industry concerns with the 10-degree slope of the catch pans used to collect the snowfall intensity rates used in the APS database.

Snow catch pans are placed on a 10-degree slope during endurance time testing to account for similar slopes of many aircraft surfaces. Significant research has gone into developing this protocol, which is now provided in an SAE International (SAE) standard. Since the use of the 10-degree slope catch pans is the same method used in evaluating anti-icing fluid endurance times, it provides a direct relationship between the determination of snowfall intensity using the FAA Snowfall Intensity vs. Visibility Table and the appropriate holdover time of the anti-icing fluid. Therefore, the snowfall intensity data collected using a catch pan with a 10-degree slope is valid.

10.5 Presentation

The culmination of this research and analysis was presented at an FAA/industry meeting that was held on April 28, 2009, at the FAA Tech Center in Atlantic City, New Jersey. APS gave a presentation to industry representatives that contained a detailed description of the APS database and its source data, a full explanation and presentation of the analysis completed, and a summary of the findings.

A copy of this presentation, *APS Snowfall Intensity/Visibility Data and Analysis,* is provided in Appendix I.

10.6 Conclusion

As a result of the analysis conducted by APS and others, changes were made to FAA guidance material for the winter of 2009-10: the FAA Winter Notice for 2009-10 specifies that the FAA Snowfall Intensity vs. Visibility Table must be used to determine appropriate holdover times in snowfall conditions for all types of anti-icing fluid, including Type II, III, and IV fluids.

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11. HOLDOVER TIME GUIDELINES WEBSITE

11.1 Background

The development and use of holdover time (HOT) guideline tables has represented an important contribution to the enhancement of flight safety in winter aircraft operations throughout the industry. In the years since their introduction, the tables have become a standard and an essential part of winter operations.

Two kinds of HOT guidelines currently exist: fluid-specific HOT guidelines and generic HOT guidelines. Once developed, the tables are published, or referenced, in various industry media. At one time, Transport Canada (TC) published the tables in both English and French in three different locations:

a) The Transport Canada Civil Aviation (TCCA) Commercial and Business Aviation Advisory Circular (CBAAC) document;

b) The TCCA website; and

c) The Transportation Development Centre (TDC) website.

It is not unusual that the processing of common information for use in different media results in discrepancies between displays. Formatting of website contents in different computer languages can easily lead to errors in content and format. Translation between English and French can also cause these errors. Reducing the number of information sources available to operators was seen as a way to eliminate potential sources of incorrect information.

Therefore, in the summer of 2003, TC asked APS Aviation Inc. (APS) to develop and implement a website for official TC HOT guidelines to standardize the holdover time information published on websites and to eliminate the safety risks associated with information discrepancies. This single source of holdover time information was first made available when the 2003-04 HOT Guidelines were published on a common website in July 2003. It was published in English and French, primarily for Canadian operators, although the information was made public for others to use.

11.2 Changes to the Website

Each July since 2003, APS has published the HOT Guidelines for the upcoming winter on the website. In July 2009, the 2009-10 HOT Guidelines were published on the website and replaced the 2008-09 HOT Guidelines, which were archived on the site. Appendix K contains the original issue of the 2009-10 HOT Guidelines as

they appear in English on the website. As has been done in previous years, the changes from the previous year's guidelines are summarized on page 3 of the document and explained in detail in the TC report, TP 14933E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2008-09 Winter* (12).

The changes made for the 2009-10 HOT Guidelines include the following:

- Addition of one new Type II fluid, Aviation Shaanxi Cleanwing II;
- Removal of two fluids, Aviation Xi'an Hi-Tech KHF-II and Kilfrost ABC-II Plus;
- Addition of two new Type IV fluids, ABAX Ecowing AD-49 and Kilfrost ABC-$4^{sustain}$;
- Removal of the active frost column in all tables, with a separate table now available for active frost holdover times;
- Removal of the below -25°C row, with a note included to ensure that the lowest operational use temperature (LOUT) is respected;
- Recent tests have shown that light freezing rain holdover times can be used in conditions of light snow mixed with light rain. A note to this effect was added to all Type I, Type II, Type III, and Type IV holdover time tables; and
- The guidance material for operations during ice pellet conditions was expanded and modified. Specifically, changes were made to include guidance for operations in light ice pellets mixed with moderate rain and to expand the guidance for operations in light ice pellets mixed with light or moderate snow.

For the changes to be approved, APS is required to obtain approval from both TC and the TDC. The form provided in Figure 11.1 is used for this purpose.

11.3 Future Responsibilities

APS has undertaken the responsibility to ensure the website is operational, in terms of Internet availability, for a period of one year. In the summer of 2010, APS intends to update the website with new data from 2009-10 testing and upload the 2010-11 HOT Guidelines.

Request for Change to Holdover Time Guidelines Website

Date: _____

Description of Change: _____

_____

_____

Affected Pages: _____

Requested By: _____

Reason for Change: _____

_____

_____

Confirmed by:	Confirmed by:
_____	_____
Angelo Boccanfuso	Douglas Ingold
Senior Development Officer	Specialist Flight Technical
Transportation Development Centre	Transport Canada Civil Aviation

Procedure for making changes to the holdover time guidelines website:

1. Fill out this form
2. Submit to APS (John D'Avirro/Victoria Zoitakis)
3. APS will acquire the necessary signatures or email confirmations
4. APS will submit changes to its IT department after approval is received[1]

[1] The website files are located on a secure server with restricted access. This access is limited to the APS IT department.

Figure 11.1: HOT Guideline Change Form

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12. TEST PROCEDURES, PRESENTATIONS, AND FLUID MANUFACTURER REPORTS

This section contains an account of the test procedures, presentations, and fluid manufacturer reports that were prepared by APS Aviation Inc. (APS) in 2008-09.

12.1 Procedures

Several procedures were developed to guide and support the research team in the methodology for conducting tests. Table 12.1 at the end of this section provides a list of the procedures developed for each major project. Each major project has been documented in a separate report, and each complete procedure has been included in at least one of these reports.

12.2 Presentations

During the course of a research program, subcommittees of the SAE International (SAE) G-12 Committee hold several meetings. During these and other meetings, APS presents the findings of the work that has been completed. Much of the research presented at these meetings is eventually documented in various reports.

In 2008-09, the following meetings were held:

a) Visibility Tables Meeting at the FAA Tech Centre, Atlantic City, United States, April 2009;

b) SAE G-12 HOT Subcommittee, Charleston, United States, May 2009;

c) ROGIDS Working Group Meeting, Montreal, Canada, June 2009;

d) ROGIDS Working Group Meeting, Toronto, Canada, September 2009; and

e) Standing Committee Meeting, Toronto, Canada, October 2009.

The presentations given by APS at each of these meetings are listed in the following subsections. A copy of each presentation is contained in Appendix I.

12.2.1 Visibility Tables Meeting at the FAA Tech Centre, Atlantic City, United States, April 2009

One presentation was prepared for the Visibility Tables Meeting at the FAA Tech Centre, Atlantic City, held on April 28, 2009:

1) APS Snowfall Intensity/Visibility Data and Analysis.

12.2.2 SAE G-12 Meeting, Charleston, United States, May 2009

Eight presentations were prepared for the SAE G-12 HOT Subcommittee meeting in Charleston on May 12, 2009:

1) Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2008-09 Winter Test Season;
2) Anti-Icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time;
3) De/Anti-Icing Fluid Endurance Times on Composite Surfaces;
4) Holdover Times Below -25°C for Anti-Icing Fluids;
5) Holdover Times in Conditions of Rain Mixed With Snow;
6) Proposed Changes to Frost Holdover Time Guidelines;
7) Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables; and
8) Airport Siting Considerations for Holdover Time Determination Systems.

One presentation was prepared for the SAE G-12 Fluids (AERO) Working Group meeting in Charleston on May 7-8, 2009:

1) Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables.

This presentation has not been included in the appendix as it is similar to the presentation given at the SAE G-12 Meeting on May 12, 2009 (Presentation #7).

12.2.3 ROGIDS Working Group Meeting, Montreal, Canada, June 2009

Two presentations were prepared for the Remote On-Ground Ice Detection Systems (ROGIDS) Working Group meeting in Montreal on June 10-11, 2009:

1) Research/Action Plan for Enabling Use of ROGIDS at End-of-Runway; and
2) Summary of Previous Studies Relating to End-of-Runway Ice Detection.

12.2.4 ROGIDS Working Group Meeting, Toronto, Canada, September 2009

One presentation was prepared for the ROGIDS Working Group meeting in Toronto on September 15-16, 2009:

1) Summary of Previous Studies on Holdover Time.

12.2.5 Standing Committee Meeting, Toronto, Canada, October 2009

Three presentations were prepared for the Standing Committee for Operations under Icing Conditions meeting in Toronto on October 6, 2009:

1) Anti-Icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time;
2) Holdover Time Guidelines Update for 2009-10 Winter Operations; and
3) Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables.

12.3 Fluid Manufacturer Reports

As part of the research program, several fluids are tested for holdover performance every year. Some of this data is then published for holdover time use in the industry, while the remaining data is maintained by the fluid manufacturers for research purposes.

During the winter of 2008-09, four fluids were tested. APS prepared a report for each fluid and provided these reports directly to the fluid manufacturers. Reports were prepared for:

a) Aviation Shaanxi Hi-Tech Cleanwing II (Type II);
b) ABAX Ecowing AD-49 (Type IV);
c) Type III fluid (not commercialized); and
d) Kilfrost ABC-4^{sustain} (Type IV).

The reports for the fluids that were qualified in the winter of 2009-10 have also been included as appendices to TP 14933E (12).

Table 12.1: List of Procedures for Winter 2008-09

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
2.2.1	7.1	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Simulated Freezing Precipitation Flat Plate Testing	17-Dec-08	1.0	HOT
2.2.1	7.2	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing	23-Dec-04	1.0	HOT
2.2.1	7.3	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Overall Program of Tests at NRC, March-April 2009	26-Mar-09	1.0	HOT
2.2.1	7.4	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval	14-Dec-07	1.2	HOT
2.2.1	7.5	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing (Type III Fluid Use Type I Protocol)	14-Dec-07	1.2	HOT
2.2.2	8.1	Endurance Time Testing in Frost – Type I/II/III/IV Fluid	Endurance Time Testing in Frost	13-Nov-03	1.0	Frost
2.2.2	8.3	Endurance Time Testing in Frost – Type I/II/III/IV Fluid	Full Scale Validation of Flat Plate Endurance Time Testing in Frost with Type II, III and IV Fluids	29-Dec-08	1.0	Frost
2.2.3	9.1	Endurance Time Testing on Non-Aluminum Plates	Flat Plate at NRC (at 20°C)	28-Mar-06	1.0	Composite
2.2.3	9.2	Endurance Time Testing on Non-Aluminum Plates	Frost Endurance Time Testing on Non-Aluminum Plates	29-Dec-08	1.0	Composite
2.2.4	10.1	Endurance Time Testing in Simulated Snow Pellets	Endurance Time Test Requirements for Snow Pellet Flat Plate Testing	17-Dec-08	1.0	General & Exploratory

Table 12.1: List of Procedures for Winter 2008-09 (cont'd)

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
2.2.5	11.1	New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker and Re-Evaluation of Snowmaker Hot Specifications	Endurance Time Test Requirements or Simulated Snow Flat Plate Testing	23-Jan-08	1.2	General & Exploratory
2.2.5	11.2	New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker and Re-Evaluation of Snowmaker Hot Specifications	Development of Type I Protocol for Indoor Snow (Arp 5945)	21-Jan-08	1.0	General & Exploratory
2.2.6	12.1	Evaluation Of Endurance Times in Heavy Snow	Endurance Time Testing with Heavy Snow with the Snowmaker in Comparison with Natural Snow	02-Jan-09	1.0	General & Exploratory
2.2.14	20.1	Rain Mixed with Snow Additional Testing	Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions Snow and Rain	31-Mar-08	1.0	General & Exploratory
2.2.15	21.1	Evaluation of Effect of Poor Application Methods on Fluid Endurance Times	Evaluation of Effect of Poor Application Methods on Fluid Endurance Times	29-Dec-08	1.0	General & Exploratory
2.2.16	22.1	Testing in Mixed Ice Pellet Conditions with Supplemental Fluids	Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions – Ice Pellets/Freezing Rain	14-Sep-06	1.0	Ice Pellet Allowance
2.2.17	23.2	Hot's for Indoor (Aircraft Hangar) Anti-Icing Applications	Evaluation of Endurance Time Values for Indoor (Aircraft Hangar) Anti-Icing Applications	11-Mar-09	1.1	General & Exploratory
2.3.1/2.3.2	24.1	Wind Tunnel Testing to Refine Allowance Times and Research to Evaluate Aerodynamic Failures	Wind Tunnel Tests to Examine Fluid Removed from Aircraft During Takeoff with Mixed Ice Pellet Precipitation Conditions	23-Feb-09	1.2	Ice Pellet Allowance

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12. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2008-09 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2009, TP 14933E, 80.

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2008-09

TRANSPORTATION DEVLOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2008-09

4.1 WEATHER RESEARCH

4.1.3 Survey of Deicing Operations in Freezing Rain and Freezing Drizzle (Final Phase)

a) Undertake a straw poll of deicers to evaluate the occurrence frequency of freezing rain and freezing drizzle based on a questionnaire provided by TDC;

b) Distribute the questionnaire using an anonymous web-based platform to conduct the survey;

c) Collect the results;

d) Follow up with non-responders to ensure the best possible response rate;

e) Compile questionnaire results into a database; and

f) Provide a summary of the results.

4.2 DE/ANTI-ICING FLUIDS RESEARCH (AND HOLDOVER TIME CREATION)

4.2.4 Endurance Time Testing in Simulated Snow Pellets

a) Develop procedure and methodology for testing:

   a. Full-Scale wind tunnel aerodynamic testing with snow pellet contamination (included in wind tunnel procedure)

   b. Comparative endurance time testing on flat plates in simulated snow and snow pellet conditions

b) Coordinate fluid selection with other laboratories for intra-laboratory comparison of endurance time results;

c) Develop a repeatable process with limited variance for manufacturing and dispensing simulated snow pellets onto flat plates;

d) Carry out endurance time testing with representative Type I/II/III/IV fluids at standard dilutions, in simulated snow pellets and in snow. Testing should be conducted at various precipitation intensities and temperatures. 20 days of testing are anticipated to do a total of 30 comparative tests. A number of trials will be conducted to verify repeatability of results;

e) Analyze the data collected;

f) Conduct an intra-laboratory comparison of results to verify consistency in results obtained;

g) Evaluate the feasibility of expanding the current snow HOT's to include snow pellet contamination; and

h) Report the findings, and present these and previous results at the SAE G-12 annual and fall meeting.

4.2.5 Endurance Time Testing with the NCAR Snowmaker

a) Organise with personnel from the National Center for Atmospheric Research (NCAR) in Boulder, Colorado for any necessary software and hardware upgrades of the NCAR snowmaker developed for TDC;

b) Endurance time testing of Type II/III/IV fluids suggests that results may be fluid dependent. The results of this research should be discussed in further detail firstly with NCAR and subsequently, with industry experts at a work group meeting to determine how to proceed;

c) Type II/IV Fluid Endurance Time Testing with Snowmaker for New Fluids:

   i) Review the procedure for testing new fluids with snowmaker to determine differences, if any, with natural snow tests;

   ii) Conduct flat plate tests under conditions of artificial snow in the refrigerated trailer at the TDC test site to record fluid endurance times, in accordance with ARP5485. It is anticipated that testing of new fluids will be conducted over a period of 10 days; and

   iii) Record individual fluid endurance times for indoor snow, at condition temperatures and precipitation intensities specific to the HOT tables.

d) Type I Fluid Endurance Time Testing with NCAR Snowmaker:

   i) Review previous findings. Further testing of Type I fluids has been recommended to confirm whether lowering the test temperature in artificial snow tests will prevent Type I fluids from meeting generic holdover times in those cases where they would not meet them if tested in natural snow. In addition, further research may be needed to confirm the Type I test procedure for the -3°C condition. It is important to maintain the enclosure temperature below -5°C. However, pouring hot fluid inside the enclosed space makes this unfeasible;

   ii) Further develop protocol for testing new fluids with the snowmaker to determine differences, if any, with natural snow tests. Based on this further research, the procedure should be developed for integration in ARP5945;

iii) Conduct flat plate tests under conditions of artificial snow in the refrigerated trailer at the TDC test site to record fluid endurance times; and

iv) Record individual fluid endurance times for indoor snow, based on samples of newly certified or re-certified Type I supplied by fluid manufacturers, at temperatures and precipitation intensities specific to the HOT tables.

e) Re-evaluate the specifications for generating HOTs using the NCAR Snowmaker;

f) Analyze the data collected; and

g) Report the findings, and prepare presentation as required for SAE G-12 meetings.

4.2.6 Endurance Time Testing in Heavy Snow

a) Review previous results from indoor and outdoor testing conducted by APS;

b) Develop procedure and methodology for further testing;

c) Conduct testing to define failure criteria in simulated heavy snow tests to correlate against outdoor data. Parameters investigated should include Brix, snow type, and possible intermittent simulated heavy snow to allow for absorption of precipitation:

   a. Conduct testing outdoors and record Brix at 5-minute intervals. It is anticipated that 3 fluids will be tested on 3 different occasions for a total of 3 tests;

   b. Simulate outdoor test conditions for indoor Snowmaker test reproduction; and

   c. Monitor indoor Brix and dilution during indoor test to isolate potential differences in fluid dilution.

d) Analyze the data collected; and

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

4.2.7 Effect of Heat on Neat/Diluted Type III Endurance Times

a) Review SAE ARP4737. Application tables in SAE ARP4737 and regulatory authority guidelines should be changed to state that HOT times are applicable only when heated fluid is applied (as per Type I);

b) Review SAE ARP5485. The test method for Type III fluid in SAE ARP5485 be changed to state that tests are to be conducted with heated fluid using Type I test protocol;

c) Review SAE ARP5718. Holdover times for new Type III fluids should be published in fluid specific tables rather than limit them to one generic table. This will enable field operations to take advantage of the longer times that improved fluids may deliver and will provide an incentive to fluid manufacturers to develop improved Type III fluids. This should be reflected in SAE ARP5718;

d) Review SAE AMS1428 and recommend changes to better reflect the unique characteristics of SAE Type III Fluid; and

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

4.2.8 Evaluation for Removal of -25°C Row in HOT Tables

a) Develop procedure and methodology for testing;

b) Conduct endurance time testing with minimum 3 representative fluids in simulated freezing precipitation conditions to examine the effect of temperature as it relates to anti-icing fluids' lowest operational use temperature;

c) Analyze the data collected;

d) Examine current holdover time tables published by TC and evaluate the feasibility of expanding the current "-14°C to -25°C" HOT's to include the fluid LOUT. Develop options for reformatting and removal of -25°C row in HOT Tables; and

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

4.2.9 Exploratory Research and Standards

The following include research activities that will be pursued on an exploratory basis and the preparation of standards that need to be developed based on the results of research accomplished. Any detailed work on these topics will be the subject of a contract amendment. This all depends on time and funding resources being available during the fiscal year.

a) Provide support to modifying and updating ARP5485;

b) Further develop, advance and ballot, as required, SAE Aerospace Recommended Practice ARP5945 for Type I fluids;

c) Develop and acquire LOUT data (aerodynamic acceptance) for the currently qualified fluids for the high and low speed ramps at the maximum dilution. Provide this information to the FAA and TC for their consideration for inclusion in the HOT guidelines;

d) Support the development of the inclusion of results from compatibility and environmental tests of Aerospace Material Specification (AMS) 1424 and AMS 1428 in the TC/FAA list of approved fluids;

e) Support activities of SAE G-12 Field Viscosity Workgroup;

f) Support activities of SAE G-12 Dry-Out Workgroup;

g) Support deicing facility operations and development of an international audit pool;

h) Develop explanatory document to support interpretation of Holdover time ranges;

i) Develop a slipstream Survey Test Plan to evaluate the effect of Propeller Wash (Slipstream) on anti-icing fluid coated wings, using either a two or four engine Department of National Defence (DND) aircraft and propose a test method to evaluate the effects of the slipstream on the anti-icing fluid;

j) Investigate the possibility of including other precipitation types in the visibility table;

k) Evaluate the effect of runway deicer fluids on anti-icing fluid endurance times;

l) Review the usage of infrared heat with Type I and Type II/IV fluids;

m) Investigate the dispersion of fluids on airport surfaces;

n) Evaluate the limitations of hot water deicing;

o) Investigate the feasibility of infrared system development for northern climates; and

p) Evaluate the effects of ice phobic materials on the use of Type IV anti-icing fluids.

4.2.14 Rain Mixed With Snow Additional Testing

a) Review previous data collected and re-evaluate methodology used for comparative testing;

b) Develop procedure for testing;

c) Conduct comparative endurance testing with six representative fluids in laboratory conditions. It is anticipated that testing will be done during one day at the NRC.

d) Analyze data and results;

e) Develop guidance material for aircraft operations in rain mixed with snow precipitation conditions;

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

4.2.15 Evaluation of Effect of Poor Application Methods on Fluid Endurance Times

a) Conduct historical study of previously collected data;

b) Develop methodology and procedure for the conduct of tests;

c) Conduct endurance time testing with six anti-icing fluids at reduced fluid film thickness. It is anticipated that testing will be conducted outdoors;

d) Significant work has been done with sheared and degraded fluid. If further testing is required, conduct endurance time testing with six anti-icing fluids that have been mechanically sheared to simulate degraded fluids that may be encountered in an actual operational environment;

e) Analyze data and results; and

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

4.2.17 HOT's for Indoor (Aircraft Hangar) Anti-icing Applications

a) Develop methodology and procedure for simulating indoor anti-icing operations. Testing will aim at determining the start time of HOT following an indoor anti-icing operation;

b) Conduct preliminary endurance time testing with limited fluids in simulated conditions at the NRC. It is anticipated that testing will be conducted in conjunction with standard HOT testing;

c) Analyze data and results;

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

4.2.18 Review of Visibility Table and Data

a) Review the APS visibility and rate database that was created in the winter of 2002-03 and do a quality control check of the data;

b) Review the assumptions used in the analysis of the data (i.e. visibility instruments, algorithms, human observers);

c) Recreate the statistical analysis that was performed on the rate database;

d) Prepare a presentation on the data and analysis for Transport Canada and the FAA;

e) Hold discussions with Transport Canada and the FAA regarding potential changes to the visibility tables; and

f) Prepare a report to document any additional analysis completed and/or any changes made to the visibility tables.

4.5 SENSORS RESEARCH

4.5.1 Support for Development of Advisory Circular for Remote On Ground Icing Detection Systems (ROGIDS) Final Phase

a) Prepare documentation, coordinate, and participate in joint internal meetings held by the FAA and TC to develop Advisory Circulars for potential Remote On-Ground Ice Detection System use. Allow for travel of 3 days to Ottawa and for travel of 3 days with location to be determined based on industry meetings.

4.5.2 Feasibility: Runway Threshold Ice Detection

a) Review previous work completed on detection of ice on aircraft surfaces at a location close to the runway threshold;

b) Identify the limitations of current technologies;

c) Participate with industry members to discuss the need to further investigate this area of study; It is anticipated that three meetings of one to two days will be needed with the work group to develop a test implementation plan;

d) Develop a test implementation plan for the introduction of ice detection cameras in airport operations;

e) Conduct preliminary full-scale or flat plate testing based on the recommendations from industry meetings. These tests will be defined during the meetings; and

f) Report on findings.

4.7 RESEARCH INFORMATION DISSEMINATION

4.7.1 Provision of Support Services and other Activities

a) Provide support services in the form of a technical assistant to assist TDC with program coordination, with reviewing, and refining data, and editing reports (also includes the review of outstanding unpublished reports from previous years) and planning of the G-12 meetings to be held in Montreal.

4.7.2 Web Site for HOT Guidelines Tables

a) Monitor that the Transport Canada Holdover Time tables website is operational, in terms of Internet availability, for a one year period;

b) Maintain a log of proposed changes to be done on the website;

c) Update the website with data from new testing; and

d) Implement changes to the website, post the new HOT Guidelines in the summer of 2009 for use in winter of 2009-10 and post any other updates that may be needed in special circumstances.

APPENDIX B

PROCEDURES FOR TESTING WITH THE SNOW MACHINE

- Procedure: Endurance Time Test Requirements for Snow Pellet Flat Plate Testing
- Procedure: Endurance Time Test Requirements for Simulated Snow Flat Plate Testing
- Procedure: Development of Type I Protocol for Indoor Snow (ARP5945)
- Procedure: Endurance Time Testing with Heavy Snow with the Snowmaker in Comparison with Natural Snow

PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SNOW PELLET FLAT PLATE TESTING

BM5611.00

PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SNOW PELLET FLAT PLATE TESTING

TYPE I,II,III, AND IV FLUIDS

2008-09

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: for Victoria Zoitakis

Reviewed by: John D'Avirro

December 17, 2008
Final Version 1.0

ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW PELLET FLAT PLATE TESTING

TYPE I, II, III, AND IV FLUIDS

1. BACKGROUND

Snow pellets are defined as white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2 to 5 mm. These grains are also brittle and easily crushed. They bounce and break on hard ground.

Although occurrences of snow pellets during aircraft operations have been reported, no HOT Guidelines currently exist for snow pellets. Some aircraft operators have voiced concern regarding the lack of HOT guidance material due to the recent increased frequency of occurrence of snow pellet conditions. Some preliminary work was conducted by APS aviation which looked at the melting time properties of simulated snow pellets versus natural snow; this work was presented at the Lisbon HOT working group meeting and was reported in Transport Canada Report TP14713E.

Some preliminary research was done in Winter 2007-08 with three fluids. The fluid endurance times in simulated snow pellet conditions were similar to simulated snow. After having presented this data at industry meetings, it was suggested to conduct more tests with other fluids.

This set of tests will produce snow pellet endurance times using the NCAR snow generation system.

2. OBJECTIVES

This main objective of this test program is to compare the endurance times of simulated snow with the endurance times of simulated snow pellets.

3. TEST REQUIREMENTS

Indoor tests will be conducted inside the refrigerated trailer at the Dorval test site.

Type I, II, III and Type IV fluids will be tested at the condition temperature. All fluids will be refrigerated to ensure temperature is according to requirements.

4. TEST PLAN

Attachment I shows the test plan for Type I/II/III/IV fluids.

Tests will be conducted with a total of six comparative fluids at standard dilutions. Each fluid will be tested at the condition temperature. In addition, Type II and IV fluids will be tested at -10°C to allow for additional data. Priorities have been assigned as the funding for this project is limited.

5. EQUIPMENT

Attachment II presents a list of required equipment for the snow pellet endurance time tests with the NCAR snow machine.

Information needed to run endurance time tests with the snowmaker is found in the procedure, Variance and New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker (see Version 1.2 from January 23, 2008, located in Appendix B of *Endurance Time Testing in Snow*: *Comparison of Indoor and Outdoor Data for 2007-08 and Other Artificial Snow Projects* interim report TP(07-08).

6. PERSONNEL

One person is required to pour the fluids and to determine the endurance time on the plate. Two people are required to prepare the snow pellets.

7. SUMMARY OF PROCEDURES

The ice core tubes must be filled with de-mineralized water and cooled to below 0°C, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

Proper steps should be taken to ensure the correct functioning of the machine as described in SAE ARP 5485.

7.1 Making of Artificial Snow Pellets

The major steps in the making of artificial snow pellets are:

1) Empty fluid collection bucket;
2) Prepare and secure ice core;

3) Place empty container on top of the collection bucket to capture simulated snow;
4) Begin precipitation and **set desired icing intensity**;
5) Once the snow is collected, form snow balls with the artificial snow; and
6) Crush snow balls through the sieves to create snow pellets.

7.2 Artificial Snow Pellet Flat Plate Test Procedure

The major steps in the artificial snow pellet flat plate test procedure are:

1) Empty fluid collection bucket;
2) **Set desired plate temperature** on Omega controller;
3) Clean panels;
4) Apply one litre of fluid to test panel. Type II, III and Type IV fluids are at the test air temperature. Fluids are poured using a single-step fluid application;
5) Using a spoon, dispense the snow pellets evenly across the test plate;
6) Using Labview "*start experiment*" and **monitor the distribution rate**;
7) Record the start of the endurance time test after fluid is applied;
8) Record crosshair end condition times;
9) Continue testing until at least five crosshairs or 30% of the plate has failed; and
10) In Labview "*end experiment*" and record pertinent data in Labview.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

8. DATA FORM

The endurance time tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment III.

9. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

a) Pathways, stairs and test areas are to be cleared of snow regularly.

b) Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;

c) Warm clothing is to be worn by all personnel to prevent frostbite;

d) Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;

e) If fluid comes into contact with skin, rinse hands under running water;

f) If fluid comes into contact with eyes, flush with a portable eye wash station;

g) A hardhat is to be worn when inside the snow machine due to equipment above; and

h) Ensure that drill is off when changing the ice core.

ATTACHMENT I
TEST MATRIX - SNOW PELLET ENDURANCE TIME TESTS

Test #	Priority	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm^2/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Estimated Snow Pellets Needed (g)	Fluid Comments
SP1	1	Kilfrost ABS-S Plus	IV	50	1	-3	25	-7	-7	-5.1	17	154	Batch 20368
SN1	1	Kilfrost ABS-S Plus	IV	50	1	-3	25	-7	-7	-5.1	17	N/A	Batch 20368
SP2	2	Kilfrost ABS-S Plus	IV	75	1	-3	25	-7	-7	-5.1	42	380	Batch 20368
SN2	2	Kilfrost ABS-S Plus	IV	75	1	-3	25	-7	-7	-5.1	42	N/A	Batch 20368
SP3	3	Kilfrost ABS-S Plus	IV	100	1	-10	25	-14	-14	-12.1	62	561	Batch 20368
SN3	3	Kilfrost ABS-S Plus	IV	100	1	-10	25	-14	-14	-12.1	62	N/A	Batch 20368
SP4	1	Kilfrost ABS-S Plus	IV	100	1	-14	25	-18	-18	-16.1	58	524	Batch 20368
SN4	1	Kilfrost ABS-S Plus	IV	100	1	-14	25	-18	-18	-16.1	58	N/A	Batch 20368
SP5	2	Kilfrost ABS-S Plus	IV	75	1	-14	25	-18	-18	-16.1	33	298	Batch 20368
SN5	2	Kilfrost ABS-S Plus	IV	75	1	-14	25	-18	-18	-16.1	33	N/A	Batch 20368
SP6	1	Octagon MaxFlo	IV	50	1	-3	10	-7	-7	-4.2	21	76	Batch 4126026
SN6	1	Octagon MaxFlo	IV	50	1	-3	10	-7	-7	-4.2	21	N/A	Batch 4126026
SP7	2	Octagon MaxFlo	IV	75	1	-3	25	-7	-7	-5.1	22	199	Batch 4126026
SN7	2	Octagon MaxFlo	IV	75	1	-3	25	-7	-7	-5.1	22	N/A	Batch 4126026
SP8	3	Octagon MaxFlo	IV	100	1	-10	25	-14	-14	-12.1	30	271	Batch 4126026
SN8	3	Octagon MaxFlo	IV	100	1	-10	25	-14	-14	-12.1	30	N/A	Batch 4126026

ATTACHMENT I (cont'd)
TEST MATRIX - SNOW PELLET ENDURANCE TIME TESTS

Test #	Priority	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm²/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Estimated Snow Pellets Needed (g)	Fluid Comments
SP9	1	Octagon MaxFlo	IV	100	1	-14	25	-18	-18	-16.1	27	244	Batch 4126026
SN9	1	Octagon MaxFlo	IV	100	1	-14	25	-18	-18	-16.1	27	N/A	Batch 4126026
SP10	2	Octagon MaxFlo	IV	75	1	-14	25	-18	-18	-16.1	16	145	Batch 4126026
SN10	2	Octagon MaxFlo	IV	75	1	-14	25	-18	-18	-16.1	16	N/A	Batch 4126026
SP11	1	Clariant Safewing MPIII 2031 ECO	III	50	1	-3	10	-6	-6	-4.2	9	33	Frost 08-09 Fluid
SN11	1	Clariant Safewing MPIII 2031 ECO	III	50	1	-3	10	-6	-6	-4.2	9	N/A	Frost 08-09 Fluid
SP12	2	Clariant Safewing MPIII 2031 ECO	III	75	1	-3	10	-6	-6	-4.2	17	61	Frost 08-09 Fluid
SN12	2	Clariant Safewing MPIII 2031 ECO	III	75	1	-3	10	-6	-6	-4.2	17	N/A	Frost 08-09 Fluid
SP13	3	Clariant Safewing MPIII 2031 ECO	III	100	1	-6	10	-6	-6	-7.2	19	69	Frost 08-09 Fluid
SN13	3	Clariant Safewing MPIII 2031 ECO	III	100	1	-6	10	-9	-9	-7.2	19	N/A	Frost 08-09 Fluid
SP14	3	Clariant Safewing MPIII 2031 ECO	III	75	1	-6	10	-9	-9	-7.2	16	58	Frost 08-09 Fluid
SN14	3	Clariant Safewing MPIII 2031 ECO	III	75	1	-6	10	-9	-9	-7.2	16	N/A	Frost 08-09 Fluid
SP15	1	Clariant Safewing MPIII 2031 ECO	III	100	1	-10	10	-9	-9	-11.2	18	65	Frost 08-09 Fluid
SN15	1	Clariant Safewing MPIII 2031 ECO	III	100	1	-10	10	-13	-13	-11.2	18	N/A	Frost 08-09 Fluid
SP16	2	Clariant Safewing MPIII 2031 ECO	III	75	1	-10	10	-13	-13	-11.2	15	54	Frost 08-09 Fluid
SN16	2	Clariant Safewing MPIII 2031 ECO	III	75	1	-10	10	-13	-13	-11.2	15	N/A	Frost 08-09 Fluid

ATTACHMENT I (cont'd)
TEST MATRIX - SNOW PELLET ENDURANCE TIME TESTS

Test #	Priority	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm²/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Estimated Snow Pellets Needed (g)	Fluid Comments
SP17	1	Clariant Safewing MPII Flight	II	50	1	-3	10	-13	-13	-4.2	24	87	Wind Tunnel 08-09 Fluid
SN17	1	Clariant Safewing MPII Flight	II	50	1	-3	10	-7	-7	-4.2	24	N/A	Wind Tunnel 08-09 Fluid
SP18	2	Clariant Safewing MPII Flight	II	75	1	-3	25	-7	-7	-5.1	42	380	Wind Tunnel 08-09 Fluid
SN18	2	Clariant Safewing MPII Flight	II	75	1	-3	25	-7	-7	-5.1	42	N/A	Wind Tunnel 08-09 Fluid
SP19	3	Clariant Safewing MPII Flight	II	100	1	-10	25	-14	-14	-12.1	44	398	Wind Tunnel 08-09 Fluid
SN19	3	Clariant Safewing MPII Flight	II	100	1	-10	25	-14	-14	-12.1	44	N/A	Wind Tunnel 08-09 Fluid
SP20	1	Clariant Safewing MPII Flight	II	100	1	-14	25	-18	-18	-16.1	41	371	Wind Tunnel 08-09 Fluid
SN20	1	Clariant Safewing MPII Flight	II	100	1	-14	25	-18	-18	-16.1	41	N/A	Wind Tunnel 08-09 Fluid
SP21	2	Clariant Safewing MPII Flight	II	75	1	-14	25	-18	-18	-16.1	22	199	Wind Tunnel 08-09 Fluid
SN21	2	Clariant Safewing MPII Flight	II	75	1	-14	25	-18	-18	-16.1	22	N/A	Wind Tunnel 08-09 Fluid
SP22	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-3	4	60	-5	N/A	14	20	Fluid Freeze Point: -13 / Brix: 21.25
SN22	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-3	4	60	-5	N/A	14	N/A	Fluid Freeze Point:-13 / Brix: 21.25
SP23	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-3	4	60	-5	N/A	14	20	Fluid Freeze Point: -13 / Brix: 21.25
SN23	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-3	4	60	-5	N/A	14	N/A	Fluid Freeze Point: -13 / Brix: 21.25
SP24	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	16	Fluid Freeze Point: -16 / Brix: 23.5
SN24	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	N/A	Fluid Freeze Point: -16 / Brix: 23.5

ATTACHMENT I (cont'd)
TEST MATRIX - SNOW PELLET ENDURANCE TIME TESTS

Test #	Priority	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm²/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Estimated Snow Pellets Needed (g)	Fluid Comments
SP25	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	16	Fluid Freeze Point: -16 / Brix: 23.5
SN25	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	N/A	Fluid Freeze Point: -16 / Brix: 23.5
SP26	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	10	Fluid Freeze Point: -20 / Brix: 27
SN26	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	N/A	Fluid Freeze Point: -20 / Brix: 27
SP27	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	10	Fluid Freeze Point: -20 / Brix: 27
SN27	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	N/A	Fluid Freeze Point: -20 / Brix: 27
SP28	3	HOT Fluid #1	II or IV	50	1	-3	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN28	3	HOT Fluid #1	II or IV	50	1	-3	25	-7	-7	-5.1	N/A	N/A	HOT Fluid that is submitted
SP29	3	HOT Fluid #1	II or IV	75	1	-3	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN29	3	HOT Fluid #1	II or IV	75	1	-3	25	-7	-7	-5.1	N/A	N/A	HOT Fluid that is submitted
SP30	3	HOT Fluid #1	II or IV	100	1	-10	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN30	3	HOT Fluid #1	II or IV	100	1	-10	25	-14	-14	-12.1	N/A	N/A	HOT Fluid that is submitted
SP31	3	HOT Fluid #1	II or IV	100	1	-14	25	-14	-14	-12.1		0	HOT Fluid that is submitted
SN31	3	HOT Fluid #1	II or IV	100	1	-14	25	-18	-18	-16.1	N/A	N/A	HOT Fluid that is submitted
SP32	3	HOT Fluid #1	II or IV	75	1	-14	25	-18	-18	-16.1		0	HOT Fluid that is submitted
SN32	3	HOT Fluid #1	II or IV	75	1	-14	25	-18	-18	-16.1	N/A	N/A	HOT Fluid that is submitted

ATTACHMENT II
Test Equipment List

- Snow making machine and related equipment;
- Aluminum plates with heating pads;
- Aluminum Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 167mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L sample fluid bottles;
- Sieves (1.4 mm and 4 mm);
- Spoon;
- Paper towels;
- Rags;
- Flood lights;
- Stopwatch;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW PELLET FLAT PLATE TESTING

Attachment III
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2008-09

LOCATION:	DATE:	RUN # :	STAND # :	NCAR

OUTPUT FILENAME:_____.txt

OAT: _____ °C

PRECIPITATION RATE: _____ g/dm²/h

FLUID TEMPERATURE: _____ °C

FLUID QUANTITY APPLIED: _____ Litres

PLATE WASHING METHOD: _____

PLATE TEMPERATURE (OMEGA): _____ °C

OTHER COMMENTS (Fluid Batch, etc):

_____

_____

_____

_____

_____

_____

_____

	PRINT	SIGN
FAILURES CALLED BY :	_____	_____
HAND WRITTTEN BY :	_____	_____
LEADER :	_____	_____

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

Time of Fluid Application: _____ h:min

FLUID NAME			
B1 B2 B3			
C1 C2 C3			
D1 D2 D3			
E1 E2 E3			
F1 F2 F3			

CALCULATED FAILURE TIME (MINUTES) _____

Final Brix (o)

B2	C1	C2	C3	D2	E2

M:\Projects\PM2XXX (NEW TC CONTRACT)\Procedures\Snow Pellets\Final Version 1.0\Snow Pellet Version 1.0.doc
Final Version 1.0, December 08

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PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING

CM2103.001 (07-08)

PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING

TYPE II,III, AND IV FLUIDS

2007-08

Prepared for

Transportation Development Centre
Transport Canada

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Reviewed by: John D'Avirro

APS Aviation Inc.

January 23, 2008
Final Version 1.2

ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING

TYPE II, III, AND IV FLUIDS

This set of tests will produce snow endurance time using the NCAR snow generation system.

1. OBJECTIVES

This document provides a brief summary of the test requirements and data forms needed for simulated snow flat plate testing in the 2007-08 winter season. SAE ARP 5485 contains a detailed description of the test equipment, test parameters, snow measurement methods, snow test conditions, and snow test procedure for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids. This procedure is an alternate procedure to the natural snow endurance time test procedure.

2. TEST REQUIREMENTS

Indoor snow tests may be conducted in a climactic chamber such as CRIQ in Montreal, PMG in Blainville, the NRC in Ottawa, or a suitable refrigerated trailer.

All Type II, III and Type IV fluids must be tested at the condition temperature. If the cold chamber is not maintained at low temperatures over night, the fluids must be refrigerated to ensure temperature is according to requirements.

3. TEST PLAN

An extract from SAE ARP 5485 is included as Attachment I, outlining the snow test conditions that are performed using the snowmaker.

Attachments II and III show the test plans for Type II/IV and Type III fluids respectively.

It is estimated that 40 hours are required to test each fluid (not including duplicates) for an experienced research assistant; this includes some time for rate verification.

A detailed test plan will be developed based on the fluids available for testing in 2007-08.

4. EQUIPMENT

Attachment IV presents a list of required equipment for the endurance time tests with the NCAR snow machine.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03).*

5. PERSONNEL

One person is required to pour the fluids and to call the failure on the plate.

6. SUMMARY OF PROCEDURES

The ice core tubes must be filled with de-mineralized water and cooled to below 0ºC, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

Proper steps should be taken to ensure the correct functioning of the machine as described in SAE ARP 5485.

The test panel will be set at the correct temperature for the test; this is done using a heating pad on the underside of the test panel.

The major steps in the artificial snow flat plate test procedure are:

1) Empty fluid collection bucket;
2) Prepare and secure ice core;
3) Begin precipitation and **set desired icing intensity**;
4) **Set desired plate temperature** on Omega controller;
5) Clean panels;
6) Apply one litre of fluid to test panel. Type II, III and Type IV fluids are at the test air temperature. Fluids are poured using a single-step fluid application;

7) Using Labview "*start experiment*" and **set linear rate function**;

8) Record the start of the endurance time test after fluid is applied;

9) Record crosshair end condition times;

10) Continue testing until at least five crosshairs or 30% of the plate has failed; and

11) In Labview "*end experiment*" and record pertinent data in Labview.

Attachment V details the setting of the snowmaker tests parameters.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

7. DATA FORM

The endurance time tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment VI.

8. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

a) Pathways, stairs and test areas are to be cleared of snow regularly;

b) Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;

c) Warm clothing is to be worn by all personnel to prevent frostbite;

d) Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;

e) If fluid comes into contact with skin, rinse hands under running water;

f) If fluid comes into contact with eyes, flush with a portable eye wash station;

g) A hard hat is to be worn when inside the snow machine due to equipment above; and

h) Ensure that drill is off when changing the ice core.

Attachment I: Snow Test Conditions
(Extract of Proposed ARP 5485)

Test Condition	SNW-A	SNW-B	SNW-C	SNW-D	SNW-E	SNW-F	SNW-G	SNW-H
Types II and IV, neat	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes	No	No	Yes	Yes	No	No
Types II and IV, 50/50 (neat fluid/water)	Yes	Yes	No	No	No	No	No	No
Types III, neat	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Types III, 75/25 (neat fluid/water)	Yes	Yes	Yes	Yes	No	No	No	No
Types III, 50/50 (neat fluid/water)	Yes	Yes	No	No	No	No	No	No
Test condition temperature, °C	-3	-3	-10	-10	-14	-14	-25	-25
Snow intensity, $g/dm^2/h$	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5
Snow intensity standard deviation	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25
Minumum plate temperature (Example 1)	-4.2 ± 0.5	-5.1 ± 0.5	-11.2 ± 0.5	-12.1 ± 0.5	-15.2 ± 0.5	-16.1 ± 0.5	-26.2 ± 0.5	-27.1 ± 0.5
Plate temperature* (Example 2), ºC	-4.2 ± 0.5	-5.1 ± 0.5	-11.2 ± 0.5	-12.1 ± 0.5	-15.2 ± 0.5	-16.1 ± 0.5	-26.2 ± 0.5	-27.1 ± 0.5
Plate temperature standard deviation (example 2)	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5
Snow intensity from the mean range across a test plate ($g/dm^2/h$)	2.0	5.0	2.0	5.0	2.0	5.0	2.0	5.0

*after stabilization, typically 5 minutes

Attachment II
Artificial Snow Test Matrix
Type II and IV Fluids

Test #	Dilution	Condition Temperature (°C)	Plate Temperature (°C)	Snow Intensity (g/dm²/hr)	Notes
1a	100	0	-1.2	10	Optional, as no HOT guidelines
1b	100	0	-1.2	10	Optional, as no HOT guidelines
2a	100	0	-2.1	25	Optional, as no HOT guidelines
2b	100	0	-2.1	25	Optional, as no HOT guidelines
3a	75	0	-1.2	10	Optional, as no HOT guidelines
3b	75	0	-1.2	10	Optional, as no HOT guidelines
4a	75	0	-2.1	25	Optional, as no HOT guidelines
4b	75	0	-2.1	25	Optional, as no HOT guidelines
5a	50	0	-1.2	10	Optional, as no HOT guidelines
5b	50	0	-1.2	10	Optional, as no HOT guidelines
6a	50	0	-2.1	25	Optional, as no HOT guidelines
6b	50	0	-2.1	25	Optional, as no HOT guidelines
7a	100	-3	-4.2	10	
7b	100	-3	-4.2	10	
8a	100	-3	-5.1	25	
8b	100	-3	-5.1	25	
9a	75	-3	-4.2	10	
9b	75	-3	-4.2	10	
10a	75	-3	-5.1	25	
10b	75	-3	-5.1	25	
11a	50	-3	-4.2	10	
11b	50	-3	-4.2	10	
12a	50	-3	-5.1	25	
12b	50	-3	-5.1	25	
13a	100	-14	-15.2	10	
13b	100	-14	-15.2	10	
14a	100	-14	-16.1	25	
14b	100	-14	-16.1	25	
15a	75	-14	-15.2	10	
15b	75	-14	-15.2	10	
16a	75	-14	-16.1	25	
16b	75	-14	-16.1	25	
17a	100	-25	-26.2	10	Optional, as generic values used in HOT
17b	100	-25	-26.2	10	Optional, as generic values used in HOT
18a	100	-25	-27.1	25	Optional, as generic values used in HOT
18b	100	-25	-27.1	25	Optional, as generic values used in HOT

Attachment III
Artificial Snow Test Matrix –Type III Fluids

Test #	Dilution	Condition Temperature (°C)	Plate Temperature (°C)	Snow Intensity (g/dm²/hr)	Notes
1a	100	0	-1.2	10	Optional, as no HOT guidelines
1b	100	0	-1.2	10	Optional, as no HOT guidelines
2a	100	0	-2.1	25	Optional, as no HOT guidelines
2b	100	0	-2.1	25	Optional, as no HOT guidelines
3a	75	0	-1.2	10	Optional, as no HOT guidelines
3b	75	0	-1.2	10	Optional, as no HOT guidelines
4a	75	0	-2.1	25	Optional, as no HOT guidelines
4b	75	0	-2.1	25	Optional, as no HOT guidelines
5a	50	0	-1.2	10	Optional, as no HOT guidelines
5b	50	0	-1.2	10	Optional, as no HOT guidelines
6a	50	0	-2.1	25	Optional, as no HOT guidelines
6b	50	0	-2.1	25	Optional, as no HOT guidelines
7a	100	-3	-4.2	10	
7b	100	-3	-4.2	10	
8a	100	-3	-5.1	25	
8b	100	-3	-5.1	25	
9a	75	-3	-4.2	10	
9b	75	-3	-4.2	10	
10a	75	-3	-5.1	25	
10b	75	-3	-5.1	25	
11a	50	-3	-4.2	10	
11b	50	-3	-4.2	10	
12a	50	-3	-5.1	25	
12b	50	-3	-5.1	25	
13a	100	-6	-7.2	10	Optional, as not described in ARP 5485
13b	100	-6	-7.2	10	Optional, as not described in ARP 5485
14a	100	-6	-8.1	25	Optional, as not described in ARP 5485
14b	100	-6	-8.1	25	Optional, as not described in ARP 5485
15a	75	-6	-7.2	10	Optional, as not described in ARP 5485
15b	75	-6	-7.2	10	Optional, as not described in ARP 5485
16a	75	-6	-8.1	25	Optional, as not described in ARP 5485
16b	75	-6	-8.1	25	Optional, as not described in ARP 5485
17a	100	-10	-11.2	10	
17b	100	-10	-11.2	10	
18a	100	-10	-12.1	25	
18b	100	-10	-12.1	25	
19a	75	-10	-11.2	10	
19b	75	-10	-11.2	10	
20a	75	-10	-12.1	25	
20b	75	-10	-12.1	25	
21a	100	-25	-26.2	10	Optional, as generic values used in HOT
21b	100	-25	-26.2	10	Optional, as generic values used in HOT
22a	100	-25	-27.1	25	Optional, as generic values used in HOT
22b	100	-25	-27.1	25	Optional, as generic values used in HOT

Attachment IV
Test Equipment Checklist

- Snow making machine and related equipment;
- Aluminum plates with heating pads;
- Aluminum Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 167mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L sample fluid bottles;
- Paper towels;
- Rags;
- Flood lights;
- Stopwatch;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

Attachment V
NCAR Snowmaker Test Parameters Guidelines

ARP 5485 includes four requirements that relate the plate, enclosure and fluid temperatures. These are:

1. The PLATE TEMPERATURE (T_P) is determined by the following equation for icing intensities up to 25 g/dm^2/h:

$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

2. The ENCLOSURE TEMPERATURE (T_E) is always below -5°C:

$$T_E <= -5°C$$

3. The ECLOSURE TEMPERATURE (T_E) is TYPICALLY 2°C below the PLATE TEMPERATURE (T_P) DURING THE TEST (no tolerance specified):

$$T_E = T_P - 2°C$$

4. The FLUID APPLICATION TEMPERATURE (T_F) is within 3°C of the ENCLOSURE TEMPERATURE (T_E):

$$T_F = T_E \pm 3°C$$

Note 1: The enclosure and the plate temperatures should be within 0.5°C at the BEGINNING OF THE TEST.

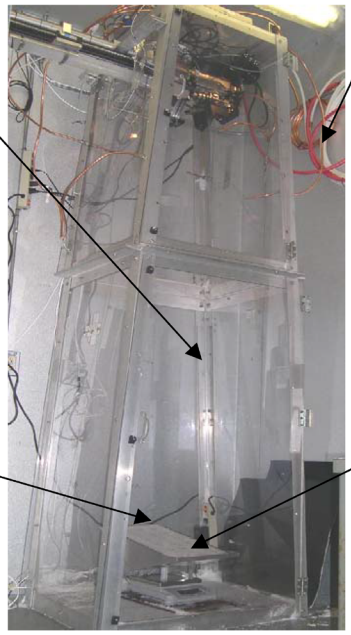
Note 2: There is no requirement for the chamber temperature. The chamber temperature is typically colder than the enclosure temperature.

EXAMPLE:

For a test performed at -14°C condition at a rate of 10 g/dm^2/h:

STEP 2: Enclosure Temp
Requirement:
The enclosure temperature is typically 2°C below the plate temperature (no tolerance specified).

Example:
T_E = -15.2°C- 2°C
T_E = -17.2°C



Note: Chamber Temp
- No specific requirement
- Typically below T_E

STEP 1: Plate Temp
Requirement:
The plate temperature is obtained with the equation shown below*.

Example:
T_P = -14°C –1.2°C
T_P = -15.2°C

STEP 3: Fluid Temp:
Requirement:
The fluid temperature is within 3°C of the enclosure temperature.

Example:
T_F = -17.2°C ± 3°C

***Plate Temperature Equation**

Requirement:
The plate temperature is obtained with the equation shown below:

$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

Attachment VI
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2003-04

LOCATION:	DATE:	RUN # :	STAND # : NCAR

OUTPUT FILENAME:_____.txt

OAT: _____°C

PRECIPITATION RATE: _____g/dm²/h

FLUID TEMPERATURE: _____°C

FLUID QUANTITY APPLIED: _____Litres

PLATE WASHING METHOD: _____

PLATE TEMPERATURE (OMEGA): _____ °C

OTHER COMMENTS (Fluid Batch, etc):

_____

_____

_____

_____

_____

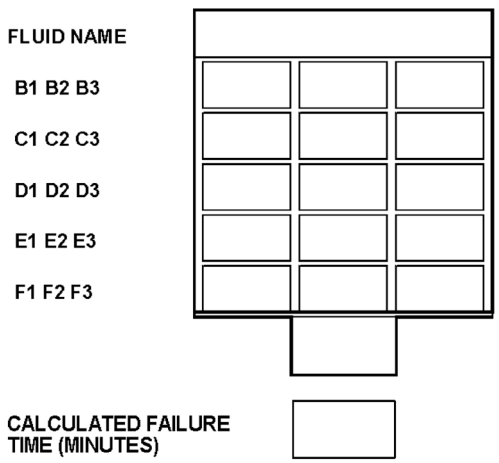
_____

_____

	PRINT	SIGN
FAILURES CALLED BY :	_____	_____
HAND WRITTTEN BY :	_____	_____
LEADER :	_____	_____

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

Time of Fluid Application: _____ h:min



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PROCEDURE:
DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW
(ARP5945)

CM2103.001 (07-08)

PROCEDURE:
DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW
(ARP 5945)

Winter 2007-08

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: George Balaban

Reviewed by: John D'Avirro

APS Aviation Inc.

January 21, 2008
Version 1.0

DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW (ARP 5945)

Winter 2007-08

1. BACKGROUND

As a result of the SAE G-12 Holdover Time Subcommittee meeting held in Toulouse, France in May 2000, a new test protocol (ARP 5945) was developed for measuring endurance times for SAE Type I fluids that closely reflects real field operations. The protocol outlines that tests in natural snow conditions are conducted on insulated 7.5 cm cold-soak box, empty, and treated with 0.5 L of fluid at 60°C. This was found to be a reasonable representation of the temperature decay rate demonstrated by wings in natural outdoor conditions. The fluid was applied along the top edge of the test surface using a specially designed 12-hole fluid spreader.

ARP 5945 in its current form does not include a procedure for SAE Type I fluid testing in artificial snow.

The National Centre for Atmospheric Research (NCAR) performed a series of artificial snow Type I fluid tests using the NCAR snowmaker. The results of these tests were presented at the SAE G-12 meeting in Pittsburgh, USA in May 2005. For these tests, a procedure similar to that used for outdoor tests was used along with some minor modifications of the NCAR snowmaker. These preliminary tests showed that the NCAR snowmaker could adequately reproduce endurance times for Type I fluids.

APS conducted a series of Type I comparison tests in 2007 that proved the feasibility of NCAR Type I testing at the Dorval test site. These tests were however run on plates, not on boxes.

In 2007-08, a series Type I tests are planned in artificial snow with ethylene-glycol (EG), propylene-glycol (PG) and non-glycol based fluids to validate the capability of the snowmaker to perform Type I tests. The use of a standard cold-soak box and a snowmaker software upgrade will be the start points in this research project.

2. OBJECTIVE

The objective of this project is to establish a Type I testing protocol in simulated snow conditions that will be included in ARP 5945.

To achieve this objective, the software of the NCAR snowmaker will be upgraded and configured for tests using the cold soak box. A series of tests will be performed with EG, PG and non-glycol fluids to validate the results obtained in the

past by NCAR and to provide direct comparison with the current holdover times. The test plan is included in Attachment I.

It is estimated that approximately 10-15 tests can be conducted during a regular day (including setup) in the refrigerated trailer at the Dorval test site. The test plan and the priorities may be altered based on the time available to conduct these tests. One week will be allocated for testing to evaluate the new NCAR setup for Type I tests.

3. PROCEDURE/TEST REQUIREMENTS

The ice core tubes must be filled with demineralised water and cooled to below 0°C, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

A snow distribution trial should be completed with every change in rate or temperature, to ensure the correct functioning of the machine.

The 7.5 cm cold-soak box, insulated on all sides but the top, empty, will be used as the test surface for the indoor tests. It will be fitted with a thermistor and will be installed on the collection bucket. The box temperature will be logged for subsequent analysis.

The major steps in the test procedure are:

1) Empty fluid collection bucket;

2) Prepare and secure ice core;

3) Apply small amount of fluid at ambient temperature to help spread the fluid over the entire plate;

4) 0.5 L[1] of fluid will be heated to 60°C with an acceptance range of + 2°C and -0°C. The fluid will be applied on the surface through a 12-hole spreader. The fluid used will be diluted to a freeze point 10°C below ambient temperature, unless otherwise specified by the fluid manufacturer.

5) Begin precipitation and **set desired icing intensity**

6) Using Labview "*start experiment*" and **set linear rate function**;

7) Record the start of the endurance time test after fluid is applied;

1 Most of the tests will be conducted with 0.5L of Type I fluid. Two additional tests with 1L of fluid will be conducted to study the heat transfer effects of the excess fluid.

8) Determine failure times on test surface, and record using standard NCAR data form (Attachment II); and

9) In Labview "*end experiment*" and record pertinent data in Labview.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

4. EQUIPMENT AND FLUIDS

Attachment III presents a list of required equipment for the Type I artificial snow tests with the NCAR snow machine.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03).*

4.1 Fluids

One ethylene-glycol, one propylene-glycol and one non-glycol based Type I fluid will be used for these tests:

- UCAR EG ADF;
- Octagon Octaflo (PG); and
- Octagon Ecoflo (non-glycol).

Fluids are to be mixed to a freeze point 10°C below OAT. The dilution table for these three fluids is presented in Attachment IV.

Fluids to be applied to the cold soak box test surfaces will be heated to 60°C.

5. PERSONNEL

One person is required to pour the fluids and call the failure on the test plate.

6. DATA FORMS

The Type I simulated snow tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment II.

ATTACHMENT I
NCAR TEST MATRIX
TYPE I EG TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate ($g/dm^2/h$)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-1	1	Type I EG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-2	1	Type I EG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-3	1	Type I EG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-4	1	Type I EG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-5	1	Type I EG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-6	1	Type I EG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-7	1	Type I EG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-8	1	Type I EG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-9	1	Type I EG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-10	1	Type I EG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-11	1	Type I EG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-12	1	Type I EG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-13	1	Type I EG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-14	1	Type I EG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-15	1	Type I EG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-16	1	Type I EG	10°C buffer	60	0.5	-14	25	-16	2	2
T1-17	2	Type I EG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-18	2	Type I EG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-19	2	Type I EG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-20	2	Type I EG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-21	2	Type I EG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-22	2	Type I EG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-23	2	Type I EG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-24	2	Type I EG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-25	2	Type I EG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-26	2	Type I EG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-27	2	Type I EG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-28	2	Type I EG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-29	2	Type I EG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-30	2	Type I EG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-31	2	Type I EG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-32	2	Type I EG	10°C buffer	60	0.5	-14	25	-16	2	2

ATTACHMENT I (cont.)
NCAR TEST MATRIX
TYPE I PG TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate ($g/dm^2/h$)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-33	1	Type I PG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-34	1	Type I PG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-35	1	Type I PG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-36	1	Type I PG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-37	1	Type I PG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-38	1	Type I PG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-39	1	Type I PG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-40	1	Type I PG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-41	1	Type I PG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-42	1	Type I PG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-43	1	Type I PG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-44	1	Type I PG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-45	1	Type I PG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-46	1	Type I PG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-47	1	Type I PG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-48	1	Type I PG	10°C buffer	60	0.5	-14	25	-16	2	2
T1-49	2	Type I PG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-50	2	Type I PG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-51	2	Type I PG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-52	2	Type I PG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-53	2	Type I PG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-54	2	Type I PG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-55	2	Type I PG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-56	2	Type I PG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-57	2	Type I PG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-58	2	Type I PG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-59	2	Type I PG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-60	2	Type I PG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-61	2	Type I PG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-62	2	Type I PG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-63	2	Type I PG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-64	2	Type I PG	10°C buffer	60	0.5	-14	25	-16	2	2

ATTACHMENT I (cont.)
NCAR TEST MATRIX
TYPE I SUPPLEMENTARY TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate ($g/dm^2/h$)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-65	3	Type I EG	10°C buffer	60	1	-3	10	-5	10	11
T1-66	3	Type I EG	10°C buffer	60	1	-6	4	-8	12	14
T1-67	3	Type I PG	10°C buffer	60	1	-3	10	-5	10	11
T1-68	3	Type I PG	10°C buffer	60	1	-6	4	-8	12	14
T1-69	4	Octagon Ecoflo	10°C buffer	60	0.5	-3	3	-5	N/A	N/A
T1-70	4	Octagon Ecoflo	10°C buffer	60	0.5	-3	10	-5	N/A	N/A
T1-71	4	Octagon Ecoflo	10°C buffer	60	0.5	-3	25	-5	N/A	N/A
T1-72	4	Octagon Ecoflo	10°C buffer	60	0.5	-10	3	-12	N/A	N/A
T1-73	4	Octagon Ecoflo	10°C buffer	60	0.5	-10	25	-12	N/A	N/A
T1-74	4	Octagon Ecoflo	10°C buffer	60	0.5	-14	10	-16	N/A	N/A

ATTACHMENT II
SIMULATED SNOW END CONDITION DATA FORM

Version 1.0 Winter 2003-04

LOCATION: DATE: RUN # : STAND # : NCAR

OUTPUT FILENAME:_____.txt

OAT: _____°C

PRECIPITATION RATE: _____g/dm²/h

FLUID TEMPERATURE: _____°C

FLUID QUANTITY APPLIED: _____Litres

PLATE WASHING METHOD: _____

PLATE TEMPERATURE (OMEGA): _____ °C

OTHER COMMENTS (Fluid Batch, etc):

_____

_____

_____

_____

_____

_____

_____

	PRINT	SIGN
FAILURES CALLED BY :	_____	_____
HAND WRITTTEN BY :	_____	_____
LEADER :	_____	_____

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

Time of Fluid Application: _____ h:min

FLUID NAME

B1 B2 B3			
C1 C2 C3			
D1 D2 D3			
E1 E2 E3			
F1 F2 F3			

CALCULATED FAILURE TIME (MINUTES)

M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\NCAR\Snow Maker Data Sheet

ATTACHMENT III
TEST EQUIPMENT CHECKLIST

- Snow making machine and related equipment;
- Aluminum cold soak box with thermister;
- Logger capability to record box temperature;
- 12-hole spreader;
- Thermoses;
- Microwave and containers used for fluid heating;
- Temperature probe;
- Aluminium Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 165mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L fluid bottles;
- Paper towels;
- Rags;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

ATTACHMENT IV
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Octagon Octaflo / EF (PG)				UCAR ADF (EG)				Octagon Ecoflo			
		% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5	15	9.75	1.2	6.8	12	8	1.0	7.0				
4	-6					14.5	9.5	1.2	6.8	19.8	13.25	1.6	6.4
3	-7					16	10.5	1.3	6.7	21.6	14.75	1.7	6.3
2	-8					18.5	12	1.5	6.5	23.5	16	1.9	6.1
1	-9	27.5	18.5	2.2	5.8	21.5	13.5	1.7	6.3	25.3	17.5	2.0	6.0
0	-10	29	19	2.3	5.7	22	14	1.8	6.2	27.1	18.75	2.2	5.8
-1	-11	30	20	2.4	5.6	23	15	1.8	6.2	28.8	20	2.3	5.7
-2	-12	31	20.5	2.5	5.5	24.5	16	2.0	6.0	30.6	21.25	2.4	5.6
-3	-13	32	21.25	2.6	5.4	26	17	2.1	5.9	32.2	22.5	2.6	5.4
-4	-14	34	22.5	2.7	5.3	28	18	2.2	5.8	33.9	23.75	2.7	5.3
-5	-15	35	23	2.8	5.2	30	19	2.4	5.6	35.5	24.75	2.8	5.2
-6	-16	36	23.5	2.9	5.1	31	19.75	2.5	5.5	37.0	26	3.0	5.0
-7	-17	37	24	3.0	5.0	32	20.5	2.6	5.4	38.6	27	3.1	4.9
-8	-18	38.5	25	3.1	4.9	33.5	21.25	2.7	5.3	40.1	28	3.2	4.8
-9	-19	40	26	3.2	4.8	34.5	21.75	2.8	5.2	41.5	29	3.3	4.7
-10	-20	42	27	3.4	4.6	36	22.5	2.9	5.1	43.0	30	3.4	4.6
-11	-21	44	28	3.5	4.5	37	23	3.0	5.0	44.4	30.75	3.5	4.5
-12	-22	45	28.5	3.6	4.4	38	23.75	3.0	5.0	45.7	31.75	3.7	4.3
-13	-23	46	29	3.7	4.3	39	24.5	3.1	4.9	47.0	32.5	3.8	4.2
-14	-24	47	29.5	3.8	4.2	40	25	3.2	4.8	48.3	33.25	3.9	4.1
-15	-25	47.5	30	3.8	4.2	41	25.5	3.3	4.7	49.6	34	4.0	4.0
-16	-26	48.5	30.5	3.9	4.1	42	26	3.4	4.6	50.8	34.75	4.1	3.9
-17	-27	49	31	3.9	4.1	43	26.5	3.4	4.6	51.9	35.5	4.2	3.8
-18	-28	50	31.5	4.0	4.0	44	27	3.5	4.5	53.1	36	4.2	3.8
-19	-29	51	32	4.1	3.9	45	27.5	3.6	4.4	54.2	36.75	4.3	3.7
-20	-30	52	32.5	4.2	3.8	45.75	28	3.7	4.3	55.3	37.25	4.4	3.6
-22	-32	53.5	33.5	4.3	3.7	47	28.75	3.8	4.2	57.3	38.253	4.6	3.4
-25	-35	56	34.5	4.5	3.5	49	30	3.9	4.1	60.1	39.25	4.8	3.2
-30	-40	60	37	4.8	3.2	53	32	4.2	3.8	64.0	40.75	5.1	2.9

M:\Groups\PM2103.001 (TC-Deicing 07-08)\Procedures\NCAR\Type I\Working Docs\ Fluid Dilution for Type I Testing.xls

PROCEDURE:
ENDURANCE TIME TESTING WITH HEAVY SNOW WITH THE SNOWMAKER IN COMPARISON WITH NATURAL SNOW

BM5611.00

PROCEDURE:
ENDURANCE TIME TESTING WITH HEAVY SNOW WITH THE SNOWMAKER IN COMPARISON WITH NATURAL SNOW

Winter 2008-09

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: for Victoria Zoitakis

Reviewed by: John D'Avirro

January 2, 2009
Final Version 1.0

ENDURANCE TIME TESTING WITH HEAVY SNOW WITH THE SNOWMAKER IN COMPARISON WITH NATURAL SNOW

1. BACKGROUND

In 2003-04, the point-by-point comparison of indoor versus outdoor data had shown that maintaining the plate at a set temperature below test temperature represents a suitable solution for producing reliable holdover times.

The plate temperature has a significant effect in determining endurance times. The equation used to calculate the plate set temperature as a function of icing intensity and air temperature was found to be satisfactory for precipitation rates up to 25 g/dm^2/h, and produced a reasonable correlation between indoor and outdoor endurance times. The plate temperature equation was included in the SAE ARP 5485.

In 2006, regression analysis was used to obtain holdover times for precipitation rates of 50 and 75 g/dm^2/h. A series of artificial snow tests were conducted at precipitation rates of 50 and 75 g/dm^2/h to verify the capability of the snowmaker to perform heavy snow endurance tests. The tests showed that the snowmaker could conduct tests in that condition. However, further testing was recommended to establish the proper snowmaker test parameters, as the endurance times measured indoors were lower than expected.

The equation relating the plate temperature to the icing intensity and the test temperature is the critical test parameter for heavy snow tests. A separate procedure, *Determination of Test Plate Temperature in Heavy Snow*, was developed to address this issue. The tests conducted in 2006-07 showed that the plate temperature should be kept 3°C below the test temperature for rates of 50 g/dm^2/h and 4°C below the test temperature for rates of 75 g/dm^2/h. Linear interpolation using the data above will be used to establish the plate temperature for other heavy snow rate values.

In Winter 2007-08, heavy snow tests were conducted with the snowmaker to see how results compare with outdoor heavy snow tests. The results showed that the endurance times with snowmaker were near about half of the outdoor results

2. OBJECTIVES

The objective of this activity would be to try to determine the reasons for the differences between the outdoor and snowmaker endurance times. For each natural heavy snow test conducted outdoors, the test will be reproduced three times in a controlled laboratory conditions using the NCAR snow machine.

Three random data points will be chosen from the outdoor test and reproduced with the snowmaker.

It is anticipated that a total of 3 outdoor heavy snow tests and 9 heavy snow tests with the snowmaker be conducted this winter. Figure 2.1 demonstrates the anticipated tests.

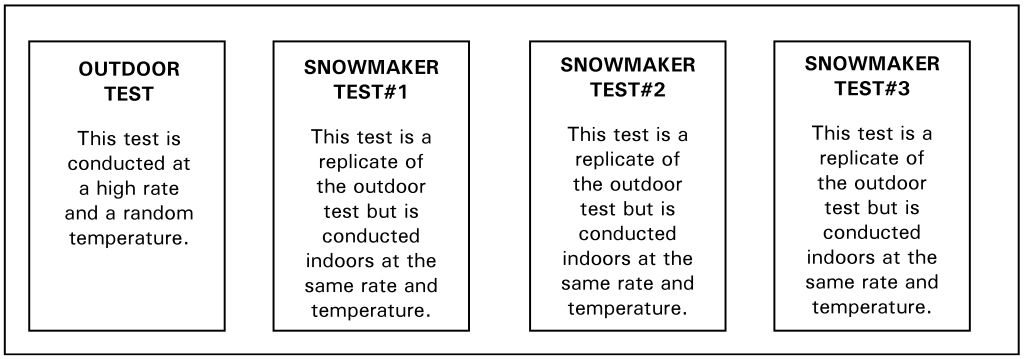


Figure 2.1: Anticipated Tests

3. TEST REQUIREMENTS

Outdoor tests will be conducted at the Dorval test site. Indoor snow tests will be conducted inside the refrigerated trailer at the Dorval Test Site with the NCAR snowmaker.

All fluids will be tested at the precipitation rate and temperature measured outside. The fluids will be refrigerated to ensure temperature is according to requirements.

4. EQUIPMENT

Attachment I presents a list of required equipment for the heavy snow tests with the NCAR snow machine.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03).*

4.1 Fluids

A holdover time fluid will be chosen for the indoor tests based on the data available in heavy snow.

5. PERSONNEL

One person is required to pour the fluids and call the failure on the test plate. One person is required to take pictures and measurements.

6. SUMMARY OF PROCEDURES

6.1 Outdoor Test Procedure

Information needed to run endurance time tests with the snowmaker is found in the procedure, Test Requirements for Natural Precipitation Flat Plate Testing (see Version 1.0 from December 23, 2004).

6.2 NCAR Snowmaker Operation

The ice core tubes must be filled with demineralised water and cooled to below 0°C, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

A snow distribution trial should be completed with every change in rate or temperature, to ensure the correct functioning of the machine.

The test panel will be set at the correct temperature for the test; this is done using a heating pad on the underside of the test panel.

The procedure for obtaining the artificial snow test parameters is summarized in Attachment II.

The major steps in the artificial snow flat plate test procedure are:

1) Empty fluid collection bucket;

2) Prepare and secure ice core;

3) Begin precipitation and **set desired icing intensity**;

4) **Set desired plate temperature** on Omega controller;

5) Clean panels;

6) Apply one litre of fluid to test panel. Type I fluids are at room temperature. Type II and Type IV fluids are at the test air temperature. Fluids are poured using a single–step fluid application;

7) Using Labview "*start experiment*" and **set linear rate function**;

8) Record the start of the endurance time test after fluid is applied;

9) Record crosshair end condition times;

10) Continue testing until at least five crosshairs or 1/3 of the plate have failed; and

11) In Labview "*end experiment*" and record pertinent data in Labview.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

6.2.1 Plate Temperature Set Point

SAE ARP 5485 states that the plate temperature should be set at approximately 1°C and 2°C colder than OAT at rates of 10 and 25 g/dm²/h, respectively.

Tests will be conducted using icing intensity (rates) and temperatures observed in selected individual natural snow data points. For these indoor tests the test plate of the NCAR bucket assembly will be maintained at a temperature that best correlates indoor endurance times with the outdoor times. The tests conducted in 2006-07 showed that the plate temperature should be kept 3°C below the test temperature for rates of 50 g/dm^2/h and 4°C below the test temperature for rates of 75 g/dm^2/h. Linear interpolation using the data above will be used to establish the plate temperature for other heavy snow rate values.

6.3 Brix Measurements

It is very important to take at least four Brix measurements for each indoor and outdoor test.

Brix should be taken at the 15 cm line:

- After fluid application;
- Two or more measurements to analyze progress; and
- At fluid failure.

Brix is used to analyze and compare the failure of the outdoor and indoor tests. Thickness measurements should also be taken at the 15 cm line when taking Brix measurements. The data form required is included in Attachment III.

6.4 Photo Documentation

Photos must be taken before each measurement to have as reference. The picture should be taken from the bottom of the plate at about a 30 degree angle to get a full picture of the plate.

7. DATA FORM

The heavy snow tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment IV. The Brix/Thickness form required is included as Attachment III.

8. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

- Pathways, stairs and test areas are to be cleared of snow regularly;
- Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;
- Warm clothing is to be worn by all personnel to prevent frostbite;

- Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;
- If fluid comes into contact with skin, rinse hands under running water; and
- If fluid comes into contact with eyes, flush with the portable eye wash station located inside the main trailer.

Attachment I
Test Equipment Checklist

- Snow making machine and related equipment;
- Aluminium plates with heating pads;
- Aluminium Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 165mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L fluid bottles;
- Paper towels;
- Rags;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

Attachment II
NCAR Snowmaker Test Parameters Guidelines

ARP 5485 includes four requirements that relate the plate, enclosure and fluid temperatures. These are:

1. The PLATE TEMPERATURE (T_P) is determined by the following equation for icing intensities up to 25 g/dm^2/h:

$$TP = TT - 0.065 * R - 0.5$$

where:

TP – Plate Temperature in °C;

TT – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

2. The ENCLOSURE TEMPERATURE (T_E) is always below -5°C:

$$TE <= -5°C$$

3. The ECLOSURE TEMPERATURE (T_E) is TYPICALLY 2°C below the PLATE TEMPERATURE (T_P) DURING THE TEST (no tolerance specified):

$$TE = TP - 2°C$$

4. The FLUID APPLICATION TEMPERATURE (T_F) is within 3°C of the ENCLOSURE TEMPERATURE (T_E):

$$TF = TE \pm 3°C$$

Note 1: The enclosure and the plate temperatures should be within 0.5°C at the BEGINNING OF THE TEST.

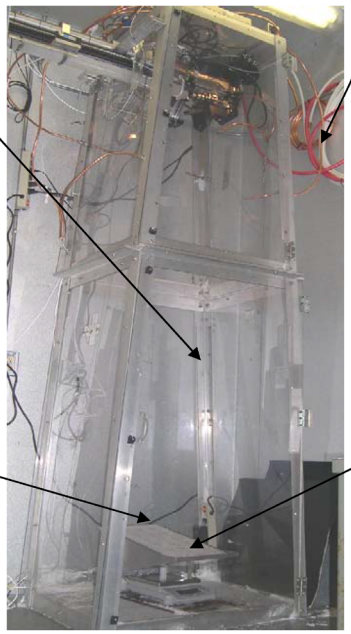
Note 2: There is no requirement for the chamber temperature. The chamber temperature is typically colder than the enclosure temperature.

EXAMPLE:

For a test performed at -14°C condition at a rate of 10 g/dm^2/h:

STEP 2: Enclosure Temp
Requirement:
The enclosure temperature is typically 2°C below the plate temperature (no tolerance specified).

Example:
T_E = -15.2°C- 2°C
T_E = -17.2°C



Note: Chamber Temp
- No specific requirement
- Typically below T_E

STEP 1: Plate Temp
Requirement:
The plate temperature is obtained with the equation shown below*.

Example:
T_P = -14°C –1.2°C
T_P = -15.2°C

STEP 3: Fluid Temp:
Requirement:
The fluid temperature is within 3°C of the enclosure temperature.

Example:
T_F = -17.2°C ± 3°C

***Plate Temperature Equation**

Requirement:
The plate temperature is obtained with the equation shown below:

$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

ATTACHMENT III:
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

ATTACHMENT IV
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2003-04

LOCATION: DATE: RUN # : STAND # : NCAR

OUTPUT FILENAME:_____.txt

OAT: _____°C

PRECIPITATION RATE: _____g/dm²/h

FLUID TEMPERATURE: _____°C

FLUID QUANTITY APPLIED: _____Litres

PLATE WASHING METHOD: _____

PLATE TEMPERATURE (OMEGA): _____ °C

OTHER COMMENTS (Fluid Batch, etc):

_____

_____

_____

_____

_____

_____

_____

	PRINT	SIGN
FAILURES CALLED BY :		
HAND WRITTTEN BY :		
LEADER :		

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

Time of Fluid Application: _____ h:min

FLUID NAME

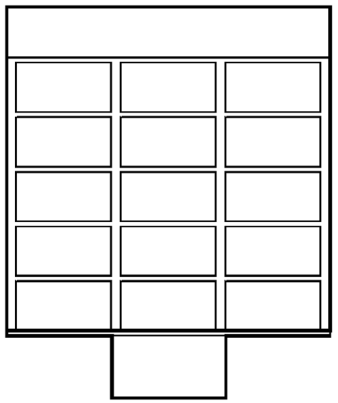
B1 B2 B3

C1 C2 C3

D1 D2 D3

E1 E2 E3

F1 F2 F3



CALCULATED FAILURE TIME (MINUTES)

M:\Groups\CM1692 (TC-Deicing 03-04)\Procedures\NCAR\Snow Maker Data Sheet

APPENDIX C

FREEZING RAIN AND FREEZING DRIZZLE SURVEY FLIGHT CREW RESULTS

FREEZING RAIN AND FREEZING DRIZZLE SURVEY FLIGHT CREW RESULTS

July 15, 2008

1. What type of operation are you primarily involved with?

604 Private Operator Transportation	2
702 Aerial Work	0
703 Air Taxi Operations	5
704 Commuter Operations	2
705 Airline Operations	6
406 Flight Training Unit	0
General Aviation	2
Other (specify below)	1

Note: "Other" respondent did not comment

2. Are you IFR rated?

Yes	18
No	0

3. Do you have experience operating in airborne icing conditions?

Yes	18
No	0

4. Does the company you are employed with have an Approved Ground Icing Program?

Yes	13
No	1
Don't	1

5. Do you believe that, with respect to CAR 605.30, the standards of airworthiness applicable to the aircraft types you operate allow for take-off in the following conditions:

	Yes	No	Don't know
Freezing Drizzle (FZDZ)	10	8	0
Light Freezing Rain (-FZRA)	10	7	1
Moderate Freezing Rain (FZRA)	2	15	1
Heavy Freezing Rain (+FZRA)	2	16	0
Ice Pellets (PL)	10	5	3

6. Do you believe that current aircraft type certification requirements consider take-off operations in freezing drizzle and freezing rain conditions?

Yes	4
No	14

7.a Does the company you are employed with differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, +FZRA or PL?

Yes	12
No	3

7.b As a pilot, do you differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, +FZRA or PL?

Yes	1
No	2

8.a Does the company you are employed with permit/allow take-offs in the following conditions?

	Yes	No
Freezing Drizzle (FZDZ)	10	5
Light Freezing Rain (-FZRA)	10	5
Moderate Freezing Rain (FZRA)	2	13
Heavy Freezing Rain (+FZRA)	2	13
Ice Pellets (PL)	10	5

8.b As a pilot, do you conduct take-offs in the following conditions?

	Yes	No
Freezing Drizzle (FZDZ)	1	2
Light Freezing Rain (-FZRA)	1	2
Moderate Freezing Rain (FZRA)	1	2
Heavy Freezing Rain (+FZRA)	1	2
Ice Pellets (PL)	1	2

9.a Does the company you are employed with place any special restrictions on take-offs in the following conditions?

	Yes	No	Not applicable
Freezing Drizzle (FZDZ)	6	5	1
Light Freezing Rain (-FZRA)	6	5	1
Moderate Freezing Rain (FZRA)	7	2	3
Heavy Freezing Rain (+FZRA)	7	2	3
Ice Pellets (PL)	6	5	1

9.b As a pilot, do you place any special restrictions on take-offs in the following conditions?

	Yes		No	Not applicable
Freezing Drizzle (FZDZ)	1		0	0
Light Freezing Rain (-FZRA)	1		0	0
Moderate Freezing Rain (FZRA)	1		0	0
Heavy Freezing Rain (+FZRA)	1		0	0
Ice Pellets (PL)	1		0	0

10. In the following conditions, what usually limits your departure and take-off capability? *(check any/all that apply)*

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle	3	7	5	3	11	0
Light Freezing Rain	5	7	6	3	11	0
Moderate Freezing	3	4	6	2	5	4
Heavy Freezing Rain	2	4	6	4	5	4
Ice Pellets	4	6	5	3	7	1

11. Have you experienced situations where you have halted operations while others have not?

Yes	8
No	5

12. In the situation(s) identified in the previous question, why do you suppose others continued to operate? *(check any/all that apply)*

Different aircraft types	2
Different company policies	5
Unaware of risks	5
Other (specify below)	2
Don't know	0

- Negligence
- ignorant of the fact a/c was covered in snow

13. Are you familiar with the following guidance material related to the subject matter of this survey? Links to each publication are provided.

	Yes	No
TP 14052 Guidelines for Aircraft Ground Icing Ops	12	1
TP 10643 - When in Doubt...	12	1
Holdover Time Guidelines	12	1
CBAAC 130	5	8
Airworthiness Notice D008 Edition 1	4	9
NASA Ground and Airborne Icing Resources	9	4

14. Does your Company Operations Manual contain specific information and guidance to pilots when deciding to take-off in the following conditions:

	Yes	No
Freezing Drizzle (FZDZ)	7	5
Light Freezing Rain (-FZRA)	7	5
Moderate Freezing Rain (FZRA)	8	4
Heavy Freezing Rain (+FZRA)	8	4
Ice Pellets (PL)	6	6

15.a Does the company you are employed with recommend any of the following special procedures after de/anti-icing and before take-off during the conditions specified below? *(check any/all that apply or leave blank if none apply)*

	FZDZ	-FZRZ	FZRA	+FZRA	PL
Additional visual inspection prior to taxi	5	5	3	3	3
Additional tactile inspection prior to taxi	4	2	1	1	2
Additional visual inspection prior to take-off	7	6	3	3	5
Additional tactile inspection prior to take-off	1	1	1	1	1
Take-off not authorized in this condition	0	1	6	6	2

15.b As a pilot, do you follow any of the following special procedures after de/anti-icing and before take-off during the conditions specified below? *(check any/all that apply or leave blank if none apply)*

	FZDZ	-FZRZ	FZRA	+FZRA	PL
Additional visual inspection prior to taxi	0	0	0	0	0
Additional tactile inspection prior to taxi	0	0	0	0	0
Additional visual inspection prior to take-off	0	0	0	0	0
Additional tactile inspection prior to take-off	0	0	0	0	0
Do not take-off in this condition	0	0	0	0	0

16.a Does the company you are employed with employ any of the following processes to assess the safety of taking-off in conditions of freezing drizzle, freezing rain or ice pellets? *(check all that apply)*

Safety Management Review	5
Risk Assessment	5
Other (specify below)	1
Don't know	6

- *Advisement of rapid fluid failure with ice pellets.*

16.b Which of the following do you consider while assessing the safety of taking-off in conditions of freezing drizzle, freezing rain or ice pellets? *(check all that apply)*

Aircraft flight into known icing certification status	0
AFM limitations / restrictions	1
Postponing take-off	0
Severity and horizontal/vertical extent of icing conditions	0
Condition of critical aircraft surfaces prior to take-off	0
Take-off performance and control associated with reduced runway friction	0
Effect of possible failure conditions, such as a critical engine failure during the take-off phase	0
Ability to return and land	0
Other (specify below)	1

- *Other: aéroport fermer*

17. Do the manufacturers of the aircraft types you operate provide specific limitations or restrictions with respect to take-off in the following conditions:

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	2	8	3
Light Freezing Rain (-FZRA)	3	7	3
Moderate Freezing Rain (FZRA)	5	5	3
Heavy Freezing Rain (+FZRA)	5	5	3
Ice Pellets (PL)	2	7	4

18. Do the manufacturers of the aircraft types you operate provide specific guidance with respect to take-off in the following conditions:

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	4	8	1
Light Freezing Rain (-FZRA)	4	8	1
Moderate Freezing Rain (FZRA)	4	7	1
Heavy Freezing Rain (+FZRA)	4	7	1
Ice Pellets (PL)	2	9	1

19.a Does your training include information on conducting take-offs under the following conditions?

	Yes	No	Don't remember
Freezing Drizzle (FZDZ)	4	6	2
Light Freezing Rain (-FZRA)	4	6	2
Moderate Freezing Rain (FZRA)	5	6	1
Heavy Freezing Rain (+FZRA)	5	6	1
Ice Pellets (PL)	3	7	2

19.b Did your pilot training include information on conducting take-offs under the following conditions?

	Yes	No	Don't remember
Freezing Drizzle (FZDZ)	1	0	0
Light Freezing Rain (-FZRA)	0	1	0
Moderate Freezing Rain (FZRA)	0	1	0
Heavy Freezing Rain (+FZRA)	0	1	0
Ice Pellets (PL)	0	1	0

20.a Do you have access to a flight planning department?

Yes	8
No	4

20.b Which of the following do you use for flight planning purposes? *(check all that apply)*

Flight planning department	1
Dispatch service	0
NAV CANADA	0
Self	1
Other (specify below)	0

21. Does the company you are employed with have a mentoring process or some other means by which junior pilots can learn how to make safe operational decisions from more senior pilots when operating under freezing drizzle, freezing rain and ice pellet conditions?

Yes	6
No	6

- Always a two pilot operation, so I suppose the lesser experienced first officers would gain experience by flying with more experienced Captains.
- There is no established and official mentoring program within the flight department.
- Due to many reasons, the company has a very high employee turn over rate, thus making this non-existent.
- We operate a small 703 operation (~10 pilots). There is no formal mentoring program. F/Os who have gained some right seat experience are encouraged by captains to make the decisions (though captains retain final authority). New captains are also supported by more experienced captains. Phone calls and discussions between junior and senior captains are welcomed and encouraged in times of adverse weather and other challenging decisions.

22. Do you have immediate access to an operations manager or chief pilot for guidance when operating in freezing drizzle, freezing rain and ice pellet conditions?

Yes	9
No	3

- The chief pilot/ops manager is often flying too. But if they are on the ground, they will answer questions and provide support. Other captains will also support each other.

23. What type of aircraft do you principally operate?

Category:

Fixed Wing	17
Rotary Wing	0
Both	1

Class:

Single Engine	2
Multi Engine	12
Both	4

Power Plant Type:

Reciprocating/Piston	1
Turbine/Turbo-prop	15
Both	2

24. Please list the aircraft types you operate:

- B767 / B757
- C-560, C-550(SII), SA-227-AC
- CL-65
- Beech C90A
- DA-900
- B757
- Cessna L-19 Cessna 152 Cessna 170 King Air Airbus A-320 Airbus A-340
- Challenger 300
- Boeing 767-200 and -300
- B757, A320
- DHC-6
- P28A C182
- B90, 100, 200.- PA31,34,44 - C550, C172.... DV20
- PC12
- Beechcraft C90A

25. GENERAL COMMENTS:

Please provide any comments you feel would enhance safety in this area. Alternatively, you may provide additional information on operations in this area not addressed by the questions in this survey, or expand on any answers you provided.

- It would be very helpful if ALL airports updated there ramp, taxiway and runway conditions MUCH more frequently. I have also noticed that AUTO weather stations cannot be relied on. These stations seem to have difficulty telling the difference between Rain, Freezing and Ice Pallets.
- Company FOM provides guidance and some restrictions regarding flight and ground operations in icing conditions. However, it is always up to the Captain to determine if his aircraft can depart or not in conditions that are not restricted. Still a very subjective determination with regard to rate and intensity of precipitation as well as runway contamination. HOT tables are good however there is still some confusion with regard to minimum and maximum hold over times published. The clock cannot be stopped once the aircraft is deiced however the precipitation can stop. If the precipitation has stopped shortly after deicing has been completed and you do not get airborne prior to your maximum HOT time there is some discussion whether or not a PCI is all that is required, or if the aircraft must return for another spray. Common sense would dictate a PCI is all that is required, however common sense seems to be something that is being removed from things relating to icing. Ultimately the pilot should have the ability to determine if his aircraft needs to go back or not regardless of the upper number. It is my opinion that only the minimum HOT time is required and after that time has been exceeded then it is up to the pilot. The maximum time is of limited value particularly since precipitation rates and intensities can vary dramatically in only a very few minutes.
- This is ICING in its worst form.
- In our company, there is no official guidance (in the Ops Manual). But unofficial policy for any freezing precip is 'Don't Go - Wait it Out'. All captains currently agree on this unwritten policy and we are able to maintain a consistent record. Management, for their part, has never pressured captains to fly in such conditions and supports the captains' decisions. That being said, it would be nice to see more guidance material published on this issue for flight crews.

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APPENDIX D

PROPOSED CHANGES TO SAE ARP5485, SAE ARP5718, AND SAE ARP4737

EXCERPTS OF PROPOSED CHANGES TO SAE ARP5485

3.3.1 Manufacturer's Authorization to Proceed:

After reviewing the reports sent by the designated testing agent, the fluid manufacturer (if desirous of proceeding with endurance tests) shall send to the designated testing agent authorization to proceed. For Type III fluids, the fluid manufacturer shall advise the testing agent whether the fluid is to be tested heated, unheated, or both, reflecting the intended method of fluid use.

4.7.4 Report:

The report shall include:

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

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

c. Date(s) tests conducted;

d. Manufacturer or vendor's name and address;

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

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

g. Quantity of fluid applied to test surfaces;

h. Temperature of the applied fluid;

i. Summary of test results and the icing intensity results for each test;

j. Icing intensity measurement method including ice-catch raw data;

k. Method of estimation of failure area;

l. Description of appearance of frozen contamination. For natural snow report the form of the snow according to Figure 9;

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

n. Distance from test plates and location of air temperature sensor; and

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

6.1.1 Environmental Chamber Equipment and Plates:

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

Table 2: Requirements for Freezing Fog Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Minimum volume	7 m³ for each 300 x 500 mm test plate
Air temperature range	0 °C to at least –25 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 0.4 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10.0° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Temperature at start of test	Within 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid	
For Type II, IV and unheated Type III fluid test:	
Fluid application temperature	Within 3 °C of the air temperature
Fluid quantity	500 mL
For heated Type III fluid test:	
Fluid application temperature	20 °C ± 5
Fluid quantity	1.0 L
Ice-catch Plates	
Ice-catch plates	100 x 100 x 1.6 mm thick
Number of reference ice-catch plates	8 surrounding each test plate
Number of ice-catch plates for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Water supply temperature	≤ 2 °C measured just before the nozzle
Water droplet median volume diameter	22 μm ± 5

6.4.3 Failure Time:

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

8.1.1 Environmental Chamber Equipment and Plates:

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

Table 4: Requirements for Freezing Drizzle Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Air temperature range	0 °C to -10 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra = ≤ 0.5 μm
Temperature at start of test	Within ± 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid	
For Type II, IV and unheated Type III fluid test:	
Fluid application temperature	Within 3 °C of the air temperature
Fluid quantity	500 mL
For heated Type III fluid test:	
Fluid application temperature	20 °C ± 5
Fluid quantity	1.0 L
† Ice-catch Pans	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of reference ice-catch pans	8 surrounding each test plate
Number of ice-catch pans for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle
Water droplet median volume diameter	300 μm ± 100

9.1.1 Environmental Chamber Equipment and Plates:

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

Table 6: Requirements for Light Freezing Rain Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Air temperature range	0 °C to -10 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Temperature at start of test	Within ± 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid	
For Type II, IV and unheated Type III fluid test:	
Fluid application temperature	Within 3 °C of the air temperature
Fluid quantity	500 mL
For heated Type III fluid test:	
Fluid application temperature	20 °C ± 5
Fluid quantity	1.0 L
† Ice-catch Pans	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of ice-catch pans	8 surrounding each test plate
Number of ice-catch pans for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle
Water droplet median volume diameter	1000 μm ± 100

9.3 Light Freezing Rain Test Conditions:

Test conditions for light freezing rain are in Table 7.

Table 7: Light Freezing Rain Test Conditions

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

10.1.1 Environmental Chamber Equipment and Plates:

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

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

Test Parameters	Requirements
Environmental Chamber	
Air temperature range	1 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Number of test plates	2 per fluid tested
Fluid	
For Type II, IV and unheated Type III fluid test:	
Fluid application temperature	Within 3 °C of the air temperature
Fluid quantity	500 mL
For heated Type III fluid test:	
Fluid application temperature	20 °C ± 5
Fluid quantity	1.0 L
† Ice-catch Pans	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of reference ice-catch pans	8 surrounding each test plate
Cold Soak Box	
Material	Aluminum alloy AMS 4037 or 4041
Material Thickness	1.6 mm
Dimensions	430 mm x 300 mm x 75 mm
Coolant in box	65 % propylene glycol, 35 % water
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle

10.3 Rain on Cold Soaked Wing Test Conditions:

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

Table 9: Rain on Cold Soaked Wing Test Condition

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

11.1.1 Conditions and Equipment

Test equipment and other requirements for natural snow endurance time testing are given in Table 10 and in the following paragraphs. Tests on heated Type III fluid will be conducted on the cold soak box test surface, as described in Figure 5.

Table 10: Requirements for Snow Outside Test Equipment

Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plates dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10.0° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 1.0 μm
Plate temperature at start of test	Within ± 0.5 °C of air temperature
Number of tests	
Fluid application temperature	
Cold Soak Box (for heated Type III fluid test)	
Material	Aluminum alloy AMS 4037 or 4041
Material Thickness	1.6 mm
Dimensions	430 mm x 300 mm x 75 mm
Coolant in box	65 % propylene glycol, 35 % water
Fluid	
For Type II, IV and unheated Type III fluid test:	
Fluid application temperature	Within ± 1°C of the air temperature
Fluid quantity	1.0 L
For heated Type III fluid test:	
Fluid application temperature	60°C (+2°C and -0°C)
Fluid quantity	0.5 L
Ice Catch Pans	
Ice-catch pan dimensions	Typically, 430 x 300 x 0.8 mm thick with all around rim 40 mm high and 35 mm flanges protruding from the shorter side.

11.4.2 Fluid Application for Type II, IV and unheated Type III fluid tests

Anti-icing fluids should be placed outside, stored according to manufacturer's recommendations, and cold-soaked to ambient air temperature conditions prior to the start of the test session. Anti-icing fluid temperature shall typically be within ± 1°C of the ambient air temperature and applied to the test surface at this temperature.

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

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

11.4.3 Fluid Application for Heated Type III fluid tests

Tests on heated Type III fluid in natural snow will be conducted on the cold soak box test surface, as described in Figure 5. Treat the test surface according to the procedure outlined below;

- Clean all contamination from the test surface and wet the surface with a small amount of test fluid at ambient temperature prior to applying test fluid;
- Apply 0.5 L of test fluid heated to 60ºC (+2ºC and -0ºC) using a fluid spreader; and
- Position the spreader horizontally at the top end of the test plate, supported at a fixed distance above the plate surface by wood forms at each end. The spreader is constructed from a length of PVC pipe, 30 cm long and with a 15 cm diameter. The upper side of the pipe has a large opening, which allows fluid to be poured quickly into the pipe. The underside of the pipe has 12 drain holes, 4.8 mm (3/16 in.) diameter, at equal intervals along the length.

Prior to the application of fluid, the test surface temperature should be at equilibrium with the outside air temperature. The actual temperature may be different than the outside air temperature due to radiation effects, possibly as much as 2 °C.

EXCERPTS OF PROPOSED CHANGES TO SAE ARP5718

5.1 Holdover Time Table Format

Holdover time tables for Type II, III and IV anti-icing fluids have 7 columns representing categories of freezing or frozen precipitation:

1) Active frost
2) Freezing fog
3) Snow or snow grains
4) Freezing drizzle
5) Light freezing rain
6) Rain on cold soaked wing
7) Other

Because endurance times for heated Type III fluid may differ from that for unheated fluid, separate Type III holdover time tables may be provided for heated and unheated fluid.

5.2 Notes

Notes are added to the holdover time tables, such as:

a) Use light freezing rain holdover time if positive identification of freezing drizzle is not possible;
b) "Other" comprises heavy snow, snow pellets, moderate and heavy freezing rain, and hail;
c) No holdover time exists for freezing drizzle or light freezing rain below OAT of -10ºC (-14ºF);
d) Ensure that the lowest operational temperature (LOUT) is respected; and
e) To use Type III holdover time guidelines for heated fluid, fluid temperature shall be at least 60 °C (140 °F) at the nozzle and at least 1 liter/m^2 (~2 gal/100 ft^2) must be applied to the de-iced surfaces.

5.5 Restrictions

Fluid manufacturers must inform the Chairs of the SAE Holdover Time Subcommittee of the restrictions on use of their fluid, for instance, if the fluid is not to be used diluted or if the fluid cannot be used below a certain temperature.

For Type III fluids, fluid manufacturers must advise the Chairs how the fluid is intended to be used; as a heated one-step deicing/anti-icing fluid, as a heated anti-icing fluid or as an unheated anti-icing fluid. Fluid endurance testing will be conducted with heated or unheated fluid, or both, to correspond with the intended use.

5.10.1 New Fluids

A draft holdover time guideline is prepared for every fluid submitted. The fluid manufacturer may request to see the brand-specific holdover time guideline in advance and may decide not to have it published. For type III fluids, draft holdover time guidelines may be prepared separately for heated and unheated fluid, to correspond to the fluid manufacturer's intended use of the fluid.

5.11 Development of Generic Holdover Time Guidelines

The terms *generic* applies to holdover time guidelines comprised of the lowest holdover time performance (worst case) of all qualified fluids separated by AMS 1428 fluid type (II, III, or IV) under all conditions. The combined results of all tests conducted with any qualified anti-icing fluid (including results from both heated and unheated Type III fluid tests, if the fluid is intended for use both ways) are compared on a cell-by-cell basis to determine the lowest holdover time values for each cell of the holdover time table.

EXCERPT OF PROPOSED CHANGES TO SAE ARP4737

3.3.2 Anti-Icing Fluids Are:

- Heated SAE Type I fluid (see previous caution);
- Heated mixtures of water and SAE Type I fluid;
- Concentrates or mixtures of SAE Type II fluid and water;
- Concentrates or mixtures of SAE Type III fluid and water; and
- Concentrates or mixtures of SAE Type IV fluid and water.

NOTE: Temperature of both a. and b. shall be at least 60 °C (140 °F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturer's recommendations.

SAE Type II and IV fluids for anti-icing are normally applied unheated on clean aircraft surfaces but may be applied heated. The same HOT values apply for heated and unheated Type II and IV fluids.

SAE Type III fluids for anti-icing may be applied heated or unheated on clean aircraft surfaces. Different HOT values may apply for heated and unheated Type III fluid.

Table A2

NOTE: 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.

- Fluids must only be used at temperatures above their LOUT

NOTE: For Type III fluid, holdover time guidelines may be different for heated and unheated fluid applications.

NOTE: To use Type III holdover time guidelines for heated fluid, fluid temperature shall be at least 60 °C (140 °F) at the nozzle and at least 1 liter/m^2 (~2 gal/100 ft^2) must be applied to the de-iced surfaces.

CAUTION: 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.
CAUTION: As fluid freezing may occur, 50/50 Type II, III and IV fluid shall not be used as an anti-icing step of a cold soaked wing as indicated by ice or frost on the lower surface of the wing in the area of the fuel tank.

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APPENDIX E

PROCEDURE:
OVERALL PROGRAM OF TESTS AT NRC, MARCH-APRIL 2009

CM2169.001 (08-09)

OVERALL PROGRAM OF TESTS AT NRC, MARCH-APRIL 2009

Winter 2008-09

Prepared for

Transportation Development Centre
Transport Canada

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OVERALL PROGRAM OF TESTS AT NRC, MARCH-APRIL 2009

Winter 2008-09

1. INTRODUCTION

This document was prepared to bring together several projects that require testing at the National Research Council Climactic Engineering Facility (NRC) in Ottawa. Tests will be carried out from March 30 to April 7, 2008.

The primary objective of the test session is to measure the endurance times of new de/anti-icing fluids. During this time, testing for other related 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 these projects.

A tentative test schedule is included in Figure 1.

2. PROJECTS, PROCEDURES AND OBJECTIVES

The objectives and procedures for each project are detailed in this section. Each project has been given a shortened name (shown in brackets following full title) which is used throughout this document.

The test procedures for some projects are given in separate documents; these documents are listed in Section 9.

2.1 Endurance Times of New Fluids (Endurance Times)

The objective of this project is to measure endurance times of new fluids in simulated freezing precipitation.

Four fluids will be tested:

- ABAX F394 (Type IV);
- Clariant Safewing MP III Solo (Type III)
- Kilfrost P2282 (Type IV); and
- Xi'an Cleanwing II (Type II).

The procedure for conducting these 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.

Due to time and financial limitations, the Type III fluid will not be tested in freezing fog at -10°C. Instead, it will be tested in freezing fog at -3 and -14°C and interpolation will be used to ascertain the fluid endurance times in freezing fog at -10°C. All other standard Type III test protocol will be followed; test temperatures in other precipitation types will not be altered. This decision was made previously in conjunction with Transport Canada.

It should be noted that the lowest operational use temperature (LOUT) of the Type III fluid for low rotation speed aircraft may be above -25°C; however, Type III fluids are also certified for use with high rotation speed aircraft, and the LOUT for high rotation speed aircraft is close to -25°C. Therefore, this fluid will be tested in the -25°C conditions.

The test plan for endurance time tests is given in Table 1.

2.2 Endurance Times of Heated Type III Fluid (Heated Type III)

The objective of these tests is to measure endurance times of a Type III fluid (Clariant Safewing MP III Solo) when applied using the standard Type I test protocol. The standard endurance time testing procedure and methodology (see Section 2.1) will be followed. The test protocol for Type I fluids differs from the protocol for Type II/III/IV fluids in that fluids are applied heated to 20°C rather than at ambient air temperature.

Tests will be conducted at the standard endurance time testing temperatures, dilutions, precipitation types and precipitation rates. The test plan is given in Table 2.

2.3 Thickness of New Fluids (Fluid Thickness)

The objective of these tests is to measure thicknesses of new fluids on flat plates. The procedure for these tests is entitled *Experimental Program to Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates* (2) and can be found in Transport Canada Report TP 13991E, Appendix I. The test plan is given in Table 3.

2.4 Endurance Times of Type II/IV Fluid at LOUT vs. -25°C (LOUT vs. -25°C)

The objective of these tests is to determine if there is a significant difference in the endurance times of Type II/IV fluid at -25°C versus at the fluid's lowest operational use temperature (LOUT). Preliminary work was conducted during the winter of 2007-08; the results indicated similar results at -25°C and at the fluid LOUT; however, further work was recommended. The standard endurance time testing procedure and methodology (see Section 2.1) will be followed; a separate procedure for these tests was not compiled. Brix and thickness measurements will be taken every ten minutes during the tests and at time of failure, and plate temperature will be logged. Tests are scheduled to be conducted at a rate of 5 g/dm^2/h; however, the tests may also be conducted at 2 g/dm^2/h, so long as all of the tests are conducted at this rate. The test plan is given in Table 4.

2.5 Effect of Poor Application Methods on Fluid Endurance Times (Poor Application)

The objective of these tests is to investigate the effects of reduced fluid film thickness on endurance times. A series of outdoor tests have been conducted this winter using the procedure *Evaluation of Effect of Poor Application Methods on Fluid Endurance Times* (3). Following the preliminary work completed outdoors, the FAA recommended pursuing further testing indoors at the NRC. A test plan has been compiled using the endurance time fluids being tested (see Section 2.1) and the Type IV fluids used in the outdoor testing. The test plan is given in Table 5.

2.6 Effect of Surface Material on Endurance Times (Composite)

The objective of this project is to investigate the impact non-aluminum test plate material has on fluid endurance time. Comparative testing will be conducted with Type I fluids to evaluate fluid endurance times on a standard plate, white painted aluminium plate, and white painted cross weave carbon fibre test plate (Carbon 05). Previous work was conducted during the winter of 2005-06, however further work was recommended to obtain a comprehensive data set. Details can be found in the separate procedure entitled *Indoor Endurance Time Testing on Non-Aluminum Plates* (4).

These tests will be run concurrently with endurance time tests, but will be conducted on a side stand positioned perpendicular to the holdover time test

stand. The test stand layout for these tests is shown in Figure 3. Brix measurements will be taken at the time of failure; plate temperature logging and thickness measurements are not necessary. The test plan is given in Table 6.

2.7 Endurance Times for Aircraft Hangar Anti-Icing Applications (Hangar)

The objective of this project is to investigate the effect that conducting anti-icing indoors in aircraft hangers (rather than outdoors) has on endurance time. This will be done by conducting tests with different lapse times between end of anti-icing and exposure to precipitation, and comparing the resulting endurance times. Previous work has been conducted in natural snow using the procedure *Evaluation of Endurance Time Values for Indoor (Aircraft Hanger) Anti-Icing Applications* (5). This procedure will also be followed for the indoor tests.

These tests will be run concurrently with endurance time tests, but will be conducted on the side stand positioned perpendicular to the holdover time test stand. Fluid thickness, fluid Brix and plate temperature will be measured on select tests: Tests HG9 to HG12 and HG25 to HG28. These measurements will be taken upon application of fluid, and at 15 minute intervals throughout the tests. The test plan is given in Table 7.

2.8 Adhesion in Mixed Snow and Rain Conditions (Mixed Snow/Rain)

Transport Canada and the FAA currently do not provide guidelines for operations in mixed snow and rain conditions. However, some aircraft operators have implemented protocols for dealing with such conditions. Previous preliminary work was conducted during the winter of 2007-08 which showed slightly longer endurance times for rain mixed with snow as compared to light freezing rain. The purpose of these tests is to identify whether the current guidelines can be expanded to include mixed rain and snow conditions.

The objective of this project is to determine the endurance time of neat Type II and Type IV fluids during mixed precipitation conditions (snow/rain) as compared to light freezing rain, and to determine the level, and severity, of fluid adhesion experienced at the time of fluid failure. The procedure for conducting these tests is given in the document *Experimental Program: Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions Snow and Rain* (6). Brix, thickness, and adherence measurements will be taken every five minutes and at time of failure during the tests, and plate temperature will be logged during the test. The test plan for is given in Table 8.

2.9 Ice Pellet Allowance Time Expansion (Mixed Ice Pellets)

Ice pellet allowance times were issued for neat Type IV fluids within the Transport Canada HOT Guidelines and the Federal Aviation Administration Approved Deicing Program updates for the winter of 2007-08. Allowance times for operations during mixed conditions with ice pellets have been generated based on the results obtained in the Wind Tunnel and with the Falcon 20 aircraft during the winters of 2005-06, 2006-07, and 2007-08. Restrictions for the allowance times were issued based on residual contamination observed on the airfoil, lift characteristics, and limitations of the data collected regarding rotation speeds, test temperatures and fluid types and dilution, and other pertinent parameters. The objective of this project is to conduct a series of preliminary flat plate tests with Type II, Type III, and Type IV fluids to provide support for the ongoing expansion of the current ice pellet guidelines.

The procedure for conducting these tests is given in the document *Experimental Program Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions – Ice Pellets/Freezing Rain* (7). The duration of the tests (target allowance time) has been derived based on previous full scale testing conducted. Brix, thickness, and adherence measurements will be taken every five minutes and at time of failure during the tests, and plate temperature will be logged during the test. The test plan is given in Table 9.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel requirements for each project are as follows:

1. Endurance Times: HOT Team
2. Heated Type III: HOT Team
3. Thickness: SB, VZ
4. LOUT vs. -25°C: HOT Team
5. Poor Application: HOT Team
6. Composite: MR, VZ, Rates Team
7. Hangar: MR, VZ, Rates Team
8. Mixed Snow/Rain: MR, VZ, JD, YOW1, YOW2, SB
9. Mixed Ice Pellets: MR, VZ, JD, YOW1, YOW2, SB

The HOT Team will consist of:

- HOT Manager: JD
- Rate Manager: SB
- Rate Assistant: YOW1

In addition, personnel will be designated responsible for:

- Equipment: MR
- Pre-test Setup: MR
- Data Forms: SB
- HOT Data Management: SB
- Cold-soak Prep: MR, YOW1, YOW2

The individual personnel responsibilities are shown in Table 10.

4. FLUIDS

The required fluids and fluid quantities are shown in Table 11. The freeze point dilution table for Octagon Octaflo is given in Table 12.

5. EQUIPMENT

Table 13 gives a list of the equipment required.

6. DATA FORMS

The data forms required for each project are indicated below.

1. Endurance Times
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Cold-Soak Wing Endurance Time Data Form (Figure 5)
2. Heated Type III
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Cold-Soak Wing Endurance Time Data Form (Figure 5)
3. Thickness
   - Fluid Thickness Data Form (Figure 6)

4. LOUT vs. -25°C:
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Thickness Data Form (Figure 7)
5. Poor Application
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Thickness Data Form (Figure 7)
6. Composite
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Thickness Data Form (Figure 7)
7. Hangar
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Fluid Thickness/Plate Temperature Data Form (Figure 8)
8. Mixed Snow/Rain:
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Thickness Data Form (Figure 7)
   - Adherence of Fluid Failure Data Form (Figure 9)
   - Position of Ice Pellet Dispenser System Data Form (Figure 10)
9. Mixed Ice Pellets:
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Fluid Brix/Thickness Data Form (Figure 7)
   - Adherence of Fluid Failure Data Form (Figure 9)
   - Position of Ice Pellet Dispenser System Data Form (Figure 10)

7. 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.

8. PRE–TEST SET–UP ACTIVITIES

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

1. Mark plates and boxes.
2. Ensure plates and boxes are equipped with operational and verified thermistors.
3. Make more wooden CSW box holders.
4. Make more white plate covers.
5. Determine number of loggers required (loggers are on stands already).
6. Prepare PC for logging plate temperatures.
7. Ensure fluids are prepared in advance (see Table 11).
8. Prepare labels for pour containers (MP).
9. Empty 1 litre containers must be labelled and cleaned for pouring.
10. Check rate pans: check quantity, check for holes, check all pans are properly labelled.
11. Rent cube van.
12. Check laptop (new Dell) works for rate station.
13. Ensure backup computer works for rate station.

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

1. Large Funnels (4)
2. White Cotton Gloves (10)
3. Floor Mats (10)
4. Pump for Waste (1)
5. Ink Cartridge for Printer (1)
6. Clipboards (6)

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. Procedure: Evaluation of Effect of Poor Application Methods on Fluid Endurance Times, Final Version 1.0, December 29, 2008.

4. Experimental Program: Indoor Endurance Time Testing on Non-Aluminum Plates, Version 1.0, March 28, 2006.

5. Procedure: Evaluation of Endurance Time Values for Indoor (Aircraft Hanger) Anti-Icing Applications, Final Version 1.1, March 10, 2009.

6. Experimental Program: Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions – Snow and Rain, Final Version 1.0, March 31, 2008.

7. Experimental Program: Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions – Ice Pellets / Freezing Rain, Final Version 2.0, September 14, 2006.

OVERALL PROGRAM OF TESTS AT NRC, MARCH-APRIL 2009

FIGURE 1: TEST SCHEDULE

	Fri Mar 27	Mon Mar 30	Tues Mar 31	Wed Apr 1	Thurs Apr 2	Fri Apr 3	Mon Apr 6	Tue Apr 7	Wed Apr 8
8:00		ZR, -10, 13 Composite Hangar Poor App.	Mixed IP @ -10°C	ZR, -3, 25 Composite Hangar Poor App. R/SN Tests	ZD, -3, 13 Composite Hangar Poor App.	CSW, 1, 5	ZF,-28.5, 5/2* LOUT Tests	ZF, -14, 2	
8:30									
9:00	Setup								Packup Drive to YUL Unpack
9:30							Warm to -25°C		
10:00							ZF, -25, 5 LOUT Tests (if-28.5 tests @ 5)	Warm to -3°C	
10:30									
11:00									
11:30		ZR, -10, 25 Composite Hangar Poor App.		Warm to +1°C	ZD, -3, 5 Composite Hangar Poor App.	CSW, 1, 75			
12:00									
12:30			Cool to -5°C	R/SN, +1,12+13		Cool to -3°C Setup Fog	ZF, -25, 2 LOUT Tests (if-28.5 tests @ 2)	ZF, -3, 5	
13:00									
13:30									
14:00									
14:30		ZD, -10, 13 Composite Hangar Poor App.	Mixed IP @ -5°C			ZF, -3, 2 Thickness			
15:00									
15:30							Warm to -14°C		
16:00									
16:30									
17:00					ZR, -3, 13 Composite Hangar Poor App.		ZF, -14, 5		
17:30		ZD, -10, 5 Composite Hangar Poor App.							
18:00									
18:30									
19:00									
19:30									

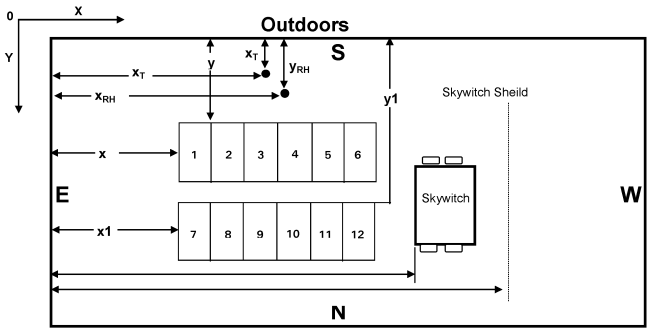
Personnel Requirements									
JD	maybe	yes	yes	yes	yes	yes	yes	yes	-
SB	-	yes	yes	yes	yes	yes	yes	yes	yes
YOW1	yes	rates	IP/SN	rates + IP/SN**	rates	CSW	rates	rates	yes
MR	yes	yes	yes	yes	yes	CSW	-	-	-
VZ	yes	yes	yes	yes	yes	rates	-	-	-
YOW2	yes	IP/SN	IP/SN	IP/SN	yes	CSW	misc	misc	yes

*Preferable to run these tests at rate of 5, but can also be done at 2
**YOW1 will run rates during first condition and do IP/Snow in second condition
*** VZ will run rates during CSW and may run thickness tests in ZF

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).

FIGURE 3: LAYOUT FOR HANGAR TESTS

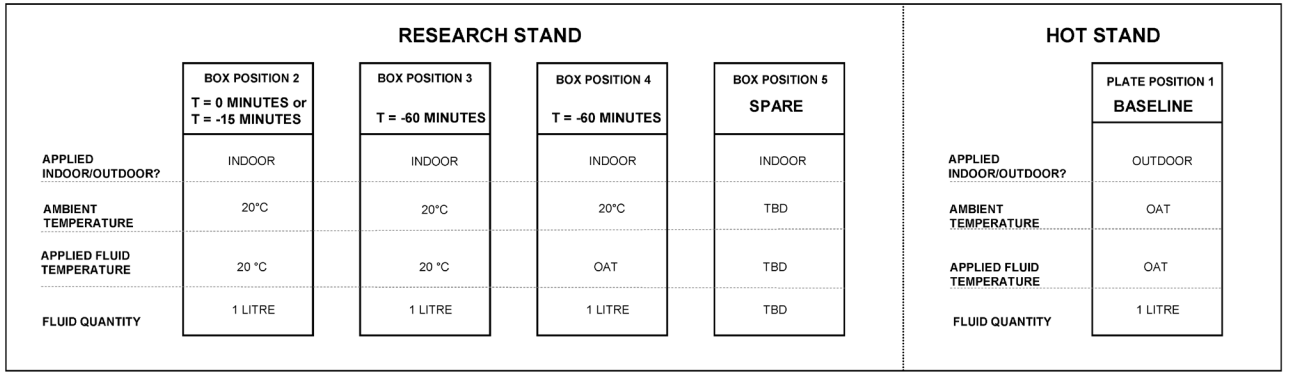


TABLE 1: ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Dilution (%)	Test Surface	Comments
1	Freezing Fog	-3	2	ABAX F394	100	Plate	
2	Freezing Fog	-3	2	ABAX F394	100	Plate	
3	Freezing Fog	-3	2	Kilfrost P2282	100	Plate	
4	Freezing Fog	-3	2	Kilfrost P2282	100	Plate	
5	Freezing Fog	-3	2	Xi'an Cleanwing II	100	Plate	
6	Freezing Fog	-3	2	Xi'an Cleanwing II	100	Plate	
7	Freezing Fog	-3	2	Clariant MP III Solo	100	Plate	
8	Freezing Fog	-3	2	Clariant MP III Solo	100	Plate	
9	Freezing Fog	-3	2	ABAX F394	75	Plate	
10	Freezing Fog	-3	2	ABAX F394	75	Plate	
11	Freezing Fog	-3	2	Kilfrost P2282	75	Plate	
12	Freezing Fog	-3	2	Kilfrost P2282	75	Plate	
13	Freezing Fog	-3	2	Xi'an Cleanwing II	75	Plate	
14	Freezing Fog	-3	2	Xi'an Cleanwing II	75	Plate	
15	Freezing Fog	-3	2	Clariant MP III Solo	75	Plate	
16	Freezing Fog	-3	2	Clariant MP III Solo	75	Plate	
17	Freezing Fog	-3	2	ABAX F394	50	Plate	
18	Freezing Fog	-3	2	ABAX F394	50	Plate	
19	Freezing Fog	-3	2	Kilfrost P2282	50	Plate	
20	Freezing Fog	-3	2	Kilfrost P2282	50	Plate	
21	Freezing Fog	-3	2	Xi'an Cleanwing II	50	Plate	
22	Freezing Fog	-3	2	Xi'an Cleanwing II	50	Plate	
23	Freezing Fog	-3	2	Clariant MP III Solo	50	Plate	
24	Freezing Fog	-3	2	Clariant MP III Solo	50	Plate	
25	Freezing Fog	-3	5	ABAX F394	100	Plate	
26	Freezing Fog	-3	5	ABAX F394	100	Plate	
27	Freezing Fog	-3	5	Kilfrost P2282	100	Plate	
28	Freezing Fog	-3	5	Kilfrost P2282	100	Plate	
29	Freezing Fog	-3	5	Xi'an Cleanwing II	100	Plate	
30	Freezing Fog	-3	5	Xi'an Cleanwing II	100	Plate	
31	Freezing Fog	-3	5	Clariant MP III Solo	100	Plate	
32	Freezing Fog	-3	5	Clariant MP III Solo	100	Plate	
33	Freezing Fog	-3	5	ABAX F394	75	Plate	
34	Freezing Fog	-3	5	ABAX F394	75	Plate	
35	Freezing Fog	-3	5	Kilfrost P2282	75	Plate	
36	Freezing Fog	-3	5	Kilfrost P2282	75	Plate	
37	Freezing Fog	-3	5	Xi'an Cleanwing II	75	Plate	
38	Freezing Fog	-3	5	Xi'an Cleanwing II	75	Plate	
39	Freezing Fog	-3	5	Clariant MP III Solo	75	Plate	
40	Freezing Fog	-3	5	Clariant MP III Solo	75	Plate	
41	Freezing Fog	-3	5	ABAX F394	50	Plate	
42	Freezing Fog	-3	5	ABAX F394	50	Plate	
43	Freezing Fog	-3	5	Kilfrost P2282	50	Plate	
44	Freezing Fog	-3	5	Kilfrost P2282	50	Plate	
45	Freezing Fog	-3	5	Xi'an Cleanwing II	50	Plate	
46	Freezing Fog	-3	5	Xi'an Cleanwing II	50	Plate	
47	Freezing Fog	-3	5	Clariant MP III Solo	50	Plate	
48	Freezing Fog	-3	5	Clariant MP III Solo	50	Plate	
49	Freezing Fog	-14	2	ABAX F394	100	Plate	
50	Freezing Fog	-14	2	ABAX F394	100	Plate	
51	Freezing Fog	-14	2	Kilfrost P2282	100	Plate	
52	Freezing Fog	-14	2	Kilfrost P2282	100	Plate	
53	Freezing Fog	-14	2	Xi'an Cleanwing II	100	Plate	
54	Freezing Fog	-14	2	Xi'an Cleanwing II	100	Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
55	Freezing Fog	-14	2	Clariant MP III Solo	100	Plate	
56	Freezing Fog	-14	2	Clariant MP III Solo	100	Plate	
57	Freezing Fog	-14	2	ABAX F394	75	Plate	
58	Freezing Fog	-14	2	ABAX F394	75	Plate	
59	Freezing Fog	-14	2	Kilfrost P2282	75	Plate	
60	Freezing Fog	-14	2	Kilfrost P2282	75	Plate	
61	Freezing Fog	-14	2	Xi'an Cleanwing II	75	Plate	
62	Freezing Fog	-14	2	Xi'an Cleanwing II	75	Plate	
63	Freezing Fog	-14	2	Clariant MP III Solo	75	Plate	
64	Freezing Fog	-14	2	Clariant MP III Solo	75	Plate	
65	Freezing Fog	-14	5	ABAX F394	100	Plate	
66	Freezing Fog	-14	5	ABAX F394	100	Plate	
67	Freezing Fog	-14	5	Kilfrost P2282	100	Plate	
68	Freezing Fog	-14	5	Kilfrost P2282	100	Plate	
69	Freezing Fog	-14	5	Xi'an Cleanwing II	100	Plate	
70	Freezing Fog	-14	5	Xi'an Cleanwing II	100	Plate	
71	Freezing Fog	-14	5	Clariant MP III Solo	100	Plate	
72	Freezing Fog	-14	5	Clariant MP III Solo	100	Plate	
73	Freezing Fog	-14	5	ABAX F394	75	Plate	
74	Freezing Fog	-14	5	ABAX F394	75	Plate	
75	Freezing Fog	-14	5	Kilfrost P2282	75	Plate	
76	Freezing Fog	-14	5	Kilfrost P2282	75	Plate	
77	Freezing Fog	-14	5	Xi'an Cleanwing II	75	Plate	
78	Freezing Fog	-14	5	Xi'an Cleanwing II	75	Plate	
79	Freezing Fog	-14	5	Clariant MP III Solo	75	Plate	
80	Freezing Fog	-14	5	Clariant MP III Solo	75	Plate	
81	Freezing Fog	-25	2	ABAX F394	100	Plate	
82	Freezing Fog	-25	2	ABAX F394	100	Plate	
83	Freezing Fog	-25	2	Kilfrost P2282	100	Plate	
84	Freezing Fog	-25	2	Kilfrost P2282	100	Plate	
85	Freezing Fog	-25	2	Xi'an Cleanwing II	100	Plate	
86	Freezing Fog	-25	2	Xi'an Cleanwing II	100	Plate	
87	Freezing Fog	-25	2	Clariant MP III Solo	100	Plate	
88	Freezing Fog	-25	2	Clariant MP III Solo	100	Plate	
89	Freezing Fog	-25	5	ABAX F394	100	Plate	
90	Freezing Fog	-25	5	ABAX F394	100	Plate	
91	Freezing Fog	-25	5	Kilfrost P2282	100	Plate	
92	Freezing Fog	-25	5	Kilfrost P2282	100	Plate	
93	Freezing Fog	-25	5	Xi'an Cleanwing II	100	Plate	
94	Freezing Fog	-25	5	Xi'an Cleanwing II	100	Plate	
95	Freezing Fog	-25	5	Clariant MP III Solo	100	Plate	
96	Freezing Fog	-25	5	Clariant MP III Solo	100	Plate	
97	Light Freezing Rain	-3	13	ABAX F394	100	Plate	
98	Light Freezing Rain	-3	13	ABAX F394	100	Plate	
99	Light Freezing Rain	-3	13	Kilfrost P2282	100	Plate	
100	Light Freezing Rain	-3	13	Kilfrost P2282	100	Plate	
101	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Plate	
102	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Plate	
103	Light Freezing Rain	-3	13	Clariant MP III Solo	100	Plate	
104	Light Freezing Rain	-3	13	Clariant MP III Solo	100	Plate	
105	Light Freezing Rain	-3	13	ABAX F394	75	Plate	
106	Light Freezing Rain	-3	13	ABAX F394	75	Plate	
107	Light Freezing Rain	-3	13	Kilfrost P2282	75	Plate	
108	Light Freezing Rain	-3	13	Kilfrost P2282	75	Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
109	Light Freezing Rain	-3	13	Xi'an Cleanwing II	75	Plate	
110	Light Freezing Rain	-3	13	Xi'an Cleanwing II	75	Plate	
111	Light Freezing Rain	-3	13	Clariant MP III Solo	75	Plate	
112	Light Freezing Rain	-3	13	Clariant MP III Solo	75	Plate	
113	Light Freezing Rain	-3	13	ABAX F394	50	Plate	
114	Light Freezing Rain	-3	13	ABAX F394	50	Plate	
115	Light Freezing Rain	-3	13	Kilfrost P2282	50	Plate	
116	Light Freezing Rain	-3	13	Kilfrost P2282	50	Plate	
117	Light Freezing Rain	-3	13	Xi'an Cleanwing II	50	Plate	
118	Light Freezing Rain	-3	13	Xi'an Cleanwing II	50	Plate	
119	Light Freezing Rain	-3	13	Clariant MP III Solo	50	Plate	
120	Light Freezing Rain	-3	13	Clariant MP III Solo	50	Plate	
121	Light Freezing Rain	-3	25	ABAX F394	100	Plate	
122	Light Freezing Rain	-3	25	ABAX F394	100	Plate	
123	Light Freezing Rain	-3	25	Kilfrost P2282	100	Plate	
124	Light Freezing Rain	-3	25	Kilfrost P2282	100	Plate	
125	Light Freezing Rain	-3	25	Xi'an Cleanwing II	100	Plate	
126	Light Freezing Rain	-3	25	Xi'an Cleanwing II	100	Plate	
127	Light Freezing Rain	-3	25	Clariant MP III Solo	100	Plate	
128	Light Freezing Rain	-3	25	Clariant MP III Solo	100	Plate	
129	Light Freezing Rain	-3	25	ABAX F394	75	Plate	
130	Light Freezing Rain	-3	25	ABAX F394	75	Plate	
131	Light Freezing Rain	-3	25	Kilfrost P2282	75	Plate	
132	Light Freezing Rain	-3	25	Kilfrost P2282	75	Plate	
133	Light Freezing Rain	-3	25	Xi'an Cleanwing II	75	Plate	
134	Light Freezing Rain	-3	25	Xi'an Cleanwing II	75	Plate	
135	Light Freezing Rain	-3	25	Clariant MP III Solo	75	Plate	
136	Light Freezing Rain	-3	25	Clariant MP III Solo	75	Plate	
137	Light Freezing Rain	-3	25	ABAX F394	50	Plate	
138	Light Freezing Rain	-3	25	ABAX F394	50	Plate	
139	Light Freezing Rain	-3	25	Kilfrost P2282	50	Plate	
140	Light Freezing Rain	-3	25	Kilfrost P2282	50	Plate	
141	Light Freezing Rain	-3	25	Xi'an Cleanwing II	50	Plate	
142	Light Freezing Rain	-3	25	Xi'an Cleanwing II	50	Plate	
143	Light Freezing Rain	-3	25	Clariant MP III Solo	50	Plate	
144	Light Freezing Rain	-3	25	Clariant MP III Solo	50	Plate	
145	Light Freezing Rain	-10	13	ABAX F394	100	Plate	
146	Light Freezing Rain	-10	13	ABAX F394	100	Plate	
147	Light Freezing Rain	-10	13	Kilfrost P2282	100	Plate	
148	Light Freezing Rain	-10	13	Kilfrost P2282	100	Plate	
149	Light Freezing Rain	-10	13	Xi'an Cleanwing II	100	Plate	
150	Light Freezing Rain	-10	13	Xi'an Cleanwing II	100	Plate	
151	Light Freezing Rain	-10	13	Clariant MP III Solo	100	Plate	
152	Light Freezing Rain	-10	13	Clariant MP III Solo	100	Plate	
153	Light Freezing Rain	-10	13	ABAX F394	75	Plate	
154	Light Freezing Rain	-10	13	ABAX F394	75	Plate	
155	Light Freezing Rain	-10	13	Kilfrost P2282	75	Plate	
156	Light Freezing Rain	-10	13	Kilfrost P2282	75	Plate	
157	Light Freezing Rain	-10	13	Xi'an Cleanwing II	75	Plate	
158	Light Freezing Rain	-10	13	Xi'an Cleanwing II	75	Plate	
159	Light Freezing Rain	-10	13	Clariant MP III Solo	75	Plate	
160	Light Freezing Rain	-10	13	Clariant MP III Solo	75	Plate	
161	Light Freezing Rain	-10	25	ABAX F394	100	Plate	
162	Light Freezing Rain	-10	25	ABAX F394	100	Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
163	Light Freezing Rain	-10	25	Kilfrost P2282	100	Plate	
164	Light Freezing Rain	-10	25	Kilfrost P2282	100	Plate	
165	Light Freezing Rain	-10	25	Xi'an Cleanwing II	100	Plate	
166	Light Freezing Rain	-10	25	Xi'an Cleanwing II	100	Plate	
167	Light Freezing Rain	-10	25	Clariant MP III Solo	100	Plate	
168	Light Freezing Rain	-10	25	Clariant MP III Solo	100	Plate	
169	Light Freezing Rain	-10	25	ABAX F394	75	Plate	
170	Light Freezing Rain	-10	25	ABAX F394	75	Plate	
171	Light Freezing Rain	-10	25	Kilfrost P2282	75	Plate	
172	Light Freezing Rain	-10	25	Kilfrost P2282	75	Plate	
173	Light Freezing Rain	-10	25	Xi'an Cleanwing II	75	Plate	
174	Light Freezing Rain	-10	25	Xi'an Cleanwing II	75	Plate	
175	Light Freezing Rain	-10	25	Clariant MP III Solo	75	Plate	
176	Light Freezing Rain	-10	25	Clariant MP III Solo	75	Plate	
177	Freezing Drizzle	-3	5	ABAX F394	100	Plate	
178	Freezing Drizzle	-3	5	ABAX F394	100	Plate	
179	Freezing Drizzle	-3	5	Kilfrost P2282	100	Plate	
180	Freezing Drizzle	-3	5	Kilfrost P2282	100	Plate	
181	Freezing Drizzle	-3	5	Xi'an Cleanwing II	100	Plate	
182	Freezing Drizzle	-3	5	Xi'an Cleanwing II	100	Plate	
183	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Plate	
184	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Plate	
185	Freezing Drizzle	-3	5	ABAX F394	75	Plate	
186	Freezing Drizzle	-3	5	ABAX F394	75	Plate	
187	Freezing Drizzle	-3	5	Kilfrost P2282	75	Plate	
188	Freezing Drizzle	-3	5	Kilfrost P2282	75	Plate	
189	Freezing Drizzle	-3	5	Xi'an Cleanwing II	75	Plate	
190	Freezing Drizzle	-3	5	Xi'an Cleanwing II	75	Plate	
191	Freezing Drizzle	-3	5	Clariant MP III Solo	75	Plate	
192	Freezing Drizzle	-3	5	Clariant MP III Solo	75	Plate	
193	Freezing Drizzle	-3	5	ABAX F394	50	Plate	
194	Freezing Drizzle	-3	5	ABAX F394	50	Plate	
195	Freezing Drizzle	-3	5	Kilfrost P2282	50	Plate	
196	Freezing Drizzle	-3	5	Kilfrost P2282	50	Plate	
197	Freezing Drizzle	-3	5	Xi'an Cleanwing II	50	Plate	
198	Freezing Drizzle	-3	5	Xi'an Cleanwing II	50	Plate	
199	Freezing Drizzle	-3	5	Clariant MP III Solo	50	Plate	
200	Freezing Drizzle	-3	5	Clariant MP III Solo	50	Plate	
201	Freezing Drizzle	-3	13	ABAX F394	100	Plate	
202	Freezing Drizzle	-3	13	ABAX F394	100	Plate	
203	Freezing Drizzle	-3	13	Kilfrost P2282	100	Plate	
204	Freezing Drizzle	-3	13	Kilfrost P2282	100	Plate	
205	Freezing Drizzle	-3	13	Xi'an Cleanwing II	100	Plate	
206	Freezing Drizzle	-3	13	Xi'an Cleanwing II	100	Plate	
207	Freezing Drizzle	-3	13	Clariant MP III Solo	100	Plate	
208	Freezing Drizzle	-3	13	Clariant MP III Solo	100	Plate	
209	Freezing Drizzle	-3	13	ABAX F394	75	Plate	
210	Freezing Drizzle	-3	13	ABAX F394	75	Plate	
211	Freezing Drizzle	-3	13	Kilfrost P2282	75	Plate	
212	Freezing Drizzle	-3	13	Kilfrost P2282	75	Plate	
213	Freezing Drizzle	-3	13	Xi'an Cleanwing II	75	Plate	
214	Freezing Drizzle	-3	13	Xi'an Cleanwing II	75	Plate	
215	Freezing Drizzle	-3	13	Clariant MP III Solo	75	Plate	
216	Freezing Drizzle	-3	13	Clariant MP III Solo	75	Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
217	Freezing Drizzle	-3	13	ABAX F394	50	Plate	
218	Freezing Drizzle	-3	13	ABAX F394	50	Plate	
219	Freezing Drizzle	-3	13	Kilfrost P2282	50	Plate	
220	Freezing Drizzle	-3	13	Kilfrost P2282	50	Plate	
221	Freezing Drizzle	-3	13	Xi'an Cleanwing II	50	Plate	
222	Freezing Drizzle	-3	13	Xi'an Cleanwing II	50	Plate	
223	Freezing Drizzle	-3	13	Clariant MP III Solo	50	Plate	
224	Freezing Drizzle	-3	13	Clariant MP III Solo	50	Plate	
225	Freezing Drizzle	-10	5	ABAX F394	100	Plate	
226	Freezing Drizzle	-10	5	ABAX F394	100	Plate	
227	Freezing Drizzle	-10	5	Kilfrost P2282	100	Plate	
228	Freezing Drizzle	-10	5	Kilfrost P2282	100	Plate	
229	Freezing Drizzle	-10	5	Xi'an Cleanwing II	100	Plate	
230	Freezing Drizzle	-10	5	Xi'an Cleanwing II	100	Plate	
231	Freezing Drizzle	-10	5	Clariant MP III Solo	100	Plate	
232	Freezing Drizzle	-10	5	Clariant MP III Solo	100	Plate	
233	Freezing Drizzle	-10	5	ABAX F394	75	Plate	
234	Freezing Drizzle	-10	5	ABAX F394	75	Plate	
235	Freezing Drizzle	-10	5	Kilfrost P2282	75	Plate	
236	Freezing Drizzle	-10	5	Kilfrost P2282	75	Plate	
237	Freezing Drizzle	-10	5	Xi'an Cleanwing II	75	Plate	
238	Freezing Drizzle	-10	5	Xi'an Cleanwing II	75	Plate	
239	Freezing Drizzle	-10	5	Clariant MP III Solo	75	Plate	
240	Freezing Drizzle	-10	5	Clariant MP III Solo	75	Plate	
241	Freezing Drizzle	-10	13	ABAX F394	100	Plate	
242	Freezing Drizzle	-10	13	ABAX F394	100	Plate	
243	Freezing Drizzle	-10	13	Kilfrost P2282	100	Plate	
244	Freezing Drizzle	-10	13	Kilfrost P2282	100	Plate	
245	Freezing Drizzle	-10	13	Xi'an Cleanwing II	100	Plate	
246	Freezing Drizzle	-10	13	Xi'an Cleanwing II	100	Plate	
247	Freezing Drizzle	-10	13	Clariant MP III Solo	100	Plate	
248	Freezing Drizzle	-10	13	Clariant MP III Solo	100	Plate	
249	Freezing Drizzle	-10	13	ABAX F394	75	Plate	
250	Freezing Drizzle	-10	13	ABAX F394	75	Plate	
251	Freezing Drizzle	-10	13	Kilfrost P2282	75	Plate	
252	Freezing Drizzle	-10	13	Kilfrost P2282	75	Plate	
253	Freezing Drizzle	-10	13	Xi'an Cleanwing II	75	Plate	
254	Freezing Drizzle	-10	13	Xi'an Cleanwing II	75	Plate	
255	Freezing Drizzle	-10	13	Clariant MP III Solo	75	Plate	
256	Freezing Drizzle	-10	13	Clariant MP III Solo	75	Plate	
257	Cold Soak Box	1	5	ABAX F394	100	Box	
258	Cold Soak Box	1	5	ABAX F394	100	Box	
259	Cold Soak Box	1	5	Kilfrost P2282	100	Box	
260	Cold Soak Box	1	5	Kilfrost P2282	100	Box	
261	Cold Soak Box	1	5	Xi'an Cleanwing II	100	Box	
262	Cold Soak Box	1	5	Xi'an Cleanwing II	100	Box	
263	Cold Soak Box	1	5	Clariant MP III Solo	100	Box	
264	Cold Soak Box	1	5	Clariant MP III Solo	100	Box	
265	Cold Soak Box	1	5	ABAX F394	75	Box	
266	Cold Soak Box	1	5	ABAX F394	75	Box	
267	Cold Soak Box	1	5	Kilfrost P2282	75	Box	
268	Cold Soak Box	1	5	Kilfrost P2282	75	Box	
269	Cold Soak Box	1	5	Xi'an Cleanwing II	75	Box	
270	Cold Soak Box	1	5	Xi'an Cleanwing II	75	Box	

TABLE 1: ENDURANCE TIME TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
271	Cold Soak Box	1	5	Clariant MP III Solo	75	Box	
272	Cold Soak Box	1	5	Clariant MP III Solo	75	Box	
273	Cold Soak Box	1	75	ABAX F394	100	Box	
274	Cold Soak Box	1	75	ABAX F394	100	Box	
275	Cold Soak Box	1	75	Kilfrost P2282	100	Box	
276	Cold Soak Box	1	75	Kilfrost P2282	100	Box	
277	Cold Soak Box	1	75	Xi'an Cleanwing II	100	Box	
278	Cold Soak Box	1	75	Xi'an Cleanwing II	100	Box	
279	Cold Soak Box	1	75	Clariant MP III Solo	100	Box	
280	Cold Soak Box	1	75	Clariant MP III Solo	100	Box	
281	Cold Soak Box	1	75	ABAX F394	75	Box	
282	Cold Soak Box	1	75	ABAX F394	75	Box	
283	Cold Soak Box	1	75	Kilfrost P2282	75	Box	
284	Cold Soak Box	1	75	Kilfrost P2282	75	Box	
285	Cold Soak Box	1	75	Xi'an Cleanwing II	75	Box	
286	Cold Soak Box	1	75	Xi'an Cleanwing II	75	Box	
287	Cold Soak Box	1	75	Clariant MP III Solo	75	Box	
288	Cold Soak Box	1	75	Clariant MP III Solo	75	Box	

TABLE 2: HEATED TYPE III TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
HT1	Freezing Fog	-25	5	Clariant MP III Solo	100	Plate	
HT2	Freezing Fog	-25	5	Clariant MP III Solo	100	Plate	
HT3	Freezing Fog	-25	2	Clariant MP III Solo	100	Plate	
HT4	Freezing Fog	-25	2	Clariant MP III Solo	100	Plate	
HT5	Freezing Fog	-14	5	Clariant MP III Solo	100	Plate	
HT6	Freezing Fog	-14	5	Clariant MP III Solo	100	Plate	
HT7	Freezing Fog	-14	5	Clariant MP III Solo	75	Plate	
HT8	Freezing Fog	-14	5	Clariant MP III Solo	75	Plate	
HT9	Freezing Fog	-14	2	Clariant MP III Solo	100	Plate	
HT10	Freezing Fog	-14	2	Clariant MP III Solo	100	Plate	
HT11	Freezing Fog	-14	2	Clariant MP III Solo	75	Plate	
HT12	Freezing Fog	-14	2	Clariant MP III Solo	75	Plate	
HT13	Freezing Fog	-3	5	Clariant MP III Solo	100	Plate	
HT14	Freezing Fog	-3	5	Clariant MP III Solo	100	Plate	
HT15	Freezing Fog	-3	5	Clariant MP III Solo	75	Plate	
HT16	Freezing Fog	-3	5	Clariant MP III Solo	75	Plate	
HT17	Freezing Fog	-3	5	Clariant MP III Solo	50	Plate	
HT18	Freezing Fog	-3	5	Clariant MP III Solo	50	Plate	
HT19	Freezing Fog	-3	2	Clariant MP III Solo	100	Plate	
HT20	Freezing Fog	-3	2	Clariant MP III Solo	100	Plate	
HT21	Freezing Fog	-3	2	Clariant MP III Solo	75	Plate	
HT22	Freezing Fog	-3	2	Clariant MP III Solo	75	Plate	
HT23	Freezing Fog	-3	2	Clariant MP III Solo	50	Plate	
HT24	Freezing Fog	-3	2	Clariant MP III Solo	50	Plate	
HT25	Freezing Drizzle	-10	13	Clariant MP III Solo	100	Plate	
HT26	Freezing Drizzle	-10	13	Clariant MP III Solo	100	Plate	
HT27	Freezing Drizzle	-10	13	Clariant MP III Solo	75	Plate	
HT28	Freezing Drizzle	-10	13	Clariant MP III Solo	75	Plate	
HT29	Freezing Drizzle	-10	5	Clariant MP III Solo	100	Plate	
HT30	Freezing Drizzle	-10	5	Clariant MP III Solo	100	Plate	
HT31	Freezing Drizzle	-10	5	Clariant MP III Solo	75	Plate	
HT32	Freezing Drizzle	-10	5	Clariant MP III Solo	75	Plate	
HT33	Freezing Drizzle	-3	13	Clariant MP III Solo	100	Plate	
HT34	Freezing Drizzle	-3	13	Clariant MP III Solo	100	Plate	
HT35	Freezing Drizzle	-3	13	Clariant MP III Solo	75	Plate	
HT36	Freezing Drizzle	-3	13	Clariant MP III Solo	75	Plate	
HT37	Freezing Drizzle	-3	13	Clariant MP III Solo	50	Plate	
HT38	Freezing Drizzle	-3	13	Clariant MP III Solo	50	Plate	
HT39	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Plate	
HT40	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Plate	
HT41	Freezing Drizzle	-3	5	Clariant MP III Solo	75	Plate	
HT42	Freezing Drizzle	-3	5	Clariant MP III Solo	75	Plate	
HT43	Freezing Drizzle	-3	5	Clariant MP III Solo	50	Plate	
HT44	Freezing Drizzle	-3	5	Clariant MP III Solo	50	Plate	
HT45	Light Freezing Rain	-10	25	Clariant MP III Solo	100	Plate	
HT46	Light Freezing Rain	-10	25	Clariant MP III Solo	100	Plate	
HT47	Light Freezing Rain	-10	25	Clariant MP III Solo	75	Plate	
HT48	Light Freezing Rain	-10	25	Clariant MP III Solo	75	Plate	
HT49	Light Freezing Rain	-10	13	Clariant MP III Solo	100	Plate	
HT50	Light Freezing Rain	-10	13	Clariant MP III Solo	100	Plate	
HT51	Light Freezing Rain	-10	13	Clariant MP III Solo	75	Plate	
HT52	Light Freezing Rain	-10	13	Clariant MP III Solo	75	Plate	
HT53	Light Freezing Rain	-3	25	Clariant MP III Solo	100	Plate	
HT54	Light Freezing Rain	-3	25	Clariant MP III Solo	100	Plate	

TABLE 2: HEATED TYPE III TEST PLAN (cont'd)

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid	Dilution (%)	Test Surface	Comments
HT55	Light Freezing Rain	-3	25	Clariant MP III Solo	75	Plate	
HT56	Light Freezing Rain	-3	25	Clariant MP III Solo	75	Plate	
HT57	Light Freezing Rain	-3	25	Clariant MP III Solo	50	Plate	
HT58	Light Freezing Rain	-3	25	Clariant MP III Solo	50	Plate	
HT59	Light Freezing Rain	-3	13	Clariant MP III Solo	100	Plate	
HT60	Light Freezing Rain	-3	13	Clariant MP III Solo	100	Plate	
HT61	Light Freezing Rain	-3	13	Clariant MP III Solo	75	Plate	
HT62	Light Freezing Rain	-3	13	Clariant MP III Solo	75	Plate	
HT63	Light Freezing Rain	-3	13	Clariant MP III Solo	50	Plate	
HT64	Light Freezing Rain	-3	13	Clariant MP III Solo	50	Plate	
HT65	Cold Soak Box	1	75	Clariant MP III Solo	100	Box	
HT66	Cold Soak Box	1	75	Clariant MP III Solo	100	Box	
HT67	Cold Soak Box	1	75	Clariant MP III Solo	75	Box	
HT68	Cold Soak Box	1	75	Clariant MP III Solo	75	Box	
HT69	Cold Soak Box	1	5	Clariant MP III Solo	100	Box	
HT70	Cold Soak Box	1	5	Clariant MP III Solo	100	Box	
HT71	Cold Soak Box	1	5	Clariant MP III Solo	75	Box	
HT72	Cold Soak Box	1	5	Clariant MP III Solo	75	Box	

TABLE 3: FLUID THICKNESS TEST PLAN

Test #	Fluid Manufacturer	Fluid Name	Fluid Dilution	Ambient Air Temperature
TH1	ABAX	F394	100/0	-3°C
TH2	ABAX	F394	100/0	-3°C
TH3	ABAX	F394	75/25	-3°C
TH4	ABAX	F394	75/25	-3°C
TH5	ABAX	F394	50/50	-3°C
TH6	ABAX	F394	50/50	-3°C
TH7	Kilfrost	P2282	100/0	-3°C
TH8	Kilfrost	P2282	100/0	-3°C
TH9	Kilfrost	P2282	75/25	-3°C
TH10	Kilfrost	P2282	75/25	-3°C
TH11	Kilfrost	P2282	50/50	-3°C
TH12	Kilfrost	P2282	50/50	-3°C
TH13	Xi'an	Cleanwing II	100/0	-3°C
TH14	Xi'an	Cleanwing II	100/0	-3°C
TH15	Xi'an	Cleanwing II	75/25	-3°C
TH16	Xi'an	Cleanwing II	75/25	-3°C
TH17	Xi'an	Cleanwing II	50/50	-3°C
TH18	Xi'an	Cleanwing II	50/50	-3°C
TH19	Clariant	Safewing MP III Solo (OAT)	100/0	-3°C
TH20	Clariant	Safewing MP III Solo (OAT)	100/0	-3°C
TH21	Clariant	Safewing MP III Solo (OAT)	75/25	-3°C
TH22	Clariant	Safewing MP III Solo (OAT)	75/25	-3°C
TH23	Clariant	Safewing MP III Solo (OAT)	50/50	-3°C
TH24	Clariant	Safewing MP III Solo (OAT)	50/50	-3°C
TH25	Clariant	Safewing MP III Solo (20°C)	100/0	-3°C
TH26	Clariant	Safewing MP III Solo (20°C)	100/0	-3°C
TH27	Clariant	Safewing MP III Solo (20°C)	75/25	-3°C
TH28	Clariant	Safewing MP III Solo (20°C)	75/25	-3°C
TH29	Clariant	Safewing MP III Solo (20°C)	50/50	-3°C
TH30	Clariant	Safewing MP III Solo (20°C)	50/50	-3°C

Notes:

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

TABLE 4: LOUT VS. -25°C TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate** ($g/dm^2/h$)	Fluid	Dilution	Test Surface	Test Stand	Comments
L1	Freezing Fog	-28.5	5 (2)	Dow Endurance EG106	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L2	Freezing Fog	-28.5	5 (2)	Kilfrost ABC-S+	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L3	Freezing Fog	-28.5	5 (2)	Clariant Launch	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L4	Freezing Fog	-28.5	5 (2)	ABAX F394	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L5	Freezing Fog	-28.5	5 (2)	Kilfrost P2282	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L6	Freezing Fog	-28.5	5 (2)	Xi'an Cleanwing II	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L7	Freezing Fog	-25	5 (2)	Dow Endurance EG106	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L8	Freezing Fog	-25	5 (2)	Kilfrost ABC-S+	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L9	Freezing Fog	-25	5 (2)	Clariant Launch	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L10*	Freezing Fog	-25	5 (2)	ABAX F394	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L11*	Freezing Fog	-25	5 (2)	Kilfrost P2282	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure
L12*	Freezing Fog	-25	5 (2)	Xi'an Cleanwing II	Neat	Plate	Main	Measure Brix/thickness every 10 mins and at failure

* Use HOT test and take measurements

** Preferable to run these tests at rate of 5 but can also be done at rate of 2, as long as all tests are conducted at the same rate

TABLE 5: POOR APPLICATION TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid**	Dilution	Test Surface	Test Stand	Comments
PA1	Freezing Drizzle	-3	5	Type I + Kilfrost P2282	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA2*	Freezing Drizzle	-3	5	Kilfrost P2282	75	Plate	Main	Apply 1 L at OAT
PA3	Freezing Drizzle	-3	5	Type I + Xi'an Cleanwing II	50	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA4*	Freezing Drizzle	-3	5	Xi'an Cleanwing II	50	Plate	Main	Apply 1 L at OAT
PA5	Freezing Drizzle	-3	13	Type I + Clariant Safewing MP III Solo	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA6*	Freezing Drizzle	-3	13	Clariant Safewing MP III Solo	100	Plate	Main	Apply 1 L at OAT
PA7	Freezing Drizzle	-3	13	Type I + Kilfrost P2282	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA8*	Freezing Drizzle	-3	13	Kilfrost P2282	100	Plate	Main	Apply 1 L at OAT
PA9	Freezing Drizzle	-10	5	Type I + Xi'an Cleanwing II	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA10*	Freezing Drizzle	-10	5	Xi'an Cleanwing II	100	Plate	Main	Apply 1 L at OAT
PA11	Freezing Drizzle	-10	5	Type I + ABAX F394	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA12*	Freezing Drizzle	-10	5	ABAX F394	75	Plate	Main	Apply 1 L at OAT
PA13	Freezing Drizzle	-10	13	Type I + ABAX F394	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA14*	Freezing Drizzle	-10	13	ABAX F394	100	Plate	Main	Apply 1 L at OAT
PA15	Freezing Drizzle	-10	13	Type I + Clariant Safewing MP III Solo	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA16*	Freezing Drizzle	-10	13	Clariant Safewing MP III Solo	75	Plate	Main	Apply 1 L at OAT
PA17	Light Freezing Rain	-3	13	Type I + Kilfrost P2282	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/2 L Type II/III/IV @ OAT Conduct with PA18
PA18	Light Freezing Rain	-3	13	Type I + Kilfrost P2282	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT Conduct with PA17
PA19*	Light Freezing Rain	-3	13	Kilfrost P2282	100	Plate	Main	Apply 1 L at OAT
PA20	Light Freezing Rain	-3	13	Type I + Xi'an Cleanwing II	50	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA21*	Light Freezing Rain	-3	13	Xi'an Cleanwing II	50	Plate	Main	Apply 1 L at OAT
PA22	Light Freezing Rain	-3	25	Type I + Clariant Safewing MP III Solo	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT
PA23*	Light Freezing Rain	-3	25	Clariant Safewing MP III Solo	100	Plate	Main	Apply 1 L at OAT

TABLE 5: POOR APPLICATION TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid**	Dilution	Test Surface	Test Stand	Comments
PA24	Light Freezing Rain	-3	25	Type I + ABAX F394	50	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA25*	Light Freezing Rain	-3	25	ABAX F394	50	Plate	Main	Apply 1 L at OAT.
PA26	Light Freezing Rain	-3	25	Type I + Kilfrost ABC-S	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA27	Light Freezing Rain	-3	25	Kilfrost ABC-S	75	Plate	Main	Apply 1 L at OAT.
PA28	Light Freezing Rain	-3	25	Type I + Clariant Safewing MPIV Launch	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA29	Light Freezing Rain	-3	25	Clariant Safewing MPIV Launch	100	Plate	Main	Apply 1 L at OAT.
PA30	Light Freezing Rain	-3	25	Type I + Octagon MaxFlo	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA31	Light Freezing Rain	-3	25	Octagon MaxFlo	100	Plate	Main	Apply 1 L at OAT.
PA32	Light Freezing Rain	-10	13	Type I + ABAX F394	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA33*	Light Freezing Rain	-10	13	ABAX F394	100	Plate	Main	Apply 1 L at OAT.
PA34	Light Freezing Rain	-10	13	Type I + Clariant Safewing MP III Solo	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA35*	Light Freezing Rain	-10	13	Clariant Safewing MP III Solo	75	Plate	Main	Apply 1 L at OAT.
PA36	Light Freezing Rain	-10	25	Type I + Kilfrost P2282	100	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA37*	Light Freezing Rain	-10	25	Kilfrost P2282	100	Plate	Main	Apply 1 L at OAT.
PA38	Light Freezing Rain	-10	25	Type I + Xi'an Cleanwing II	75	Plate	Main	Apply 1 L Type I @ 20°C, wait 3 mins, apply 1/8 L Type II/III/IV @ OAT.
PA39*	Light Freezing Rain	-10	25	Xi'an Cleanwing II	75	Plate	Main	Apply 1 L at OAT.

* Use HOT test and take measurements

** Type I Fluid = Octagon Octaflo mixed to 10° buffer

TABLE 6: COMPOSITE TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Dilution	Test Surface	Test Stand	Comments
C1a	Freezing Drizzle	-3	5	Octagon Octaflo	10° Buff. (Brix = 21.5)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C1b	Freezing Drizzle	-3	5	Octagon Octaflo	10° Buff. (Brix = 21.5)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C1c	Freezing Drizzle	-3	5	Octagon Octaflo	10° Buff. (Brix = 21.5)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C2a	Freezing Drizzle	-3	13	Type I EG	10° Buff. (Brix = 17.6)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C2b	Freezing Drizzle	-3	13	Type I EG	10° Buff. (Brix = 17.6)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C2c	Freezing Drizzle	-3	13	Type I EG	10° Buff. (Brix = 17.6)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C3a	Freezing Drizzle	-10	5	Type I EG	10° Buff. (Brix = 22.9)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C3b	Freezing Drizzle	-10	5	Type I EG	10° Buff. (Brix = 22.9)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C3c	Freezing Drizzle	-10	5	Type I EG	10° Buff. (Brix = 22.9)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C4a	Freezing Drizzle	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C4b	Freezing Drizzle	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C4c	Freezing Drizzle	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C5a	Light Freezing Rain	-3	13	Octagon Octaflo	10° Buff. (Brix = 21.5)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C5b	Light Freezing Rain	-3	13	Octagon Octaflo	10° Buff. (Brix = 21.5)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C5c	Light Freezing Rain	-3	13	Octagon Octaflo	10° Buff. (Brix = 21.5)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C6a	Light Freezing Rain	-3	25	Octagon Octaflo	10° Buff. (Brix = 21.5)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C6b	Light Freezing Rain	-3	25	Octagon Octaflo	10° Buff. (Brix = 21.5)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C6c	Light Freezing Rain	-3	25	Octagon Octaflo	10° Buff. (Brix = 21.5)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C7a	Light Freezing Rain	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C7b	Light Freezing Rain	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C7c	Light Freezing Rain	-10	13	Octagon Octaflo	10° Buff. (Brix = 26.75)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C8a	Light Freezing Rain	-10	25	Octagon Octaflo	10° Buff. (Brix = 26.75)	White Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C8b	Light Freezing Rain	-10	25	Octagon Octaflo	10° Buff. (Brix = 26.75)	Comp 05	Side	Apply 1 L of fluid at 20°C using 12-hole spreader
C8c	Light Freezing Rain	-10	25	Octagon Octaflo	10° Buff. (Brix = 26.75)	Std. Al.	Side	Apply 1 L of fluid at 20°C using 12-hole spreader

Notes:

1. Brix is to be measured at failure.
2. In case of lack of time, consider omitting baseline "c" tests.

TABLE 7: HANGAR TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Dilution	Test Surface**	Test Stand	Comments
HG1*	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Cold Plate	Side	Apply 1 L of fluid at OAT
HG2	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG3	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG4	Freezing Drizzle	-3	5	Clariant MP III Solo	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 15 mins prior to placing under precipitation
HG5*	Freezing Drizzle	-3	13	ABAX F394	100	Cold Plate	Main	Apply 1 L of fluid at OAT
HG6	Freezing Drizzle	-3	13	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG7	Freezing Drizzle	-3	13	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG8	Freezing Drizzle	-3	13	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 0 mins prior to placing under precipitation
HG9*	Freezing Drizzle	-10	5	Dow Endurance EG106	100	Cold Plate	Side	Apply 1 L of fluid at OAT. Measure Brix/thickness/plate temp every 15 mins.
HG10	Freezing Drizzle	-10	5	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG11	Freezing Drizzle	-10	5	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG12	Freezing Drizzle	-10	5	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 0 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG13*	Freezing Drizzle	-10	13	Kilfrost P2282	100	Cold Plate	Main	Apply 1 L of fluid at OAT
HG14	Freezing Drizzle	-10	13	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG15	Freezing Drizzle	-10	13	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG16	Freezing Drizzle	-10	13	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 15 mins prior to placing under precipitation
HG17*	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Cold Plate	Main	Apply 1 L of fluid at OAT
HG18	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG19	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG20	Light Freezing Rain	-3	13	Xi'an Cleanwing II	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 15 mins prior to placing under precipitation

TABLE 7: HANGAR TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Dilution	Test Surface**	Test Stand	Comments
HG21*	Light Freezing Rain	-3	25	Kilfrost P2282	100	Cold Plate	Main	Apply 1 L of fluid at OAT
HG22	Light Freezing Rain	-3	25	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG23	Light Freezing Rain	-3	25	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG24	Light Freezing Rain	-3	25	Kilfrost P2282	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 0 mins prior to placing under precipitation
HG25*	Light Freezing Rain	-10	13	Dow Endurance EG106	100	Cold Plate	Side	Apply 1 L of fluid at OAT. Measure Brix/thickness/plate temp every 15 mins.
HG26	Light Freezing Rain	-10	13	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG27	Light Freezing Rain	-10	13	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG28	Light Freezing Rain	-10	13	Dow Endurance EG106	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 15 mins prior to placing under precipitation. Measure Brix/thickness/plate temp every 15 mins.
HG29*	Light Freezing Rain	-10	25	ABAX F394	100	Cold Plate	Main	Apply 1 L of fluid at OAT
HG30	Light Freezing Rain	-10	25	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 60 mins prior to placing under precipitation
HG31	Light Freezing Rain	-10	25	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at OAT indoors 60 mins prior to placing under precipitation
HG32	Light Freezing Rain	-10	25	ABAX F394	100	Warm Empty Box	Side	Apply 1 L fluid at 20°C indoors 0 mins prior to placing under precipitation

* Use HOT test and take measurements if necessary

** Warm empty boxes should be at approximately 20°C

TABLE 8: ADHERENCE IN MIXED SNOW AND RAIN CONDITIONS TEST PLAN

Test #	Priority	Fluid Type	Fluid Brand	Dilution	Fluid Temp. [°C]	Precip Type	Test Temp. [°C]	Snow Precip Rate [g/dm²/h]	R or ZR Precip Rate [g/dm²/h]	Combined Precip Rate [g/dm²/h]	NRC Condition	LOWV ZR -3 25 HOT [min]	Maesurements	Timing With HOT Tests
RS1, RS1A*	1	IV	Kilfrost ABC-S	Neat	1	SN/R	1	12	13	25	R +1	60	Brix/thickness/adherence every 5 mins and at failure, temperature	Invasive (following HOT)
RS2, RS1A*	1	IV	Clariant Safewing MP IV Launch	Neat	1	SN/R	1	12	13	25	R +1	60	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS3, RS3A*	1	II	SPCA Ecowing 26	Neat	1	SN/R	1	12	13	25	R +1	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS4, RS4A*	1	II	Kilfrost ABC-2000	Neat	1	SN/R	1	12	13	25	R +1	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS5, RS5A*	2	III	Clariant Safewing MP III 2031	Neat	1	SN/R	1	12	13	25	R +1	8	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS6, RS6A*	2	IV	Lyondell Arctic Shield	50/50	1	SN/R	1	12	13	25	R +1	10	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS7	1	IV	Kilfrost ABC-S	Neat	-3	ZR	-3	-	25	25	ZR -3	60	Brix/thickness/adherence every 5 mins and at failure, temperature	in Conjunction
RS8	1	IV	Clariant Safewing MP IV Launch	Neat	-3	ZR	-3	-	25	25	ZR -3	60	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS9	1	II	SPCA Ecowing 26	Neat	-3	ZR	-3	-	25	25	ZR -3	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS10	1	II	Kilfrost ABC-2000	Neat	-3	ZR	-3	-	25	25	ZR -3	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS11	2	III	Clariant Safewing MP III 2031	Neat	-3	ZR	-3	-	25	25	ZR -3	8	Brix/thickness/adherence every 5 mins and at failure, temperature	
RS12	2	IV	Lyondell Arctic Shield	50/50	-3	ZR	-3	-	25	25	ZR -3	10	Brix/thickness/adherence every 5 mins and at failure, temperature	

* If time permits, duplicates of each test should be conducted simultaneously. Duplcate tests will be labled "Test #" A. i.e.RS1A

NOTE: Water temperature is increased by opening the drain and closing the back pressure. Cooling systems use MA5 and MA6.

TABLE 9: ICE PELLET ALLOWANCE TIME EXPANSION TEST PLAN

Test # *	Priority	Fluid Type	Fluid Brand	Dilution	Precip Type	Test Temp. [°C]	Fluid Temp. [°C]	ZR + IP Precip Rate [g/dm²/h] **	NRC Condition	Target Allowance Time [min] ***	LOWV HOT ZR25 @ -3 and -10 [min]	Maesurements	Timing With HOT Tests
IP1, IP1A*	1	IV	Kilfrost ABC-S	Neat	ZR/IP	-5	-5	25 + 25	ZR -5 25	25+5	60	Brix/thickness/adherence every 5 mins and at failure, temperature	Invasive (following HOT)
IP2, IP2A*	1	IV	Clariant Safewing MP IV Launch	Neat	ZR/IP	-5	-5	25 + 25	ZR -5 25	25+5	60	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP3, IP4A*	1	II	SPCA Ecowing 26	Neat	ZR/IP	-5	-5	25 + 25	ZR -5 25	20+5	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP4, IP4A*	1	II	Kilfrost ABC-2000	Neat	ZR/IP	-5	-5	25 + 25	ZR -5 25	20+5	40	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP5, IP5A*	2	III	Clariant Safewing MP III 2031	Neat	ZR/IP	-5	-5	25 + 25	ZR -5 25	10+5	8	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP6, IP6A*	2	III	Clariant Safewing MP III 2031 (Heated)	Neat	ZR/IP	-5	1L @ 20	25 + 25	ZR -5 25	10+5	8	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP7, IP7A*	1	IV	Kilfrost ABC-S	Neat	ZR/IP	-10	-10	25 + 25	ZR -5 25	10+5	10	Brix/thickness/adherence every 5 mins and at failure, temperature	Invasive (following HOT)
IP8, IP8A*	1	IV	Clariant Safewing MP IV Launch	Neat	ZR/IP	-10	-10	25 + 25	ZR -5 25	10+5	25	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP9, IP9A*	1	II	SPCA Ecowing 26	Neat	ZR/IP	-10	-10	25 + 25	ZR -5 25	10+5	15	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP10, IP10A*	1	II	Kilfrost ABC-2000	Neat	ZR/IP	-10	-10	25 + 25	ZR -5 25	10+5	10	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP11, IP11A*	2	III	Clariant Safewing MP III 2031	Neat	ZR/IP	-10	-10	25 + 25	ZR -5 25	5+5	8	Brix/thickness/adherence every 5 mins and at failure, temperature	
IP12, IP12A*	2	III	Clariant Safewing MP III 2031 (Heated)	Neat	ZR/IP	-10	1L @ 20	25 + 25	ZR -5 25	5+5	8	Brix/thickness/adherence every 5 mins and at failure, temperature	

* If time permits, duplicates of each test should be conducted simultaneously. Duplcate tests will be labled "Test #" A. i.e.IP1A

** If target allowance times are not achieved, consider repeating tests with rates of ZR 13 + IP 12

*** Tests should be run at least 5 minutes longer than target allowance time

TABLE 10: PERSONNEL REQUIREMENTS

PERSONNEL	PROJECT								
	Endurance Times		Thickness	LOUT vs. -25°C	Poor Application	Composite	Hangar	Mixed Rain/Snow	Mixed IP
	ZF, ZD, ZR	CSW							
JD	Mgr	Mgr	-	Mgr	Mgr	-	-	Ast	Ast
SB	Rate Mgr	Rate Mgr	Mgr	Rate Mgr	Rate Mgr	Rate Mgr	Rate Mgr	Rates	Rates
YOW1	Rate Ast	Box Prep	-	Rate Ast	Rate Ast	Rate Ast	Rate Ast	IP/Snow	IP/Snow
MR	-	Box Mgr	-	-	-	Mgr	Mgr	Mgr	Mgr
VZ	-	Rate Ast	Ast	-	-	Ast	Ast	IP Mgr	IP Mgr
YOW2	Misc	Box Prep	-	Brix/Thick	-	-	-	IP/Snow	IP/Snow

TABLE 11: LIST OF FLUIDS

Fluid Name	Batch #	Fluid Type	Dilution (%)	Litres Required									
				ETs	Heated Type III	Thick.	LOUT	Poor App.	Comp.	Hangar	Mixed Rain/ Snow	Mixed IP	Total
ABAX F394	L8-302	IV	100	32	-	2	1	2	-	6	-	-	**43**
ABAX F394	L8-302	IV	75	28	-	2	-	1	-	-	-	-	**31**
ABAX F394	L8-302	IV	50	12	-	2	-	1	-	-	-	-	**15**
Kilfrost P2282	K02162009IV	II	100	32	-	2	1	4	-	6	-	-	**45**
Kilfrost P2282	K02162009IV	II	75	28	-	2	-	1	-	-	-	-	**31**
Kilfrost P2282	K02162009IV	II	50	12	-	2	-	-	-	-	-	-	**14**
Xi'an Cleanwing II	X04022009II	II	100	32	-	2	1	1	-	3	-	-	**39**
Xi'an Cleanwing II	X04022009II	II	75	28	-	2	-	1	-	-	-	-	**31**
Xi'an Cleanwing II	X04022009II	II	50	12	-	2	-	2	-	-	-	-	**16**
Clariant MP III Solo	TV475	III	100	32	32	-	-	2	-	4	-	-	**70**
Clariant MP III Solo	TV475	III	75	28	28	-	-	2	-	-	-	-	**58**
Clariant MP III Solo	TV475	III	50	12	12	-	-	-	-	-	-	-	**24**
Clariant Launch	TV428	IV	100	-	-	-	-	2	-	-	4	4	**10**
Clariant Launch	C02192009IV	IV	100	-	-	-	2	-	-	-	-	-	**2**
Clariant MP III 2031	TV473	III	100	-	-	-	-	-	-	-	4	8	**12**
Dow Endurance EG106	VK0601GKDR	IV	100	-	-	-	2	-	-	8	-	-	**10**
Kilfrost ABC 2000	KIL08-09LOWV	II	100	-	-	-	-	-	-	-	4	4	**8**
Kilfrost ABC-S+	K01212009IV	IV	100	-	-	-	2	-	-	-	-	-	**2**
Kilfrost ABC-S	KIL08-09LOWV	IV	100	-	-	-	-	-	-	-	4	4	**8**
Kilfrost ABC-S	KIL08-09LOWV	IV	75	-	-	-	-	2	-	-	-	-	**2**
Lyondell Arctic Shield	1132330	IV	100	-	-	-	-	-	-	-	4	-	**4**
Octagon Maxflo	4126026	IV	100	-	-	-	-	2	-	-	-	-	**2**
SPCA Ecowing 26	L-8-343	II	100	-	-	-	-	-	-	-	4	4	**8**
Octagon Octaflo (FFP=-13)	unknown	I	B=21.5	-	-	-	-	12	9	-	-	-	**21**
Octagon Octaflo (FFP=-20)	unknown	I	B=26.75	-	-	-	-	8	9	-	-	-	**17**
Type I EG (FFP=-13)	unknown	I	B=17.6	-	-	-	-	-	3	-	-	-	**3**
Type I EG (FFP=-20)	unknown	I	B=22.9	-	-	-	-	-	3	-	-	-	**3**
				288	**72**	**18**	**9**	**43**	**24**	**27**	**24**	**24**	**529**

TABLE 12: OCTAGON OCTAFLO DILUTION TABLE

Dilution (Fluid/Water)	Refractive Index	Brix	Freezing Point
100/0	1.425	52.25	??
65/35	1.398	39.00	-54°C
60/40	1.394	37.00	-40°C
56/44	not available	34.25	-35°C
55/45	1.389	34.25	-34°C
50/50	1.384	31.50	-28°C
45/55	1.378	28.50	-22°C
42/58	not available	26.75	-20°C
40/60	1.374	26.00	-19°C
35/65	1.369	23.00	-15°C
32/68	not available	21.50	-13°C
30/70	1.364	20.00	-11°C
28/72	not available	18.50	-9°C
25/75	1.358	16.50	- 8°C
20/80	1.352	12.75	- 6°C
10/90	1.343	6.75	- 4°C

TABLE 13: EQUIPMENT LIST

EQUIPMENT	LOCATION
1L Pour containers (8 filled/fluid-dil)	Site
Adherence probes	Site + Office
Boards for cold-soak test x 13	Site
Brixometer x 2 + Palm	Site + Office
Buckets for mixing cold-soak fluid*	Site
Close circuit TV camera for rates	Site
Cold-soak boxes 7.5 cm x 14 (Polybrand)	Site
Cold-soak box filling stand	Site
Collection pans for stands (2x6, 1x3, 2x2, 2x1)	Site
Electrical Extension Cords - Many	Site
Fluids (see Table 10)	Site
Funnels (Site + purchase x4)	Site + Purchase
Marker for Waste x 3	Site
Inclinometer (yellow level) x 1	Site
Isopropyl x 10	Site
Laptop Computers x 2 (new Dell & JD's old)	Site
Large digital clock x 2	Site
Microwave	Site
Paper Towels (lots)	Site
Plate covers x 14	Site
Plates: 12 w/logging +8 w/o logging	Site
Plate: White painted aluminum	Site
Plate: Carbon cross weave carbon fibre	Site
Precipitation Rate Pans x 100	Site
Protective clothing x 6	Site
Rubber squeegees x 6	Site
Scrapers x 3	Site
Shop Vac	Site
Shelving unit x 1	Site
Spreaders: 12-hole x 2	Site
Still Digital Camera Rebel (suitcase)	Site
Storage bins for small equipment	Site
Temperature probes: surface x 2	Site
Temperature probes: immersion x 2	Site
Tape measure	Site
Test Stands: 2 x 6-position	Site
Test Stands: 1 x 3-position	Site
Test Stands: 2 x 2-position	Site
Test Stands: 2 x 1-position	Site
Thermistor Kit + Logger 12 pos.	Site

EQUIPMENT	LOCATION
Thermos x 4	Site
Thickness Gauges x 4 (both types)	Site
Walkie Talkies x 4	Site
Waste containers x MANY (10-15)	Site
Weigh Scale x 2 (sartorius) + wiring	Site
White Billboard for water run-off	Site
Yellow Carrying Cases for Pour Containers x 2	Site
Yellow Ice Pic	Site
Clipboards x 6	Purchase
Ink cartridge for printer	Purchase
Cotton gloves	Purchase
Pump (for waste)	Purchase
Accordian Folder	Office
ARP 5485 and ARP 5945	Office
Data Forms (SB)	Office
Envelopes (9x12) x box	Office
HOT Report + HOT Tables	Office
NRC Flow Settings (SB)	Office
Paper for printer (1 pack)	Office
Pencils + pens + markers	Office
Precipitation Rate Data Forms (SB)	Office
Printer	Office
Test Procedures x 2 (1 sided)	Office
Trend Reader Express Software	Office
Fluid for cold-soak boxes (barrel)	NRC
Cold-soak fluid pump	NRC
Rubber Mats	NRC + Purchase

Ice Pellets Fabrication Equipment	LOCATION
Blenders (x 6)	Site
Folding tables	Site
Ice pellets dispensing devices x6, stands, adapter*	Site
Ice pellets sieves (round and square)	Site
Measuring cups + wooden spoons	Site
Styrofoam containers x 20	Site
Weigh scale (NCAR)	Site
Ice bags + freezer (Lake Ontario Ice)	NRC

*Use transport containers
**Fix adapters

FIGURE 4: FREEZING PRECIPITATION ENDURANCE TIME DATA FORM

REMEMBER TO SYNCHRONIZE TIME

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

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

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

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

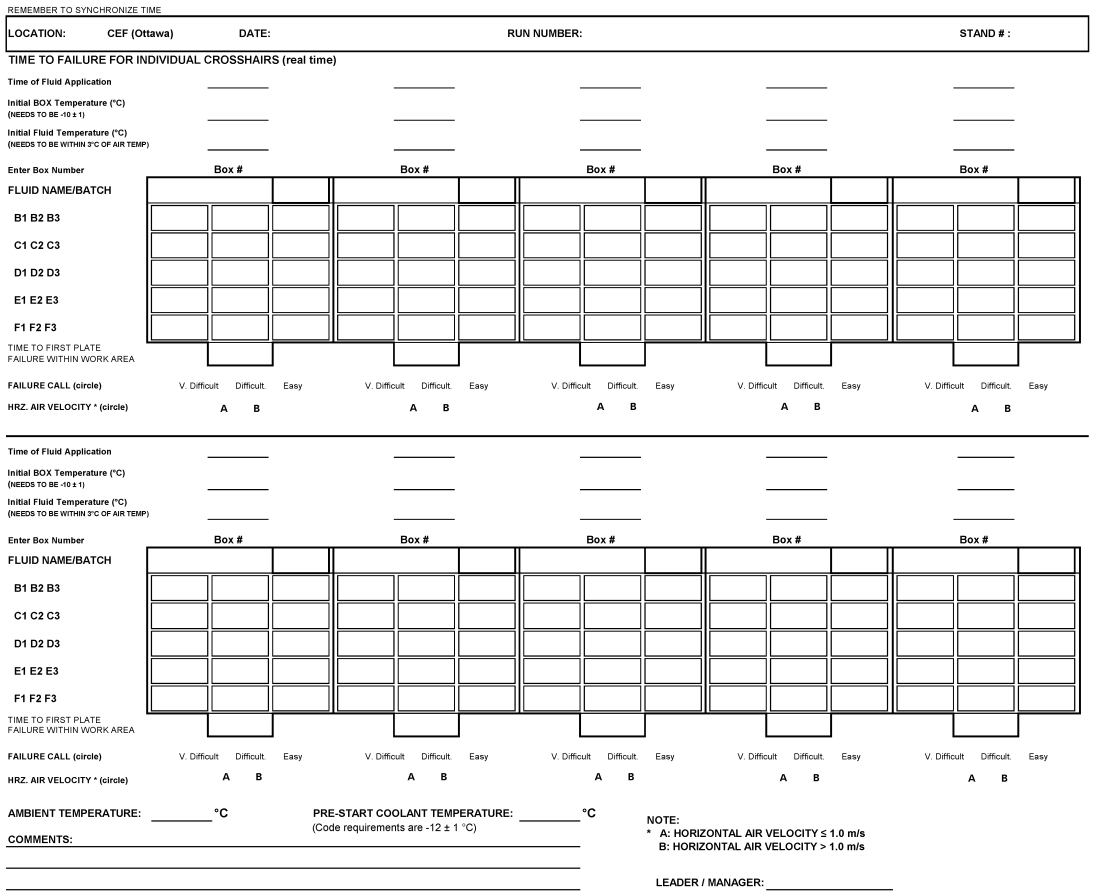
PRECIP (circle): ZF , ZD , ZR-, MOD **AMBIENT TEMPERATURE:** _____ °C

COMMENTS: _____

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

LEADER / MANAGER: _____

FIGURE 5: COLD-SOAK WING 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 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 6: 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

FIGURE 7: FLUID BRIX / THICKNESS DATA FORM

DATE: _____ PERFORMED BY: _____

RUN #: _____ WRITTEN BY: _____

STAND: _____ LOCATION: _____

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

FIGURE 8: FLUID BRIX / FLUID THICKNESS / PLATE TEMPERATURE DATA FORM

DATE: _____ PERFORMED BY: _____

RUN #: _____ WRITTEN BY: _____

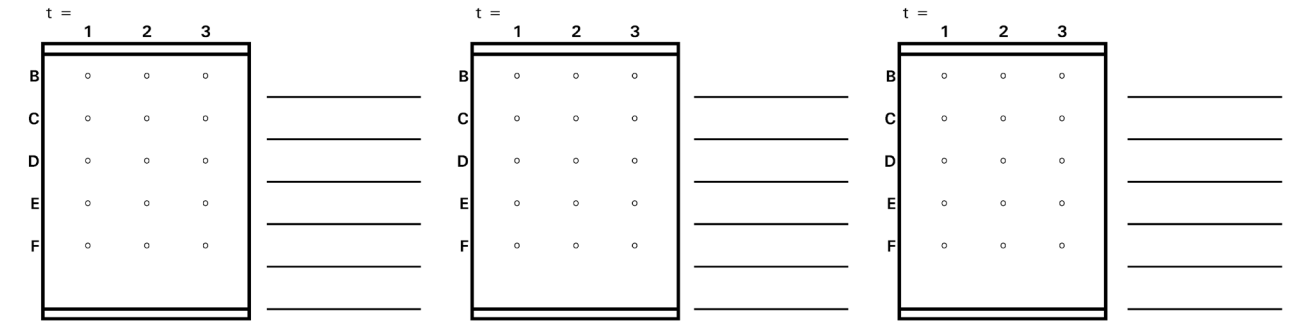
STAND: _____ LOCATION: _____

Plate / BOX: _____ Fluid:				Plate/BOX: _____ Fluid:				Plate/BOX: _____ Fluid:				Plate/BOX: _____ Fluid:			
TIME	Brix	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.

FIGURE 9: ADHERENCE OF FLUID FAILURE DATA FORM

Date: _____

Test #: _____ Fluid / Dilution: _____ Plate Location: _____



Test #: _____ Fluid / Dilution: _____ Plate Location: _____

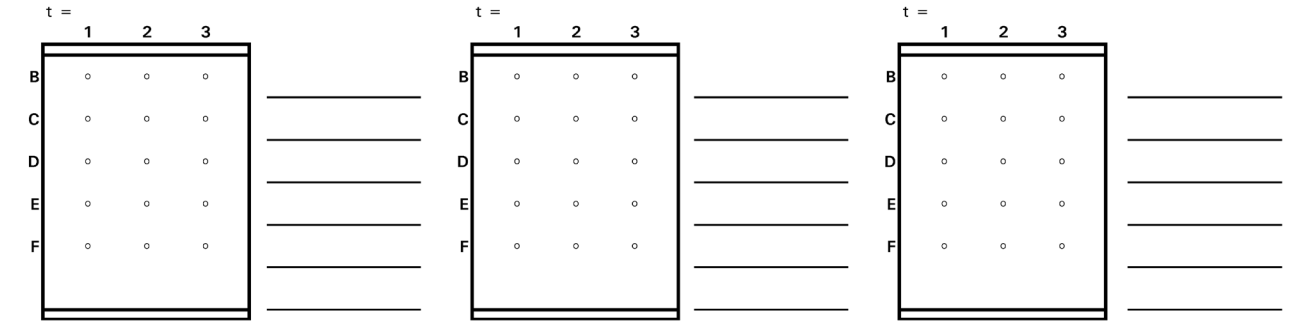


FIGURE 10: POSITION OF ICE PELLET DISPENSER SYSTEM DATA FORM

DATE:_____ CONDITION:_____ TIME:_____

TYPE OF PRECIPITATION ON PLATE (circle precip. type)

Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6
ZR	ZR	ZR	ZR	ZR	ZR
IP	IP	IP	IP	IP	IP
ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP

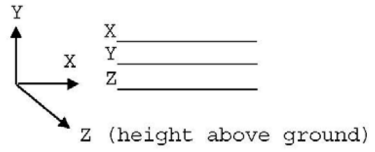
Pos. 7	Pos. 8	Pos. 9	Pos.10	Pos.11	Pos.12
ZR	ZR	ZR	ZR	ZR	ZR
IP	IP	IP	IP	IP	IP
ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP

OPERATIONAL TIME LOG OF ICE PELLET DISPENSER

IP DISPENSER ON	IP DISPENSER OFF	IP DISPENSER ON	IP DISPENSER OFF

MARK POSITION OF DISPENSER RELATIVE TO PLATES WITH AN "X" IN SPACE

POSITION(1) OF ICE PELLET DISPENSER



(1) Origin is bottom left corner of stand

APPENDIX F

PROCEDURE:
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIPITATION CONDITIONS SNOW AND RAIN

CM2103.001 (07-08)

EXPERIMENTAL PROGRAM
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIPITATION CONDITIONS SNOW AND RAIN

Winter 08

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro

March 31, 2008
Final Version 1.0

EXPERIMENTAL PROGRAM
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIPITATION CONDITIONS SNOW AND RAIN

March 31, 2008

1. BACKGROUND

As the accuracy of meteorological reporting continues to improve, especially with the introduction of HOT Determination Systems, there has been an industry need to provide HOT Guidelines for operations in mixed precipitation conditions. Transitional precipitation periods often include a mix of multiple precipitation types, and although these periods are generally short, on many occasions, especially at warmer temperatures, these transitional periods can last several hours. As a result, there has been a recent industry need to provide proper guidance material during these transitional periods of mixed precipitation. In addition, providing HOT guidance material for mixed precipitation conditions will further aid the development of HOT Determination technology.

2. OBJECTIVE

The objective of this project is to investigate if endurance time testing conducted during mixed precipitation conditions (snow/rain) will demonstrate signs of fluid adhesion to aluminum test surfaces with Neat Type II and Type IV fluids.

3. TEST PLAN

A detailed test matrix is shown in Table 3.1. The failure times (estimated based on severity of fluid condition) on test surfaces will be recorded using the standard ET data form (Attachment I). Measurements will be continued beyond the failure time in an attempt to properly document the fluid adherence. Fluid type, fluid appearance, OAT, rate of precipitation and other factors will determine the duration of the test. After fluid failure, the test surface will be examined to determine whether or not adherence occurs. Progressive measurements will be conducted to help in reaching a decision. The methodology for measuring fluid adhesion is described in Section 4.6.

Table 3.1: Test Matrix

Test #	Priority	Fluid Type	Fluid Brand	Dilution	Fluid Temp. [°C]	Precip Type	Test Temp. [°C]	Water Temp. [°C]	Water Temp Increase	Snow Precip Rate [g/dm²/h]	Freezing Rain Precip Rate [g/dm²/h]	Combined Precip Rate [g/dm²/h]	NRC Condition	Timing With HOT Tests
RS1	1	IV	EG 106	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS2	2	IV	ABC-S +	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS3	3	II	Kilfrost 2143-3500	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS4	1	IV	EG 106	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction
RS5	2	IV	ABC-S +	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction
RS6	3	II	Kilfrost 2143-3500	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction

* Duplicates of each test will be conducted simultaneously. Duplcate tests will be labled "Test #" A. i.e. RS1-A
** Water temperature must be raised incrementally until rain is no longer freezing on cold soaked surfaces.

The parameters to be measured during testing are the following: test surface temperature, fluid dilution (Brix), precipitation rate, fluid failure (estimated based on severity of fluid condition), and fluid adhesion. Photo documentation of each test will also be collected. Photos will be taken at set intervals during each test using a digital camera. All of these parameters are to be measured as the test progresses to gain a better understanding of the phenomena that take place as the fluid becomes diluted.

4. PROCEDURE

Endurance time testing will be conducted in the NRC cold chamber using the standard flat plate HOT test procedure. Test plates will be positioned directly underneath the simulated freezing precipitation sprayer assembly. The "Ice Pellet Dispenser" will be positioned approximately 0.3 m (1 ft.) away from, and 0.9 m (3 ft) above the test plate.

4.1 Type II/IV Fluid Application

1L of fluid at OAT will be poured onto the test plate. Fluid dilution, fluid thickness, surface temperature, fluid failure, and adhesion will be documented throughout the test. Photos of the test plate will be taken every 5 minutes for the duration of the test. Rate of precipitation will be verified just prior to the test and immediately following the end of the test.

4.2 Precipitation Rate

To verify that the appropriate rate of precipitation is being produced, the following procedure will be followed. It should be noted that the chamber temperature during the tests will be set to -3°C.

Freezing Rain @ 25 g/dm²/h

1. Follow standard protocol for HOT testing in simulated freezing precipitation conditions.

Rain @ 13 g/dm²/h

1. Adjust flow meter to setting for ZR/-3/13 conditions;
2. Increase feed water temperature to the sprayer head incrementally by 1°C until the spray produced changes from freezing rain to rain. This can be verified using a cold soaked test plate to -3°C (ideal water temperature is when the precipitation stops freezing on the test plate);

3. Manually measure rate of precipitation on test plate (see indoor HOT procedure);
4. Verify that light freezing rain rate of precipitation is within a 1 g/dm²/h tolerance; and
5. Adjust light freezing rain sprayer assembly to obtain desired rate.

Snow @ 12 g/dm²/h

1. Adjust "Ice Pellet Dispenser" to obtain the desired rate;
2. Manually measure the combined rate of precipitation (ZR and IP) on test plate (see indoor HOT procedure); and
3. Verify that combined rate of precipitation is within a 2 g/dm²/h tolerance.

4.3 Surface Temperature

Test surface temperature logging is to be implemented using one thermistor probe mounted at the 15 cm (6") line on the underside of the test plate. The connection will be designed to last for the entire test season and to not impede the fluid flow. A SmartReader Eight-Channel temperature logger will be used to measure and record temperature. This temperature logger will run continuously and is independent of any external power supply or computer; the logger constantly measures and records readings from any enabled channels. The sampling rate (how often the logger takes readings) will be set to eight seconds, the smallest possible increment.

4.4 Fluid Dilution

Fluid dilution will be measured at the 15 cm (6") line, using a Misco 10431VP brixometer. These measurements determine the concentration of the fluid on the test surface before and after fluid failure (estimate based on severity of fluid condition). The Brix value will originally be measured in the container before pouring. The second measurement will be taken right after pouring on the test surface, and at set intervals until fluid failure. After fluid failure the dilution measurements will be conducted every 5 minutes. Brix values and corresponding sample times will be recorded on the Brix/Thickness data form (Attachment II).

4.5 Fluid Failure

Previous endurance time testing in simulated ice pellet conditions demonstrated that visual fluid failure was difficult to determine. Fluid failure determination is not

critical to this project. APS members will use their best judgment in approximating the fluid time of failure.

4.6 Fluid Adherence

The first occurrence of fluid adherence at any location on the surface of the plate will be recorded. Fluid adherence will be determined at the 5th crosshair immediately following failure at this location and at location B2 (see Attachment III). When the entire plate (15 crosshairs) has failed, again verify the fluid adherence at the 15 cm (6") line, and at all crosshairs B2, C2, D2, E2 and F2. Adherence will be noted by the plate observer on the Adherence of Fluid Failure data form (Attachment III). In addition to measuring adherence at the time of plate failure and complete plate failure, adherence will be measured progressively following fluid failure to determine the onset of adherence. A narrative description of the appearance of the fluid as it progresses toward failure will also be recorded.

In the absence of a recognized standard method or apparatus for measuring failure adhesion, the degree of bonding will be determined using an electronic dental flossing device. During operation, the device spins a thread of floss. The floss segment extends about 3 to 4 mm from the tip of the unit, and upon spinning could carve out a circle (or not, depending upon whether adhesion had occurred) 3 to 4 mm in radius on a failed surface element. In a layer of non-adhered fluid failure, the force of the spinning floss is sufficient to expose the surface of the test plate. As the rotation speed of the unit is fixed, the applied force will be constant for all tests, providing a basis of comparison among various test conditions, and between different stages of contamination for individual tests. This device proved to be the most satisfactory of the various approaches to establish whether an area had undergone surface bonding to the substrate and to give a measure of the strength of the bond formed.

An analysis of the shearing force exerted by this instrument (presented as Appendix C of the Transport Canada report, TP 14377E, *Adhesion of Aircraft Anti-Icing Fluids on Aluminum Surfaces (2003-04)*, December 2004) determined it to be in the range of 1.3×10^{-4} to 2.0×10^{-4} MPa.

4.7 Test Sequence

The steps to be followed are specific to each precipitation type.

1) Synchronize computer and test clocks to the atomic clock;
2) Prepare test plate and test stand;
3) Initiate temperature logging;

4) Prepare fluids for testing. The fluid types, fluid amounts and application temperatures are specific to each test;
5) Monitor precipitation rates;
6) Just before pouring the fluid, the test surface will be cleaned of all contamination with a scraper and a squeegee;
7) Apply the fluid to the test surfaces according to specific test procedure;
8) Determine failure time (estimated based on severity of fluid condition) on test surfaces, and record using standard ET data forms (Attachment I);
9) Measure Brix of the fluid and record on Brix/Thickness data form (Attachment II);
10) Determine fluid adherence and record on Adherence of Fluid Failure data form (Attachment III); and
11) At the end of the testing session save the temperature data on a memory stick or floppy disk. Label the diskette and place in the same envelope with the data forms.

5. EQUIPMENT AND FLUIDS

5.1 Equipment

The equipment to be used is, in general, the same as for the fluid holdover time tests. A comprehensive description of the equipment can be found in Transport Canada Report *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter*, TP 14144E, December 2004.

- Test plates and test stand;
- SmartReader Eight-Channel temperature logger and thermistor probes will be used for logging test surface temperatures;
- Wet film thickness gauges;
- Misco 10431VP brixometer will be utilized for fluid dilution rate measurements; and
- Ice Pellet Dispenser.

A detailed list of the equipment required for testing at the NRC facility is included in Attachment I.

5.2 Fluids

Tests shall be conducted using Type II/IV fluids as presented in Table 5.1. All fluids tested will be as close as possible to the lowest on wing viscosity and will conform to the viscosities stated in the HOT Guidelines.

Table 5.1: Fluid Required for Testing

Fluid Name	Fluid Type	Test Condition OAT [°C]	Tentative # of Tests	Total Litres Required [L]
Dow EG 106	4	-3	4	4
Kilfrost ABC-S +	4	-3	4	4
Kilfrost Type II	2	-3	4	4

6. PERSONNEL

Four technicians are needed to conduct the tests:

- Technician one calls failure, and documents adherence (MR);
- Technician two prepares fluids, measures precipitation rates and measures Brix and thickness (JT);
- Technician three will be in charge of running the ice pellet dispenser system and in charge of making simulated ice pellets (YOW 1); and
- Technician four will be in charge of managing the rate station (SB).

7. DATA FORMS

Some of the same data forms from the procedure, *Adhesion Of Aircraft De/Anti-Icing Fluids On Aluminum Surfaces* (see Version 1.0 from November 13, 2003, located in Appendix B of TP 14144E) will be used for this project. Some fields of the data forms will not need to be filled out as they are not relevant to this project (refer to Section 3 for pertinent data). The following data forms are included in this procedure:

- End Condition data form (Attachment II);
- Fluid Brix/Thickness data form (Attachment III);
- Adherence of Fluid Failure data form (Attachment IV); and
- Position of Ice Pellet Dispenser System data form (Attachment V).

ATTACHMENT I
EQUIPMENT LIST

Test Equipment	
Test Procedure, data forms	
Large clock	
Ice pellets dispensing devices x 6 / stands and adapter	
Desktop/Laptop computer with printer with paper	
Temperature Probe x 2 and spare batteries / immersion and surface probes	
Thickness Gauges (large and small)	
Brixometers x 3	
Adherence Probes	
Weigh scale (NCAR and HOT)	
Large Umbrella x2	
Ice Pellets Fabrication Equipment	
Styrofoam containers x 20	
Ice bags	
Blenders (x 6)	
Ice pellets sieves (round and square)	
Folding tables	
Scrapers	
Measuring cups	
Rubber mats	

ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS

ATTACHMENT II
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME

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

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

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

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

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

AMBIENT TEMPERATURE: _____ **°C**

COMMENTS:

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

LEADER / MANAGER: _____

ATTACHMENT III
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

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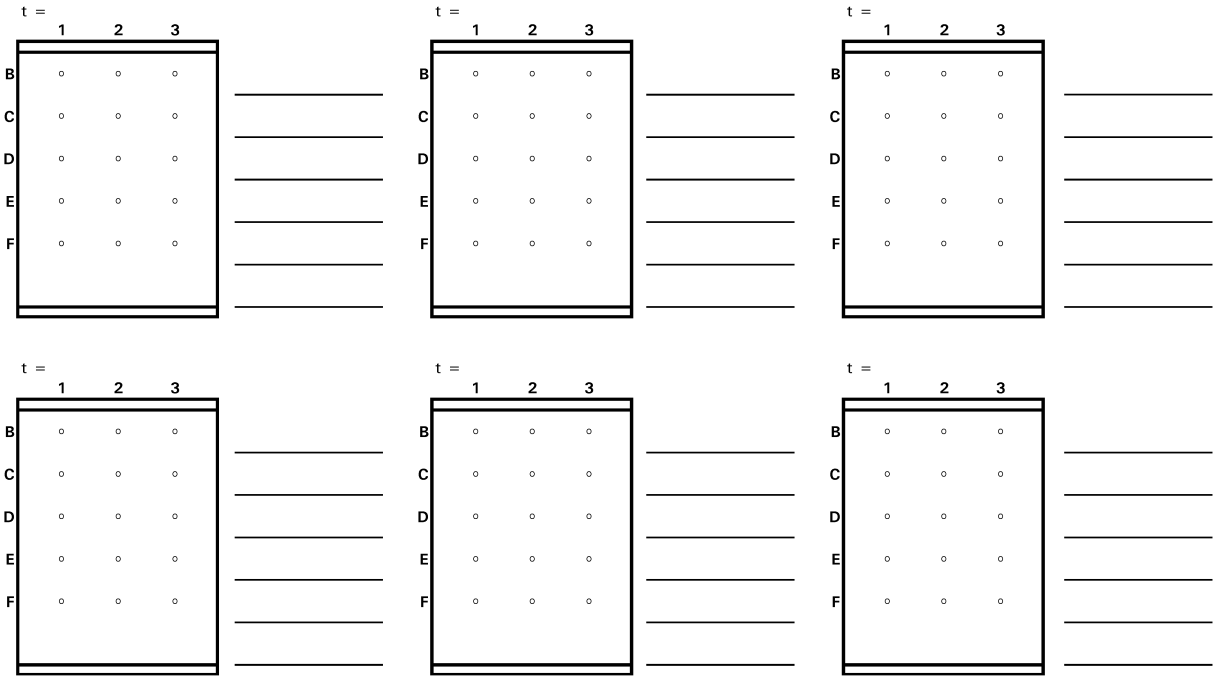
ATTACHMENT IV

ADHERENCE OF FLUID FAILURE

Date: _____ Time: _____ Plate Location: _____

Run #: _____ Fluid Name: _____ Fluid Dilution: _____



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ATTACHMENT V

POSITION OF ICE PELLET DISPENSER SYSTEM DATA FORM

DATE:_____ CONDITION:_____ TIME:_____

TYPE OF PRECIPITATION ON PLATE (circle precip.)

Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6
ZR	ZR	ZR	ZR	ZR	ZR
IP	IP	IP	IP	IP	IP
ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP

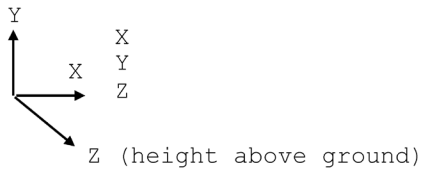
Pos. 7	Pos. 8	Pos. 9	Pos.10	Pos.11	Pos.12
ZR	ZR	ZR	ZR	ZR	ZR
IP	IP	IP	IP	IP	IP
ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP	ZR/ IP

OPERATIONAL TIME LOG OF ICE PELLET

IP DISPENSER ON	IP DISPENSER OFF	IP DISPENSER ON	IP DISPENSER

MARK POSITION OF DISPENSER RELATIVE TO PLATES WITH AN "X" IN SPACE

POSITION(1) OF ICE PELLET DISPENSER



(1) Origin is bottom left corner of stand

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APPENDIX G

PROCEDURE:
EVALUATION OF EFFECT OF POOR APPLICATION METHODS ON FLUID ENDURANCE TIMES

BM5611.00

PROCEDURE:
EVALUATION OF EFFECT OF POOR APPLICATION METHODS ON FLUID ENDURANCE TIMES

Winter 2008-09

Prepared for

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Transport Canada

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December 29, 2008
Final Version 1.0

EVALUATION OF EFFECT OF POOR APPLICATION METHODS ON FLUID ENDURANCE TIMES

Winter 2008-09

1. BACKGROUND

In recent years, poor fluid application has been an important topic of discussion throughout industry meetings. Limited data is currently available on this subject and the effect poor application methods have on endurance times. In an attempt to better understand this process as well as to make data readily available, a series of test will be performed. Preliminary work has been conducted in the past to investigate the effects fluid quantity amount has on endurance times.

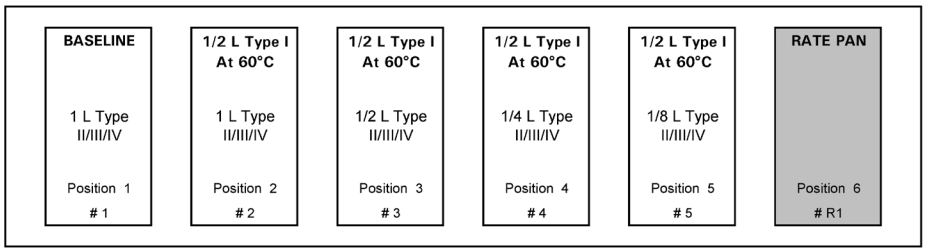
2. OBJECTIVE

The objective of this project is to investigate the effects of reduced fluid film thickness on endurance times. In order to achieve this objective, a series of tests will be performed using six representative anti-icing fluids on standard aluminum plates

3. PROCEDURE

Endurance time tests will be conducted outdoors with the various fluids at the P. E. Trudeau International Airport test site. A six position test stand will be required for testing, which is demonstrated in Figure 3.1. Test stand position one will be used as the baseline for endurance times test and test stand position six will have a rate pan that will be used for measuring the rate of precipitation during each test.

Figure 3.1: Six Position Test Stand Setup



3.1 First Step with Heated Type I Fluids

Half a litre of Type I fluid (mixed to a 10°C buffer) will be heated to 60ºC and poured onto test plates two through five using a 12-hole spreader. Test plate one will not require Type I fluid to be applied. After the Type I fluid has been applied onto the test plates, a waiting period of three minutes is required before Type II/III/IV fluids are to be applied.

3.2 Second Step with Type II/III/IV Fluids

1L, 1/2 L, 1/4 L and 1/8 L of fluid at OAT will be hand poured simultaneously onto test plate positions one through five. The fluid will be poured following the application of Type I fluid. The same fluid and dilution should be applied to each test surface.

3.3 Measurements

Rate measurements will be taken according to standard Holdover Time practices. To assist in analyzing the results, fluid thickness and brix will be measured on approximately 30% of the tests conducted. These measurements will be taken after Type II/III/IV fluid have been applied, after 15 minutes, after 30 minutes and following the completion of the tests. With the focus of this project being on fluid film thickness, it is essential that fluid thickness be recorded.

4. TEST PLAN

A test plan has been compiled for Type I/II/III/IV fluids and is included in Attachment I. A total of 18 runs are anticipated for this project. Depending on the initial results, it may be necessary to change the application procedures.

5. EQUIPMENT

The same equipment that is used for Endurance Time testing will be used for these tests. In addition, a thickness gauge and a brixometer will be required to obtain measurements.

6. FLUIDS

The fluids listed in Table 6.1 will be used for endurance time testing.

Table 5.1: List of Fluids Required for Testing

Fluid	Fluid Type	Dilution	Quantity Needed
Type I EG	I	Conc.	5 L
Type I PG	I	Conc.	20 L
Clariant Safewing MPIV Launch	IV	100	10 L
	IV	75	10 L
Clariant Safewing MPIII 2031 ECO	III	100	10 L
	III	50	10L
Ecowing 26	II	100	10 L
	II	75	10 L
	II	25	10 L
Kilfrost ABC-S Plus	IV	100	10 L
	IV	75	10 L
	IV	50	10 L
Lyondell ARTIC Shield	IV	100	10 L
Octagon MaxFlo	IV	100	10 L
	IV	75	10 L

7. PERSONNEL

Two personnel will be required to conduct these tests. One individual will be responsible to measure endurance times, and the remaining individual will collect rates, prepare fluids, and assist with fluid application.

8. DATA FORMS

The endurance time tests will require the end condition data form which is included as Attachment II, as well as the fluid brix/thickness form which can be

found in Attachment III. When fluid brix and thickness are measured, it is best to always take measurements on plate one and plate two; and two of the remaining plates.

9. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

- Pathways, stairs and test areas are to be cleared of snow regularly;
- Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;
- Warm clothing is to be worn by all personnel to prevent frostbite;
- Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;
- If fluid comes into contact with skin, rinse hands under running water; and
- If fluid comes into contact with eyes, flush with the portable eye wash station located inside the main trailer.

ATTACHMENT I: MATRIX OF OUTDOOR TESTS

Run #	Fluid Type	Fluid Brand	Dilution
1	IV	Clariant MPIV Launch	Neat
2	IV	Clariant MPIV Launch	Neat
3	IV	Clariant MPIV Launch	75/25
4	III	Clariant MPIII 2031	Neat
5	III	Clariant MPIII 2031	Neat
6	III	Clariant MPIII 2031	50/50
7	II	Eco 26	Neat
8	II	Eco 26	75/25
9	II	Eco 26	50/50
10	IV	ABC-S Plus	Neat
11	IV	ABC-S Plus	Neat
12	IV	ABC-S Plus	75/25
13	IV	ABC-S Plus	50/50
14	IV	Arctic Shield	Neat
15	IV	Arctic Shield	Neat
16	IV	Maxflo	Neat
17	IV	Maxflo	Neat
18	IV	Maxflo	75/25

ATTACHMENT II: END CONDITION FORM FOR ENDURANCE TIME TESTING

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

LOCATION:	DATE:	RUN NUMBER:	STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

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

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 2°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

AMBIENT TEMPERATURE: _____ °C

COMMENTS: _____

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

FAILURES CALLED BY: _____

LEADER / MANAGER: _____

ATTACHMENT III: 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 H

REFERENCES:
EFFECT OF FLUID VISCOSITY ON ENDURANCE TIMES

Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1997-98 Winter TP 13318E

Author: APS
Date: December 1998

Document Summary:

A series of tests was conducted at the NRC's CEF aimed at determining the effect of the fluid application method on the holdover time of Type IV fluids.

The test plan consisted of spraying a Type IV fluid on two plates, and pouring the same fluid on two more plates. Tests were performed in light freezing rain at a temperature of -3°C. The fluid endurance times were then compared.

For Union Carbide Ultra+ Neat fluid, the sprayed fluid endurance time was slightly longer than that for the poured fluid.

For Union Carbide PG AAF, a large difference in endurance time was observed. The poured fluid lasted 25 percent longer on average than the sprayed fluid. The PG AAF was noted to be an extremely viscous fluid, and the performance was undoubtedly affected by the shearing of the fluid. Union Carbide PG AAF is not a certified fluid.

Aircraft Ground De/Anti-Icing Fluid Holdover Time Field Testing Program for the 1998-99 Winter TP 13477E

Author: APS
Date: October 1999

Document Summary:

A preliminary evaluation of the effect of fluid viscosity on holdover time conducted in 1997-98 demonstrated that fluid viscosity might significantly influence fluid holdover times

In 1998-99, tests were conducted on unsheared fluid samples along with sheared fluid used for holdover time testing. The holdover times of the sheared (low viscosity) and unsheared (high viscosity) fluid samples in simulated precipitation conditions were compared to study the effect of fluid viscosity on holdover time.

The results are shown in the following Table 1.

In general, the high viscosity samples of the various anti-icing fluids tested had longer endurance times than the low viscosity samples.

In freezing drizzle at -10°C, the sheared Clariant Safewing Four and Kilfrost ABC-S outperformed the unsheared samples, because the high viscosity samples did not flow as freely and failures occurred in the upper fluid layers.

Table 1: Comparison of Endurance Times for Unsheared Fluid and Fluid Sheared to HOT Test Viscosity

Fluid	Condition	OAT (°C)	Rate ($g/dm^2/h$)	Ratio of endurance time (high viscosity / low viscosity)
Clariant Safewing MPIV 1957	ZD	-3	5	1.5
		-10	5	1.5
	ZR	-3	25	1.7
		-10	25	1.0
Clariant Safewing Four	ZD	-3	5	1.0
		-10	5	0.9
	ZR	-3	25	1.2
		-10	25	1.0
Kilfrost ABC-II Plus	ZD	-3	5	1.3
		-10	5	1.3
	ZR	-3	25	1.0
		-10	25	1.5
Kilfrost ABC-S	ZD	-3	5	1.5
		-10	5	0.9
	ZR	-3	25	1.0
		-10	25	1.3
Octagon Maxflight	ZD	-3	5	1.3
		-10	5	1.1
	ZR	-3	25	2.6
		-10	25	1.0

Influence of Application Procedure on Anti-icing Fluid Viscosity TP 13996E

Author: Chebil S. and Alwaid A., APS
Date: November 2002

Document Summary:

The primary objective of this research was to compare the viscosity of the sprayed fluids versus that of the undisturbed fluids. This comparison led to an evaluation of the spraying and shearing effects on Type IV fluid endurance times.

Three sub-projects were carried out over the two winter seasons:

a) Preliminary Spray Tests (conducted in Winter 2000-01). An airfoil was sprayed with Type IV fluid using a Task Force Tips nozzle. In general, the procedure involved pouring heated Type I fluid on the airfoil followed by a spray application of Type IV. Eight runs using three fluids were carried out at the Dorval test site on a clear sunny day. The viscosity of the collected samples was immediately measured;

   The results showed a decrease in viscosity due to the combination of two variables, shearing and the presence of Type I fluid;

b) Full-Scale Standard Spray Tests (conducted in Winter 2001-02). Trained deicing operators used a one-step application method to spray Type IV fluid onto aircraft wings. Five full-scale runs were conducted at various deicing locations in North America on days with no precipitation. Four fluid brands were used for the tests and were sprayed from six deicing trucks. Fluid samples were collected and the viscosity was measured; and

c) Endurance Time Testing (also conducted in Winter 2001-02). Type IV fluids were sprayed directly onto test plates. Endurance time was measured and results compared to endurance times from the standard test procedure.

The results of the tests on aircraft and laboratory fluid endurance tests based on sprayed fluid are shown in Table 2.

Table 2: Summary of Overall Results by Fluid Brand

Fluid	Full-Scale Aircraft Standard Application Tests Average deviation from the tank fluid viscosity	Endurance Time Tests			
		Sprayed, no Type I		Sprayed over Type I	
		Viscosity deviation from the poured fluid	Endurance Time deviation from the poured fluid	Viscosity deviation from the poured fluid	Endurance Time deviation from the poured fluid
A	NT	NT	NT	NT	NT
B	-11%	NT	NT	NT	NT
C	-6%	-7%	-12%	-11%	-30%
D	-38%	-46%	-22%	-45%	-43%
E	-22%	NT	NT	NT	NT
F*	NT	-1%	-6%	-3%	-2%
G*	NT	-7%	+8%	-36%	-40%

NT: Not Tested
*: Discontinued fluid

The full-scale aircraft standard application tests showed a reduction in viscosity for the tested Type IV fluids, due to spraying. The extent of reduction varied by fluid brand.

In the endurance tests, the viscosity reduction due to spraying corresponded to that seen in the full-scale tests, based on Fluids C and D.

The relationship between viscosity reduction and endurance time varied by fluid brand, but generally some decrease in fluid endurance time resulted from a decrease in fluid viscosity.

In tests where Type IV fluids were sprayed over Type I, the viscosity of the mixed fluid was generally further reduced, as was the resulting endurance time. This must be a result of mixing of the Type I and Type IV fluids. It demonstrates the importance of applying sufficient amounts of the second-step fluid.

A Potential Solution for De/Anti-Icing of Commuter Aircraft TP 14152E

Author: Chaput, M., APS
Date: November 2003

Document Summary:

A research program examined potential solutions to address the holdover time limitations of Type I fluid. Research focussed on the possibility of spraying heated Type II or IV fluids through Type I spray equipment as a means of producing a lower viscosity fluid.

Research included creating a new fluid type based on a heavily sheared anti-icing fluid. Three simulated Type III fluids were produced by mechanically shearing certified Type II products to low viscosity levels. The resulting fluids were then tested for endurance times in natural snow and simulated precipitation, and the results compared to holdover times for Type I and type III fluids.

Review of results relative to shearing of Type II fluids:

The test data can be used to examine the extent that fluid shearing reduces endurance times.

Endurance time tests were performed with two certified Type II products that were mechanically sheared to varying degrees to simulate potential Type III fluids:

a) Clariant Safewing MP II 2025 Type II, mechanically sheared to a viscosity of 1,500 cP, referred to as Clariant 2025 D1500;
b) Clariant Safewing MP II 2025 Type II, mechanically sheared to a viscosity of 500 cP, referred to as Clariant 2025 D500; and
c) Octagon E-Max II Type II, mechanically sheared to a viscosity of 500 cP,referred to as Octagon E Max II D500.

The Clariant 2025 D500 was tested in all simulated conditions. The other two products were tested in very limited fashion.

Endurance times from the reduced viscosity fluids are compared to corresponding holdover times for the original non-sheared fluid in the following discussion.

Endurance Time Results – Clariant 2025 D500

Endurance times produced by this fluid version were used to construct potential HOT values, for certain cells. In Table 3, these HOT values are compared to the published HOT values for the non-sheared fluid.

Clariant 2025 D500 fluid, having a viscosity at about 10% of that of the non-sheared fluid, produced endurance times ranging from 60 to 80% of the non-sheared fluid HOT values.

Table 3: Comparison of Clariant 2025 D500 Endurance Time Results to Clariant

OAT		Approximate Holdover Times Under Various Weather Conditions (minutes) (hours)					
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
-3 and above	27 and above		90-125 **55-95**	40-70 **25-40**	40-60 **30-50**	25-35 **20-25**	
below -3 to -14	below 27 to 7		45-110 **40-80**	35-60 **25-40**	*35-65 **20-40**	*20-35 **15-25**	
below -14 to -25°C	below 7 to -13						

Clariant 2025 Holdover Time Guidelines

Note: Italic values are the published Clariant 2025 100% HOT values
Bold values are the endurance time results with C2025 D500
*To -10°C

Viscosity for Clariant 2025 100% = 5500 mPa.s
Viscosity for Clariant 2025 D500 100% fluid = 500 mPa.s

Endurance Time Results – Clariant 2025 D1500

a) Three endurance time tests were run with a less-sheared sample (viscosity 1500 cP) of the Clariant 2025 product, Clariant 2025 D1500.

Table 4 compares the endurance time obtained in each test with the holdover times in the Clariant 2025 HOT guideline.

Clariant 2025 D1500 fluid, having a viscosity about 25% of that of the non-sheared fluid, produced endurance times ranging from 70 to 90% of the non-sheared fluid HOT values.

Table 4: Comparison of Endurance Time Results with Clariant 2025 D1500 to Clariant 2025 Holdover Time Guidelines

Clariant 2025 D1500 Endurance Time					Clariant 2025	Clariant 2025 D1500 Fail Time as % of HOT
Endurance Time Test	Precip. (g/dm2/h)	Precip. Type	OAT (°C)	Fail Time (min)	HOT (min)	
02 Apr	4.6	Z fog	-3.2	64	90	71%
08 Apr	26	ZR	-9.9	18	20	90%
04 Apr	5	ZD	-3.2	54	60	90%

Viscosity for Clariant 2025 100% = 5500 mPa.s
Viscosity for Clariant 2025 D1500 100% fluid = 1500 mPa.s

Endurance Time Results – Octagon E-Max D500

Five endurance time tests were run with another simulated Type III product, Octagon E-Max D500.

Table 5 provides a comparison of the endurance time obtained in each test with the holdover times in the current Octagon E-Max table.

Octagon E-Max D500 fluid, having a viscosity about 5% of that of the non-sheared fluid, produced endurance times ranging from 30 to 55% of the non-sheared fluid HOT values.

Table 5: Comparison of Octagon E-Max D500 Endurance Time Results to Octagon E-Max Holdover Time Guidelines

Octagon E-Max D500 Endurance Time					Octagon E-Max	Octagon E-Max D500 Fail Time as % of HOT
Endurance Time Test	Precip. (g/dm2/h)	Precip. Type	OAT (°C)	Fail Time (min)	HOT (min)	
02 Apr	4.6	Z fog	-3.2	37	125	30%
08 Apr	26	ZR	-9.8	11	20	55%
09 Apr	25	ZR	-3.0	11	30	37%
04 Apr	5.2	ZD	-3.2	34	95	36%
09 Apr	12	ZD	-3.3	18	45	40%

Viscosity for Octagon E-Max 100% = 13520 mPa.s
Viscosity for Octagon E-Max D500 100% fluid = 500 mPa.s

Endurance Time Reduction Due Shearing – All Fluids Tested

Table 6 is a consolidation of test results from the three sheared fluids, without regard to the fluid brand. Report TP 13996E, discussed separately, indicates that the effect of reduced viscosity on endurance times varies widely between different fluid brands.

Table 6: Test Results from the Three Sheared Fluids

Viscosity of sheared fluid as % of non-sheared fluid	5%	10%	25%
Endurance time of sheared fluid as % of non-sheared fluid	30 - 55%	60 - 80%	70 - 90%

Development of Holdover Time Guidelines for Type III Fluids TP 14379E

Author: Chaput, M., APS
Date: November 2004

Document Summary:

Prior to the 2003-04 winter testing season, de/anti-icing fluid manufacturers were encouraged to produce and submit candidate Type III fluids, based on a low-viscosity anti-icing fluid formulation, for endurance time testing. Only one fluid, Clariant Safewing MP III 2031 ECO, was received.

Before the fluid endurance time tests with the new product, a series of spray tests were performed at DFW using an American Eagle Saab 340 aircraft. The objectives of these tests were to:

- Spray heated Clariant Safewing MP III 2031 ECO fluid through a Type I spray nozzle; and
- Determine a suitable viscosity for the Type III fluid used in endurance time testing, based on comparisons of the viscosities of the sprayed and virgin fluids from DFW tests.

The Clariant Type III fluid, heated to a temperature of 64°C at the nozzle, was applied to the aircraft, using the standard Type I fluid application method (narrow stream, high pressure). A Task Force Tips Type I nozzle was used for this test.

After the fluid was heated and sprayed onto the aircraft, fluid samples were collected from the wing and were returned to Montreal for viscosity testing.

The data offers two sets of comparisons between truck tank fluid viscosity and viscosity following spraying with the Type I nozzle. Because the spraying was conducted with a Type I fluid nozzle, the result doesn't represent what might typically result from spraying with a nozzle intended for type II/IV fluids. However, it does serve as a reminder of the large degradation in viscosity that may result if a wrong nozzle is used.

A summary of the viscosity results for the sprayed Type III tests is given in Table 7. The measured viscosities of the fluid sprayed on the wing in the two tests, 980 cP and 1 200 cP respectively, were used by Clariant to determine an appropriate viscosity at which the fluid would be tested for endurance times.

Table 7: Summary of the Viscosity Results of the Heated Type III Fluid Samples Sprayed Through Type I Equipment

Date	Test Location	Fluid Applied	Sample	Avg. Measured Viscosity (cP)*
20-Jan-04	DFW	Clariant Safewing MP III 2031 ECO	Barrel Sample	5220
20-Jan-04	DFW	Clariant Safewing MP III 2031 ECO	Truck Sample - Spray 1	4140
20-Jan-04	DFW	Clariant Safewing MP III 2031 ECO	Sample Collected off Wing - Spray 1	980
20-Jan-04	DFW	Clariant Safewing MP III 2031 ECO	Truck Sample - Spray 2 (Recirculated)	1620
20-Jan-04	DFW	Clariant Safewing MP III 2031 ECO	Sample Collected off Wing - Spray 2 (Recirculated)	1200

*Viscosity Measurement Method: Spindle LV1, 0°C, 0.3 rpm, 15 minutes, 500 mL of fluid

Endurance Times of Fluids Applied with Forced Air Systems TP 14153E

Author: Dawson, P., APS
Date: October 2003

Document Summary:

This study investigated whether the test procedure that examines the applicability of holdover time guidelines for forced-air-assist applications of SAE Type II/IV fluid should include the measurement of endurance times.

Samples of fluids applied with forced air-assist were obtained from field operators, and tested for viscosity and fluid endurance. Operators known to have tested or to have a potential interest in using forced air-assist Type II or Type IV fluid application were contacted. Two operators, FedEx and US Airways, provided fluid samples.

The two operators used the same fluid, SAE Type IV Fluid, Lyondell/Clariant Safewing MP IV 2001.

Results

For one operator, the test data showed a noteworthy reduction in fluid viscosity for fluid applied with the conventional nozzle, compared to fluid samples taken from the truck tank. The data is shown in Table 8.

Fluid viscosity following spray application with the conventional nozzle was reduced to 86% of truck tank fluid viscosity.

Endurance times for the conventional nozzle sprayed fluid were 84% and 67% of the truck tank fluid endurance times, for snow and freezing rain conditions.

Table 8: Endurance Times for Conventional Nozzle Compared to Tank Sample

			Tank Sample	Conv'l Nozzle	Nozzle as % of Tank
Fluid Viscosity (mPa.s)			29600	25600	86%
Precipitation Type	**Temp (°C)**	**Rate ($g/dm^2/h$)**	**Endurance Time (min)**		
Snow	-6	13	75	63	84%
ZR	-3	25	60	40	67%

The test fluid submitted included fluid collected from various air-assist applications, where different degrees of viscosity reduction were experienced. The most extreme cases examined were those in which fluid was injected into the air stream (FedEx samples).

The viscosity reduction and effect on endurance time for these extreme cases is shown in the following table

Table 9: Endurance Times for Air Assist Applications Compared to Conventional Nozzle

	Full Airflow	**1/2 Airflow**	**1/3 Airflow**
Viscosity as % of conventional nozzle	51%	60%	75%
Endurance time as % of conventional nozzle	53 to 75%	55 to 93%	77 to 87%

A Protocol for Testing Fluids Applied with Forced Air Systems TP 14380E

Author: Bendickson, S., APS
Date: October 2004

Evaluation of Type IV Fluids Applied Using Forced Air Assist Equipment TP 14445E

Author: Bendickson, S., APS
Date: November 2005

Document Summary:

These documents report on further work to establish test procedures for examining the effect of forced-air assist on application of deicing fluids.

Work completed in the winter of 2002-03 (TP14153) concluded that fluid viscosity could be used in place of endurance times as a gauge for approval of forced air assist systems. As a result, a new procedure was developed using viscosity to evaluate forced air assist systems.

When tests were conducted with FedEx equipment in 2003-04 using the new procedure, fluid viscosity was found to decrease more when fluid was applied using forced air assist compared to the conventional application.

Two changes were made to the Type II/IV procedure following the 2003-04 tests:

1) The approval criterion was changed - the viscosity of fluid applied with the forced air system would be compared to the lowest on-wing viscosity (LOWV) instead of to the conventional application viscosity; and
2) The equipment settings had to be fixed prior to test.

Tests in 2004-05 using the new test procedure evaluated four FedEx forced air systems (two trucks, both with and without an air sleeve) and four anti-icing fluids.

The two major changes made to the Type II/IV forced air test procedure in 2004-05 were validated:

1) The addition of a requirement to conduct pre-tests to fix the equipment set-up proved to be a valuable addition as it ensures test results are applicable to actual operations, and assists operators in determining appropriate set-ups prior to the actual test session; and
2) The change to the acceptance criterion, to compare viscosities of fluids applied with forced air to the fluids LOWV, proved to be a reasonable approach for evaluating forced air systems.

The new procedure defined a method to determine if a forced air system is acceptable for use with a specific fluid. In this method, a formula is applied to determine the *lowest acceptable delivered viscosity* (LADV) of the specific fluid.

A fluid must have a viscosity at or above the LADV when it is delivered to ensure its viscosity will not go below the LOWV when it is applied with the forced air system. Holdover times may be shorter than indicated in the holdover time tables if fluids have a viscosity below the LOWV.

The LADV formula is based on the ratio of fluid viscosity reduction applied to the LOWV. The LADV is calculated as follows:

- $\text{LADV} = \text{LOWV} \times \dfrac{\text{Fluid Viscosity in Tote}}{\text{Test On-Wing Viscosity}}$
- The calculated value is rounded up to the nearest even 500 mPa.s.

The acceptable range of delivered fluid viscosity for use of holdover time guidelines with forced air will be from the lowest viscosity derived from the formula, to the high end of the manufacturer's delivery range.

It was concluded the some forced air deicing truck / specific fluid combinations were acceptable for fluid delivered within the standard delivery range, while others required an adjustment to the fluid delivery range to accommodate the LADV.

Fluid Viscosity Reduction from Conventional Nozzles

Data from the fluid application tests in Winter 2002-03 and 2003-04 included measurements of fluid viscosity following application with conventional nozzles.

This data can be examined using the same routine as established above for forced-air assist applications, to determine the seriousness of any viscosity reductions from conventional applications.

The results of this examination are shown in Table 10.

The test data from Winter 2003-04 TP 14380 indicates the following:

- The Lyondell/clariant 2001 LADV values for both truck LMD 2000 and truck Tempest II with the FedEx conventional nozzle lie above the low end of the standard fluid delivery range;
- The Octagon Max-Flight LADV values for both truck LMD 2000 and truck Tempest II with the FedEx conventional nozzle lie above the low end of the standard fluid delivery range. The value shown in the report for the low end of the standard fluid delivery range now shows as a higher value (8000 mPa.s) in the fluid web site description. The higher value would satisfy the calculated LADV; and
- The Kilfrost ABC-S LADV for both truck LMD 2000 and truck Tempest II with the FedEx conventional nozzle lies below the low end of the standard fluid delivery range.

The test data from Winter 2002-03 TP 14153 indicates the following:

- The Lyondell/clariant 2001 LADV value for FedEx truck LMD 2000 with the FedEx conventional nozzle lies above the low end of the standard fluid delivery range; and
- The Lyondell/clariant 2001 LADV value for USAirways LMD 2000 with the US Airways conventional nozzle lies below the low end of the standard fluid delivery range.

Although the fluid applications using conventional nozzles was not as rigidly controlled as in the forced-air assist tests, the method of fluid application reflects real-life as would be experienced in field operations.

The results suggest that fluid application using conventional nozzles can reduce viscosity to an extent that impinges on published holdover times, for some fluids.

Table 10: Acceptable Delivery Viscosity Ranges for Use with LMD 2000 and Tempest II Trucks with Conventional Nozzles

(from FedEx tests, Winter 2003-04 TP 14380)

Fluid	Truck	Fluid Tote (mPa.s)	Sample Acceptance	LOWV (mPa.s)	Conventional Nozzle (mPa.s)	LADV (mPa.s)	LADV Rounded Up To 500 (mPa.s)	Std Fluid Delivery Range (mPa.s)	Conventional nozzle delivery range (mPa.s)
lyondel/clariant 2001	LMD 2000	29100	Yes	18000	24700	21206	21500	20000 to 30000	21500 to 30000
lyondel/clariant 2001	Tempest II				25500	0	21000		21000 to 30000
clariant 2012	LMD 2000	15600	?	7800	14500	8392	8500	?	
clariant 2012	Tempest II				14800	8222	8500		
octagon Max-Flight	LMD 2000	11000	Yes	5500	7900	7658	8000	7000 to 12000	8000 to 12000
octagon Max-Flight	Tempest II				7800	7756	8000		8000 to 12000
octagon Max-Flight 04	LMD 2000	11200	Yes	5500	7900	7797	8000	7000 to 12000	8000 to 12000
octagon Max-Flight 04	Tempest II				8200	7512	8000		8000 to 12000
Kilfrost ABC-S	LMD 2000	19650	No	17000	19600	17043	17500	25000 to 30000	25000 to 30000
Kilfrost ABC-S	Tempest II				20750	16099	16500		25000 to 30000

(from Winter 2002-03 TP 14153)

lyondel/clariant 2001	LMD 2000 (FedEx)	29600	Yes	18000	25600	20813	21000	20000 to 30000	21000 to 30000
lyondel/clariant 2001	LMD 2000 (USAirways)	30600	No	18000	29200	18863	19000	20000 to 30000	20000 to 30000

APPENDIX I

PRESENTATIONS AT VARIOUS MEETINGS

PRESENTATIONS AT VARIOUS MEETINGS

1. Visibility Tables Meeting at the FAA Tech Centre, Atlantic City, United States, April 2009

a. APS Snowfall Intensity/Visibility Data and Analysis.

2. SAE G-12 Meeting, Charleston, United States, May 2009

a. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2008-09 Winter Test Season;

b. Anti-Icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time;

c. De/Anti-Icing Fluid Endurance Times on Composite Surfaces;

d. Holdover Times Below -25°C for Anti-Icing Fluids;

e. Holdover Times in Conditions of Rain Mixed With Snow;

f. Proposed Changes to Frost Holdover Time Guidelines;

g. Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables;

h. Airport Siting Considerations for Holdover Time Determination Systems; and

i. Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables.

3. ROGIDS Working Group Meeting, Montreal, Canada, June 2009

a. Research/Action Plan for Enabling Use of ROGIDS at End-of-Runway; and

b. Summary of Previous Studies Relating to End-of-Runway Ice Detection.

4. ROGIDS Working Group Meeting, Toronto, Canada, September 2009

a. Summary of Previous Studies on Holdover Time.

5. Standing Committee Meeting, Toronto, Canada, October 2009

a. Anti-Icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time;

b. Holdover Time Guidelines Update for 2009-10 Winter Operations; and

c. Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables.

APS SNOWFALL INTENSITY / VISIBILITY DATA AND ANALYSIS

APS Aviation Inc.

ISO 9001:2000

Presented by Stephanie Bendickson

April 28, 2009

OUTLINE

- Background
- Data Collection Methodology
- Presentation of Data
- Data Analysis: Comparison of FMH-1 and FAA Visibility Guidelines
- Data Analysis: Comparison of FAA and Rasmussen 1999 Visibility Guidelines

2

BACKGROUND

- APS undertook a project in the winter of 2002-03 to harmonize the Transport Canada and FAA Type I Holdover Time (HOT) guidelines
- Initial analysis showed that differences in the visibility tables contributed largely to the TC and FAA guidelines providing very different HOTs in some conditions
- The project was also carried out partly in response to reports from users that the visibility tables reported different values from the METAR somewhat frequently
- The research was also used to add a column for "very light snow" to the TC and FAA visibility tables

3

BACKGROUND

- APS reviewed the research/analysis previously conducted by Roy Rasmussen that the visibility tables were based upon:
  - database somewhat limited and used a different method for measuring snowfall intensity
  - TC and FAA had interpreted wind factor differently, resulting in different table values

4

BACKGROUND

- APS undertook a project to create a larger database of visibility and snowfall intensity data
- Visibility and snowfall intensity data collected during seven winters of HOT testing (1995-96 to 2001-02) was gathered
- The resulting 7,000 point database was used to make modifications to both the TC and FAA visibility tables
- The modified tables have used since the winter of 2003-04 in conjunction with the Type I HOT Guidelines

5

DATA COLLECTION

- Two types of data were collected:
  - Snowfall intensity data
  - Visibility data
- All data was collected at Montréal - Trudeau Airport

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DATA COLLECTION

Snowfall Intensity Data

- Collected by APS during Holdover Time (HOT) testing
- Measured in wetted collection pans inclined at a 10° slope
  - This procedure was developed to simulate how snow is caught on aircraft wings (also referred to as catch rate)
  - HOTs are calculated based on snowfall intensity rates measured this way
- Each snowfall intensity data point represents one rate measurement collected over a 5 to 12 minute period

7

Pans Inclined at 10° to Measure Snowfall Intensity

DATA COLLECTION

Visibility Data

- Measured by Meteorological Services Canada (MSC)
- Measured using a Belfort Forward Scatter Meter
  - Measurements taken each minute; value reported is the average of the previous 10 measurements
- MSC weather station is located adjacent to APS test site; Belfort forward scatter meter approx 50 m from collection pans
- Visibility data corresponding to each snowfall intensity data point was collected

Belfort Forward Scatter Meter at Montreal-Trudeau Airport

VISIBILITY AT WARM/COLD TEMPERATURES

- Visibility is typically greater in warmer temperatures due to the presence of wet snow
- To compensate for this phenomenon the TC/FAA visibility tables are split into two temperature ranges:
  - *below -1 °C (cold)*
  - *above -1 °C (warm)*
- The APS databases were split to reflect the temperature divisions in the FAA table

DAYTIME VS. NIGHTTIME VISIBILITY

- The human eye can see approx. two times further in darkness (night) than in daylight (day)
- The Belfort Forward Scatter Meter is not affected by lighting condition, but it can apply an algorithm to measurements so the reported values are equivalent to those taken by a human observer
  - US: algorithm is applied
  - Canada: algorithm is not applied

Example	Human Observer		Belfort Scatter Meter	
	United States	Canada	United States	Canada
Day	1 mile	1 mile	1 mile	1 mile
Night	2 miles	2 miles	2 miles	1 mile

DAYTIME VS. NIGHTTIME VISIBILITY

- Implication: APS data was collected from a Belfort Forward Scatter Meter in Canada, therefore all of the data represents daytime values
- Issue: To analyze the visibility tables we need daytime and nighttime data
- Solution: A night/day conversion formula was applied to the daytime data points to create equivalent nighttime data points

SUMMARY OF APS DATABASES

- The FAA visibility table is divided by lighting condition and temperature to give four environmental conditions:
  - Day Cold
  - Day Warm
  - Night Cold
  - Night Warm
- The APS data was sorted to produce a separate database for each environmental condition

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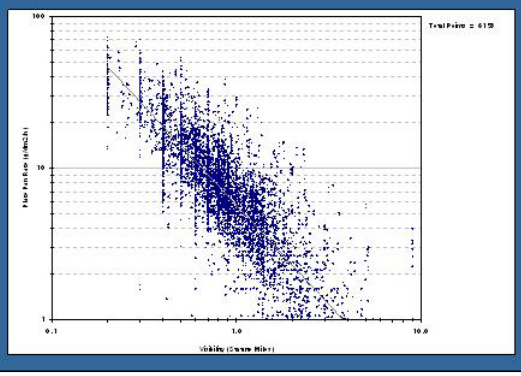
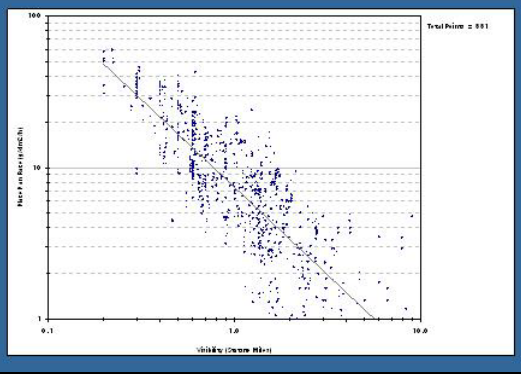
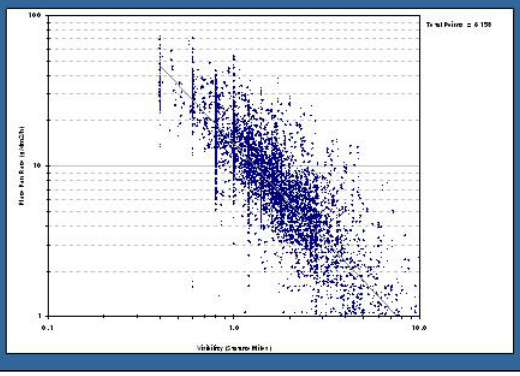
APS DAY COLD DATA



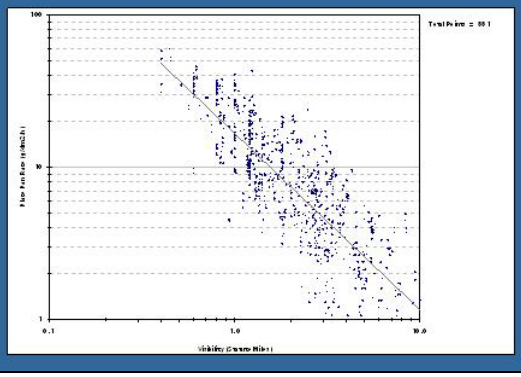
APS DAY WARM DATA



APS NIGHT COLD DATA



APS NIGHT WARM DATA



ANALYSIS: FMH-1 vs. FAA

- Objective: To use the APS visibility / snowfall intensity databases to evaluate the ability of the FAA and FMH-1 guidelines to accurately predict snowfall intensity
- The categorization of snowfall intensity by the guidelines will be compared to the categorization by the plate pan rates. Three criteria will be evaluated:
  - Agreement
  - Balance
  - Conservative tendency (preferred over liberal tendency)
- The following slides describe step-by-step how this was done, using Day Cold as an example

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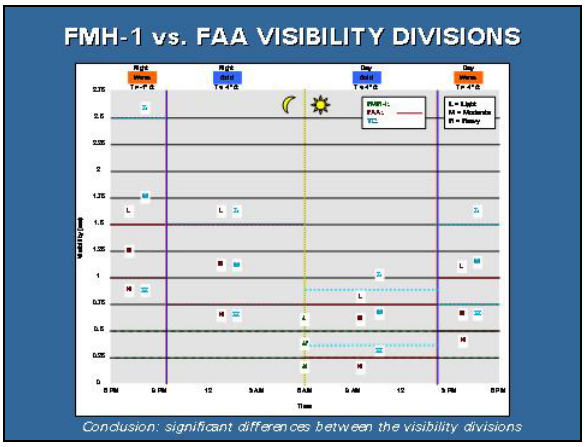
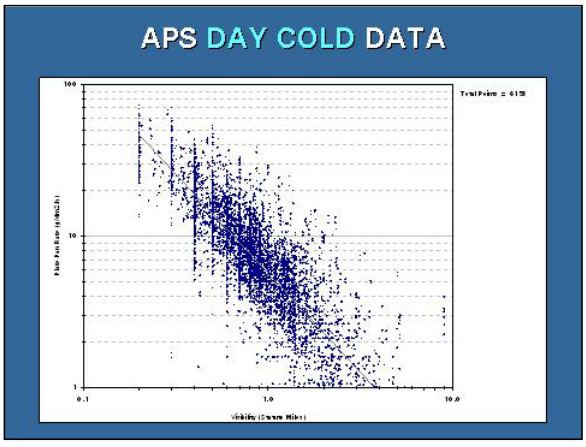
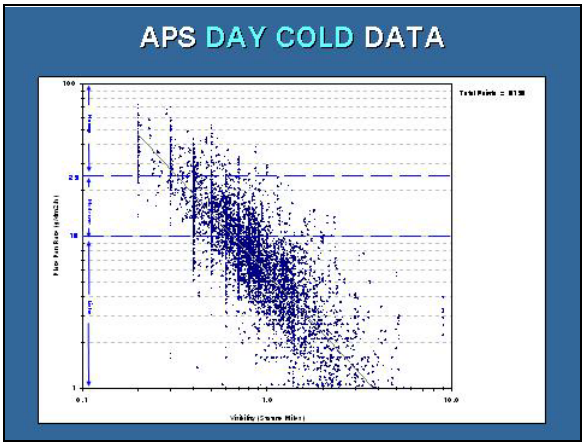

FMH-1 vs. FAA VISIBILITY DIVISIONS
Conclusion: significant differences between the visibility divisions


APS DAY COLD DATA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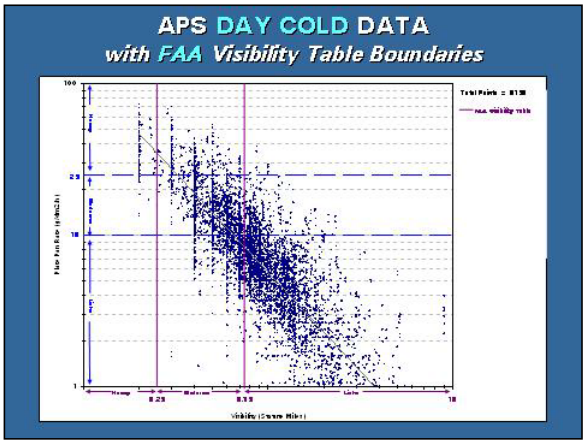
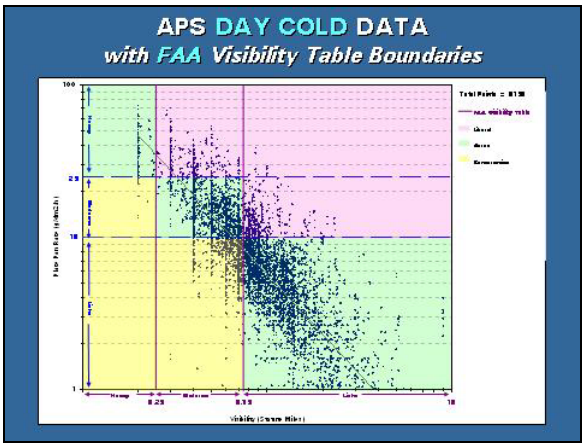
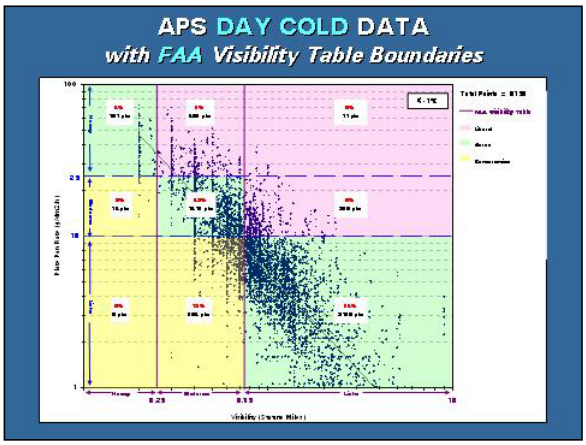
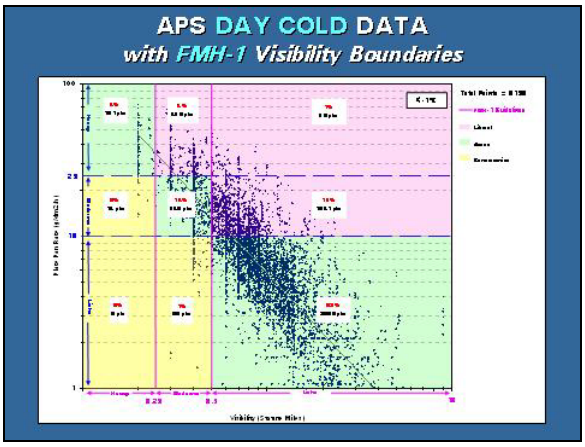
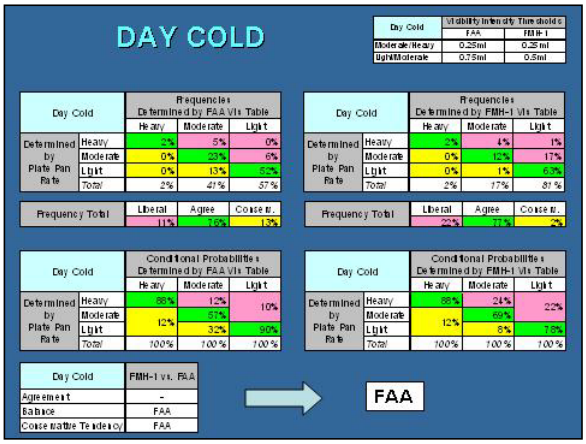
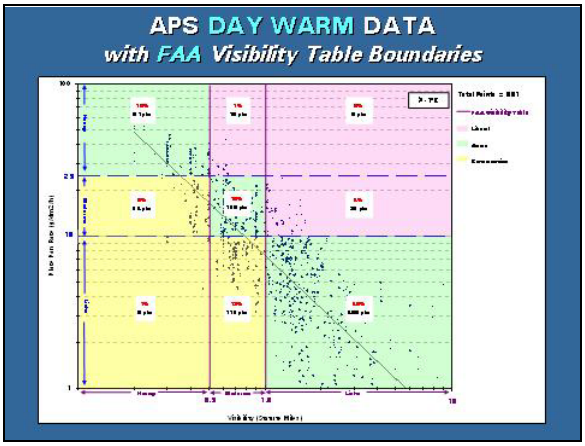

APS DAY COLD DATA
with FAA Visibility Table Boundaries

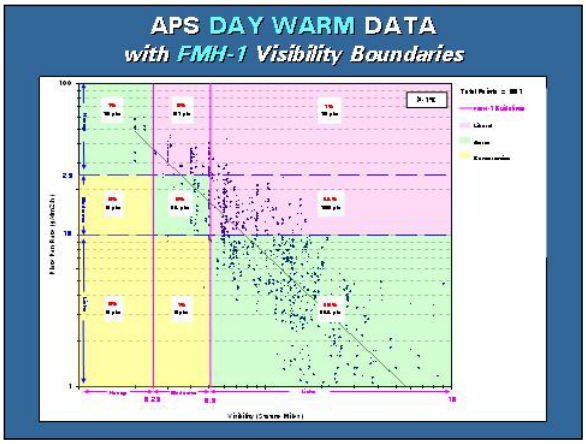

APS DAY COLD DATA
with FAA Visibility Table Boundaries

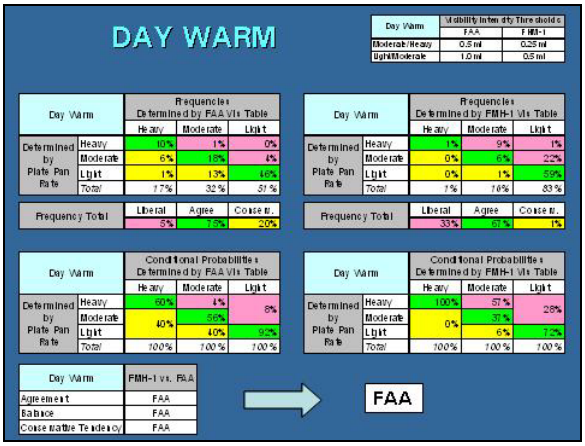

APS DAY COLD DATA
with FAA Visibility Table Boundaries

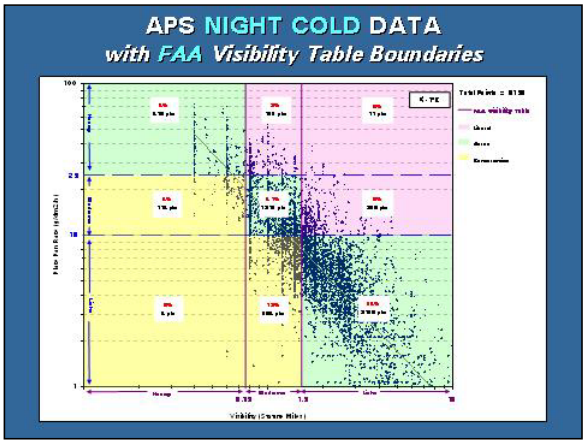

APS DAY COLD DATA
with FMH-1 Visibility Boundaries

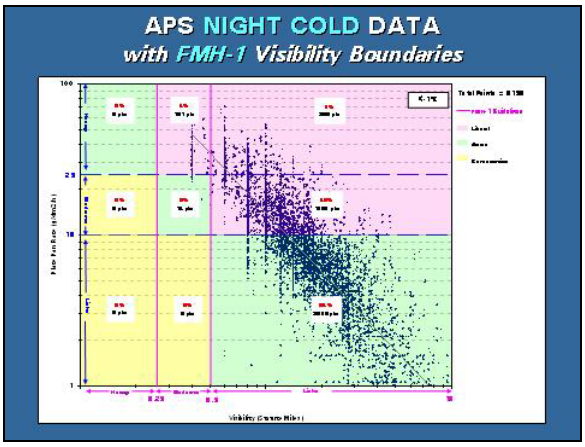

DAY COLD
FAA

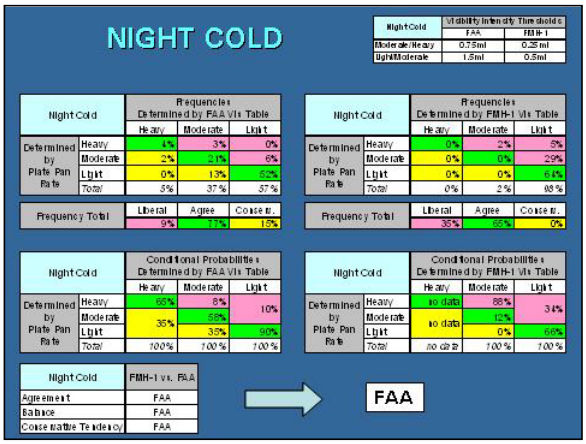

APS DAY WARM DATA
with FAA Visibility Table Boundaries

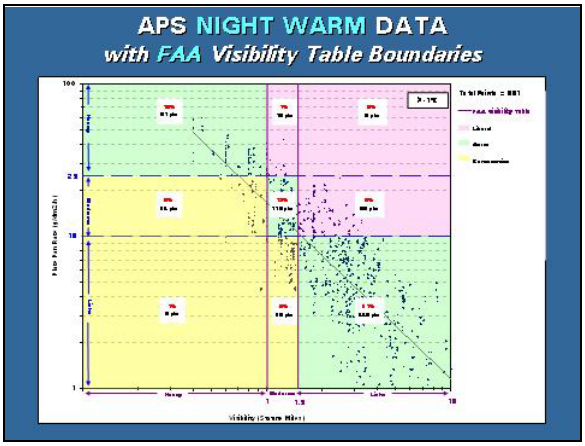

APS DAY WARM DATA
with FMH-1 Visibility Boundaries

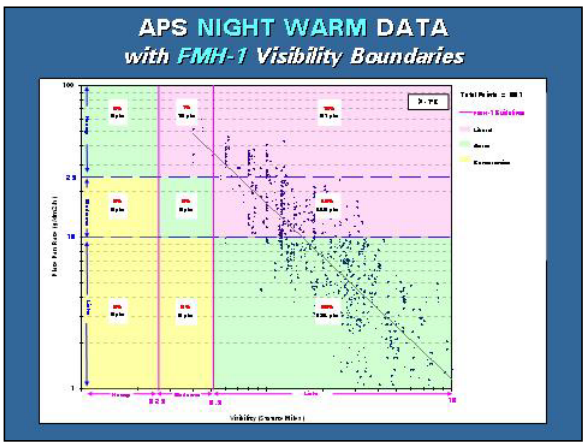

DAY WARM
FAA

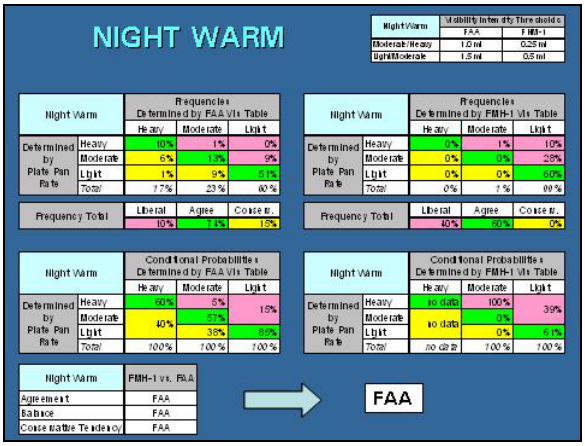

APS NIGHT COLD DATA
with FAA Visibility Table Boundaries

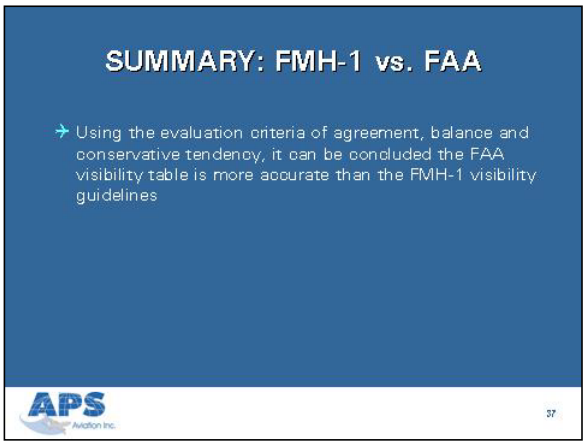

APS NIGHT COLD DATA
with FMH-1 Visibility Boundaries


NIGHT COLD
Night Cold
Visibility Intensity Thresholds
FAA
FMH-1
Moderate/Heavy
0.75mi
0.25mi
Light/Moderate
1.5mi
0.5mi
Night Cold
Frequencies Determined by FAA Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
4%
3%
0%
Moderate
2%
21%
6%
Light
0%
13%
62%
Total
5%
37%
67%
Frequency Total
Liberal
Agree
Conserv.
9%
77%
15%
Night Cold
Frequencies Determined by FMH-1 Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
0%
2%
5%
Moderate
0%
0%
29%
Light
0%
0%
64%
Total
0%
2%
98%
Frequency Total
Liberal
Agree
Conserv.
35%
65%
0%
Night Cold
Conditional Probabilities Determined by FAA Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
65%
8%
10%
Moderate
35%
58%
Light
33%
90%
Total
100%
100%
100%
Night Cold
Conditional Probabilities Determined by FMH-1 Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
no data
86%
34%
Moderate
no data
12%
Light
0%
66%
Total
no data
100%
100%
Night Cold
FMH-1 vs. FAA
Agreement
FAA
Balance
FAA
Conservative Tendency
FAA
FAA


APS NIGHT WARM DATA
with FAA Visibility Table Boundaries


APS NIGHT WARM DATA
with FMH-1 Visibility Boundaries


NIGHT WARM
Night Warm
Visibility Intensity Thresholds
FAA
FMH-1
Moderate/Heavy
1.0 mi
0.25 mi
Light/Moderate
1.5 mi
0.5 mi
Night Warm
Frequencies Determined by FAA Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
10%
1%
0%
Moderate
6%
13%
9%
Light
1%
9%
51%
Total
17%
23%
60%
Frequency Total
Liberal
Agree
Conserv.
10%
74%
15%
Night Warm
Frequencies Determined by FMH-1 Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
0%
1%
10%
Moderate
0%
0%
28%
Light
0%
0%
60%
Total
0%
1%
99%
Frequency Total
Liberal
Agree
Conserv.
40%
60%
0%
Night Warm
Conditional Probabilities Determined by FAA Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
60%
5%
15%
Moderate
40%
57%
Light
38%
85%
Total
100%
100%
100%
Night Warm
Conditional Probabilities Determined by FMH-1 Vis Table
Heavy
Moderate
Light
Determined by Plate Pan Rate
Heavy
no data
100%
39%
Moderate
no data
0%
Light
0%
61%
Total
no data
100%
100%
Night Warm
FMH-1 vs. FAA
Agreement
FAA
Balance
FAA
Conservative Tendency
FAA
FAA


SUMMARY: FMH-1 vs. FAA
Using the evaluation criteria of agreement, balance and conservative tendency, it can be concluded the FAA visibility table is more accurate than the FMH-1 visibility guidelines
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ANALYSIS: FAA vs. RASMUSSEN

- Objective: To use the APS visibility / snowfall intensity databases to evaluate the ability of the FAA and Rasmussen visibility tables to accurately predict snowfall intensity
- The analysis follows the same pattern as the FAA/FMH-1 analysis

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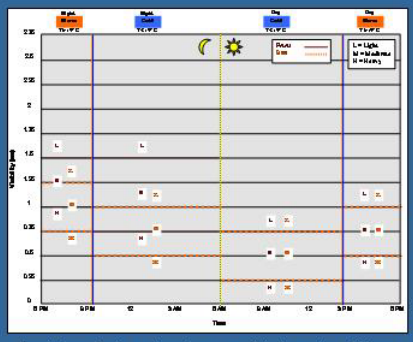
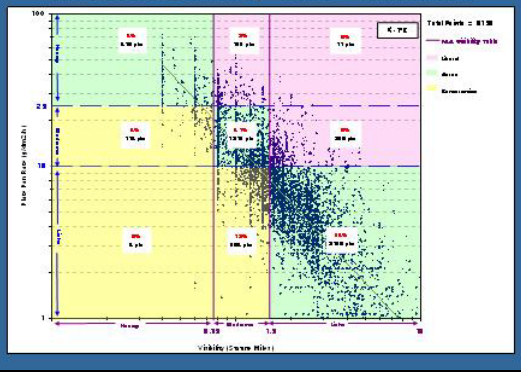
FAA vs. RASMUSSEN VISIBILITY DIVISIONS

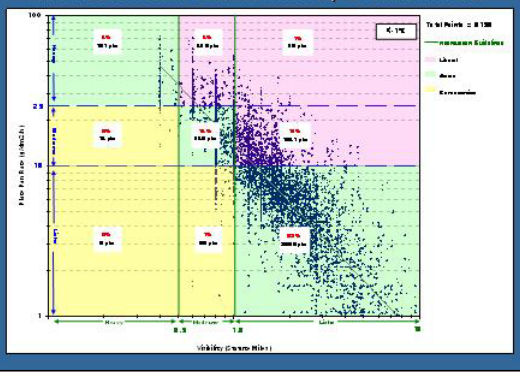


Conclusion: daytime values the same, nighttime values different

APS NIGHT COLD DATA
with FAA Visibility Table Boundaries



APS NIGHT COLD DATA
with Rasmussen Visibility Boundaries



NIGHT COLD

Night Cold	Visibility Intensity Thresholds	
	FAA	Rasmussen
Moderate/Heavy	0.75mi	0.5mi
Light/Moderate	1.5mi	1.0mi

Night Cold		Frequencies Determined by FAA Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	4%	3%	0%
	Moderate	2%	21%	6%
	Light	0%	13%	52%
	Total	*5%*	*37%*	*57%*
Frequency Total		Liberal	Agree	Conserv.
		9%	77%	15%

Night Cold		Frequencies Determined by RAS Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	2%	1%	1%
	Moderate	0%	12%	17%
	Light	0%	1%	63%
	Total	*2%*	*17%*	*81%*
Frequency Total		Liberal	Agree	Conserv.
		2%	79%	2%

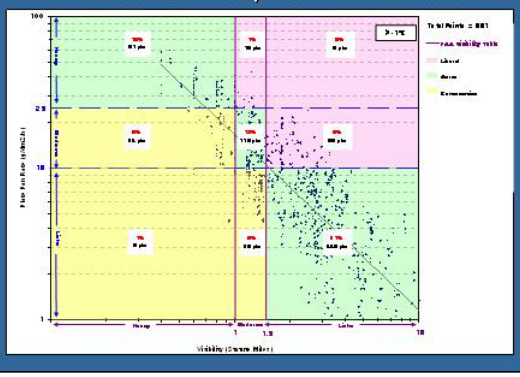
Night Cold		Conditional Probabilities Determined by FAA Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	65%	8%	10%
	Moderate	35%	58%	
	Light		35%	90%
	Total	*100%*	*100%*	*100%*

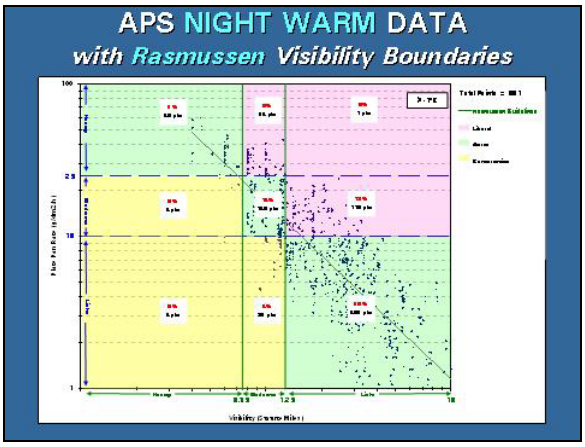
Night Cold		Conditional Probabilities Determined by RAS Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	88%	24%	22%
	Moderate	12%	69%	
	Light		8%	78%
	Total	*100%*	*100%*	*100%*

Night Cold	FAA vs. RAS
Agreement	-
Balance	FAA
Conservative Tendency	FAA

→ FAA

APS NIGHT WARM DATA
with FAA Visibility Table Boundaries





NIGHT WARM

Night Warm	Visibility Intensity Thresholds	
	FAA	Rasmussen
Moderate/Heavy	1.0mi	0.75mi
Light/Moderate	1.5mi	1.25mi

Night Warm		Frequencies Determined by FAA Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	10%	1%	0%
	Moderate	6%	13%	9%
	Light	1%	9%	51%
	Total	17%	23%	60%
Frequency Total		Liberal	Agree	Conserv.
		10%	71%	19%

Night Warm		Frequencies Determined by RAS Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	5%	6%	0%
	Moderate	0%	14%	13%
	Light	0%	4%	58%
	Total	6%	24%	70%
Frequency Total		Liberal	Agree	Conserv.
		20%	76%	5%

Night Warm		Conditional Probabilities Determined by FAA Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	60%	5%	15%
	Moderate	40%	57%	15%
	Light	-	38%	85%
	Total	100%	100%	100%

Night Warm		Conditional Probabilities Determined by RAS Vis Table		
		Heavy	Moderate	Light
Determined by Plate Pan Rate	Heavy	88%	25%	19%
	Moderate	12%	59%	6%
	Light	-	16%	81%
	Total	100%	100%	100%

Night Warm	FAA vs. RAS
Agreement	-
Balance	FAA
Conservative Tendency	FAA

FAA

SUMMARY: RASMUSSEN vs. FAA

- When evaluated by agreement, balance and conservative tendency, the FAA visibility table appears to be more accurate than the Rasmussen visibility table

APS Aviation Inc.

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AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2008-09 WINTER TEST SEASON

APS Aviation Inc.

ISO-9001:2000

SAE G-12 HOLDOVER TIME SUBCOMMITTEE CHARLESTON - MAY 12, 2009

Presented by Stephanie Bendickson

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

OUTLINE

- Endurance Time Test Program 2008-09
  - Procedure and methodology
  - Type II test results
  - Type IV test results
- Changes to HOT Guidelines for 2009-10
  - Type I
  - Type II
  - Type III
  - Type IV

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ENDURANCE TIME TEST PROGRAM

Winter 2008-09

PROCEDURE/METHODOLOGY

- Endurance time testing is conducted in:
  - Natural Snow
  - Freezing Fog
  - Freezing Drizzle
  - Light Freezing Rain
  - Rain on Cold-Soaked Wing

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PROCEDURE/METHODOLOGY

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45	0:10 – 0:20	CAUTION: No holdover time guidelines exist	
		75/25	5:00	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30	0:05 – 0:15		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 – 0:20	0:15 – 0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

NATURAL SNOW

- No control over rate, temperature, wind
- Entire snow data set is considered when analyzing the performance of any fluid
- Snow holdover time range is determined at 10 and 25 g/dm²/h

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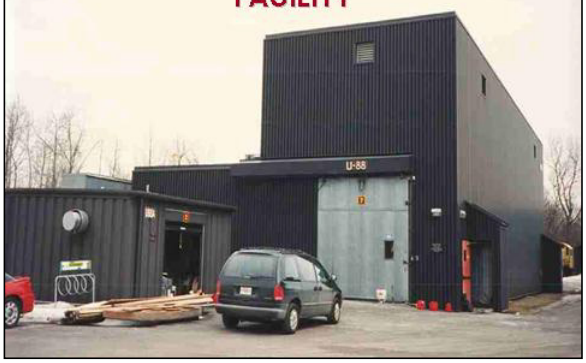
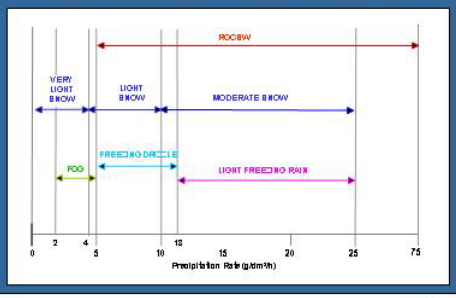
NRC CLIMATIC ENGINEERING FACILITY



DATA RANGES USED FOR EVALUATION OF HOLDOVER TIME LIMITS



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PROCEDURE/METHODOLOGY

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45	0:10 – 0:20	CAUTION: No holdover time guidelines exist	
		75/25	5:00	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30	0:05 – 0:15		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 – 0:20	0:15 – 0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

FREEZING FOG

- Tests are conducted at 2 and 5 g/dm²/h
- Test temperatures: -3, -14 and -25°C

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FREEZING DRIZZLE

- Tests are conducted at 5 and 13 g/dm²/h
- Test temperatures: -3 and -10°C

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LIGHT FREEZING RAIN

- Tests are conducted at 13 and 25 g/dm²/h
- Test temperatures: -3 and -10°C

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RAIN ON A COLD-SOAKED WING

- Drizzle and moderate rain are simulated:
  - Drizzle (low end) rate: 5 g/dm²/h
  - Moderate rain (high end) rate: 75 g/dm²/h
- Ambient air temp. = +1°C
- Cooled box temp. = -10°C

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FLUID FAILURE

Fluid failure occurs when:

- Accumulation of snow bridging on top of the fluid or plate; or
- Accumulation of ice on top of the fluid or plate, or ice suspended within the fluid

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PLATE END CONDITION

Plate end condition is achieved when fluid failures occur:

- At any 5 of the crosshair markings on the panel; or
- On more than 30% of the entire plate surface

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ENDURANCE TIME DATA ANALYSIS METHODOLOGY

- Endurance times are derived using regression analysis that provides a power law relationship
- General form of the equation for freezing fog, freezing drizzle, light freezing rain, and rain on a cold-soaked wing is: $t = cR^b$
- General form of the equation for snow is: $t = cR^b(2\text{-}T)^a$
- Where
  - t = Endurance time
  - R = Rate of precipitation
  - T = Temperature
  - a, b, c = Coefficients determined from the regression

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SUMMARY OF PROCEDURE USED TO DETERMINE HOLDOVER TIME LIMITS

- Curves are plotted for each fluid and each cell of the holdover time table using the MOST RESTRICTIVE TEMPERATURE in the cell
- Upper and lower holdover time values are determined using the specific precipitation rate ranges for each condition
- Numbers are rounded to the nearest whole "5" value
- For safety reasons, holdover times below 10 minutes are always rounded down

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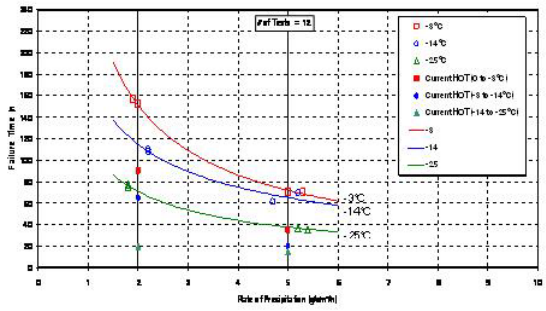
EXAMPLE OF REGRESSION ANALYSIS



WINTER 2008-09 TEST PROGRAM

- Type I: No new non-glycol fluids will be commercialized
- Type II: One fluid will be commercialized
  - **Aviation Shaanxi Hi-Tech Cleanwing II**
- Type III: No fluids will be commercialized
- Type IV: Two fluids will be commercialized
  - **ABAX Ecowing AD-49**
  - **Kilfrost ABC-4^{sustain}**

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WSET RESULTS

(Provided by AMIL)

Aviation Shaanxi Cleanwing II	ABAX Ecowing AD-49	Kilfrost ABC-4^{sustain}
32 mins.	99 mins.	88 mins.

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TESTS CONDUCTED

FLUID	Aviation Shaanxi Cleanwing II			ABAX Ecowing AD-49			Kilfrost ABC-4^{sustain}		
	Neat	75/25	50/50	Neat	75/25	50/50	Neat	75/25	50/50
Freezing Fog	12	8	4	14	8	4	12	8	4
Natural Snow	16	16	10	12	13	12	14	15	11
Freezing Drizzle	8	8	4	8	8	4	8	8	4
Freezing Rain	8	8	4	8	14	4	8	8	4
Cold-Soak Surface	4	4	n/a	4	5	n/a	4	4	n/a
Total	48	44	22	46	48	24	46	43	23

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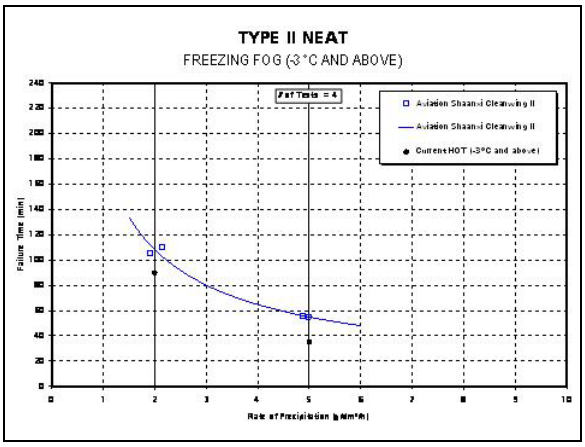
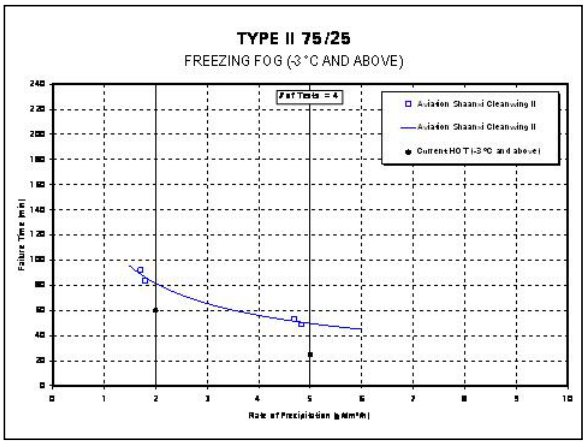
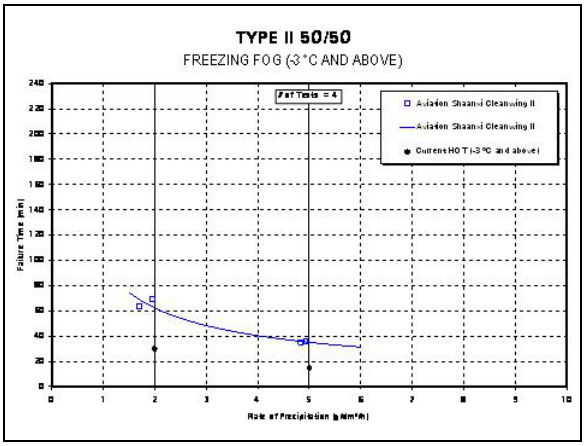
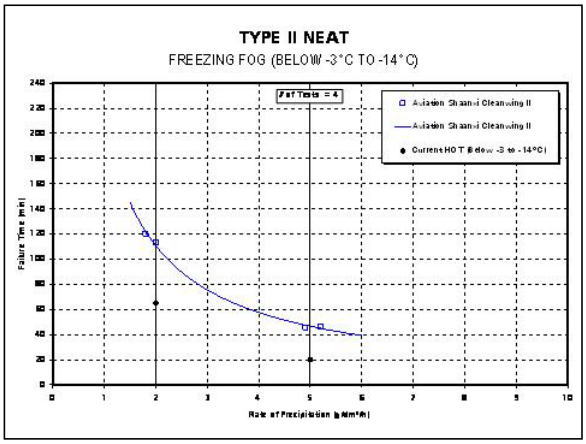
TYPE II TEST RESULTS

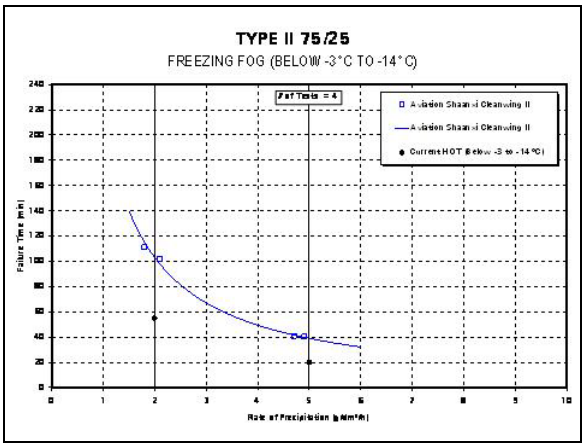
- **Aviation Shaanxi Hi-Tech Cleanwing II**

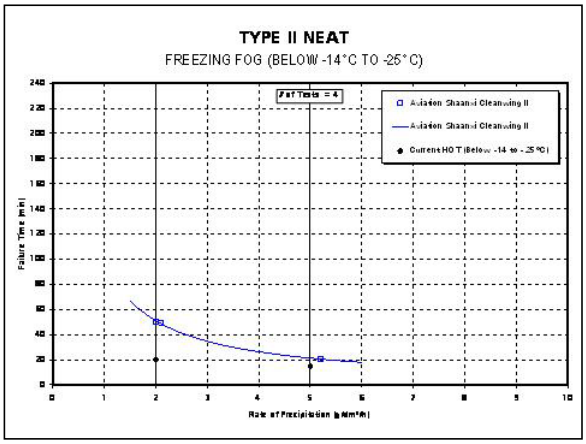

TYPE II NEAT
FREEZING FOG (-3°C AND ABOVE)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)


TYPE II 75/25
FREEZING FOG (-3°C AND ABOVE)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)

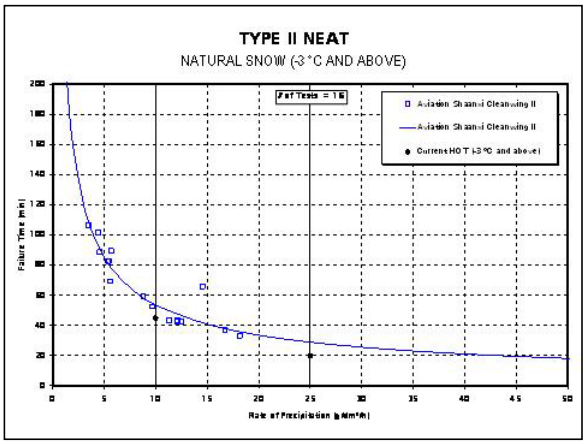

TYPE II 50/50
FREEZING FOG (-3°C AND ABOVE)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)

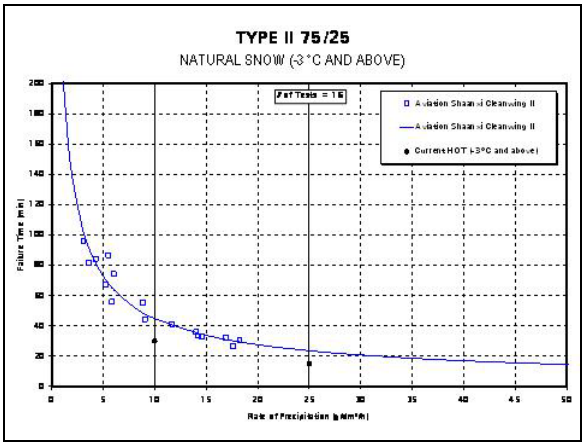

TYPE II NEAT
FREEZING FOG (BELOW -3°C TO -14°C)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -14°C)
Failure Time (min)
Rate of Precipitation (mm*/h)

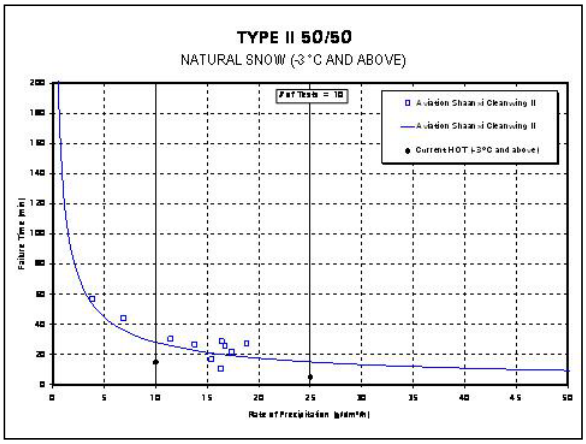

TYPE II 75/25
FREEZING FOG (BELOW -3°C TO -14°C)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -14°C)
Failure Time (min)
Rate of Precipitation (mm*/h)

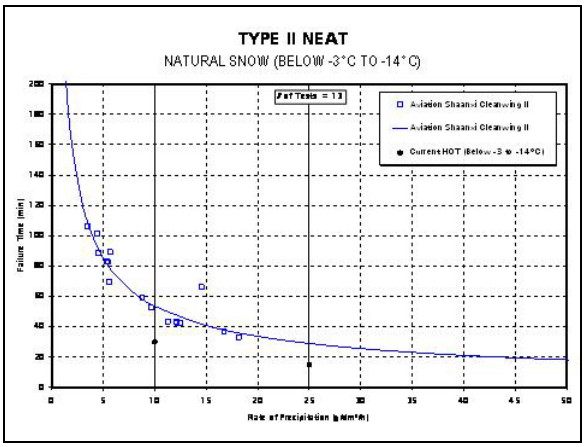

TYPE II NEAT
FREEZING FOG (BELOW -14°C TO -25°C)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -14 to -25°C)
Failure Time (min)
Rate of Precipitation (mm*/h)

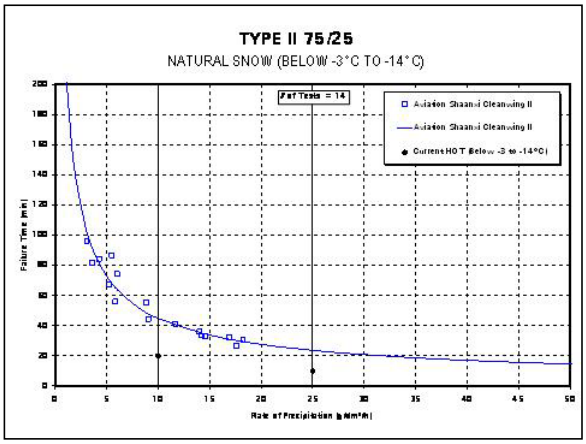
NATURAL SNOW

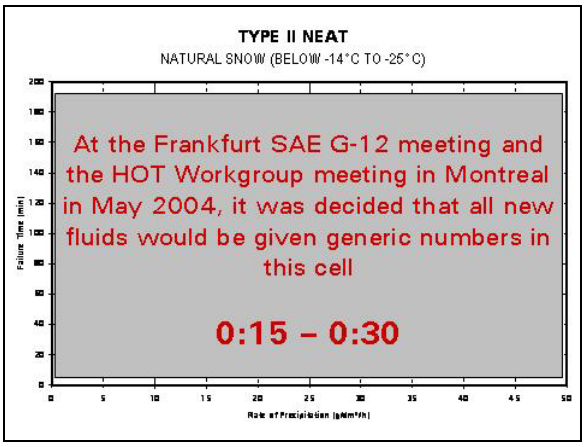

TYPE II NEAT
NATURAL SNOW (-3°C AND ABOVE)
Pat Tests = 16
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)


TYPE II 75/25
NATURAL SNOW (-3°C AND ABOVE)
Pat Tests = 16
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

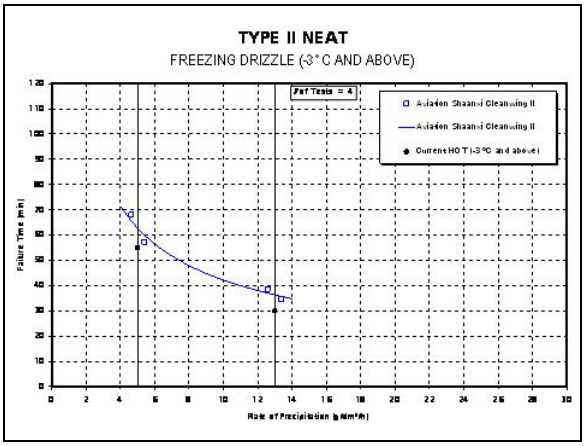

TYPE II 50/50
NATURAL SNOW (-3°C AND ABOVE)
Pat Tests = 16
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

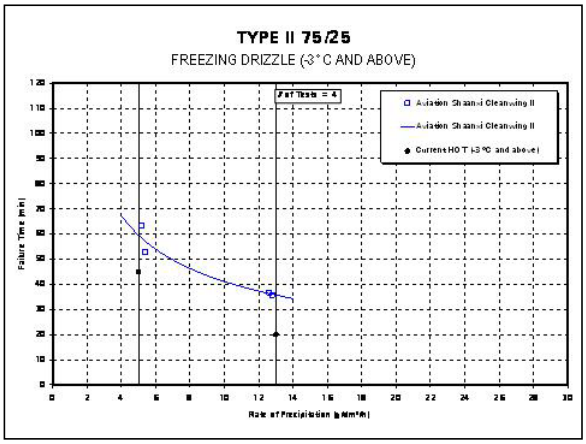

TYPE II NEAT
NATURAL SNOW (BELOW -3°C TO -14°C)
Pat Tests = 13
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -14°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

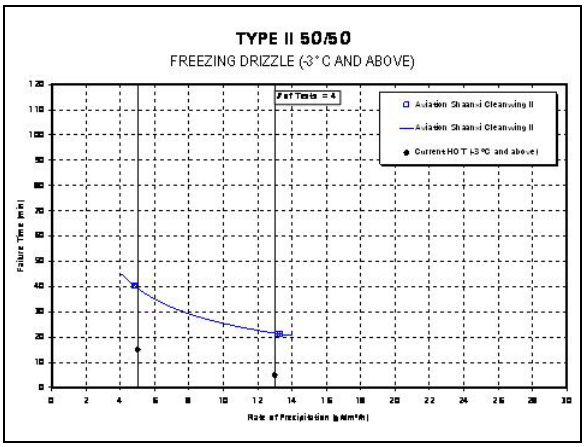

TYPE II 75/25
NATURAL SNOW (BELOW -3°C TO -14°C)
Pat Tests = 14
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT Below -3 to -14°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

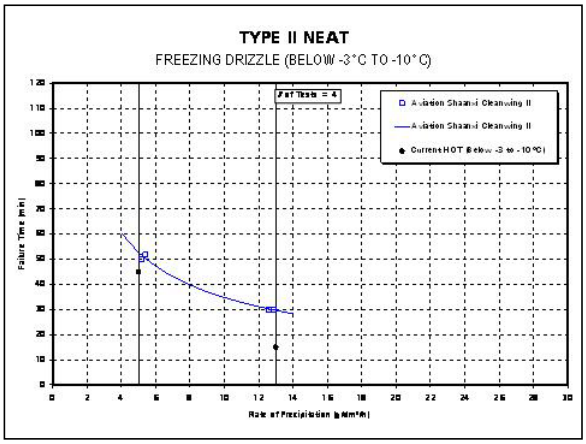

TYPE II NEAT
NATURAL SNOW (BELOW -14°C TO -25°C)
At the Frankfurt SAE G-12 meeting and the HOT Workgroup meeting in Montreal in May 2004, it was decided that all new fluids would be given generic numbers in this cell
0:15 – 0:30

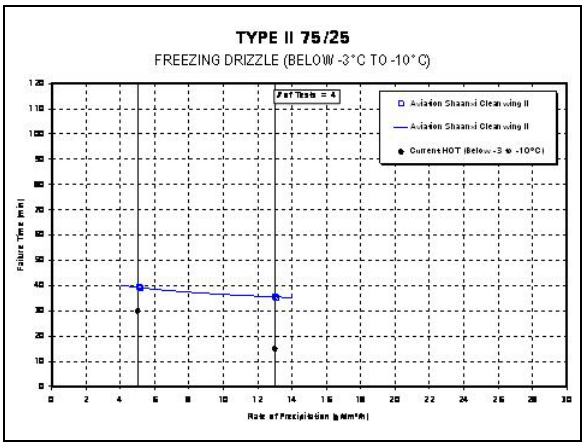
FREEZING DRIZZLE


TYPE II NEAT
FREEZING DRIZZLE (-3°C AND ABOVE)

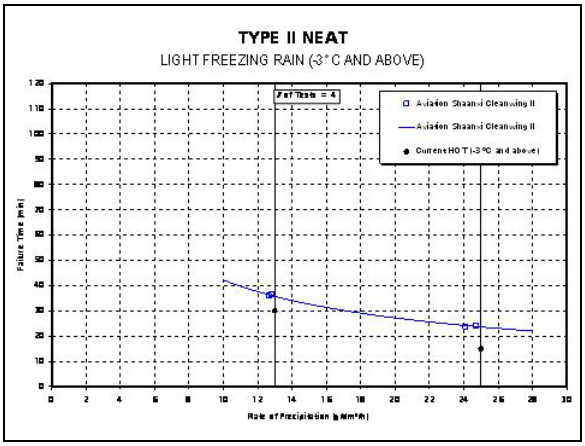

TYPE II 75/25
FREEZING DRIZZLE (-3°C AND ABOVE)

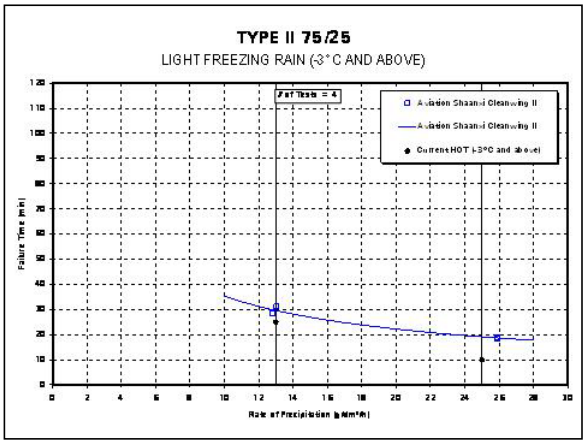

TYPE II 50/50
FREEZING DRIZZLE (-3°C AND ABOVE)

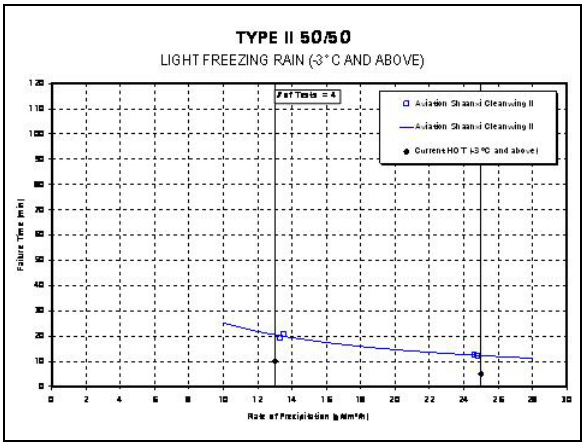

TYPE II NEAT
FREEZING DRIZZLE (BELOW -3°C TO -10°C)

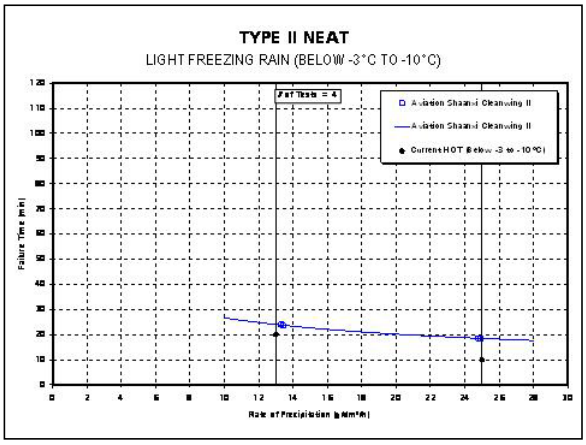

TYPE II 75/25
FREEZING DRIZZLE (BELOW -3°C TO -10°C)
# of Tests = 4
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -10°C)
Failure Time (min)
Rate of Precipitation (mm*/h)

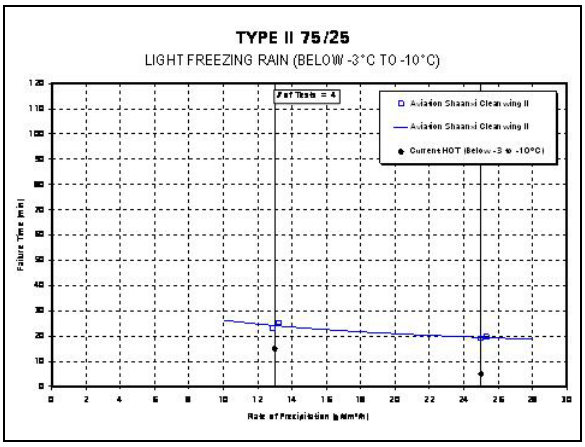
LIGHT FREEZING RAIN


TYPE II NEAT
LIGHT FREEZING RAIN (-3°C AND ABOVE)
# of Tests = 4
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)

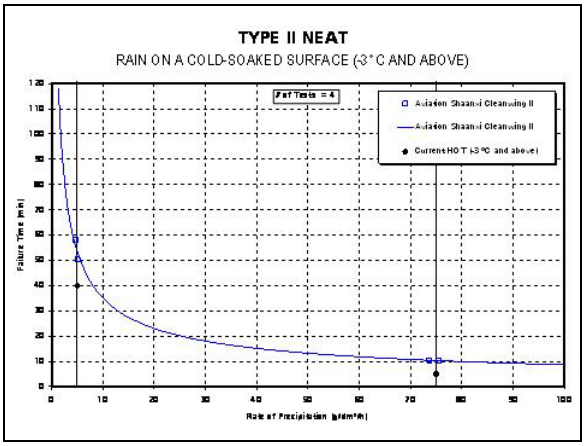

TYPE II 75/25
LIGHT FREEZING RAIN (-3°C AND ABOVE)
# of Tests = 4
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)

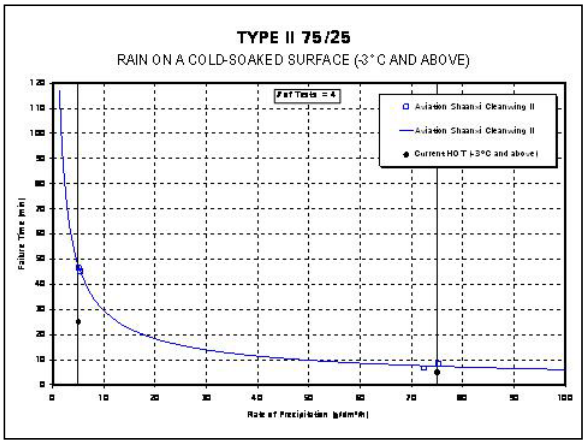

TYPE II 50/50
LIGHT FREEZING RAIN (-3°C AND ABOVE)
# of Tests = 4
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (mm*/h)

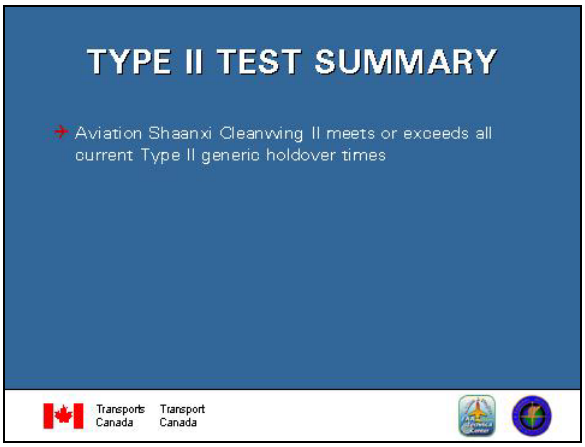

TYPE II NEAT
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)
# of Tests = 4
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -10°C)
Failure Time (min)
Rate of Precipitation (mm*/h)

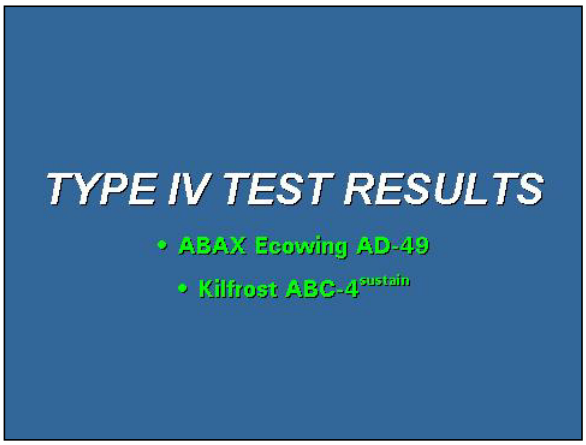

TYPE II 75/25
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (Below -3 to -10°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

RAIN ON A COLD-SOAKED WING

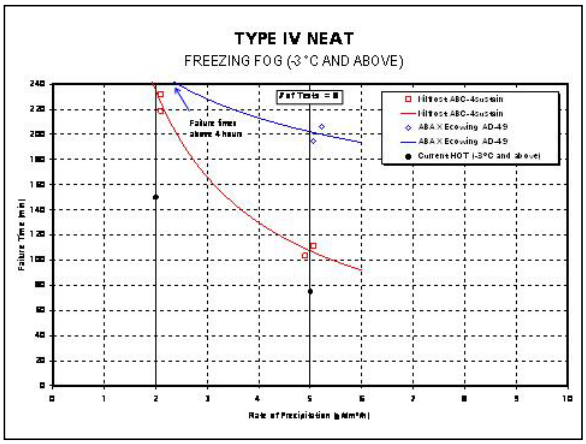

TYPE II NEAT
RAIN ON A COLD-SOAKED SURFACE (-3°C AND ABOVE)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

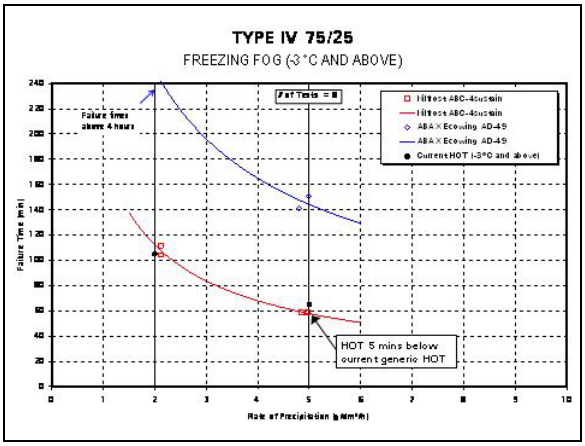

TYPE II 75/25
RAIN ON A COLD-SOAKED SURFACE (-3°C AND ABOVE)
Aviation Shaanxi Cleanwing II
Aviation Shaanxi Cleanwing II
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

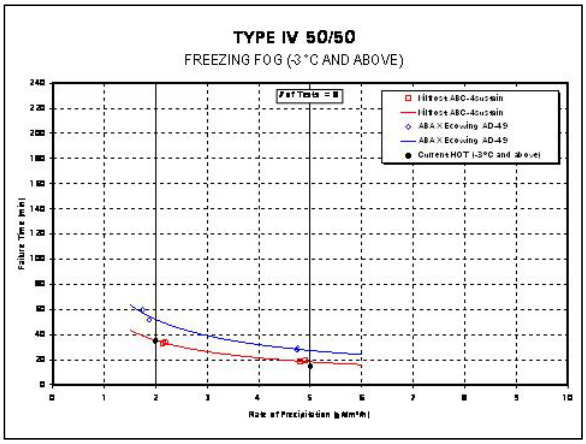

TYPE II TEST SUMMARY
Aviation Shaanxi Cleanwing II meets or exceeds all current Type II generic holdover times
Transports Canada
Transport Canada

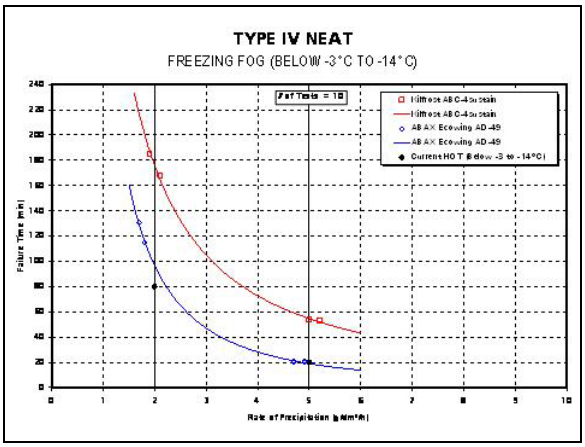

TYPE IV TEST RESULTS
• ABAX Ecowing AD-49
• Kilfrost ABC-4sustain

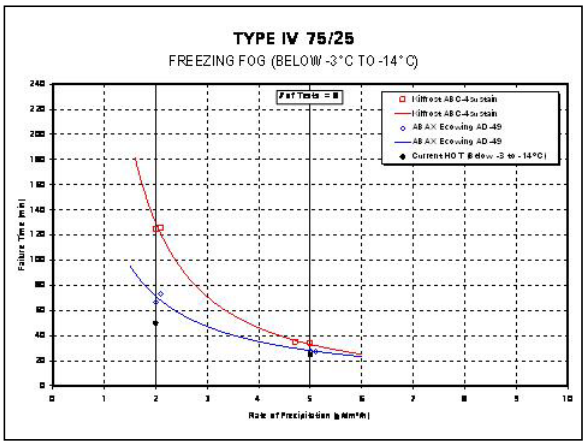
FREEZING FOG

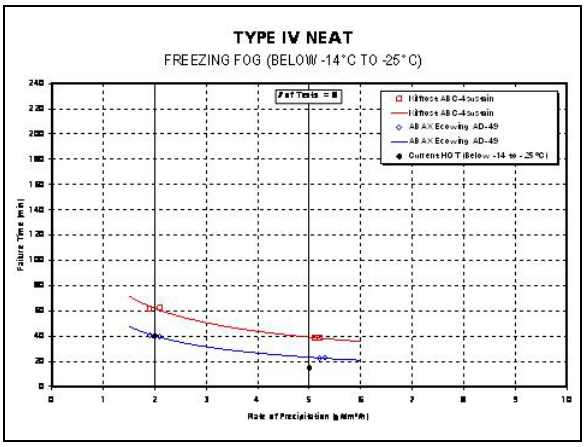

TYPE IV NEAT
FREEZING FOG (-3°C AND ABOVE)
Ref Tests = 8
Failure times above 4 hours
Failure Time (min)
Rate of Precipitation (mm*/hr)


TYPE IV 75/25
FREEZING FOG (-3°C AND ABOVE)
Ref Tests = 8
Failure times above 4 hours
HOT 5 mins below current generic HOT
Failure Time (min)
Rate of Precipitation (mm*/hr)

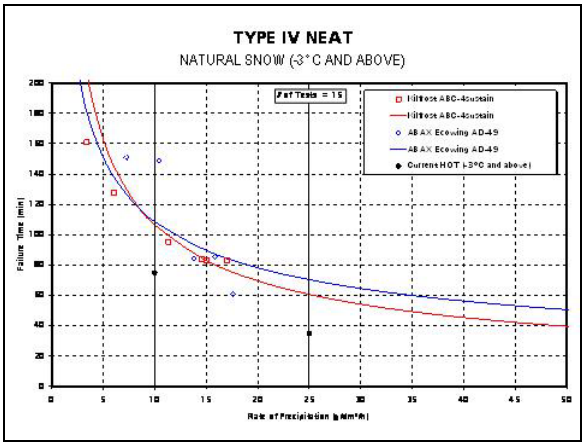

TYPE IV 50/50
FREEZING FOG (-3°C AND ABOVE)
Ref Tests = 8
Failure Time (min)
Rate of Precipitation (mm*/hr)

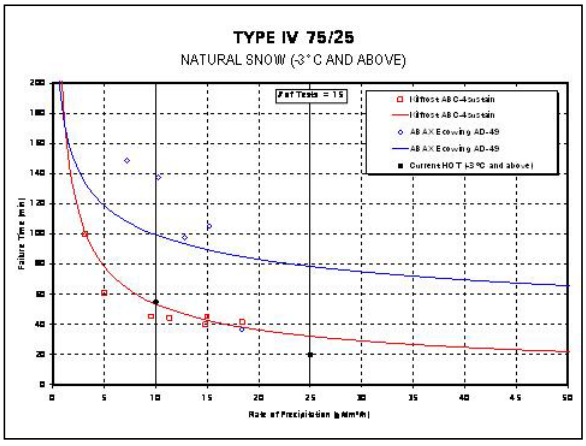

TYPE IV NEAT
FREEZING FOG (BELOW -3°C TO -14°C)
Ref Tests = 10
Failure Time (min)
Rate of Precipitation (mm*/hr)

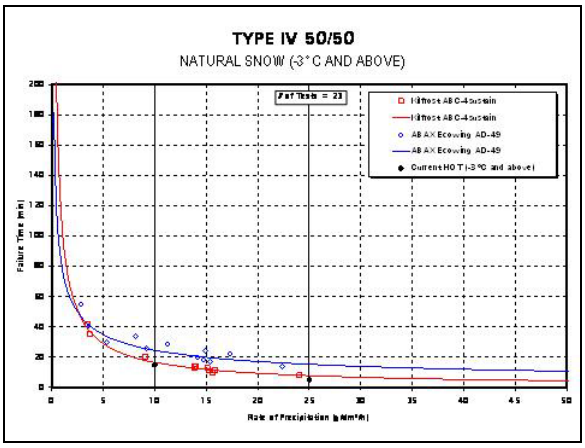

TYPE IV 75/25
FREEZING FOG (BELOW -3°C TO -14°C)
Ref Tests = 8
Failure Time (min)
Rate of Precipitation (mm*/hr)

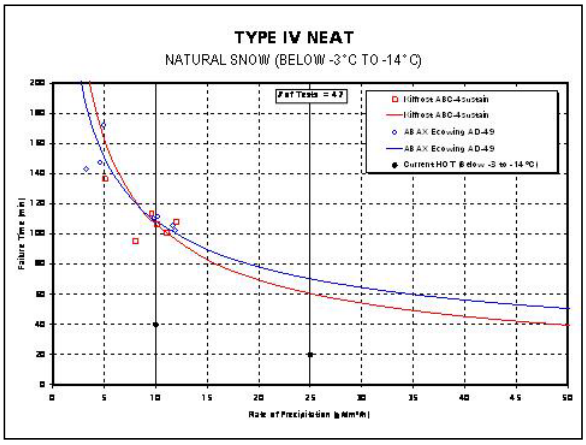

TYPE IV NEAT
FREEZING FOG (BELOW -14°C TO -25°C)
Ref Tests = 8
Hiltnose ABC-4sustain
Hiltnose ABC-4sustain
AB AX Ecowing AD-49
AB AX Ecowing AD-49
Current HOT (Below -14 to -25°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

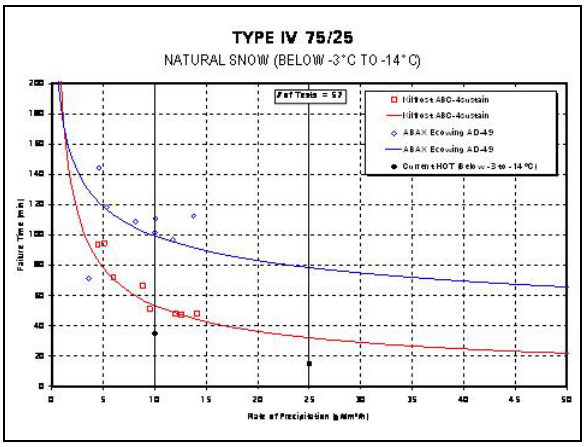
NATURAL SNOW

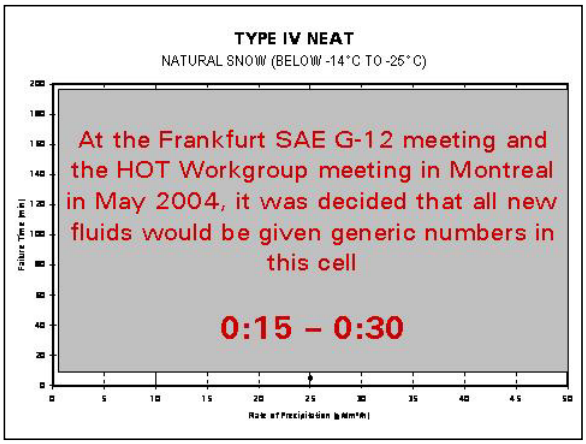

TYPE IV NEAT
NATURAL SNOW (-3°C AND ABOVE)
Ref Tests = 15
Hiltnose ABC-4sustain
Hiltnose ABC-4sustain
AB AX Ecowing AD-49
AB AX Ecowing AD-49
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)


TYPE IV 75/25
NATURAL SNOW (-3°C AND ABOVE)
Ref Tests = 15
Hiltnose ABC-4sustain
Hiltnose ABC-4sustain
AB AX Ecowing AD-49
AB AX Ecowing AD-49
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

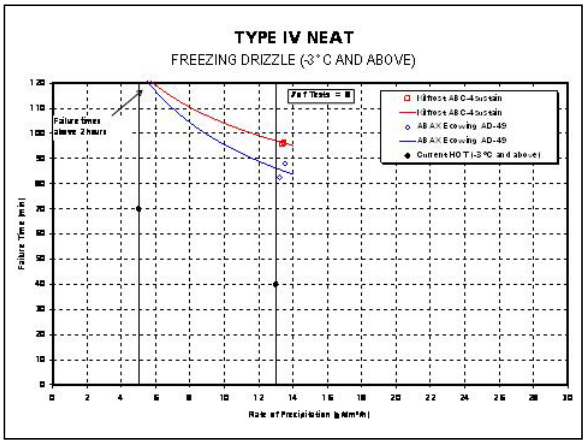

TYPE IV 50/50
NATURAL SNOW (-3°C AND ABOVE)
Ref Tests = 23
Hiltnose ABC-4sustain
Hiltnose ABC-4sustain
AB AX Ecowing AD-49
AB AX Ecowing AD-49
Current HOT (-3°C and above)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

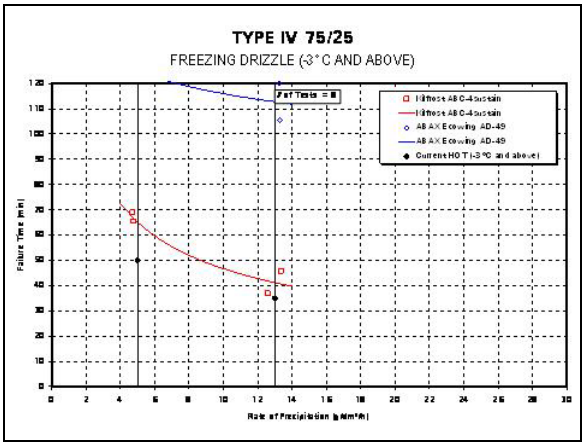

TYPE IV NEAT
NATURAL SNOW (BELOW -3°C TO -14°C)
Ref Tests = 42
Hiltnose ABC-4sustain
Hiltnose ABC-4sustain
AB AX Ecowing AD-49
AB AX Ecowing AD-49
Current HOT (Below -3 to -14°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

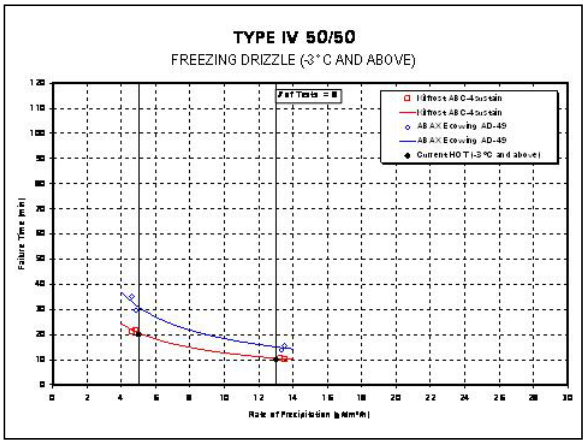

TYPE IV 75/25
NATURAL SNOW (BELOW -3°C TO -14°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

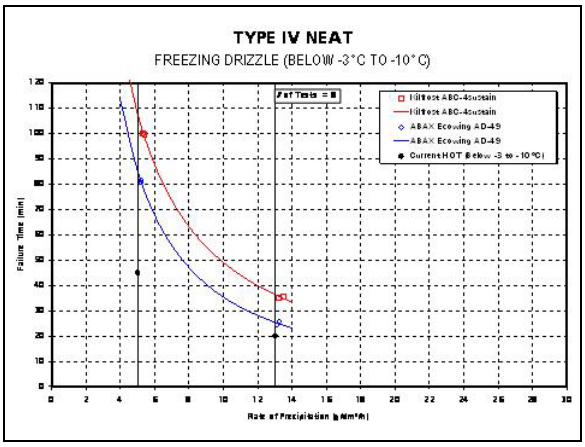

TYPE IV NEAT
NATURAL SNOW (BELOW -14°C TO -25°C)
At the Frankfurt SAE G-12 meeting and the HOT Workgroup meeting in Montreal in May 2004, it was decided that all new fluids would be given generic numbers in this cell
0:15 – 0:30
Failure Time (min)
Rate of Precipitation (g/dm²/h)

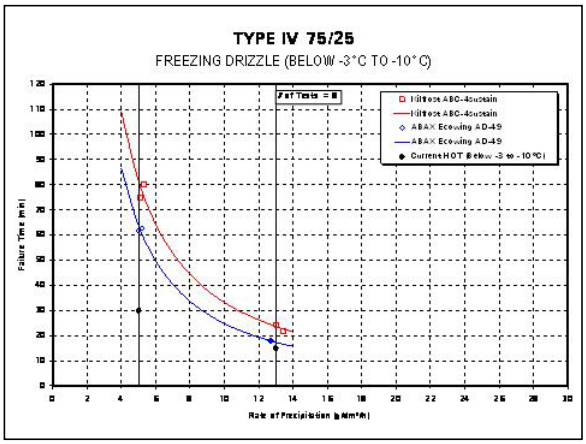
FREEZING DRIZZLE


TYPE IV NEAT
FREEZING DRIZZLE (-3°C AND ABOVE)
Failure times above 2 hours
Failure Time (min)
Rate of Precipitation (g/dm²/h)

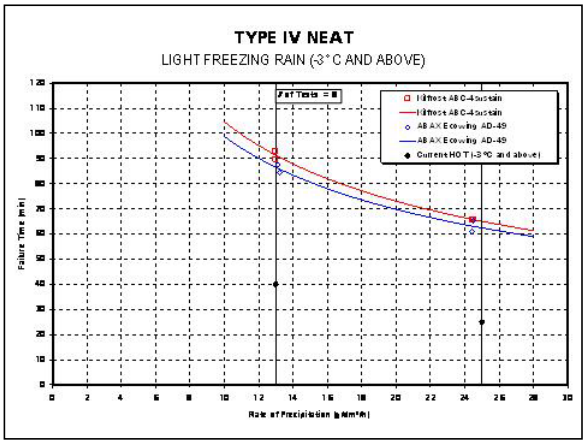

TYPE IV 75/25
FREEZING DRIZZLE (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

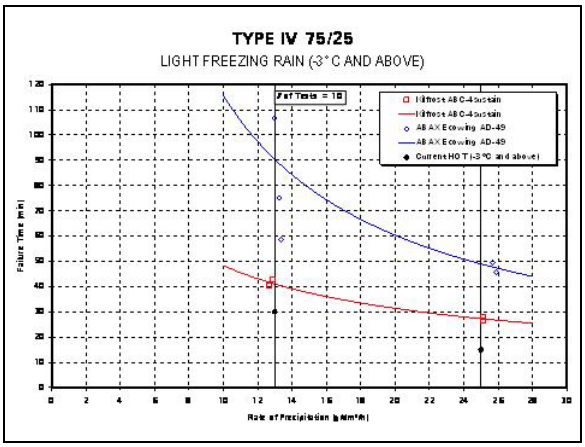

TYPE IV 50/50
FREEZING DRIZZLE (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

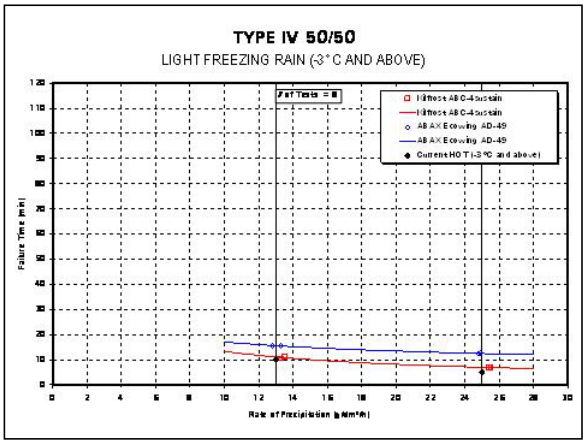

TYPE IV NEAT
FREEZING DRIZZLE (BELOW -3°C TO -10°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

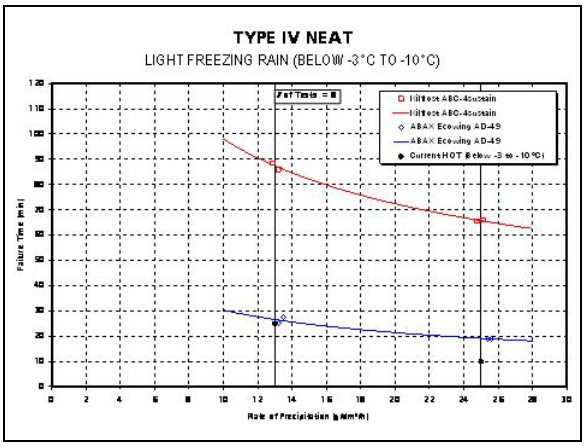

TYPE IV 75/25
FREEZING DRIZZLE (BELOW -3°C TO -10°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

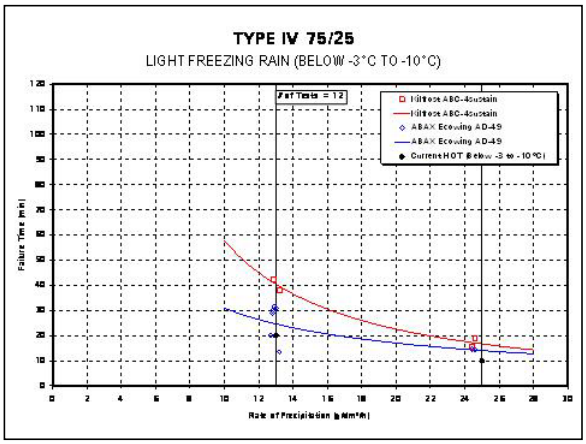
LIGHT FREEZING RAIN


TYPE IV NEAT
LIGHT FREEZING RAIN (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

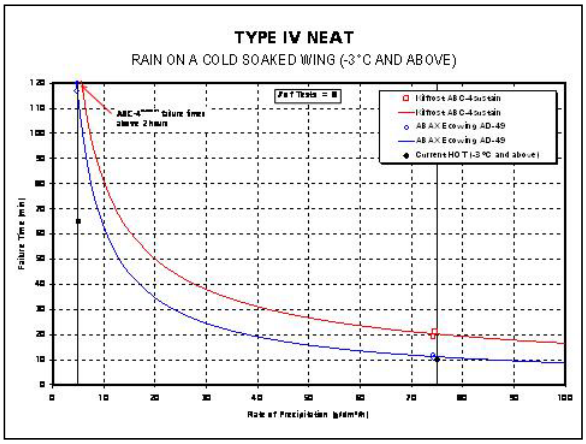

TYPE IV 75/25
LIGHT FREEZING RAIN (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

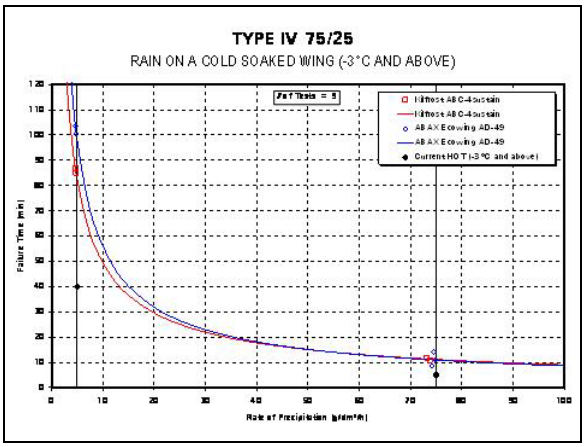

TYPE IV 50/50
LIGHT FREEZING RAIN (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

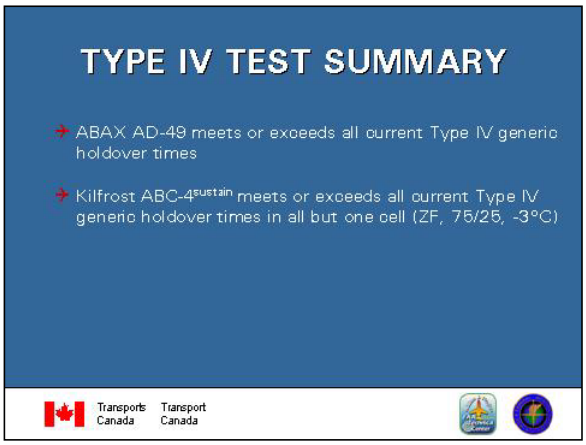

TYPE IV NEAT
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)


TYPE IV 75/25
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)
Failure Time (min)
Rate of Precipitation (g/dm²/h)

RAIN ON A COLD-SOAKED WING


TYPE IV NEAT
RAIN ON A COLD SOAKED WING (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)


TYPE IV 75/25
RAIN ON A COLD SOAKED WING (-3°C AND ABOVE)
Failure Time (min)
Rate of Precipitation (g/dm²/h)


TYPE IV TEST SUMMARY
ABAX AD-49 meets or exceeds all current Type IV generic holdover times
Kilfrost ABC-4sustain meets or exceeds all current Type IV generic holdover times in all but one cell (ZF, 75/25, -3°C)
Transports Canada
Transport Canada

OUTLINE

- Endurance Time Test Program 2008-09
  - Procedure and methodology
  - Type II test results
  - Type IV test results
- Changes to HOT Guidelines for 2009-10
  - Type I
  - Type II
  - Type III
  - Type IV

Transports Canada Transport Canada

CHANGES TO HOT GUIDELINES

For the Winter 2009-10 Season

TYPE I

TYPE I

- No changes will be made to the generic Type I HOT guidelines for the winter of 2009-10
- No changes will be made to the associated visibility tables for the winter of 2009-10

Transports Canada Transport Canada

FAA/TC TYPE I HOT GUIDELINES 2009-10

FAA TYPE I HOLDOVER TIME GUIDELINE

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow/Snow Grains			Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing[1,2]	Other[3]
				Very Light[4,5]	Light[4,5]	Moderate[4,5]				
-3 and above	27 and above	0:45	0:11-0:17	0:10-0:22	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	0:45	0:06-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	0:45	0:06-0:10	0:11-0:13	0:08-0:11	0:04-0:06	0:04-0:07			
below -10	below 14	0:45	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009

Outside Air Temperature[6]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains[7]			Freezing Drizzle[8]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[9]
				Very Light	Light	Moderate				
-3 and above	27 and above	45	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	45	6 – 13	14	6 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	45	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
below -10	below 14	45	5 – 9	7	4 – 7	2 – 4				

CAUTION: No holdover time guidelines exist

NO CHANGES

Transport Canada

FAA/TC VISIBILITY TABLES 2009-10

TABLE 8B SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY

Time of Day	Temp.	Visibility (Statute Mile)						
	Degrees Celsius / Degrees Fahrenheit	≤ 1/4	1/2	3/4	1	1 1/4	1 1/2	≥ 1 3/4
Day	warmer than -1 / warmer than 30	Light	Light	Light	Light	Moderate	Moderate	Heavy
	colder/equal -1 / colder/equal 30	Light	Light	Moderate	Moderate	Heavy	Heavy	Heavy
Night	warmer than -1 / warmer than 30	Light	Light	Moderate	Moderate	Heavy	Heavy	Heavy
	colder/equal -1 / colder/equal 30	Light	Light	Moderate	Heavy	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 fluid guidelines. It may also be used with Type II, III, or IV fluid guidelines.

TABLE 8 VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART*

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1/4	>1/4 to 2¼	>2¼ to 4	>4
	Below -1	Below 30	≤1/4	>1/4 to 1¼	>1¼ to 3	>3
Daylight	-1 and above	30 and above	≤¼	>¼ to 1¼	>1¼ to 3	>3
	Below -1	Below 30	≤1/8	>1/8 to 7/8	>7/8 to 2	>2

* Based on: Relationship between Visibility and Snowfall Intensity (TP 14103E), Transportation Development Centre, Transport Canada, November 2002; and Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility (TP 12805E), Transportation Development Centre, Transport Canada, November 1996.

NO CHANGES

Transports Canada Transport Canada

TYPE II

TYPE II
NEW FLUIDS

- Aviation Shaanxi Cleanwing II will likely be commercialized for the winter of 2009-10
- A fluid-specific HOT table will be added to the Type II guidelines for Aviation Shaanxi Cleanwing II

Transports Canada Transport Canada

TYPE II
INCLUSION OF TYPE IV DATA

- Freezing Fog, 75/25, below -3°C to -14°C, upper value
  - One Type IV fluid has a shorter HOT than the generic Type II value
  - As Type IV fluids also qualify as Type II fluids, Type II generic value must be reduced
  - Value will be reduced from **0:55** to **0:50**

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TYPE II
REMOVAL OF OBSOLETE DATA

- As per AS 5718 § 5.12.3, fluid-specific data becomes obsolete 4 years after the fluid qualification expires and is not re-certified
  - Fluid-specific HOT table is removed
  - Fluid-specific data is removed from the generic analysis
- Kilfrost ABC-II PLUS meets these requirements in 2009
  - Increases to three generic Type II HOTs
  - Changes detailed on next slide

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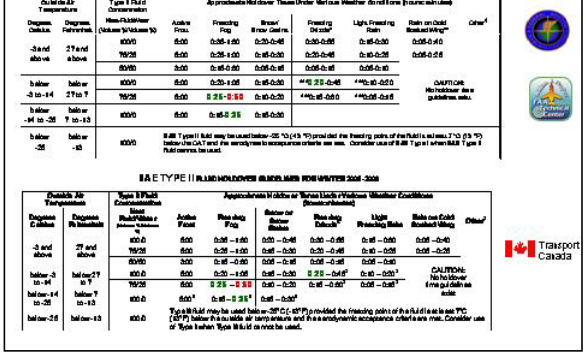
CHANGES TO GENERIC TYPE II HOT GUIDELINES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	0:15 – 0:30	0:20	0:45	0:10 – 0:20	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25	0:50	0:10 – 0:20	0:15 – 0:30	0:05 – 0:15	
below -14 to -25	below 7 to -13	100/0	8:00	0:15	0:35	0:15 – 0:30			
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

FAA/TC TYPE II HOT GUIDELINES 2009-10

FAA TYPE II HOLDOVER TIME GUIDELINE



Transport Canada

TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2009-10

1) ABAX ECOWING 26
2) AVIATION SHAANXI HI-TECH CLEANWING II **(NEW)**
3) CLARIANT SAFEWING MP II 2025 ECO
4) CLARIANT SAFEWING MP II FLIGHT
5) KILFROST ABC-2000
6) KILFROST ABC-K PLUS
7) NEWAVE AEROCHEMICAL FCY-2
8) OCTAGON E-MAX II

REMOVED: KILFROST ABC-II PLUS
AVIATION XI'AN HI-TECH KHF-II*

**Removed from TC guidelines following Charleston meeting - was removed from FAA guidelines in 2008*

Transports Canada Transport Canada

TYPE III

TYPE III

- No new Type III fluids will be commercialized in the winter of 2009-10
- No changes will be made to the generic Type III guidelines for 2009-10 winter operations

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FAA/TC TYPE III HOT GUIDELINES 2009-10

FAA TYPE III HOLDOVER TIME GUIDELINE

NO CHANGES

Transport Canada

TYPE IV

TYPE IV
NEW FLUIDS/OBSOLETE DATA

- ABAX Ecowing AD-49 and Kilfrost ABC-4^{sustain} will likely be commercialized for the winter of 2009-10
  - New fluid-specific tables will be added for both fluids
  - One reduction will be made to generic HOT guidelines
- Process for the removal of obsolete data is the same as for Type II fluids
  - No Type IV data becomes obsolete in 2009
  - No changes required

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CHANGES TO GENERIC TYPE IV HOT GUIDELINES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hour:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 1:05	
		75/25	5:00	1:00 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:40	
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45	0:10 - 0:25	CAUTION: No holdover time guidelines exist	
		75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30	0:10 - 0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 - 0:40	0:15 - 0:30				
below -25	be low -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

FAA/TC TYPE IV HOT GUIDELINES 2009-10

FAA TYPE IV HOLDOVER TIME GUIDELINE

Outside Air Temperature		Type IV Fluid Concentration Mass Fluid/Water (Volume %) (Lower %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow/ Snow Grains	Freezing Drizzle[a]	Light Freezing Rain	Rain on Cold Soaked Wing[a]	Other[a]
-3 and above	27 and above	100/0	≥2:00	0:45–2:30	0:35–1:15	0:40–1:10	0:25–0:40	0:10–0:05	
		75/25	5:00	1:00–1:45	0:20–0:55	0:35–0:50	0:15–0:30	0:05–0:40	
		50/50	3:00	0:15–0:35	0:05–0:15	0:10–0:20	0:05–0:10		
below -3 to -14	below 27 to 7	100/0	≥2:00	0:20–1:20	0:20–0:40	0:20–0:45	0:10–0:25	CAUTION: No holdover time guidelines exist.	
		75/25	5:00	0:25–0:50	0:15–0:35	0:15–0:30	0:10–0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15–0:40	0:15–0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

FAA TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

Outside Air Temperature		Type IV Fluid Concentration Mass Fluid/Water (Volume %) (Lower %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow/ Snow Grains	Freezing Drizzle[a]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[a]
-3 and above	27 and above	100/0	≥2:00	0:45 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	5:00	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	≥2:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[b]	0:10 – 0:25[b]	CAUTION: No holdover time guidelines exist.	
		75/25	5:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[b]	0:10 – 0:20[b]		
below -14 to -25	below 7 to -13	100/0	8:00	0:15 – 0:40	0:15 – 0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

Transport Canada

TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2009-10

1) ABAX AD-480
2) ABAX AD-49 (NEW)
3) CLARIANT SAFEWING MP IV 2001
4) CLARIANT SAFEWING MP IV 2012 PROTECT
5) CLARIANT SAFEWING MP IV LAUNCH
6) DOW UCAR ULTRA +
7) DOW UCAR ENDURANCE EG106
8) DOW UCAR FLIGHTGUARD AD-480
9) KILFROST ABC-S
10) KILFROST ABC-S PLUS
11) KILFROST ABC-4^{sustain} (NEW)
12) LYONDELL ARCTIC SHIELD
13) OCTAGON MAX-FLIGHT
14) OCTAGON MAX-FLIGHT 04
15) OCTAGON MAXFLO

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Anti-icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time

APS Aviation Inc.

ISO 9001:2000

Presented by Stephanie Bendickson

May 12, 2009

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

OUTLINE

- Background
- Current Guidance Material
- APS Test Program
- Test Results
- Recommendations

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BACKGROUND

- Some operators anti-ice aircraft inside aircraft hangars
- The anti-iced aircraft may wait in the hangar for some time before being exposed to precipitation
- When does the holdover time "clock" start?
  - When the anti-icing fluid application begins?
  - When the aircraft is first exposed to precipitation?

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CURRENT GUIDANCE MATERIAL
FAA

N 8900.55 §6.a.(2)(i).1.1

HOTs start as soon as the anti-icing step begins

AC135-17 / AC135-16 / AC120-60B

Holdover time begins when the final application of deicing/anti-icing fluid commences and expires when the deicing/anti-icing fluid applied to the aircraft loses its effectiveness.

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CURRENT GUIDANCE MATERIAL
Transport Canada

TP 14052 §11.1.1 (Holdover Time Guidelines – General)

The time that fluid remains effective is the time from first application of anti-icing fluid on a clean wing until such time as ice crystals form or remain in the fluid creating a surface roughness.

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CURRENT GUIDANCE MATERIAL
Transport Canada

TP 14052 §10.11 (Applying Type IV Fluid in a Hangar)

The period of time after Type IV 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 the frozen precipitation. The HOT available from a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature.

The air operator is advised to consult with the fluid manufacturer for guidance on using their fluids under these conditions. A minimum of a fluid thickness measurement may be required, dependent upon the circumstances, to ensure that the predicted fluid HOT protection is available.

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APS PRELIMINARY TEST PROGRAM

- APS conducted a preliminary test program (limited tests)
- Objective: to compare endurance times (ETs) of anti-icing fluids applied in hangars to ETs of anti-icing fluids applied outdoors
- Since fluid HOTs are established using a protocol that simulates outdoor operations, if hangar ETs are shorter than outdoor ETs we can conclude that starting the HOT clock at first exposure to precipitation poses a safety concern

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STANDARD VS. HANGAR OPERATIONS

- Standard Operation
  - Aircraft temperature near OAT
  - Fluid temperature near OAT
  - Immediate exposure to precipitation
- Hangar Operation
  - Aircraft temperature near 20°C
  - Fluid temperature near 20°C or near OAT
  - Delayed exposure to precipitation

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SIMULATING STANDARD / HANGAR OPERATIONS

- Standard Operation simulated by:
  - Using test surfaces at OAT
  - Using fluids at OAT
  - Exposing to precipitation immediately
- Hangar Operation simulated by:
  - Using test surfaces at 20°C
  - Using fluids at 20°C or OAT
  - Exposing to precipitation after a delay of 15 minutes or 60 minutes

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TEST TYPES

Chart Symbol	Test Type	Surface Temp	Fluid Temp	Time to Exposure
	Standard	OAT	OAT	0 mins
	Hangar 1	20°C	20°C	15 mins
	Hangar 2	20°C	20°C	60 mins
	Hangar 3	20°C	OAT	60 mins

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APS PRELIMINARY TEST PROGRAM

- 11 runs were conducted
- Each run consisted of:
  - 1 "standard" test used to establish the fluid HOT in the condition
  - 2-3 "hangar" tests used to measure the ETs of fluids applied in different types of hangar operations
- Runs conducted with differing fluids, precipitation types, precipitation rates and OATs

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RUN CONDITIONS

Run #	Fluid Type	Fluid Dilution	OAT (°C)	Precipitation Type	Precip. Rate (g/dm²/h)
1	Type IV	100	-1	Snow	10
2	Type III	100	-1	Snow	12
3	Type II	100	-4	Snow	14
4	Type IV	100	-10	Light Freezing Rain	13
5	Type II	100	-3	Light Freezing Rain	13
6	Type IV	100	-10	Freezing Drizzle	13
7	Type II	100	-3	Freezing Drizzle	5
8	Type IV	100	-3	Light Freezing Rain	25
9	Type IV	100	-10	Light Freezing Rain	25
10	Type IV	100	-3	Freezing Drizzle	13
11	Type IV	100	-10	Freezing Drizzle	5

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TEST PROCEDURE

- All test surfaces were exposed to precipitation at the same time
- Fluid applied in advance for tests with delayed exposure to precipitation
- ET "clock" started at first exposure to precipitation for all tests

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TEST PROCEDURE

TEST PROCEDURE

TEST PROCEDURE

TEST TYPES

Chart Symbol	Test Type	Surface Temp	Fluid Temp	Time to Exposure
	Standard	OAT	OAT	0 mins
	Hangar 1	20°C	20°C	15 mins
	Hangar 2	20°C	20°C	60 mins
	Hangar 3	20°C	OAT	60 mins

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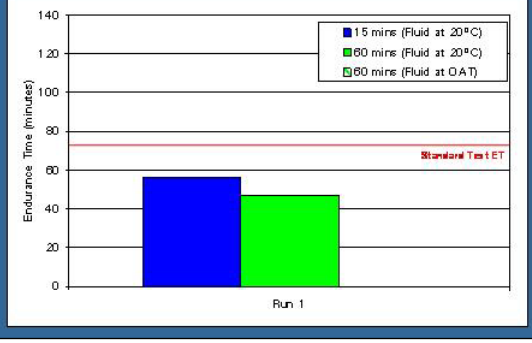
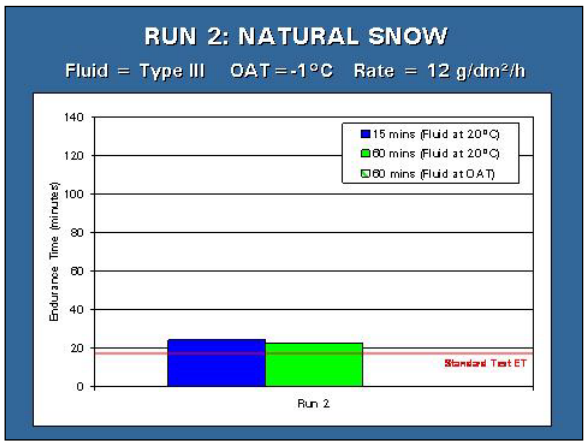
RUN 1: NATURAL SNOW

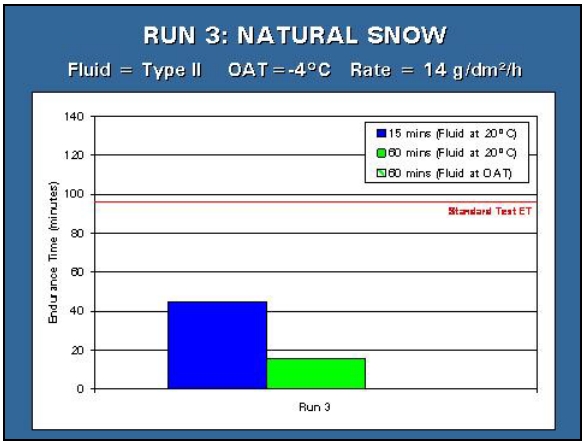
Fluid = Type IV OAT = -1°C Rate = 10 g/dm²/h

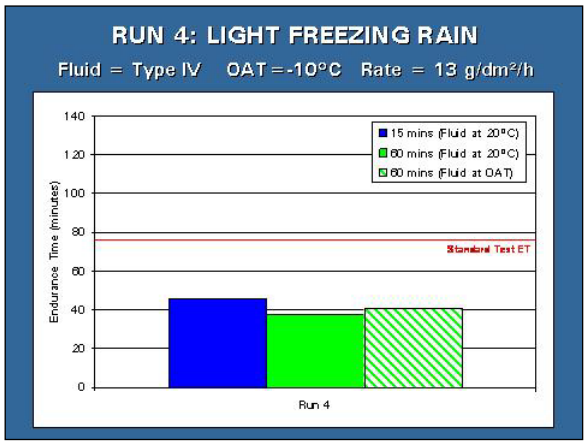


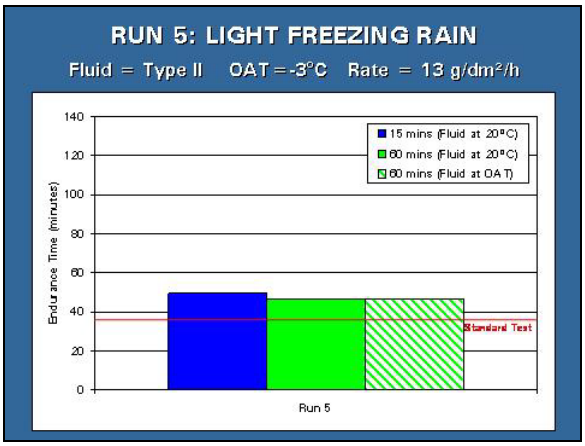
60 mins
15 mins
0 mins

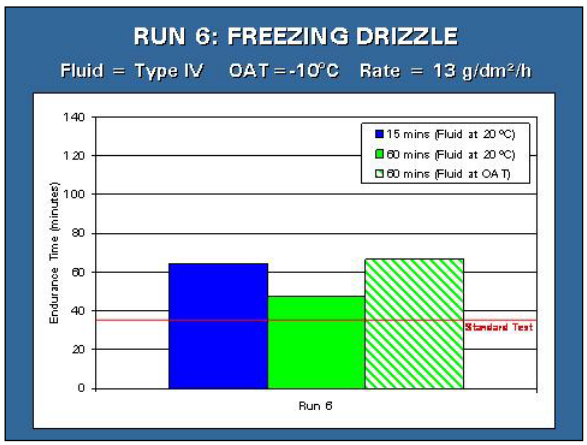
RUN 1

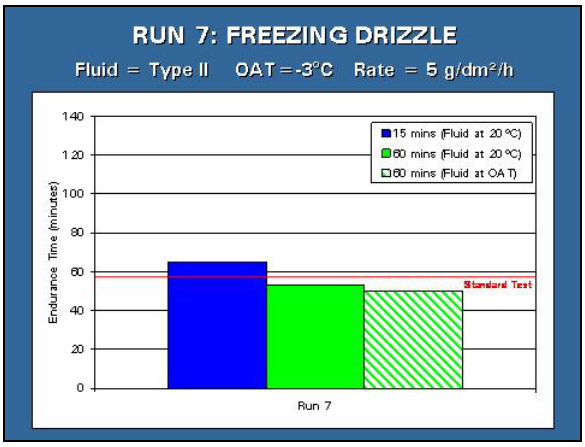

RUN 2: NATURAL SNOW
Fluid = Type III OAT = -1°C Rate = 12 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 2

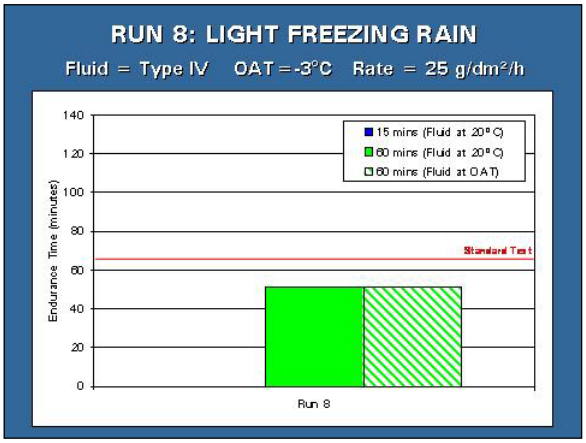

RUN 3: NATURAL SNOW
Fluid = Type II OAT = -4°C Rate = 14 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 3

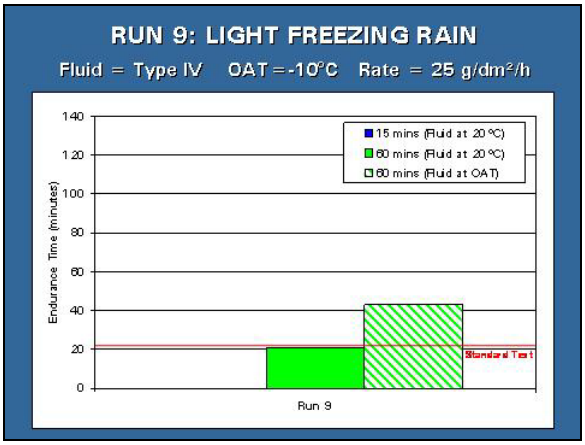

RUN 4: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -10°C Rate = 13 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 4

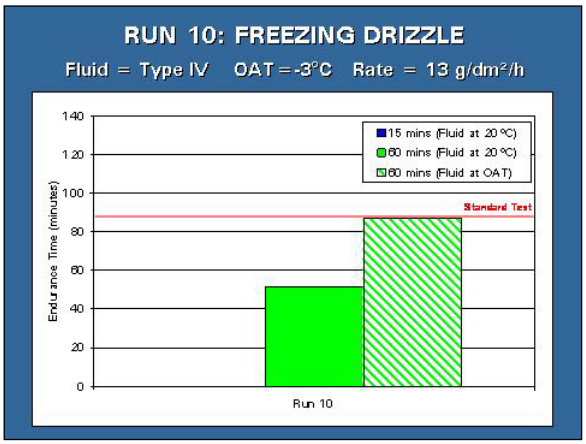

RUN 5: LIGHT FREEZING RAIN
Fluid = Type II OAT = -3°C Rate = 13 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 5

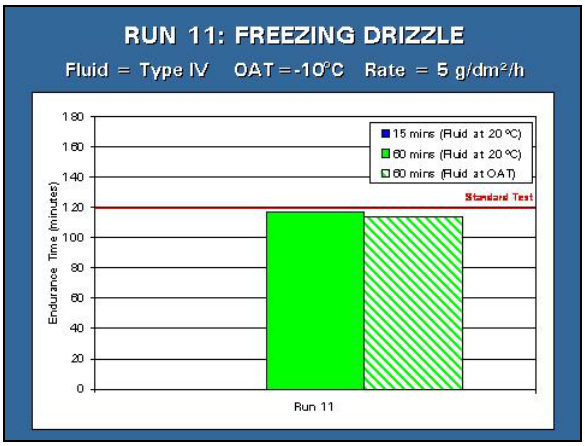

RUN 6: FREEZING DRIZZLE
Fluid = Type IV OAT = -10°C Rate = 13 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 6

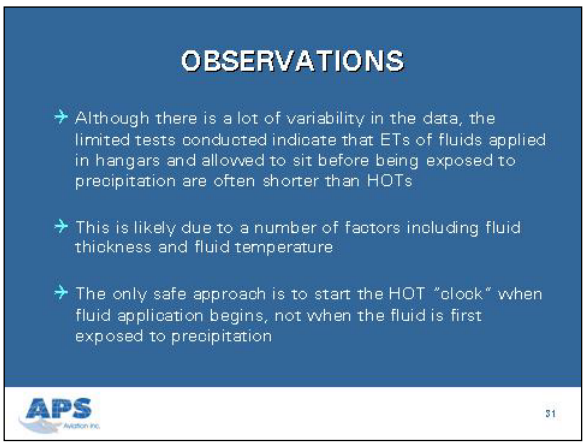

RUN 7: FREEZING DRIZZLE
Fluid = Type II OAT = -3°C Rate = 5 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 7


RUN 8: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -3°C Rate = 25 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 8


RUN 9: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -10°C Rate = 25 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 9


RUN 10: FREEZING DRIZZLE
Fluid = Type IV OAT = -3°C Rate = 13 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 10


RUN 11: FREEZING DRIZZLE
Fluid = Type IV OAT = -10°C Rate = 5 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 11


OBSERVATIONS
Although there is a lot of variability in the data, the limited tests conducted indicate that ETs of fluids applied in hangars and allowed to sit before being exposed to precipitation are often shorter than HOTs
This is likely due to a number of factors including fluid thickness and fluid temperature
The only safe approach is to start the HOT "clock" when fluid application begins, not when the fluid is first exposed to precipitation
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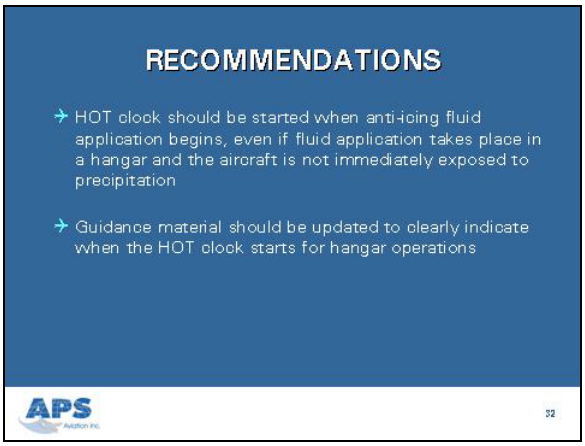
RECOMMENDATIONS
HOT clock should be started when anti-icing fluid application begins, even if fluid application takes place in a hangar and the aircraft is not immediately exposed to precipitation
Guidance material should be updated to clearly indicate when the HOT clock starts for hangar operations
APS
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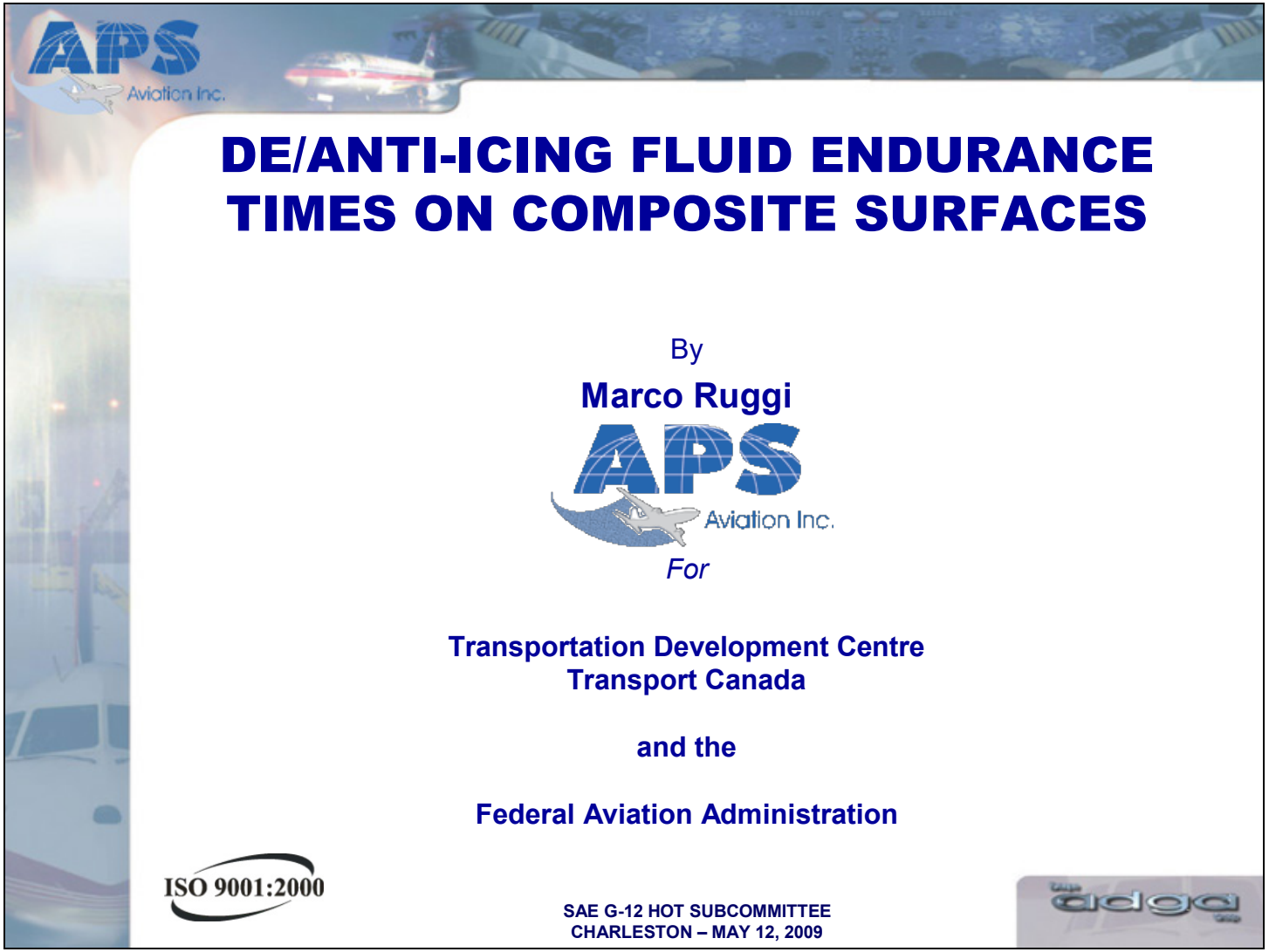

APS
Aviation Inc.
DE/ANTI-ICING FLUID ENDURANCE TIMES ON COMPOSITE SURFACES
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
ISO 9001:2000
SAE G-12 HOT SUBCOMMITTEE
CHARLESTON – MAY 12, 2009
adga

OUTLINE

- BACKGROUND
- PREVIOUS WORK
  - OUTDOOR SNOW PLATE TESTING
  - OUTDOOR FROST PLATE TESTING
  - INDOOR FREEZING PRECIP PLATE TESTING
  - OUTDOOR SNOW BOX TESTING
- 2008-09 INDOOR FREEZING PRECIPITATION DATA
- GENERAL OBSERVATIONS
- OPEN DISCUSSION

BACKGROUND

- Recent increase in manufacturing of aircraft wings with non-aluminum materials
  - Airbus A380, Boeing 787, etc
- Benefits of composite material aircraft construction include:
  - reduced aircraft weight
  - increased fuel efficiency
  - improved maintainability
- A validation of the current holdover time values is required

BACKGROUND

- Comparative endurance time testing has been conducted by APS
- Testing included:
  - Outdoor testing in snow
  - Outdoor testing in frost
  - Indoor testing in simulated freezing precipitation
- Detailed results were presented at the G-12 meeting in Warsaw May 2008

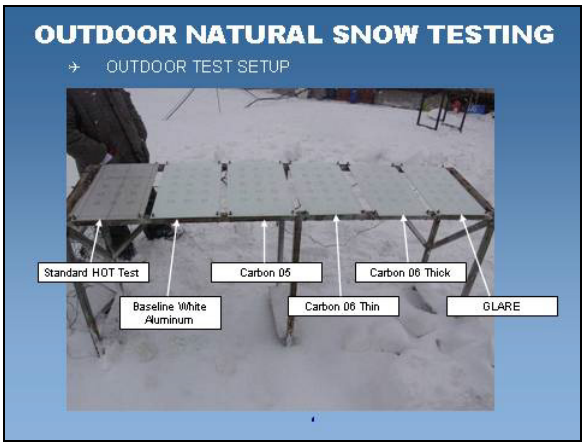
PURPOSE

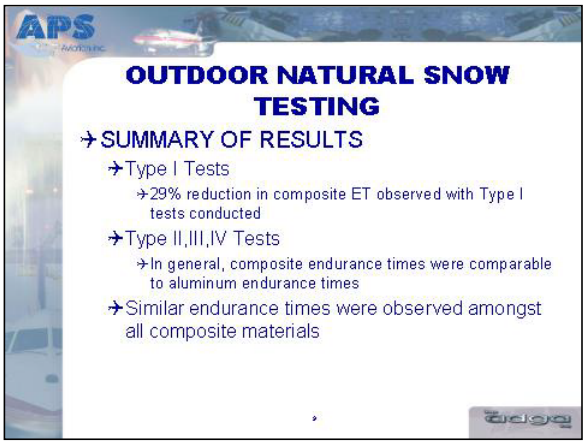
- To present latest data collected
- Acquire industry feedback regarding the issue of **"reduced Type I holdover times on composite surfaces"**

OUTLINE

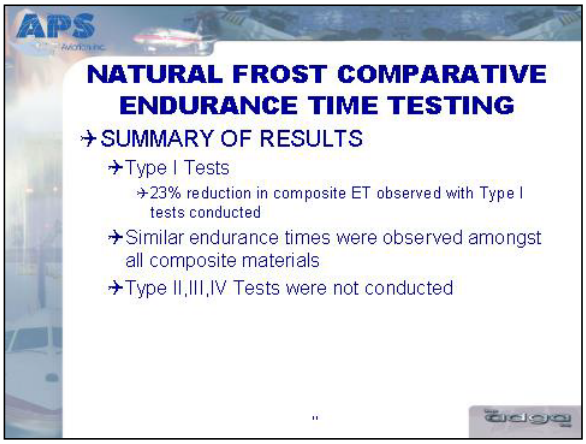
- BACKGROUND
- PREVIOUS WORK
  - OUTDOOR SNOW PLATE TESTING
  - OUTDOOR FROST PLATE TESTING
  - INDOOR FREEZING PRECIP PLATE TESTING
  - OUTDOOR SNOW BOX TESTING
- 2008-09 INDOOR FREEZING PRECIPITATION DATA
- GENERAL OBSERVATIONS
- OPEN DISCUSSION

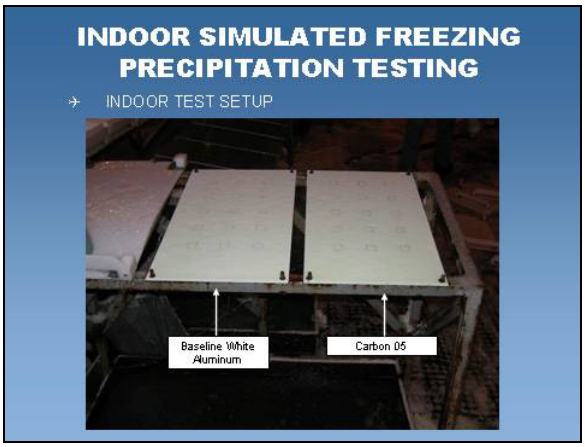
COMPOSITE MATERIALS TESTED

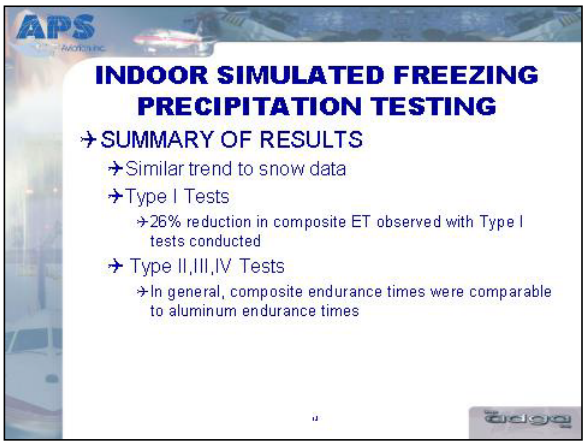

OUTDOOR NATURAL SNOW TESTING
OUTDOOR TEST SETUP
Standard HOT Test
Baseline White Aluminum
Carbon 05
Carbon 06 Thin
Carbon 06 Thick
GLARE


APS
OUTDOOR NATURAL SNOW TESTING
SUMMARY OF RESULTS
Type I Tests
29% reduction in composite ET observed with Type I tests conducted
Type II,III,IV Tests
In general, composite endurance times were comparable to aluminum endurance times
Similar endurance times were observed amongst all composite materials

OUTDOOR NATURAL FROST TESTING
OUTDOOR TEST SETUP

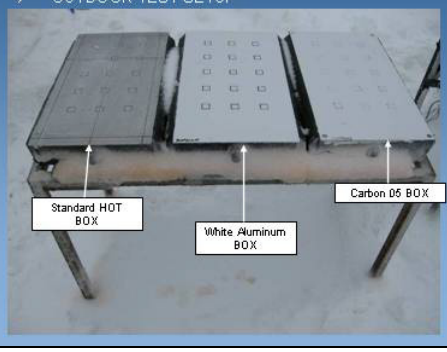

APS
NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING
SUMMARY OF RESULTS
Type I Tests
23% reduction in composite ET observed with Type I tests conducted
Similar endurance times were observed amongst all composite materials
Type II,III,IV Tests were not conducted


INDOOR SIMULATED FREEZING PRECIPITATION TESTING
INDOOR TEST SETUP
Baseline White Aluminum
Carbon 05


APS
INDOOR SIMULATED FREEZING PRECIPITATION TESTING
SUMMARY OF RESULTS
Similar trend to snow data
Type I Tests
26% reduction in composite ET observed with Type I tests conducted
Type II,III,IV Tests
In general, composite endurance times were comparable to aluminum endurance times

LEADING EDGE THERMAL EQUIVALENT BOX TESTS

- OUTDOOR TEST SETUP



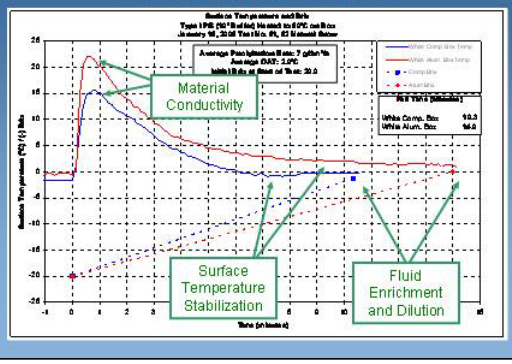
LEADING EDGE THERMAL EQUIVALENT BOX TESTS

- SUMMARY OF RESULTS
  - Similar trend as seen during plate tests
  - Type I Tests
    - 31% - 36% endurance time reduction observed with Type I tests conducted on composite box

EFFECT OF HEAT ON TYPE I ENDURANCE TIMES

- Four factors influence the reduction in endurance times using Type I fluids on composite surfaces
  - Material Conductivity
    - Amount of heat absorbed from the fluid
  - Surface Temperature Stabilization
    - Ability to retain heat absorbed from the fluid
  - Fluid Enrichment and Dilution
    - Increase in glycol due to evaporation of water when applying heated; a function of fluid temperature
    - Dilution to FFP will occur quicker with lower levels of fluid enrichment

EFFECT OF HEAT ON TYPE I ENDURANCE TIMES



OUTLINE

- BACKGROUND
- PREVIOUS WORK
  - OUTDOOR SNOW PLATE TESTING
  - OUTDOOR FROST PLATE TESTING
  - INDOOR FREEZING PRECIP PLATE TESTING
  - OUTDOOR SNOW BOX TESTING
- 2008-09 INDOOR FREEZING PRECIPITATION DATA
- GENERAL OBSERVATIONS
- OPEN DISCUSSION

INDOOR SIMULATED FREEZING PRECIPITATION TESTING

- Previous indoor Type I testing was conducted primarily with fluid heated to 60ºC
- Current endurance time protocol for indoor heated tests calls for fluid to be heated at 20ºC
- It was recommended that additional testing be conducted in 2008-09 to verify the validity of the results previously obtained

INDOOR SIMULATED FREEZING PRECIPITATION TESTING

- METHODOLOGY:
  - Previous tests showed similar results amongst all composite materials tested
  - Indoor comparative endurance time testing was conducted with
    - White painted carbon fibre plain weave fabric (Carbon 05)
    - White painted aluminum test plate
    - Standard HOT test plate (in conjunction with HOT testing)

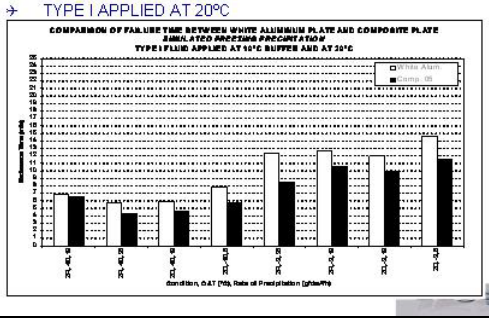
INDOOR SIMULATED FREEZING PRECIPITATION TESTING

- SUMMARY OF COMPARATIVE TEST RUNS

Test #	Composite Box Endurance Time (min)	White Aluminum Box Endurance Time (min)	Endurance Time % Ratio (Comp / White Alum.)	Endurance Time Difference (min.) (Comp - White Alum.)
Type I Fluid Heated to 85°C				
1-2	6.6	6.8	97%	-0.2
4-5	4.4	5.7	76%	-1.4
7-8	4.6	5.9	77%	-1.3
10-11	5.1	7.3	72%	-2.2
13-14	8.5	12.3	70%	-3.7
16-17	10.6	12.8	83%	-2.2
19-20	10.0	12.0	83%	-2.0
22-23	11.6	14.7	79%	-3.1
		Average	80%	-2.0

INDOOR SIMULATED FREEZING PRECIPITATION TESTING

- TYPE I APPLIED AT 20ºC



INDOOR SIMULATED FREEZING PRECIPITATION TESTING

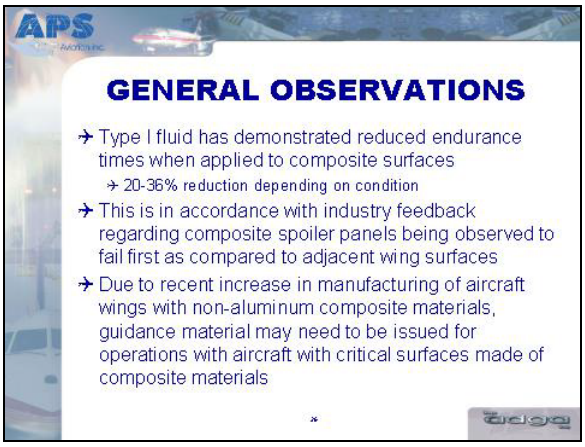
- SUMMARY OF RESULTS
  - Similar trend to snow data
  - Type I Tests
    - 20% reduction (max of 30%) in composite ET observed with Type I tests conducted
    - Reduction in Type I endurance times up to 3.7 minutes

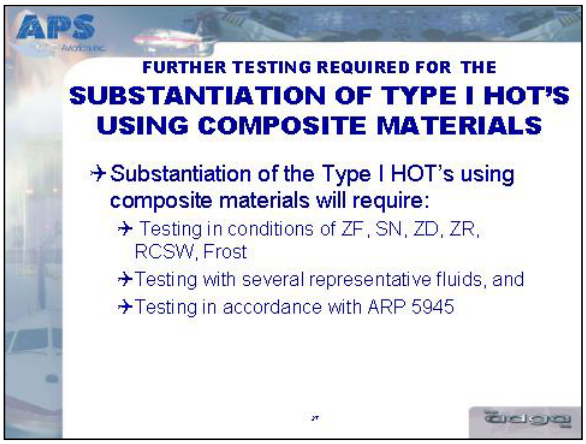
INDOOR SIMULATED FREEZING PRECIPITATION TESTING

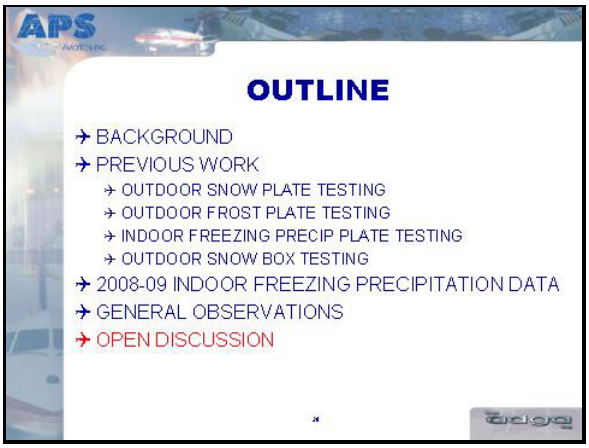
- Cumulative Summary of Indoor Results
  - Both Type I @ 20ºC and Type I @ 60ºC demonstrated on average 25% ET reductions on the composite surface as compared to the white aluminum surface

OUTLINE

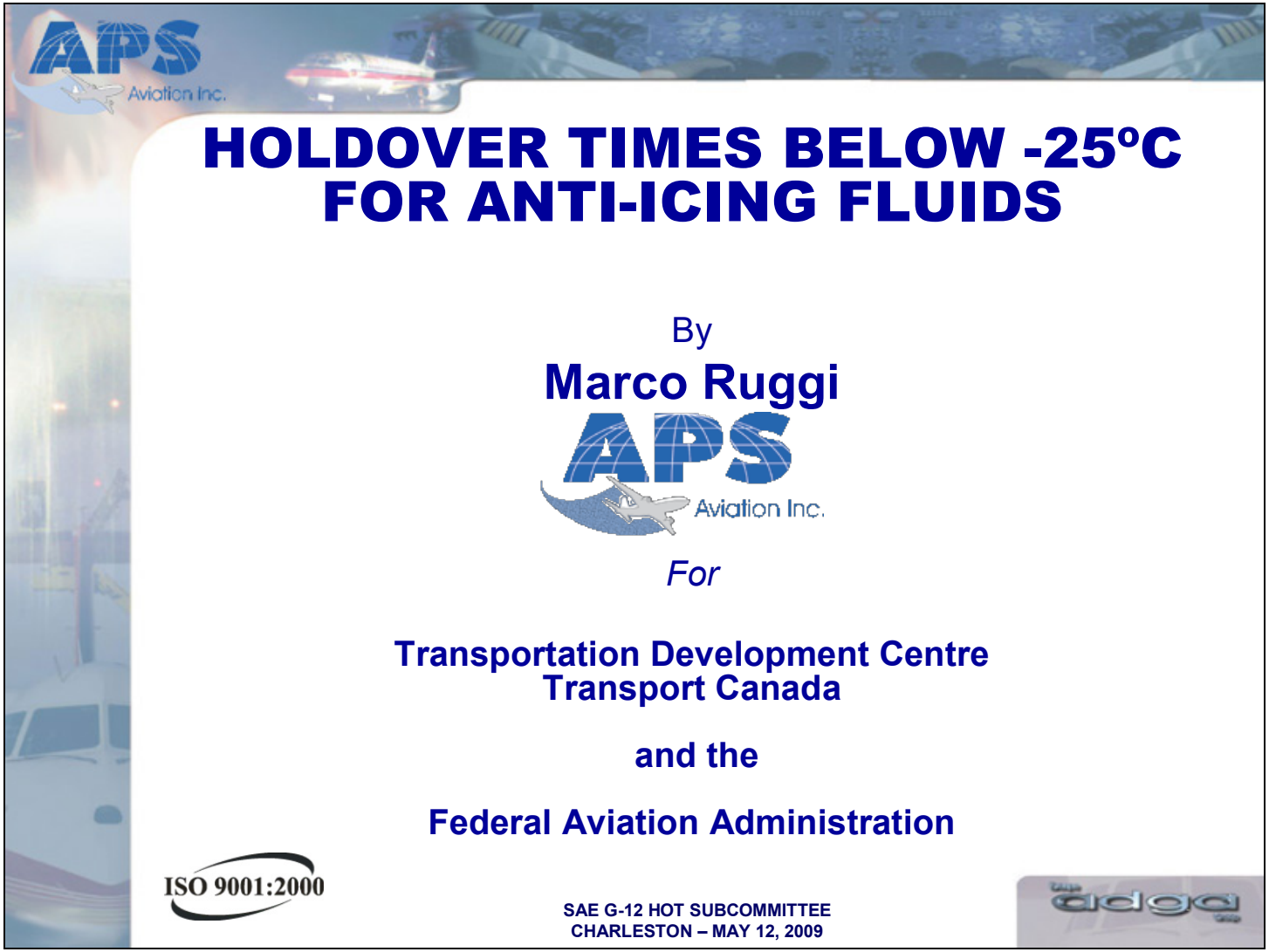
- BACKGROUND
- PREVIOUS WORK
  - OUTDOOR SNOW PLATE TESTING
  - OUTDOOR FROST PLATE TESTING
  - INDOOR FREEZING PRECIP PLATE TESTING
  - OUTDOOR SNOW BOX TESTING
- 2008-09 INDOOR FREEZING PRECIPITATION DATA
- GENERAL OBSERVATIONS
- OPEN DISCUSSION


APS
GENERAL OBSERVATIONS
Type I fluid has demonstrated reduced endurance times when applied to composite surfaces
20-36% reduction depending on condition
This is in accordance with industry feedback regarding composite spoiler panels being observed to fail first as compared to adjacent wing surfaces
Due to recent increase in manufacturing of aircraft wings with non-aluminum composite materials, guidance material may need to be issued for operations with aircraft with critical surfaces made of composite materials


APS
FURTHER TESTING REQUIRED FOR THE
SUBSTANTIATION OF TYPE I HOT'S USING COMPOSITE MATERIALS
Substantiation of the Type I HOT's using composite materials will require:
Testing in conditions of ZF, SN, ZD, ZR, RCSW, Frost
Testing with several representative fluids, and
Testing in accordance with ARP 5945


APS
OUTLINE
BACKGROUND
PREVIOUS WORK
OUTDOOR SNOW PLATE TESTING
OUTDOOR FROST PLATE TESTING
INDOOR FREEZING PRECIP PLATE TESTING
OUTDOOR SNOW BOX TESTING
2008-09 INDOOR FREEZING PRECIPITATION DATA
GENERAL OBSERVATIONS
OPEN DISCUSSION

OPEN DISCUSSION
APS
Aviation Inc.
Marco Ruggi
mruggi@adga.ca


APS
Aviation Inc.
HOLDOVER TIMES BELOW -25ºC
FOR ANTI-ICING FLUIDS
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
ISO 9001:2000
SAE G-12 HOT SUBCOMMITTEE
CHARLESTON – MAY 12, 2009

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- OBJECTIVE AND METHODOLOGY
- SUMMARY OF RESULTS AND OBSERVATIONS
- RECOMMENDATION
- OPEN DISCUSSION

BACKGROUND

- High speed lowest operational use temperature (LOUT) of thickened Type II and Type IV fluids is generally a few degrees below -25ºC
  - Type II/IV LOUT is generally -28 or -29ºC
- Holdover time (HOT) guidelines below -25ºC do not exist for these fluids

Transport Canada Holdover Time Guidelines — Winter 2007-2008

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	5:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[3]	0:15 – 0:40[3]	0:15 – 0:30[3]				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

NOTES
1 Based on the lowest holdover times of the Type IV fluids listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

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BACKGROUND

- Testing is conducted for each qualified fluid in simulated freezing fog conditions at -25ºC, however
- Natural snow data collected as part of the standard HOT testing protocol contains limited data at these colder temperatures.
- Typically, generic HOT values are assigned for Type II and Type IV fluids below -14ºC to -25ºC in snow conditions.

Transport Canada Holdover Time Guidelines — Winter 2007-2008

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	5:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[3]	0:15 – 0:40[3]	0:15 – 0:30[3]				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

NOTES
1 Based on the lowest holdover times of the Type IV fluids listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

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Generic Values

Fluid Specific

PREVIOUS WORK

- Recent industry need to provide guidance material for operations with thickened fluids below -25ºC
- Preliminary testing was conducted in 2007-08
  - Objective: Expand -25ºC HOT to LOUT for Type II and Type IV fluids
- Results did not demonstrate significant differences in endurance times for -25ºC vs. -28.5ºC tests
  - Current -25ºC HOT's could potentially be expanded to apply to the fluid LOUT
  - Additional testing recommended to substantiate results

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- OBJECTIVE AND METHODOLOGY
- SUMMARY OF RESULTS AND OBSERVATIONS
- RECOMMENDATION
- OPEN DISCUSSION

OBJECTIVE

- To determine the differences in endurance time of Type II/IV fluid at -25°C in comparison to testing conducted at the fluid LOUT.
  - To potentially expand "-14 to -25ºC" HOT's to fluid LOUT

METHODOLOGY

- Standard indoor endurance time testing procedure and methodology was followed
- 2008-09 testing was conducted with six fluids in conjunction with standard HOT testing
- Comparative endurance time testing was conducted using the same fluids and dilution at both -25ºC and -28.5ºC in freezing fog conditions
- Visual fluid failure was used as the comparative measure
  - Brix and thickness was measured to validate

PRESENTATION OUTLINE

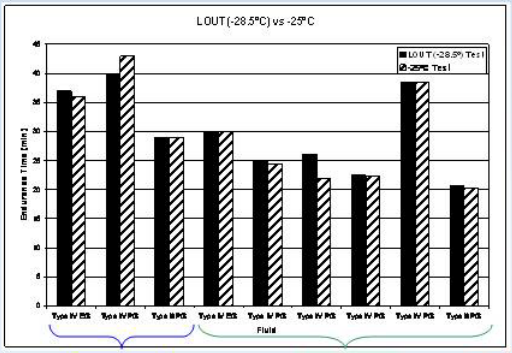
- BACKGROUND AND PREVIOUS WORK
- OBJECTIVE AND METHODOLOGY
- SUMMARY OF RESULTS AND OBSERVATIONS
- RECOMMENDATION
- OPEN DISCUSSION

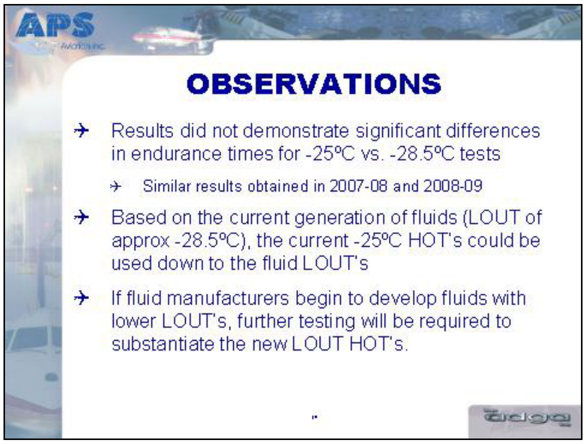
ENDURANCE TIME RESULTS

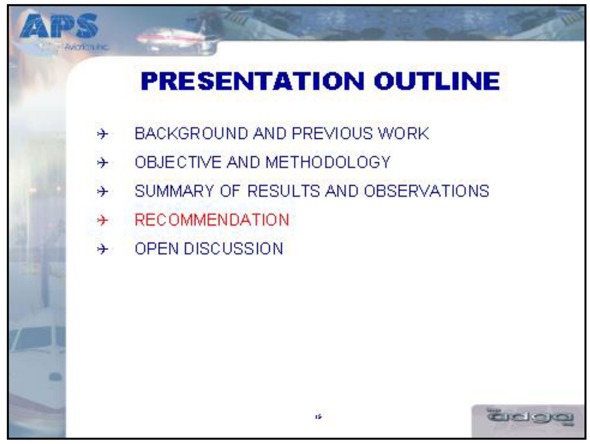
Test #	Year Tested	Fluid Type	Fluid	Fail Time [min]	Final Brix	Rate of Precip [g/dm²/hr]	Ambient Temp [°C]	Precip [Type]
LOUT1 / LOUT1A	07-08	Commercial	Type IV EG	37*	N/A	4.5*	-28.5	ZF
LOUT4 / LOUT4A	07-08	Commercial	Type IV EG	36*	N/A	5.0*	-25	ZF
LOUT2 / LOUT2A	07-08	Commercial	Type IV PG	40*	N/A	4.8*	-28.5	ZF
LOUT5 / LOUT5A	07-08	Commercial	Type IV PG	43*	N/A	5.2*	-25	ZF
LOUT3 / LOUT3A	07-08	Commercial	Type IIPG	29*	N/A	4.7*	-28.5	ZF
LOUT6 / LOUT6A	07-08	Commercial	Type IIPG	28*	N/A	5.1*	-25	ZF
LOUT7	08-09	Commercial	Type IV EG	30	31	4.9	-28.5	ZF
LOUT13	08-09	Commercial	Type IV EG	30	29	4.7	-25.0	ZF
LOUT8	08-09	Commercial	Type IV PG	25	24	4.8	-28.5	ZF
LOUT14	08-09	Commercial	Type IV PG	24	26	4.9	-25.0	ZF
LOUT9	08-09	Commercial	Type IV PG	26	25	4.7	-28.5	ZF
LOUT15	08-09	Commercial	Type IV PG	22	25	4.8	-25	ZF
LOUT10	08-09	HoT Fluid	Type IV PG	28	25	5.0	-28.5	ZF
LOUT16	08-09	HoT Fluid	Type IV PG	22	25	5.2	-25.0	ZF
LOUT11	08-09	HoT Fluid	Type IV PG	39	30	5.0	-29	ZF
LOUT17	08-09	HoT Fluid	Type IV PG	39	28	5.1	-25.0	ZF
LOUT12	08-09	HoT Fluid	Type IIPG	21	25	5.1	-28.5	ZF
LOUT18	08-09	HoT Fluid	Type IIPG	20	25	5.2	-25	ZF

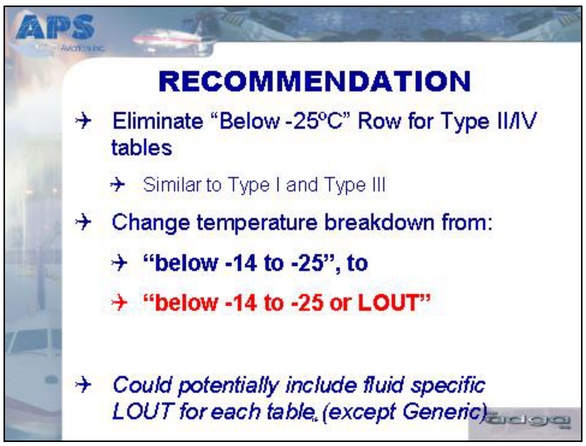
* Average of results from duplicate tests

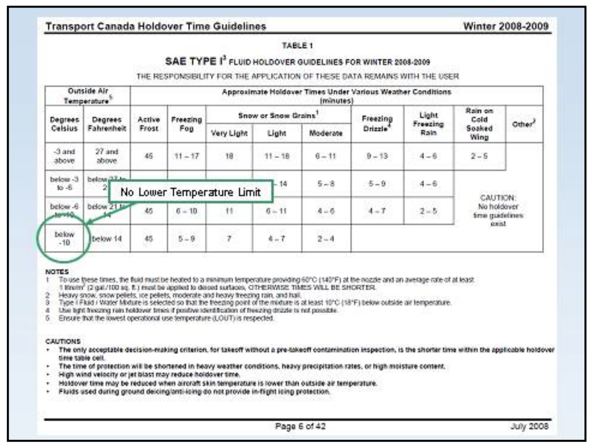
ENDURANCE TIME RESULTS











Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)								
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains[1] Very Light	Snow or Snow Grains[1] Light	Snow or Snow Grains[1] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	45	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 2[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	45	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
below -10	below 14	45	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 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.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

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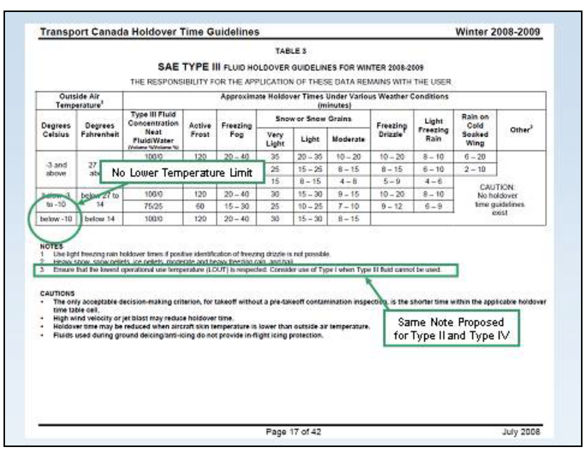

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009

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

Outside Air Temperature[3]			Approximate Holdover Times Under Various Weather Conditions (minutes)								
Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains Very Light	Snow or Snow Grains Light	Snow or Snow Grains Moderate	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	120	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	
		[illegible]	[illegible]	[illegible]	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		[illegible]	[illegible]	[illegible]	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	120	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	60	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	120	20 – 40	30	15 – 30	8 – 15				

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.

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 deicing/anti-icing do not provide in-flight icing protection.

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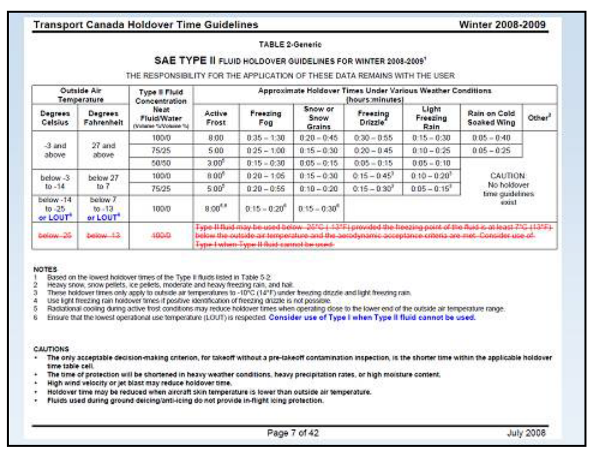

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[3]
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00[5]	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	8:00[5]	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45[3]	0:10 – 0:20[3]		
		75/25	5:00[5]	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	8:00[4,5]	0:15 – 0:20[6]	0:15 – 0:30[6]				
~~below -25~~	~~below -13~~	~~100/0~~	~~Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.~~						

NOTES
1 Based on the lowest holdover times of the Type II fluids listed in Table 5-2.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 Ensure that the lowest operational use temperature (LOUT) is respected. **Consider use of Type I when Type II fluid cannot be used.**

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 deicing/anti-icing do not provide in-flight icing protection.

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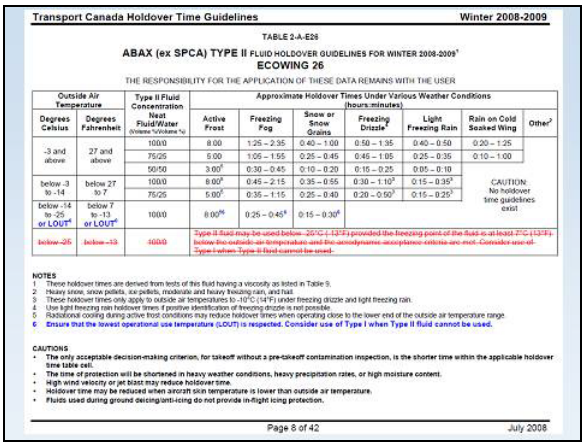

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 2-A-E26

ABAX (ex SPCA) TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]
ECOWING 26

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	8:00	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	
		75/25	5:00	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	3:00[3]	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00[4]	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10[5]	0:15 – 0:35[5]	CAUTION: No holdover time guidelines exist	
		75/25	5:00[3]	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50[3]	0:15 – 0:25[3]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	8:00[4,6]	0:25 – 0:45[4]	0:15 – 0:30[4]				
~~below -25~~	~~below -13~~	~~100/0~~	~~Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.~~						

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 **Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.**

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 deicing/anti-icing do not provide in-flight icing protection.**

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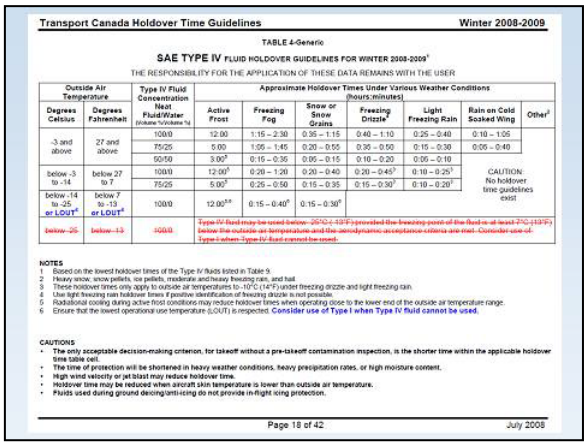

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]

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

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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00[3]	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00[3]	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]	CAUTION: No holdover time guidelines exist	
		75/25	5:00[3]	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[4]	below 7 to -13 or LOUT[4]	100/0	12:00[3,4]	0:15 – 0:40[4]	0:15 – 0:30[4]				
~~below -25~~	~~below -13~~	~~100/0~~	~~Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.~~						

NOTES
1 Based on the lowest holdover times of the Type IV fluids listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 Ensure that the lowest operational use temperature (LOUT) is respected. **Consider use of Type I when Type IV fluid cannot be used.**

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 deicing/anti-icing do not provide in-flight icing protection.**

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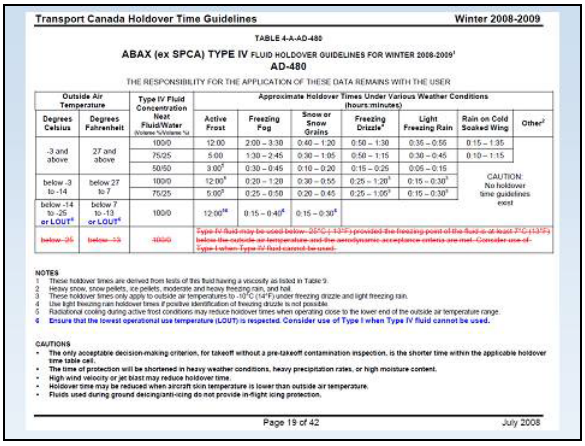

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 4-A-AD-480

ABAX (ex SPCA) TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]
AD-480

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

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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	
		75/25	5:00	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	3:00[3]	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	12:00[4]	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[5]	0:15 – 0:30[5]	CAUTION: No holdover time guidelines exist	
		75/25	5:00[3]	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	12:00[4,6]	0:15 – 0:40[4]	0:15 – 0:30[4]				
~~below -25~~	~~below -13~~	~~100/0~~	~~Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.~~						

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 **Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.**

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 deicing/anti-icing do not provide in-flight icing protection.**

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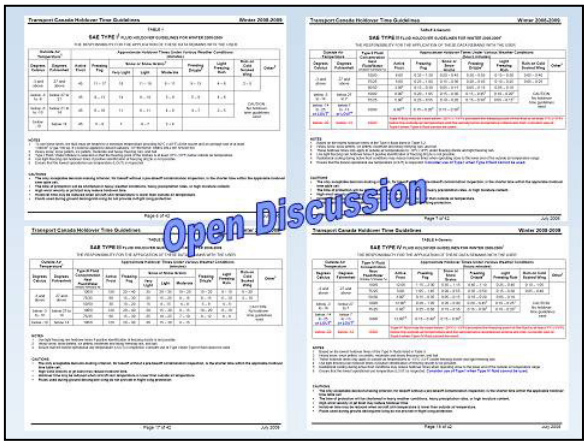

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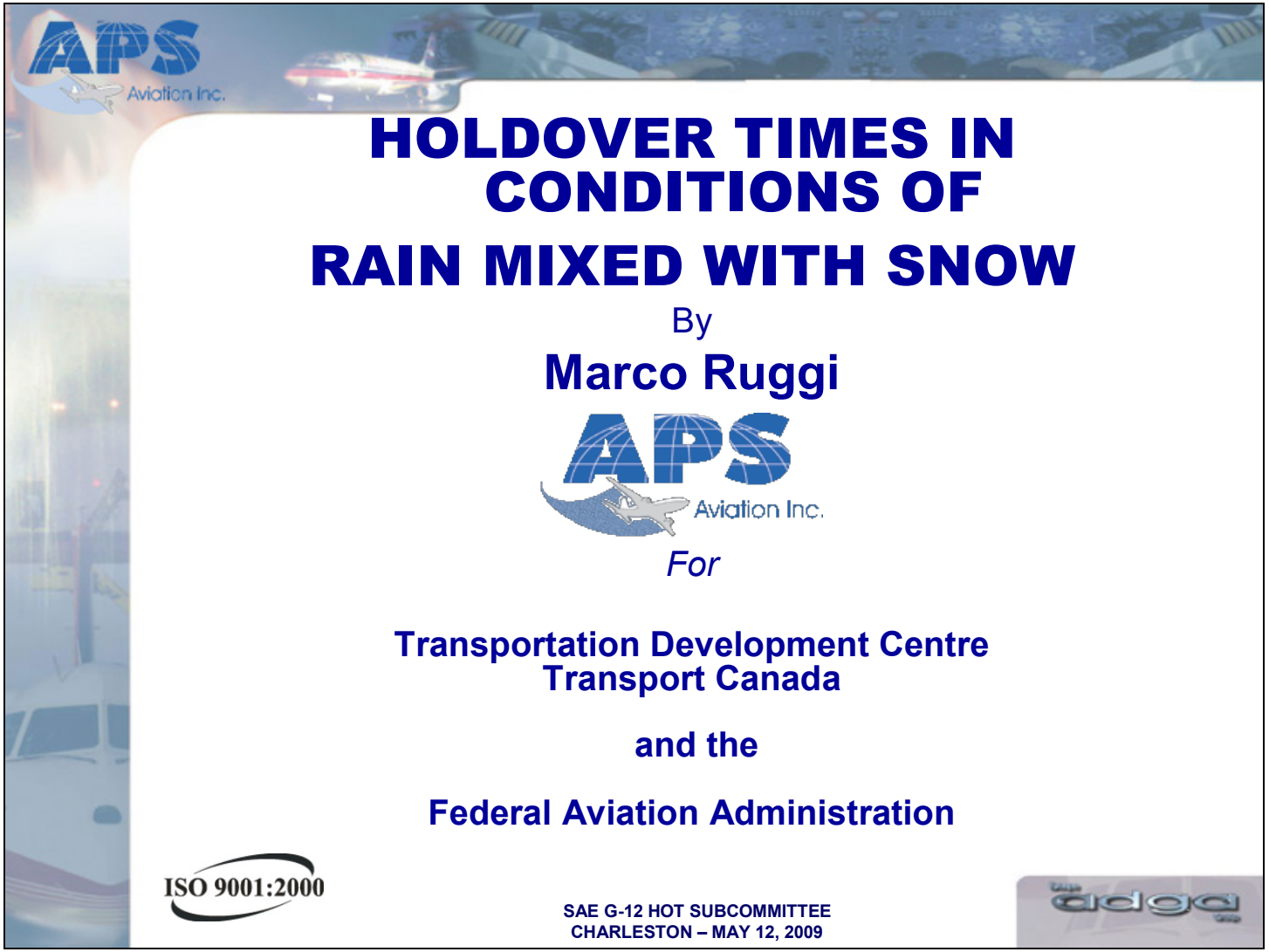
APS
Aviation Inc.
HOLDOVER TIMES IN CONDITIONS OF
RAIN MIXED WITH SNOW
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
ISO 9001:2000
SAE G-12 HOT SUBCOMMITTEE
CHARLESTON – MAY 12, 2009
adga

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS

BACKGROUND

- Transitional precipitation periods often include a mix of multiple precipitation types
- Although these periods are generally short, on many occasions, especially at warmer temperatures, these transitional periods can last several hours.

BACKGROUND

- The accuracy of meteorological reporting continues to improve
- In addition, HOT Determination Systems designers will require appropriate guidance to provide accurate HOT's during mixed precipitation conditions
- As a result, there has been a recent industry need to provide improved guidance material during these transitional periods of mixed precipitation

BACKGROUND

- Transport Canada and the FAA currently do not provide guidelines for operations in mixed light "rain and snow" conditions.
- However, the AEA have guidance for dealing with such conditions.
- The AEA recommended the use of "Light Freezing Rain" holdover times in light "Rain and Snow" conditions

TABLE 6 - Guideline for Holdover times Anticipated for Type IV Fluid Mixtures as a Function of Weather Conditions and OAT

OAT °C	OAT °F	SAE Type IV Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)							
			Active Frost	Freezing Fog	Snow/ Snow Grains (2)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	12:00	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	
		75/25	5:00	1:05-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	3:00 (5)	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00 (5)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)	CAUTION:	
		75/25	5:00 (5)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)	No holdover time	
below -14 to -25	below 7 to -13	100/0	12:00 (5)	0:15-0:40	0:15-0:30			guidelines exist	
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of type I fluid when type IV fluid cannot be used (see table 3).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) No holdover time guidelines exist for this condition below -10°C (14°F)
(6) Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the OAT range

CAUTION: The time 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 also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
EDITION 23, September 2008
Available at www.aea.be
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PREVIOUS WORK

- Preliminary work was conducted during the winter of 2007-08
- 2 comparative sets of endurance time tests were conducted using the same fluids and dilution at
  - -3°C (LZR)
  - +1°C (R-/SN-)
- Results indicated that the endurance time in light "rain and snow" was on average 10-15% longer as compared to the "light freezing rain" only test.

PURPOSE

- To collect additional data to determine if the current HOT guidelines can be expanded to include mixed conditions
  - i.e. mixed light "rain and snow" conditions.

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS

METHODOLOGY

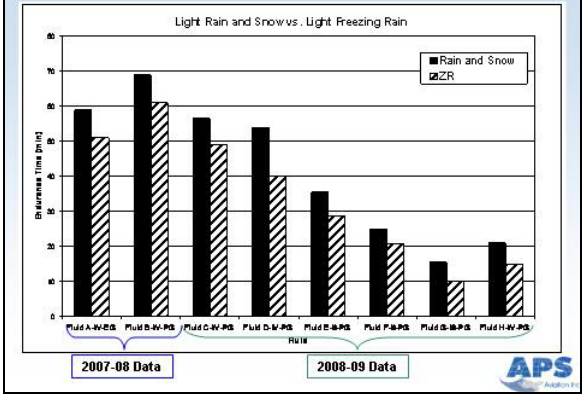
- Comparative endurance time testing was conducted using the same fluids and dilution at
  - -3°C (LZR)
  - +1°C (R-/SN-)
- Baseline light freezing rain tests (at 25 g/dm²/h) were conducted using standard indoor endurance time testing methodology
- Mixed Rain and Snow conditions generated by
  - Simulated Light Snow (Rate of 12 g/dm²/h)
  - Simulated Light Rain (Rate of 13 g/dm²/h)

ENDURANCE TIME TESTING

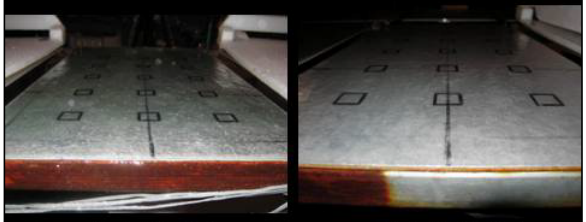
Test #	Year	Commercial Fluid	Fluid Dilution	Fail Time [min]	% Diff in Fail Time	Precip Rate [g/dm²/hr]	Temp [°C]	Precipitation [Type]
RS1-08	2007-08	Fluid A-IV-EG	100	58	16%	25	1	S +R (12+13)
RS1-1-08	2007-08	Fluid A-IV-EG	100	51		25	-3	ZR (25)
RS2-08	2007-08	Fluid B-IV-PG	100	69	13%	25	1	S +R (12+13)
RS2-1-08	2007-08	Fluid B-IV-PG	100	61		25	-3	ZR (25)
RS1-1A	2008-09	Fluid C-IV-PG	100	57	15%	25	1	S +R (12+13)
RS7	2008-09	Fluid C-IV-PG	100	48		25	-3	ZR (25)
RS2-2A	2008-09	Fluid D-IV-PG	100	54	34%	25	1	S +R (12+13)
RS8	2008-09	Fluid D-IV-PG	100	40		25	-3	ZR (25)
RS3-3A	2008-09	Fluid E-II-PG	100	38	23%	25	1	S +R (12+13)
RS9	2008-09	Fluid E-II-PG	100	29		25	-3	ZR (25)
RS4-4A	2008-09	Fluid F-II-PG	100	25	30%	25	1	S +R (12+13)
RS10	2008-09	Fluid F-II-PG	100	21		25	-3	ZR (25)
RS5-5A	2008-09	Fluid G-III-PG	100	18	55%	25	1	S +R (12+13)
RS11	2008-09	Fluid G-III-PG	100	10		25	-3	ZR (25)
RS6-6A	2008-09	Fluid H-IV-PG	50	21	40%	25	1	S +R (12+13)
RS12	2008-09	Fluid H-IV-PG	50	15		25	-3	ZR (25)

Avg %Diff in Fail Time: 27%

ENDURANCE TIME TESTING

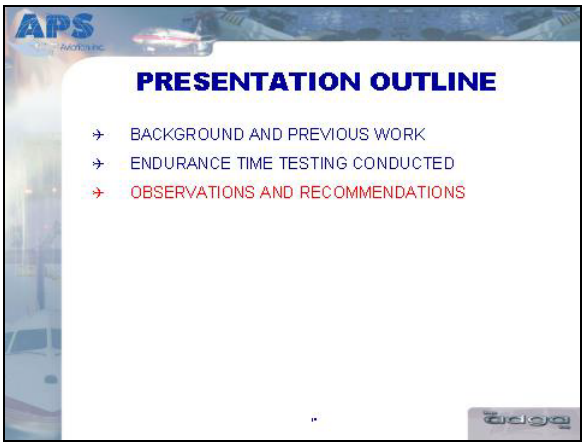


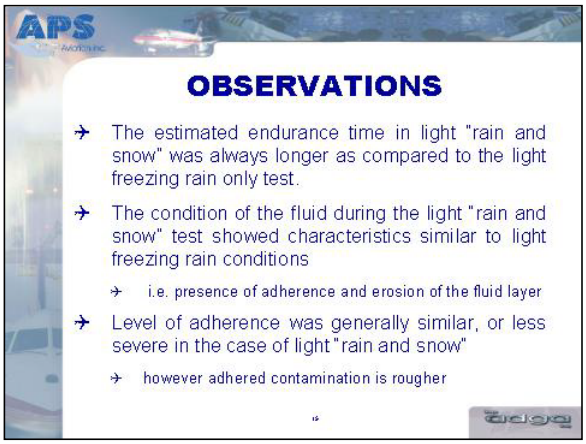
FAILURE COMPARISON TYPE IV PG



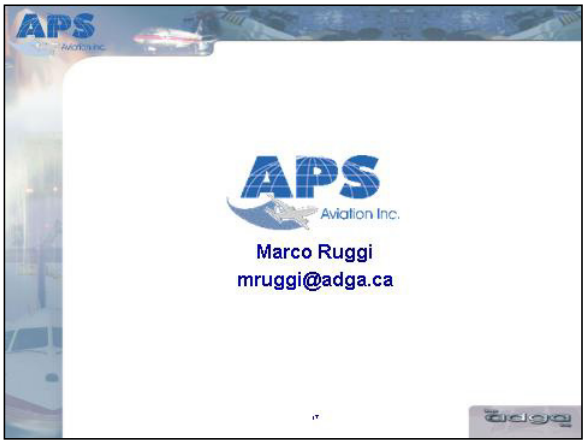
Test #RS2-08
Light Rain and Snow
ET = 69 min
Time of Photo = 57 min

Test #RS2-1-08
Light Freezing Rain
ET = 61 min
Time of Photo= 61 min

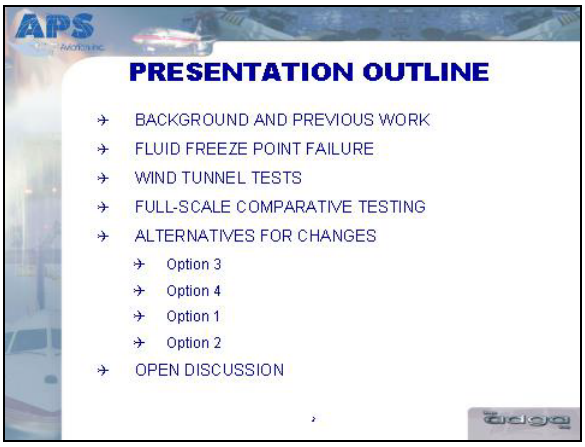

PRESENTATION OUTLINE
BACKGROUND AND PREVIOUS WORK
ENDURANCE TIME TESTING CONDUCTED
OBSERVATIONS AND RECOMMENDATIONS

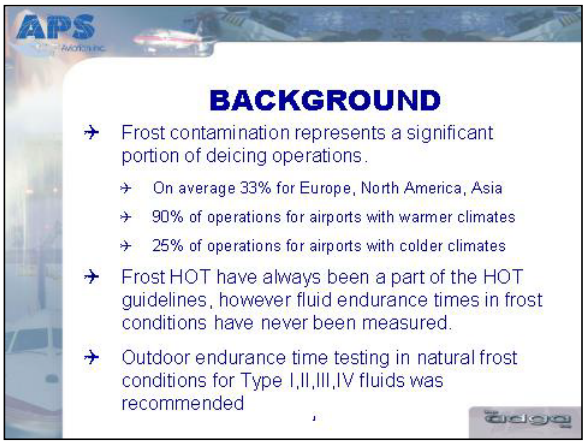

OBSERVATIONS
The estimated endurance time in light "rain and snow" was always longer as compared to the light freezing rain only test.
The condition of the fluid during the light "rain and snow" test showed characteristics similar to light freezing rain conditions
i.e. presence of adherence and erosion of the fluid layer
Level of adherence was generally similar, or less severe in the case of light "rain and snow"
however adhered contamination is rougher

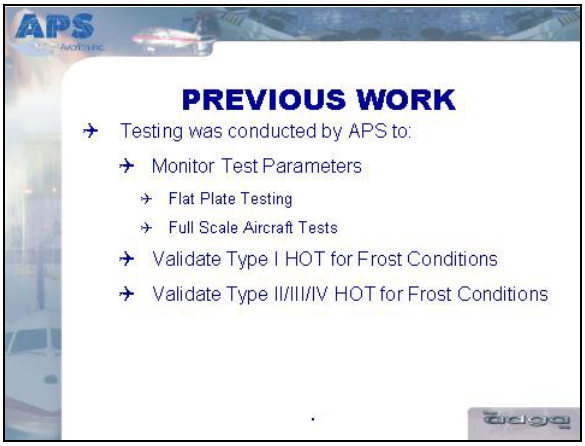
RECOMMENDATIONS
Light freezing rain holdover times seem a good conservative approach for mixed light "rain and snow" conditions
This is in accordance with the Association of European Airlines (AEA) recommendation.
Should be included in HOT Guidelines, potentially as a footnote to all tables:
i.e. "In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times"

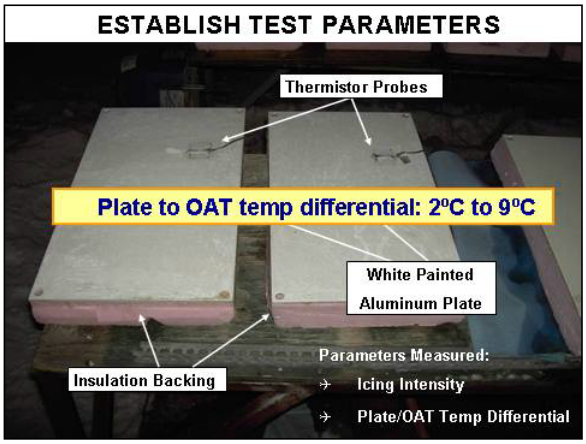

Aviation Inc.
Marco Ruggi
mruggi@adga.ca

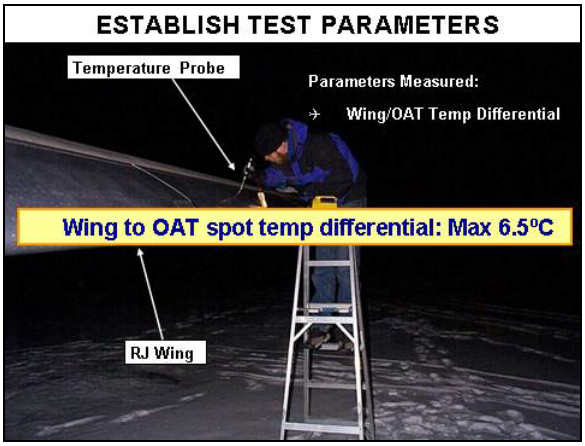
PROPOSED CHANGES TO
FROST HOT GUIDELINES
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
SAE G-12 HOT SUBCOMMITTEE
CHARLESTON – MAY 12, 2009

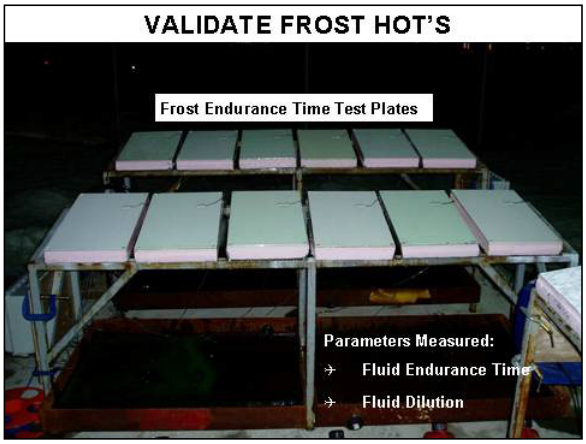

PRESENTATION OUTLINE
BACKGROUND AND PREVIOUS WORK
FLUID FREEZE POINT FAILURE
WIND TUNNEL TESTS
FULL-SCALE COMPARATIVE TESTING
ALTERNATIVES FOR CHANGES
Option 3
Option 4
Option 1
Option 2
OPEN DISCUSSION


BACKGROUND
Frost contamination represents a significant portion of deicing operations.
On average 33% for Europe, North America, Asia
90% of operations for airports with warmer climates
25% of operations for airports with colder climates
Frost HOT have always been a part of the HOT guidelines, however fluid endurance times in frost conditions have never been measured.
Outdoor endurance time testing in natural frost conditions for Type I,II,III,IV fluids was recommended


PREVIOUS WORK
Testing was conducted by APS to:
Monitor Test Parameters
Flat Plate Testing
Full Scale Aircraft Tests
Validate Type I HOT for Frost Conditions
Validate Type II/III/IV HOT for Frost Conditions


ESTABLISH TEST PARAMETERS
Thermistor Probes
Plate to OAT temp differential: 2ºC to 9ºC
White Painted Aluminum Plate
Insulation Backing
Parameters Measured:
Icing Intensity
Plate/OAT Temp Differential


ESTABLISH TEST PARAMETERS
Temperature Probe
Parameters Measured:
Wing/OAT Temp Differential
Wing to OAT spot temp differential: Max 6.5ºC
RJ Wing


VALIDATE FROST HOT'S
Frost Endurance Time Test Plates
Parameters Measured:
Fluid Endurance Time
Fluid Dilution

SUMMARY OF ENDURANCE TIME RESULTS

Fluid	# Tests	Current Endurance Time Results
Type I	47	45 min HOT substantiated
Type II	62	Reductions necessary (Primarily due to FFP Failure)
Type III	16	Based on data, no reductions required
Type IV	90	Reductions necessary (Primarily due to FFP Failure)
	215	

PURPOSE

- Data collected by APS in natural frost conditions was presented at several meetings including the G-12 meeting in
  - San Diego (May 2007)
  - Montreal (November 2007)
  - Warsaw (May 2008)
  - Montreal (November 2008)
- Attention was focused on:
  - **Reduced Endurance Times in Frost Conditions due to Fluid Freeze Point Issues**

PURPOSE

- Present proposed options for changes to frost HOT guidelines
- Obtain industry feedback to focus the direction for change

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION

FLUID FREEZE POINT FAILURE

- EXAMPLE
  - Type IV 75/25 Fluid
  - OAT = **-13.9°C** (within operational limit)
  - Plate Temperature = -13.9°C – (7°C) = **-20. 9°C**
  - Fluid Freeze Point (FFP) = **-21°C**
    - Fluid would be designed with 7°C buffer based on operational limit of -14°C
  - **Plate temperature is cooled to FFP**
  - **Fluid experiences contamination as ice crystals begin to form sporadically in fluid**

FLUID FREEZE POINT FAILURE

- Fluid freeze point failure can b… dilutions when a… tem…

FROST HOT'S SHOULD CONSIDER THE EFFECT OF SKIN TEMPERATURE

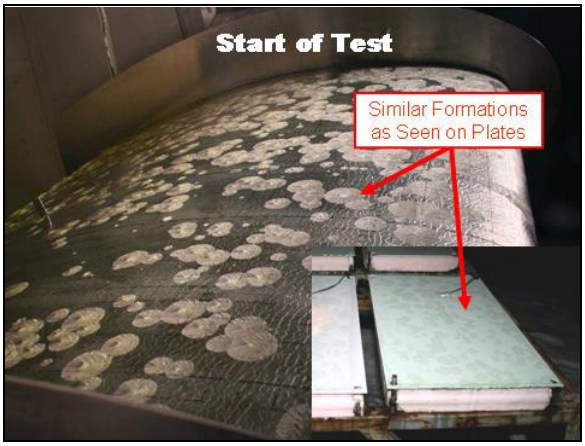
Type II/IV Dilution	Lowest Possible Condition Temperature (°C)	Approximate FFP (°C)	Possible Surface Temp. During Frost Conditions (°C)
Neat	-25	-36	-32
75/25	-14	-21	-21
50/50	-3	-10	-10

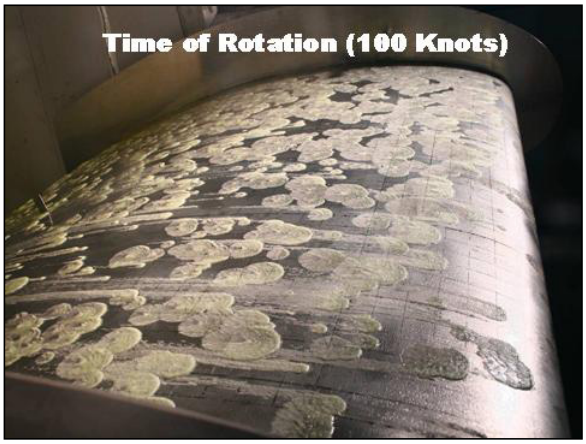
PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION

WIND TUNNEL TESTS

- Two preliminary tests were conducted in the NRC Wind Tunnel during the winter of 2008-09
- Fluid was applied with negative buffer to simulate fluid freeze point failure
- Wing was cooled down until fluid began to freeze and crystallize
- Test Conditions
  - Type IV 50/50 (FFP -10°C)
  - Wing Temp -10°C
  - OAT -16°C
  - High Speed Test





OBSERVATIONS

- Preliminary tests showed similar crystaline formations on the wing section as were seen on the test plates
- Contamination was not easily removed and was present even at the end of the test

RESULTS SUPPORT PROPOSED HOT REDUCTIONS

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION

FULL-SCALE COMPARATIVE TESTING

- **To validate fluid freeze point HOT reductions for Type II, and IV fluids through comparative endurance time testing on plates and the Jetstar wing**
- Testing was conducted during 4 events
- Target condition: simulate freeze point failure with 75/25 dilutions close to LOUT of -14 ºc
- Testing was conducted in low lighting conditions

METHODOLOGY

- Four strips of 75/25 fluid were applied to the Jetstar wing
  - Approximately 6-10L of fluid at OAT poured as a 2' wide strip the length of the chord
- Four test plates were poured simultaneously
  - 1L poured at OAT per white painted insulated test plate
- **Endurance time was measured and compared**
  - Surface temperature was monitored
  - Brix and thickness measurements were collected

JETSTAR WING

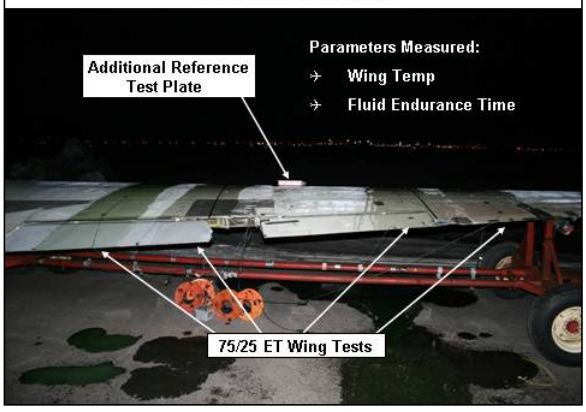
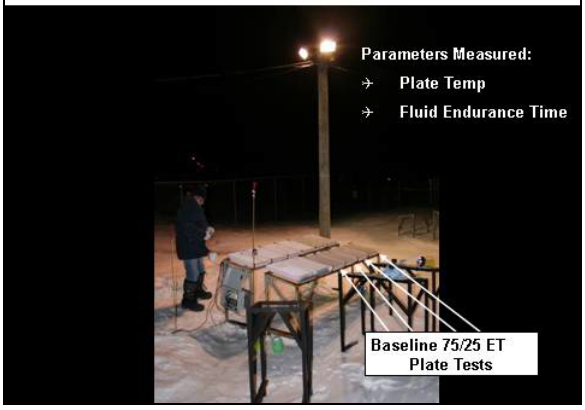
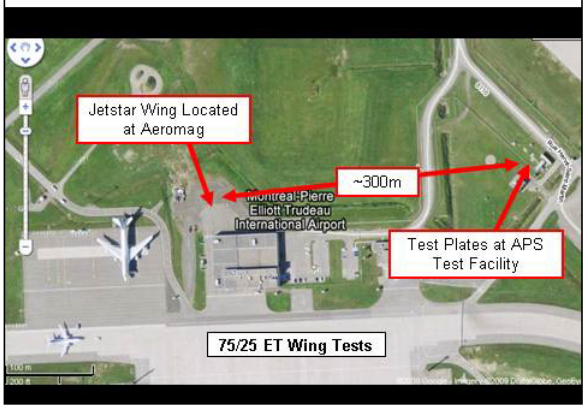
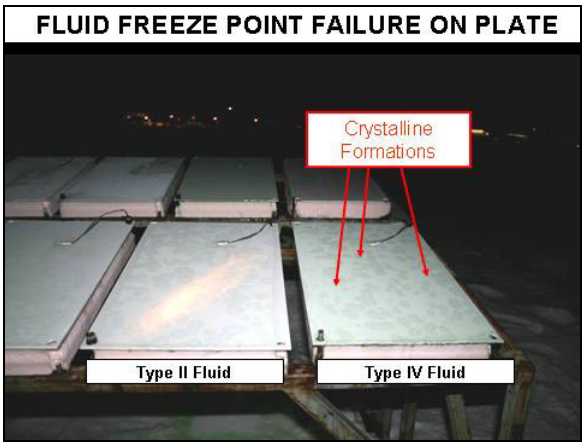


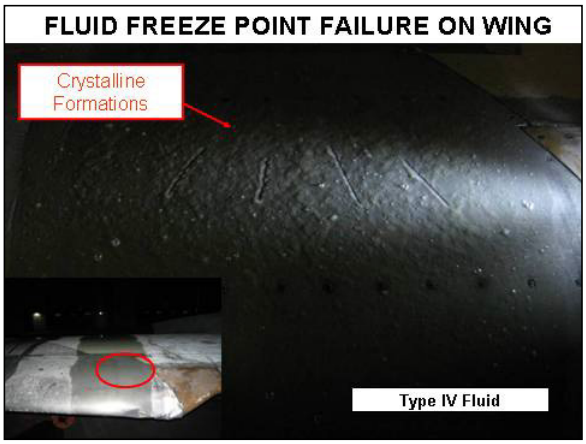
PLATE TESTS

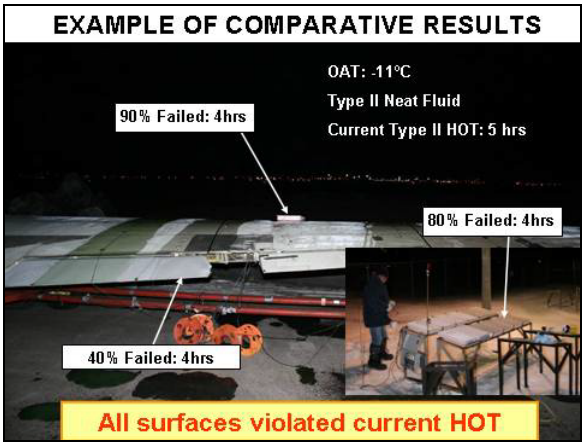


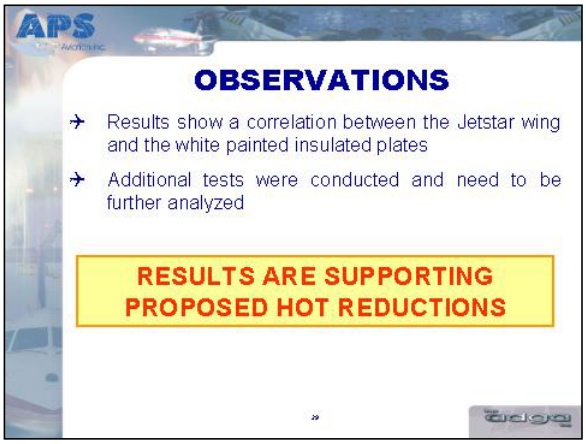
YUL TEST LOCATIONS

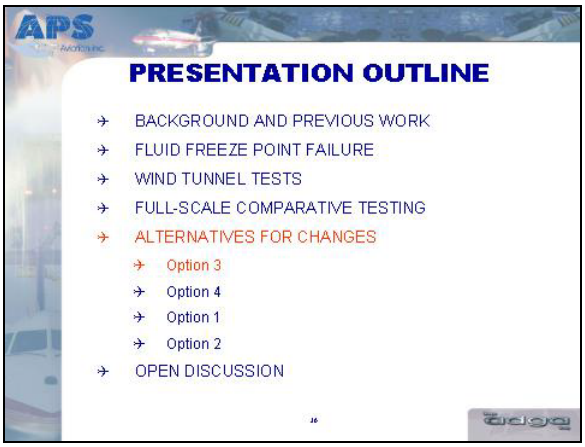


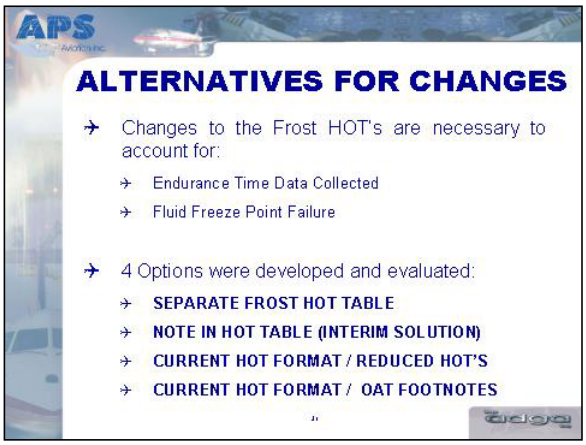

FLUID FREEZE POINT FAILURE ON PLATE
Crystalline Formations
Type II Fluid
Type IV Fluid


FLUID FREEZE POINT FAILURE ON WING
Crystalline Formations
Type IV Fluid


EXAMPLE OF COMPARATIVE RESULTS
OAT: -11°C
Type II Neat Fluid
Current Type II HOT: 5 hrs
90% Failed: 4hrs
80% Failed: 4hrs
40% Failed: 4hrs
All surfaces violated current HOT


APS
OBSERVATIONS
Results show a correlation between the Jetstar wing and the white painted insulated plates
Additional tests were conducted and need to be further analyzed
RESULTS ARE SUPPORTING PROPOSED HOT REDUCTIONS


APS
PRESENTATION OUTLINE
BACKGROUND AND PREVIOUS WORK
FLUID FREEZE POINT FAILURE
WIND TUNNEL TESTS
FULL-SCALE COMPARATIVE TESTING
ALTERNATIVES FOR CHANGES
Option 3
Option 4
Option 1
Option 2
OPEN DISCUSSION


APS
ALTERNATIVES FOR CHANGES
Changes to the Frost HOT's are necessary to account for:
Endurance Time Data Collected
Fluid Freeze Point Failure
4 Options were developed and evaluated:
SEPARATE FROST HOT TABLE
NOTE IN HOT TABLE (INTERIM SOLUTION)
CURRENT HOT FORMAT / REDUCED HOT'S
CURRENT HOT FORMAT / OAT FOOTNOTES

OPTION 3
SEPARATE FROST TABLE

- Issue frost HOT's on a separate table
- Remove frost HOT's from generic and fluid specific tables
- Change temperature ranges to reflect skin temp. differential experienced during frost conditions

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 1 - FROST

SAE TYPE I[1], II, III, IV FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	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		~~3:00~~ 1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	~~12:00~~ 10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		~~8:00~~ 8:00	2:00	~~12:00~~ 8:00
		75/25		~~5:00~~ 1:00	1:00	~~5:00~~ 1:00
below -14 to -21	below 7 to -6	100/0		~~8:00~~ 8:00	2:00	~~12:00~~ 8:00
below -21 to -25	below -6 to -13	100/0		~~8:00~~ 2:00	2:00	~~12:00~~ 4:00

NOTES (TO BE DEVELOPPED FURTHER)
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 May be used below -25°C (-13°F) provided the LOUT of the fluid is respected.

CAUTIONS (TO BE DEVELOPPED FURTHER)
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 3-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 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	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25	below 7 to -13	100/0	0:15 – 0:20[4]	0:15 – 0:30[4]				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.					

NOTES
1 Based on the lowest holdover times of the Type II fluids listed in Table 5-2.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

OPTION 3
SEPARATE FROST TABLE

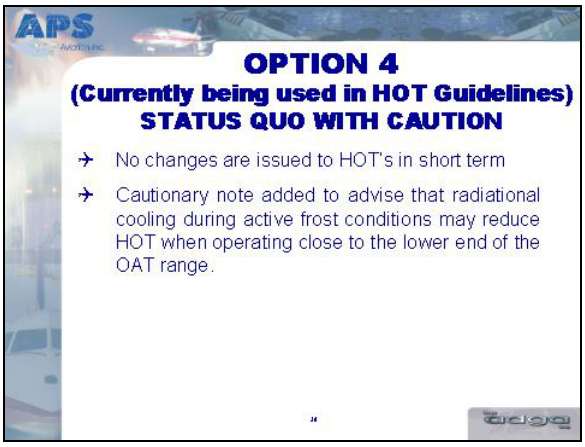
- Option 3 would allow for greater operational flexibility
- Operators could extract HOT values from Option 3 table and generate Option 1 or Option 2 tables
  - Option 1 and 2 tables are based on Option 3 HOT values

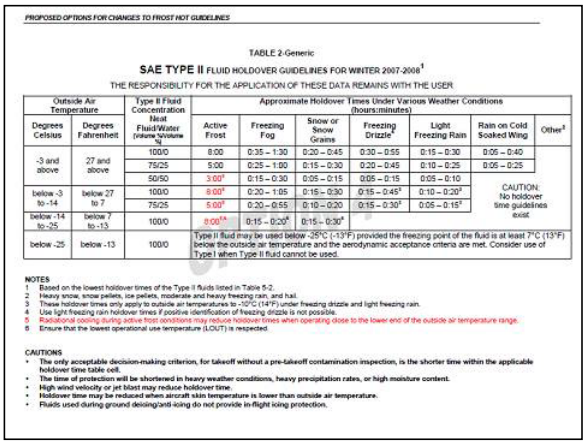
OPTION 3
SEPARATE FROST TABLE

- To evaluate the operational impact on UK operators, an analysis of minimum daily temps was conducted at three UK airports:
  - **Glasgow, Edinburgh, Aberdeen**
- Minimum daily temps over the last 10 years between November 1st and March 31st were analyzed
- Days with minimum daily temps below -10ºC accounted for approximately 0.1%
- 75/25 HOT reductions should not have a significant impact on UK operations

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION





PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 2-Generic

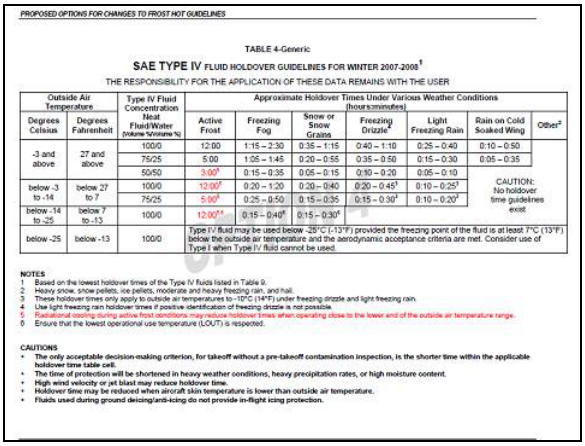
SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

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 %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00[5]	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00[5]	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45[4]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	5:00[5]	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30[4]	0:05 – 0:15[3]		
below -14 to -25	below 7 to -13	100/0	8:00[5,6]	0:15 – 0:20[4]	0:15 – 0:30[4]				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

NOTES
1 Based on the lowest holdover times of the Type II fluids listed in Table 5-2.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.



PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 4-Generic

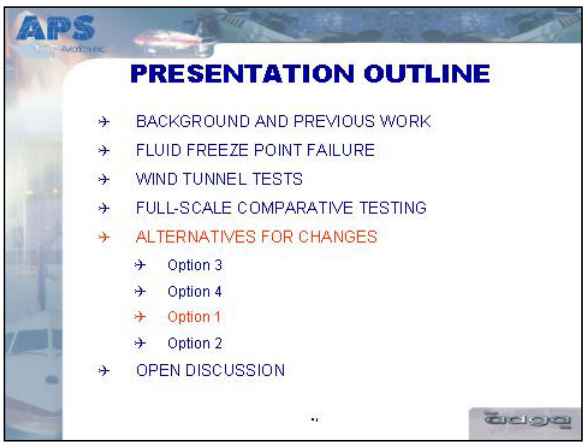
SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

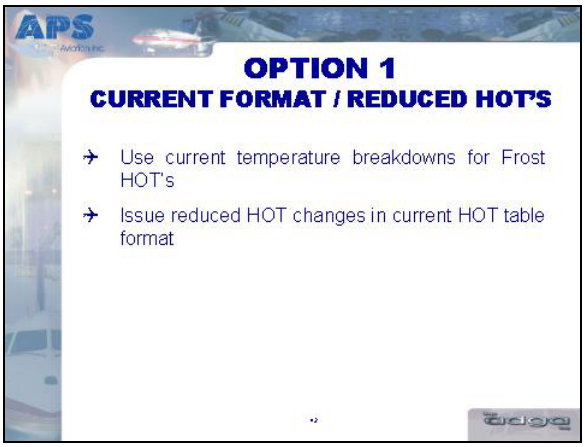
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

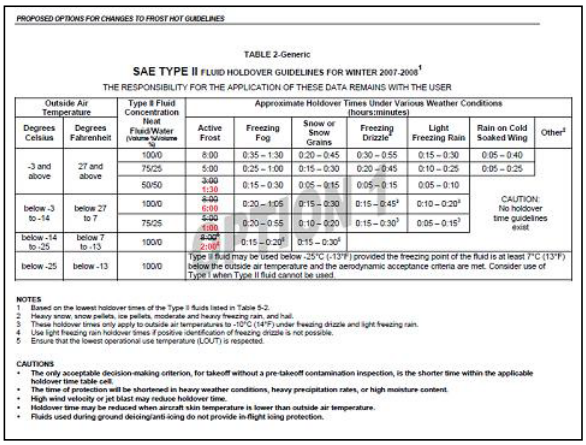
Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (volume %/volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00[5]	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00[5]	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]	CAUTION: No holdover time guidelines exist	
		75/25	5:00[5]	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[5,6]	0:15 – 0:40[4]	0:15 – 0:30[4]				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

NOTES
1 Based on the lowest holdover times of the Type IV fluids listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
6 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.







PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

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 %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00 1:30	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00 6:00	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45[4]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	5:00 4:00	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30[4]	0:05 – 0:15[3]		
below -14 to -25	below 7 to -13	100/0	8:00[5] 2:00[5]	0:15 – 0:20[4]	0:15 – 0:30[4]				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

NOTES
1 Based on the lowest holdover times of the Type II fluids listed in Table 5-2.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION

OPTION 2
CURRENT FORMAT / OAT FOOTNOTES FOR DILUTED FLUIDS

- Issue changes in the current HOT tables
- Restrict use of DILUTED fluids to reflect skin temp. differential experienced during frost conditions
- Include notes in tables to describe temperature restrictions

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

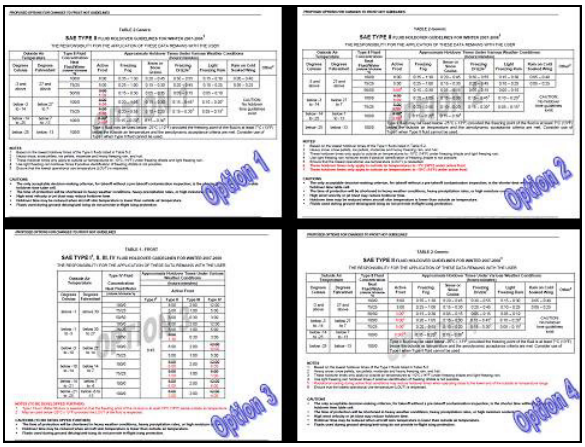
Outside Air Temperature		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (volume %/volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00[6]	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	~~2:00~~ 4:00[6]	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45[3]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	~~1:20~~ 3:00[6]	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25	below 7 to -13	100/0	~~0:20~~ 2:00[6]	0:15 – 0:20[7]	0:10 – 0:30[3]				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

NOTES
1. Based on the lowest holdover times of the Type II fluids listed in Table 5-2.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Ensure that the lowest operational use temperature (LOUT) is respected.
6. These holdover times only apply to outside air temperatures to -1°C (30°F) under active frost.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under active frost.

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 deicing/anti-icing do not provide in-flight icing protection.

PRESENTATION OUTLINE

- BACKGROUND AND PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- WIND TUNNEL TESTS
- FULL-SCALE COMPARATIVE TESTING
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- OPEN DISCUSSION



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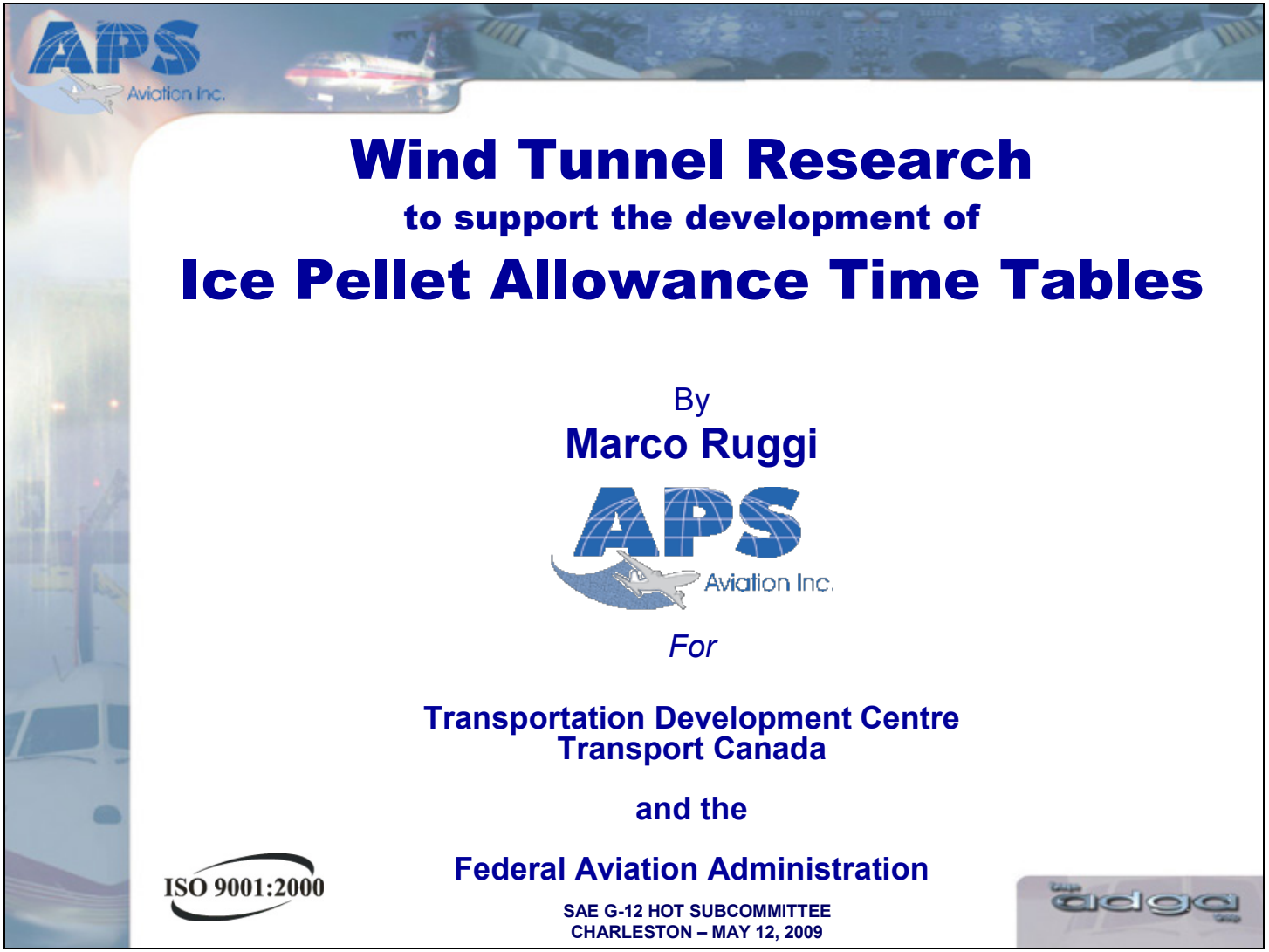

APS
Aviation Inc.
Wind Tunnel Research
to support the development of
Ice Pellet Allowance Time Tables
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
SAE G-12 HOT SUBCOMMITTEE
CHARLESTON – MAY 12, 2009
ISO 9001:2000

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Background

- Recent industry need to provide aircraft operators with holdover times for ice pellet conditions
- Ongoing research has been conducted during the winters of 2005-06 to 2008-09
- Work consisted of
  - Full scale aircraft tests
  - Wind tunnel testing
  - Flat plate testing

Current Ice Pellet Allowance Times

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		

Transports Canada Transport Canada

Current Ice Pellet Allowance Times

Table 1. Ice Pellet Allowance Times

	OAT -5° C or Warmer	OAT Colder Than -5° C
Light Ice Pellets	50 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes	Operations Not Authorized
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle, or Light Freezing Rain (Operations not authorized below -10° C OAT)	25 Minutes	10 Minutes (Operations Not Authorized below -10°C OAT)
Light Ice Pellets Mixed with Light Rain (Operations not authorized below 0° C OAT)	25 Minutes (Operations Not Authorized below 0°C OAT)	(Operations Not Authorized below 0°C OAT

Background

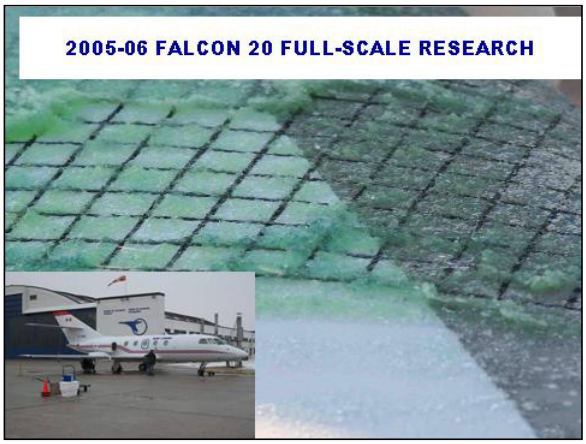
- Guidance material was followed by a list of conditions and restrictions which include
  - Type IV Neat Fluid Only
  - Rotation speed of 100 knots or greater
- Industry requested additional guidance material for operations with
  - Low rotation aircraft
  - Type III fluid

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Previous Research

- 2005-06 Research
  - Falcon 20 testing conducted in ice pellets alone
  - FAA issued 25-minute allowance time for ice pellet conditions only
  - Work presented at G-12 in Lisbon 2006



Previous Research

- 2006-07 Research
  - Wind Tunnel testing conducted in mixed conditions with ice pellets
  - Limited Falcon 20 tests conducted to validate results
  - TC and FAA issued allowance time guidance material for mixed condition with ice pellets for the winter of 2007-08
  - Work presented at G-12 in San Diego 2007

Previous Research

- 2007-08 Research
  - Wind Tunnel was not available
  - Low speed testing conducted with Falcon 20 and T-33
  - No changes made to Allowance Times
  - Aero data required
  - Work presented at G-12 in Warsaw 2008

OUTLINE

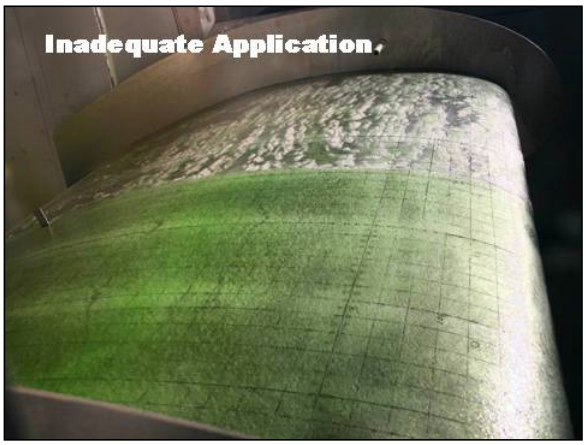
- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

2008-09 Test Summary

- Testing conducted at NRC Open Circuit Wind Tunnel
- 107 test runs completed over a period of 5 weeks
- Research geared towards Ice Pellet research and other R&D activities

2008-09 Wind Tunnel Test Plan

- Primary Research Objectives
  - Validation of Current Allowance Times
  - Expansion of Allowance Times
    - Low Rotation Speed
    - SN/IP at lower temperatures
    - Different Fluid Types
- Secondary Research Objectives
  - S++, Frost, Inadequate Application, Composite Materials, R-&SN, R&IP-, Surface Roughness
  - Likely to be presented at SAE G-12 in November 2009



Summary of Test Runs

Objective	# of Runs
Secondary Research Objectives	29
Baseline/Dry	24
Type IV High Speed	24
Type IV Low Speed	17
Type III Low Speed	11
Type II Low Speed	2
Total	***107***

ACKNOWLEDGMENTS OF FLUID MANUFACTURERS FOR PROVIDING TEST SAMPLES

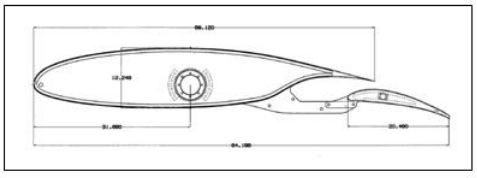
ABAX INDUSTRIES
Clariant
DOW
Kilfrost
OCTAGON

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Test Methodology

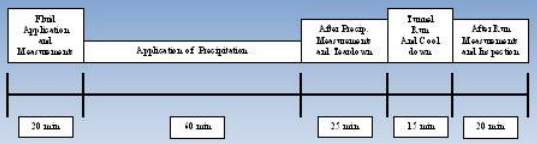
- NASA LS(1)-0417 Wing Section was used for testing
  - Fowler Flap fixed at 15°



Test Methodology

- Typical wind tunnel test profile:
  - Initial wing angle of attack 0°
  - 0 to V_R in 30-35 seconds
  - At V_R, Pitch wing to Θ_{MAX}° (2.7° per second)
  - Pitch wing back to 4° (0.25° per second)
  - Hold wing at 4° for 1 minute and stop test
- V_R = 80 knots (low speed) or 100 knots (high speed)
- Θ_{MAX}° = 8°,12°, 16°, and 20°

Sample Run Timeline



Test Methodology

- High resolution photography of each test run was collected
  - Photos of the wing condition before and after the test run
  - High speed photos of LE and TE during the test run
- Fluid brix, thickness, and skin temperature were measured
  - After fluid application
  - After precipitation application
  - After test run

Test Methodology

- Visual contamination ratings of the LE and TE were assigned during each test
  - Start of test
  - Start of Rotation
  - End of the test
- Ratings were assigned by 3 observers (WU, JD, MR)

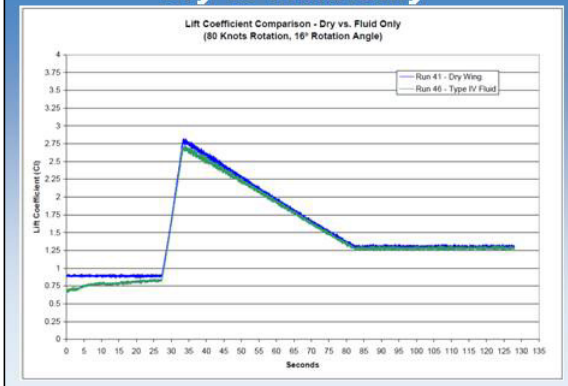
Visual Contamination Ratings (1 to 5):

1) Contamination not very visible, fluid still clean.
2) Contamination visible, but lots of fluid still present
3) Contamination visible, spots of bridging contamination
4) Contamination visible, lots of dry bridging present
5) Contamination visible, adherence of contamination

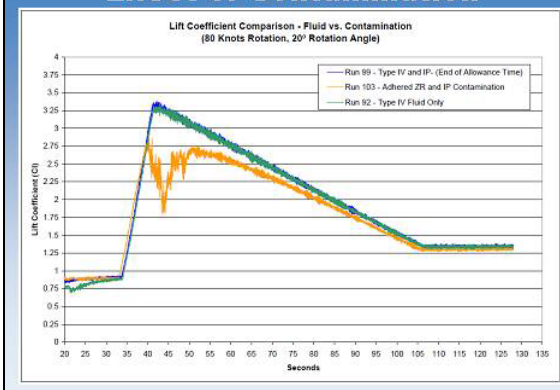
Test Methodology

- Aerodynamic data was collected by NRC
  - Lift Data, Drag Data, Wind Speed, Pitch Angle, Temperature, etc…
- Lift coefficient data (Cl) was analyzed for each of the test runs
- Visual contamination ratings showed good correlation to lift coefficient data
  - i.e. severe visual contamination ratings generally correlated with lift losses

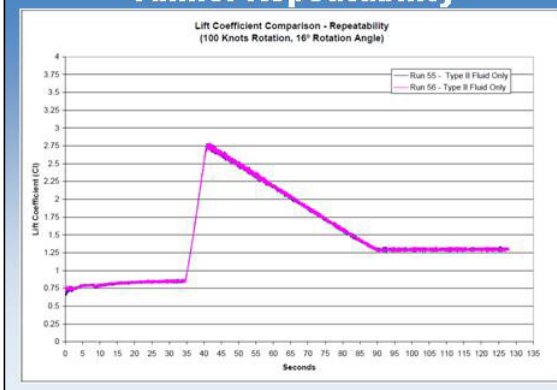
Dry vs Fluid Only



Effect of Contamination



Tunnel Repeatability



OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Type IV High Speed

- 24 tests were conducted
- Objectives:
  - To validate current allowance times
  - To potentially expand current allowance times
    - Mixed IP and SN below -5°C

Type IV High Speed

- Results
  - Current allowance times were validated
    - Data at colder temps still recommended for IP and IP-
  - Allowance times were expanded for
    - IP/SN and IP/R_{mod}
- Recommendation
  - New Type IV High Speed Allowance Time table
  - Additional testing at colder temperatures

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes		10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle			
Light Ice Pellets Mixed with [illegible]		10 minutes	
Light Ice Pellets Mixed with Light [illegible]	25 minutes		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Moderate [illegible]	25 minutes		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ ~~25 minutes~~		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

To be Published

Example: Validation Test Light Ice Pellets

- Current IP- Allowance:
  - 50 minutes for Above -5ºC
- Test Conditions:
  - Type IV PG Neat
  - IP 25 g/dm²/h for 50 min
  - OAT -9°C
  - High Speed, 8° Rotation

Old Type IV High Speed

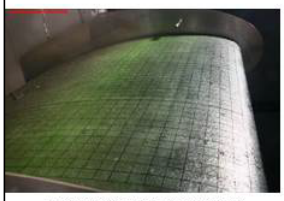
TABLE 10
ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

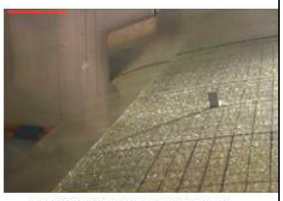
	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		

Test #21 (P45)

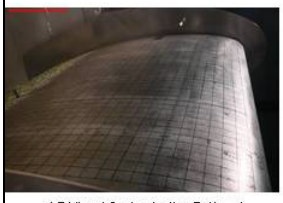
ABC-S Plus, IP 25 g/dm²/h, 50 min, -9°C,
High Speed, 8° Rotation

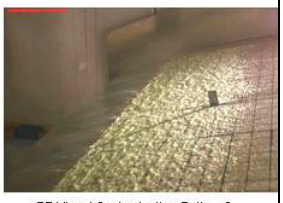
Test #21 (P45)
ABC-S Plus, IP 25 g/dm²/h, 50 min
-9°C, High Speed, 8° Rotation
Start of Test


LE Visual Contamination Rating: 3

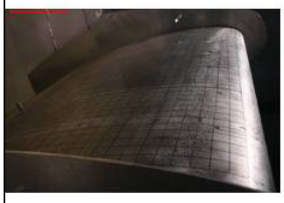

TE Visual Contamination Rating: 3

Test #21 (P45)
ABC-S Plus, IP 25 g/dm²/h, 50 min
-9°C, High Speed, 8° Rotation
Before Rotation

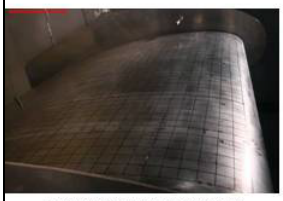

LE Visual Contamination Rating: 1


TE Visual Contamination Rating: 2

Test #21 (P45)
ABC-S Plus, IP 25 g/dm²/h, 50 min
-9°C, High Speed, 8° Rotation
End of Rotation



Test #21 (P45)
ABC-S Plus, IP 25 g/dm²/h, 50 min
-9°C, High Speed, 8° Rotation
End of Test



LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 1

Example: Validation Test
Light Ice Pellets

- Test #21 Results:
  - Visual contamination ratings were good
    - Below 3 at start
    - LE equal to 1 just before rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Good Successful Run**

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	~~25 minutes~~		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ 25 minutes		
Light Ice Pellets Mixed with Light Snow	~~25 minutes~~	~~15 minutes~~	

Validated: No changes required

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

Example: Expansion Test
Light Ice Pellets Mixed with Moderate Rain

- Current IP-/R Allowance:
  - No Current Allowance Time for Above -5ºC
- Test Conditions:
  - Type IV EG Neat
  - IP+R 25+75 g/dm²/h for 25 min
  - OAT -1°C
  - High Speed, 16° Rotation

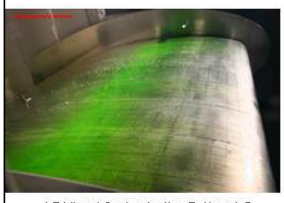
New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	~~25 minutes~~		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ 25 minutes		
Light Ice Pellets Mixed with Light Snow	~~25 minutes~~	~~15 minutes~~	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

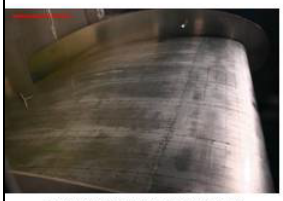
Test #85 (P70R2)
EG 106, IP+R 25+75 g/dm²/h, 25 min
-1°C, High Speed, 16° Rotation
Start of Test



LE Visual Contamination Rating: 1.5

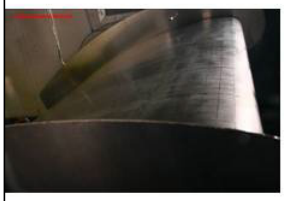
TE Visual Contamination Rating: 1.5

Test #85 (P70R2)
EG 106, IP+R 25+75 g/dm²/h, 25 min
-1°C, High Speed, 16° Rotation
Before Rotation

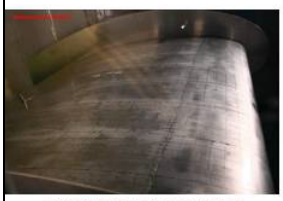

LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 1

Test #85 (P70R2)
EG 106, IP+R 25+75 g/dm²/h, 25 min
-1°C, High Speed, 16° Rotation
End of Rotation



Test #85 (P70R2)
EG 106, IP+R 25+75 g/dm²/h, 25 min
-1°C, High Speed, 16° Rotation
End of Test


LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 1

Example: Expansion Test Light Ice Pellets Mixed with Moderate Rain

- Test #85 Results:
  - Visual contamination ratings were good
    - Below 3 at start
    - LE equal to 1 just before rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Good Successful Run**

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	*25 minutes*		
Light Ice Pellets Mixed with Moderate Snow	*10 minutes*		
Light Ice Pellets Mixed with Light Snow	*25 minutes*	*15 minutes*	

25 Minutes Proposed

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

Example: Validation Test Light Ice Pellets Mixed with Moderate Snow

- Current IP-/SN Allowance:
  - 25 minutes for Above -5ºC
- Test Conditions:
  - Type IV PG Neat
  - IP+SN 25+25 g/dm²/h for 25 min
  - OAT -6°C
  - High Speed, 16° Rotation

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Snow	10 minutes 25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

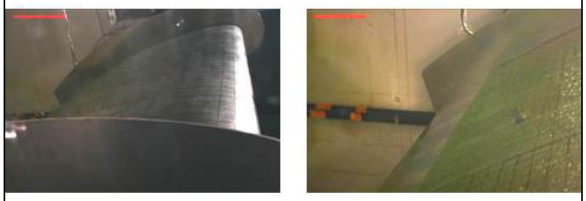
Test #58 (P25)
Launch, IP+SN 25+25 g/dm²/h, 25 min
-6°C, High Speed, 16° Rotation
Start of Test

LE Visual Contamination Rating: 3 — TE Visual Contamination Rating: 4

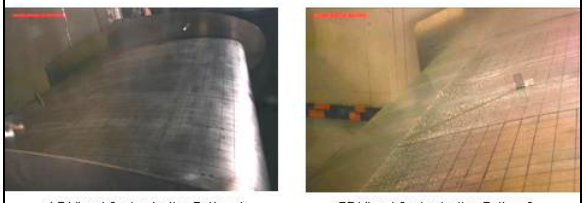
Test #58 (P25)
Launch, IP+SN 25+25 g/dm²/h, 25 min
-6°C, High Speed, 16° Rotation
Before Rotation

LE Visual Contamination Rating: 1 — TE Visual Contamination Rating: 2.5

Test #58 (P25)
Launch, IP+SN 25+25 g/dm²/h, 25 min
-6°C, High Speed, 16° Rotation
End of Rotation



Test #58 (P25)
Launch, IP+SN 25+25 g/dm²/h, 25 min
-6°C, High Speed, 16° Rotation
End of Test



LE Visual Contamination Rating: 1 — TE Visual Contamination Rating: 2

Example: Validation Test Light Ice Pellets Mixed with Moderate Snow

- Test #58 Results:
  - Visual contamination ratings not acceptable
    - TE rating of 4 at start
    - LE equal to 1 just before rotation
    - Visual contamination beyond acceptable level
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs, however was borderline
    - Good results
  - Overall Status
    - **Visual Contamination Causes Concern**

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	~~25 minutes~~		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ 25 minutes		
Light Ice Pellets Mixed with Light Snow	~~25 minutes~~	~~15 minutes~~	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

10 Minutes proposed based on limited tests

Example: Expansion Test Light Ice Pellets Mixed with Light Snow

- Current IP-/SN- Allowance:
  - Currently No Allowance Time for -5ºC to -10ºC
- Test Conditions:
  - Type IV PG Neat
  - IP+SN 25+10 g/dm²/h for 15 min
  - OAT -10°C
  - High Speed, 16° Rotation

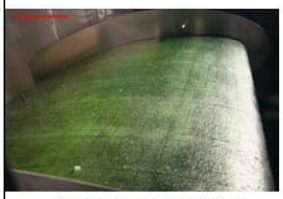
New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	~~25 minutes~~		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ 25 minutes		
Light Ice Pellets Mixed with Light Snow	~~25 minutes~~	~~15 minutes~~	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

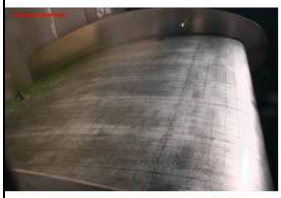
Test #76 (P28R)
Launch, IP+SN 25+10 g/dm²/h, 15 min
-10°C, High Speed, 16° Rotation
Start of Test



LE Visual Contamination Rating: 3

TE Visual Contamination Rating: 3

Test #76 (P28R)
Launch, IP+SN 25+10 g/dm²/h, 15 min
-10°C, High Speed, 16° Rotation
Before Rotation

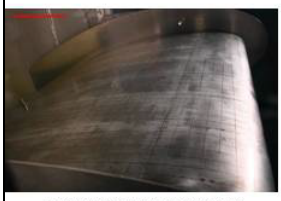


LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 2

Test #76 (P28R)
Launch, IP+SN 25+10 g/dm²/h, 15 min
-10°C, High Speed, 16° Rotation
End of Rotation

Test #76 (P28R)
Launch, IP+SN 25+10 g/dm²/h, 15 min
-10°C, High Speed, 16° Rotation
End of Test



LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 1

Example: Expansion Test
Light Ice Pellets Mixed with Light Snow

- Test #76 Results:
  - Visual contamination ratings were good
    - Equal to 3 at start
    - LE equal to 1 just before rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Good Successful Run**

New Type IV High Speed

TABLE 1.1: TYPE IV HIGH SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ 25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	~~15 minutes~~	

NOTE: Strikethrough Allowance

15 Minutes proposed

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Type IV Low Speed

- 17 tests were conducted
- Objectives:
  - To investigate if current Type IV allowance times can apply to low speed aircraft
  - To develop Type IV fluid allowance times for use with low rotation speed (80 knots) aircraft

Type IV Low Speed

- Results
  - Current high speed Type IV allowance times are not applicable to low speed aircraft
  - Preliminary results indicate significant reductions in allowance times to many of the cells
    - In some cases more than half the time
- Recommendation
  - Due to limited data collected and due to reductions, additional testing is required

Type IV Low Speed

TABLE 1.2: TYPE IV LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets			
Moderate Ice Pellets			
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle			
Light Ice Pellets Mixed with Light Freezi			
Light Ice Pellets Mixed with Light Rain			Caution: No allowance times currently exist
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ ~~25 minutes~~		
Light Ice Pellets Mixed with Light Snow	~~10 minutes~~		

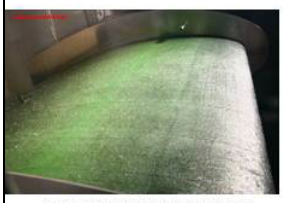
In Development

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

Example: Low Speed Light Ice Pellets

- Current High Speed IP- Allowance:
  - 50 minutes for Above -5ºC
- Test Conditions:
  - Type IV PG Neat
  - IP- 25 g/dm²/h for 50 min
  - OAT -9°C
  - Low Speed, 20° Rotation

Test #86 (PE29)
ABC-S Plus, IP- 25 g/dm²/h, 50 min
-9°C, Low Speed, 20° Rotation
Start of Test


LE Visual Contamination Rating: 3.5

TE Visual Contamination Rating: 3.5

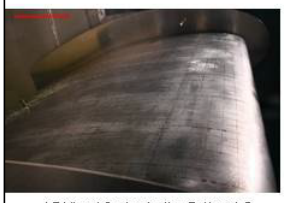
Test #86 (PE29)
ABC-S Plus, IP- 25 g/dm²/h, 50 min
-9°C, Low Speed, 20° Rotation
Before Rotation

LE Visual Contamination Rating: 1.5

TE Visual Contamination Rating: 3

Test #86 (PE29)
ABC-S Plus, IP- 25 g/dm²/h, 50 min
-9°C, Low Speed, 20° Rotation
End of Rotation

Test #86 (PE29)
ABC-S Plus, IP- 25 g/dm²/h, 50 min
-9°C, Low Speed, 20° Rotation
End of Test


LE Visual Contamination Rating: 1.5

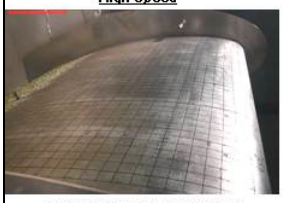
TE Visual Contamination Rating: 3

Example: Low Speed Light Ice Pellets

- Test #86 Results:
  - Visual contamination ratings were not acceptable
    - Rating of 3.5 at start (borderline)
    - LE equal to 1.5 just before rotation (fail)
    - Fail
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Visual Contamination Causes Concern**

High Speed TIV vs. Low Speed Type IV

Test #21(HS) vs. Test #86(LS)
ABC-S Plus, IP- 25 g/dm²/h, 50 min, -9°C
Before Rotation
High Speed vs. Low Speed

High Speed	*Low Speed*
	
LE Visual Contamination Rating: 1 TE Visual Contamination Rating: 2	LE Visual Contamination Rating: 1.5 TE Visual Contamination Rating: 3

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Type III Low Speed

- 11 tests were conducted
- Objective:
  - To develop Type III fluid allowance times for use with low rotation speed (80 knots) aircraft

Type III Low Speed

- Results
  - Type III showed good results in all conditions
  - Testing only conducted with Type III fluid applied cold (at OAT)
  - Data is still required at colder temps (below -10°C)
- Recommendation
  - New Type III fluid allowance time table
  - Additional testing required to expand the table to include
    - Heated Type III
    - Testing at colder temps

Type III Low Speed

TABLE 1.3: TYPE III (APPLIED AT AMBIENT) LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	~~10 minutes~~ ~~60 minutes~~	~~10 minutes~~ ~~30 minutes~~	
Moderate Ice Pellets	~~5 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	~~7 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light Freezing Rain	~~7 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light Rain	~~7 minutes~~ ~~25 minutes~~		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ ~~25 minutes~~	~~5 minutes~~	
Light Ice Pellets Mixed with Light Snow	~~10 minutes~~ ~~25 minutes~~	~~10 minutes~~	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

Being Evaluated

Example: Type III Light Ice Pellets

- Current TIV HS IP- Allowance:
  - 30 minutes for Above -5°C to -10
- Test Conditions:
  - Type III PG Neat
  - IP- 25 g/dm²/h for 10 min
  - OAT -12°C
  - Low Speed, 20° Rotation

Type III Low Speed

TABLE 1.3: TYPE III (APPLIED AT AMBIENT) LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	~~10 minutes~~ ~~60 minutes~~	~~10 minutes~~ ~~30 minutes~~	
Moderate Ice Pellets	~~5 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	~~7 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light Freezing Rain	~~7 minutes~~ ~~25 minutes~~	~~5 minutes~~ ~~10 minutes~~	
Light Ice Pellets Mixed with Light Rain	~~7 minutes~~ ~~25 minutes~~		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Moderate Snow	~~10 minutes~~ ~~25 minutes~~	~~5 minutes~~	
Light Ice Pellets Mixed with Light Snow	~~10 minutes~~ ~~25 minutes~~	~~10 minutes~~	

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

Test #101 (PE11)
2031, IP- 25 g/dm²/h, 10 min
-12°C, Low Speed, 20° Rotation
Start of Test

LE Visual Contamination Rating: 2.5

TE Visual Contamination Rating: 3

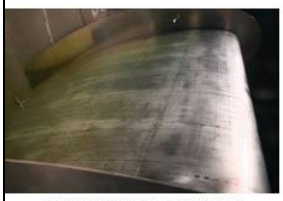
Test #101 (PE11)
2031, IP- 25 g/dm²/h, 10 min
-12°C, Low Speed, 20° Rotation
Before Rotation

LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 2

Test #101 (PE11)
2031, IP- 25 g/dm²/h, 10 min
-12°C, Low Speed, 20° Rotation
End of Rotation

Test #101 (PE11)
2031, IP- 25 g/dm²/h, 10 min
-12°C, Low Speed, 20° Rotation
End of Test



LE Visual Contamination Rating: 1

TE Visual Contamination Rating: 1

Example:
Validation Test – Light Ice Pellets

- Test #101 Results:
  - Visual contamination ratings were good
    - Below 3 at start
    - LE equal to 1 just before rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Good Successful Run**

Low Speed TIII
vs.
Low Speed Type IV

Test #101(LS) vs. Test #86(LS)
Before Rotation
Low Speed TIII vs. Low Speed Type IV

Type III Low Speed

LE Visual Contamination Rating: 1
TE Visual Contamination Rating: 2

Type IV Low Speed

LE Visual Contamination Rating: 1.5
TE Visual Contamination Rating: 3

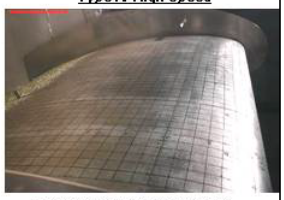
Low Speed TIII
vs.
High Speed Type IV

Test #101(LS) vs. Test #21(HS)
Before Rotation
Low Speed TIII vs. High Speed Type IV

Type III Low Speed

LE Visual Contamination Rating: 1
TE Visual Contamination Rating: 2

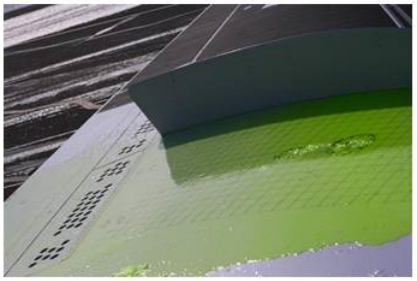
Type IV High Speed



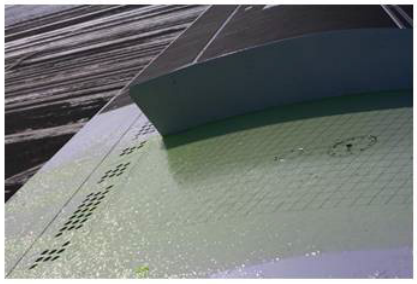
LE Visual Contamination Rating: 1
TE Visual Contamination Rating: 2

Falcon 20 Example
2007-08
Low Speed TIII

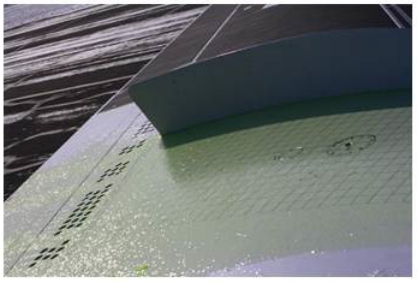
Falcon 20 2007-08, Test #2p
2031, IP 26 (g/dm²/h), 10 min -13°C
Start of Test



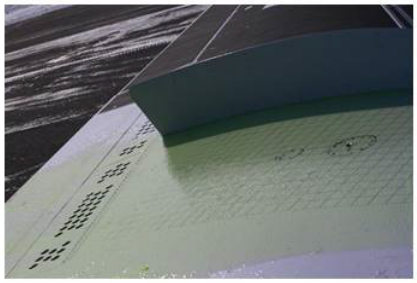
Falcon 20 2007-08, Test #2p
2031, IP 26 (g/dm²/h), 10 min -13°C
17 Seconds



Falcon 20 2007-08, Test #2p
2031, IP 26 (g/dm²/h), 10 min -13°C
Rotation



Falcon 20 2007-08, Test #2p
2031, IP 26 (g/dm²/h), 10 min -13°C
End of Test



OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Type II Fluid

- 2 tests were conducted
- Objective:
  - Preliminary testing
  - To develop Type II fluid allowance times

Type II Fluid

- Results
  - Current high speed Type IV allowance times may not be applicable to Type II fluids
  - Preliminary results indicate reductions as compared to current Type IV allowance times
- Recommendation
  - Due to limited data collected and due to potential reductions, additional testing is required

Type II Fluid

TABLE 1.4: TYPE II LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets			
Moderate Ice Pellets			
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle			
Light Ice Pellets Mixed with Light Freezing Rain		10 minutes	
Light Ice Pellets Mixed with Light Rain		0 minutes 05 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Moderate Snow			
Light Ice Pellets Mixed with Light Snow			

In Development

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE IV LOW SPEED
  - TYPE III LOW SPEED
  - TYPE II FLUID
- FUTURE WORK

Future Work

- Additional testing to expand current allowance times
  - Type IV High Speed
  - Type IV Low Speed
  - Type III Hot and Cold
  - Type II testing
- Testing using a super-critical airfoil and improved weight and balance system
  - To provide more detailed lift coefficient information at the critical stall angle

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AIRPORT SITING CONSIDERATIONS FOR HOLDOVER TIME DETERMINATION SYSTEMS

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOLDOVER TIME SUBCOMMITTEE

CHARLESTON, SC
MAY 12, 2009

MICHAEL CHAPUT

DIRECTOR OF PROJECTS

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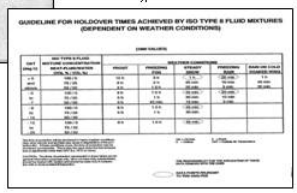
MONTREAL, QUEBEC, CANADA
MCHAPUT@ADGA.CA
WWW.APSAVIATION.CA

DE/ANTI-ICING FLUIDS
HOLDOVER TIME TABLES 1990-91

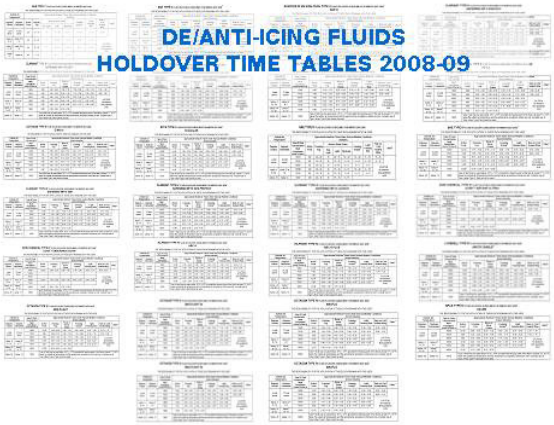
OAT [°C]	WEATHER CONDITIONS				
	Frost	Freezing Fog	Steady Snow	Freezing Rain	Rain on Cold Soaked Wing
+ 0 and above	45 min.	30 min.	15 min.	5 min.	15 min.
- 0 to - 7	45 min.	15 min.	15 min.	3 min.	
- 8 and below	30 min.	15 min.	15 min.		

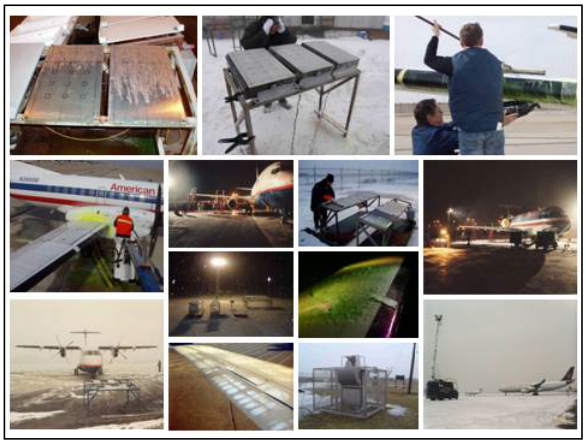
AEA/ISO Type I HOT Table

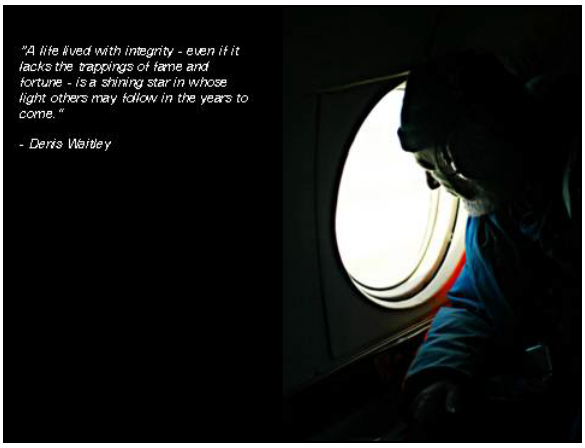
AEA/ISO Type II HOT Table



DE/ANTI-ICING FLUIDS
HOLDOVER TIME TABLES 2008-09






"A life lived with integrity - even if it lacks the trappings of fame and fortune - is a shining star in whose light others may follow in the years to come."
- Denis Waitley

AIRPORT SITING
CONSIDERATIONS
FOR HOLDOVER TIME
DETERMINATION
SYSTEMS

HOLDOVER TIME DETERMINATION SYSTEM (HOTDS)

- System consists of numerous sensors enabling the determination of:
  - Rate of precipitation
  - Type of precipitation
  - Ambient temperature
- System measurements can be employed to generate a "single-value" holdover time for each departing aircraft

AIRPORT SITING OF HOTDS

WORK PERFORMED IN WINTER 2007-08

ACRP PROJECT 10-01

- In March 2007, APS was contracted by the Airport Cooperative Research Program (ACRP) to undertake Project 10-01: *Optimizing the Use of Aircraft De/Anti-Icing Fluids*
- Objective of the ACRP 10-01 project is to examine and research technologies and procedures that could optimize current de/anti-icing practices
- One area of interest for the ACRP 10-01 Project was the future implementation of HOTDS technology

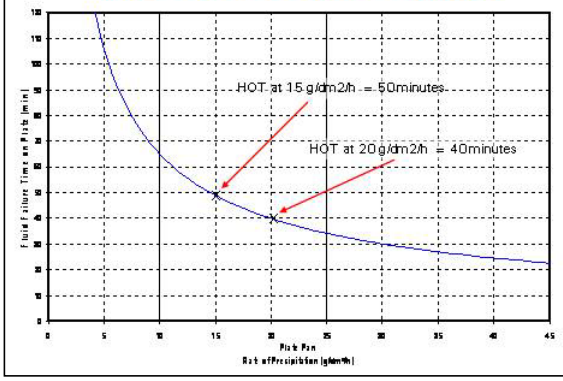
AIRPORT SITING ISSUES WITH HOTDS

- De/anti-icing holdover time is directly dependent on precipitation intensity
- Vital that the intensity measured and employed for holdover time determination is indicative of what the aircraft will be exposed to during taxi
- It was unknown whether a HOTDS at a single airport location can provide data with enough reliability for this application

AIRPORT SITING ISSUES WITH HOTDS

- Objective: Perform a preliminary study to examine if a single location HOTDS can reliably report precipitation conditions for an entire airport
- Objective was met by measuring precipitation rate, as well as other meteorological parameters affecting fluid holdover time, at two different airport locations simultaneously
  - Understand variances between test locations and determine the impact on the holdover times provided by the HOTDS

IMPACT OF RATE OF HOT VARIANCE



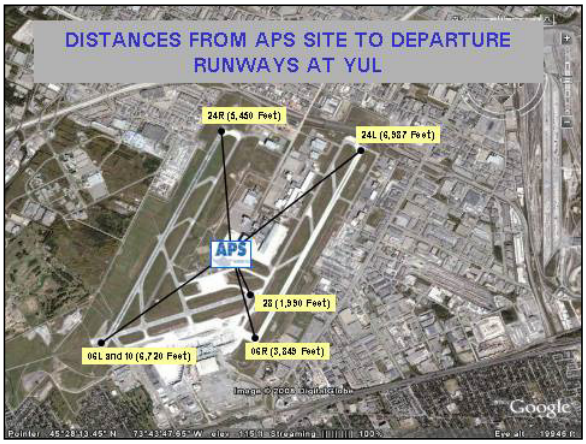
PROCEDURES

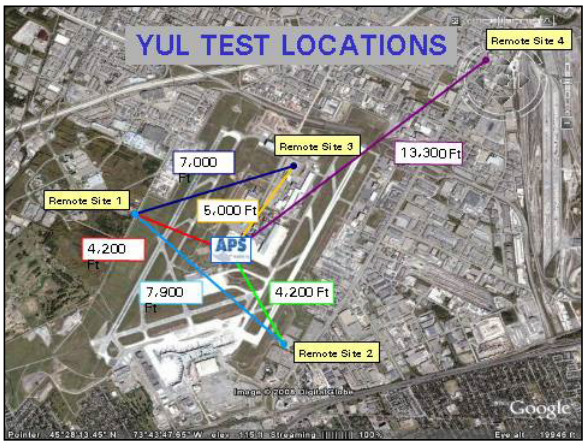
- Testing was performed at Montreal-Trudeau International Airport
- Test procedure was based on the rate measurement methodology included in ARP 5485
  - Far more stringent version of the procedure was applied
- Test procedure consisted of measuring precipitation catch in four collection pans of a known area over a known period of time

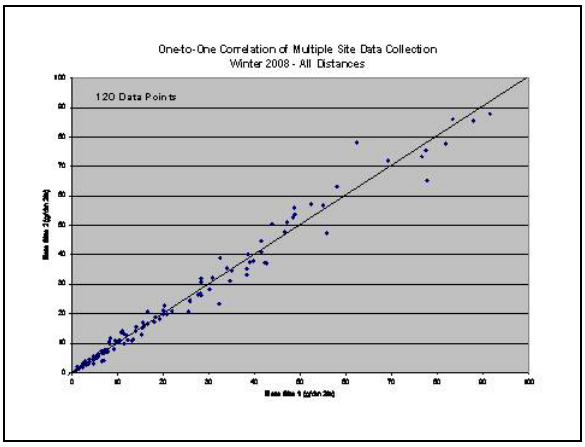
PROCEDURES

- Data collections were performed at 10-minute intervals
  - Eliminate errors associated with data collections over short periods of time
  - To simulate what an aircraft could be subjected to during taxi
- Data collection teams performed the procedure at precisely the same time intervals at two different locations at the airport site
  - Distances ranged from 4,200 feet to 13,300 feet of separation

PROCEDURES



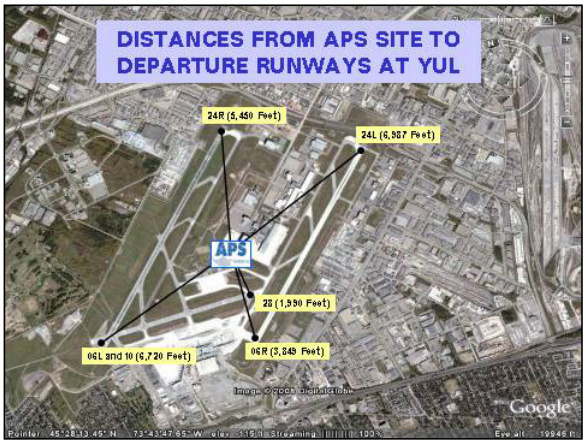




DATA ANALYSIS

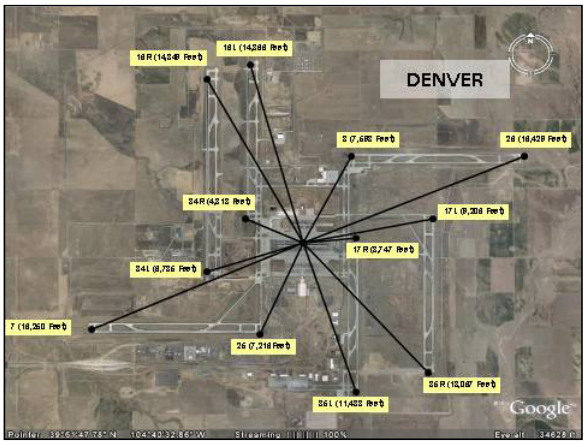
- Rate data from the various sites at YUL were similar at shorter separation distances (< 7,000 feet)
- Rate variance increased as separation distance increased

AIRPORT CONSIDERATIONS



AIRPORT-SPECIFIC CONSIDERATIONS

- The longest distance from the central location at YUL to an active departure runway was 7,000 feet
- Many other airports have significantly larger surface area than YUL
- Larger surface area may result in larger impact on the computed holdover times from HOTDS



PROPOSED ADDITIONAL WORK

- Additional work should be performed to:
  - Gather more data
  - Examine effect of longer distances between data collection sites
  - Examine different weather types, temperature ranges, precipitation rates
    - Different airports
    - Lake-Effect Snow
  - Potentially develop recommended practices (ARP) for implementing HOTDS at airport sites

AIRPORT SITING OF HOTDS

WORK PERFORMED IN WINTER 2008-09

TEST SITES IN WINTER 2008-09

- Long Separation Distance
  - Montreal-Mirabel International Airport
  - Denver International Airport
- Lake-Effect Snow
  - Syracuse-Hancock International Airport

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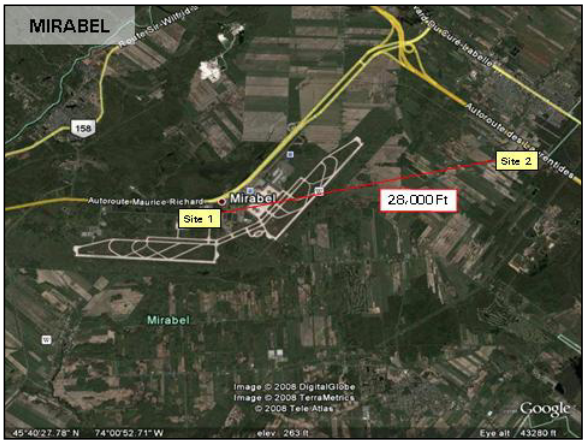
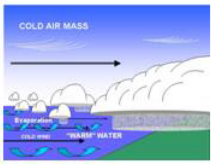
LONG SEPARATION DISTANCES



LAKE-EFFECT SNOW

LAKE-EFFECT SNOW

- Lake-Effect Snow: produced when cold winds move across long expanses of warmer lake water, picking up water vapor which freezes and is deposited on the lee shores of the lake
- Lake-effect stations:
  - Marquette, MI
  - Buffalo, NY
  - Syracuse, NY
  - Rochester, NY
  - Erie, PA



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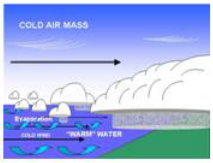

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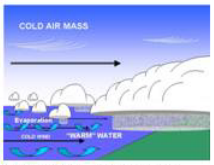


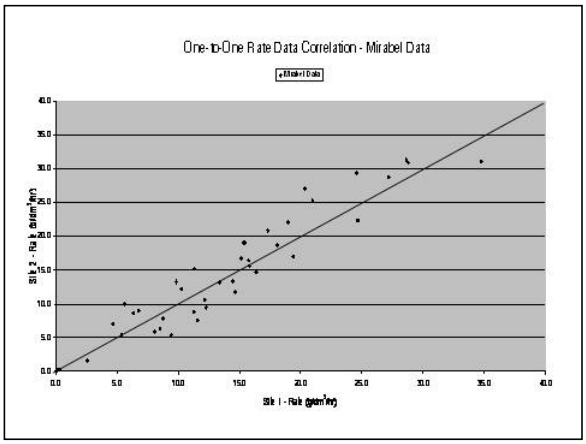
- Syracuse receives approx. 300 cm of snow annually

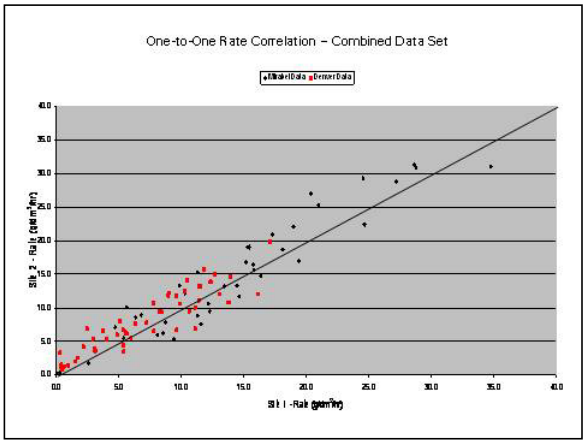
TEST RESULTS

DATA COLLECTED WINTER 2008-09

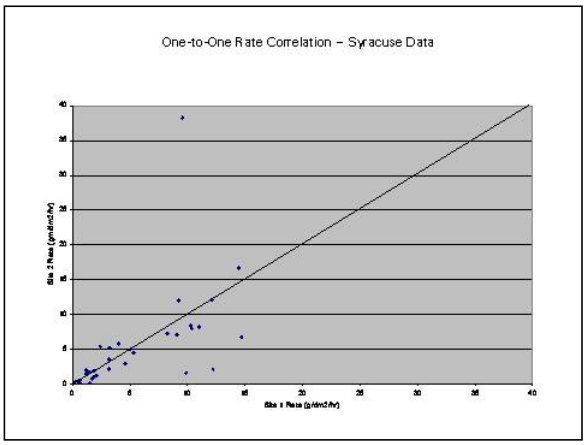
- Six data collection events (135 data points)
  - Mirabel – 2 events (41 data points)
  - Syracuse – 2 events (42 data points)
  - Denver – 2 events (52 data points)

LONG SEPARATION DISTANCES





LAKE-EFFECT SNOW



DATA ANALYSIS

- Data collected at Mirabel and Denver were similar
  - Rate variance at long separation distances is increased in comparison to data collected at short separation distances in winter 2007-08
- Rate variance due to lake-effect snow is greater than long separation distance
- Impact on resulting holdover times for various fluid types is currently being analyzed

NEXT STEPS

NEXT STEPS

- Data analysis will be completed in the upcoming weeks
- End goal of this activity is the development of an ARP document to provide airports, air carriers, DSPs with guidance for siting of HOTDS equipment
  - Holdover time implications
  - Airport siting considerations
    - Minimum distances of systems from airport infrastructure, taxiways, jet blast areas, glide slope etc, to ensure integrity of data provided by the system
    - Availability of power, ease of access
- APS has volunteered to sponsor the development of the ARP

ARP DEVELOPMENT

- Table of contents for the ARP document is currently being drafted
- Consultation process with stakeholders will be initiated
  - Manufacturers of HOTDS equipment
  - Regulators
  - End users of HOTDS outputs (service providers, air carriers)
  - Airports
- Update progress at next HOT subcommittee meeting

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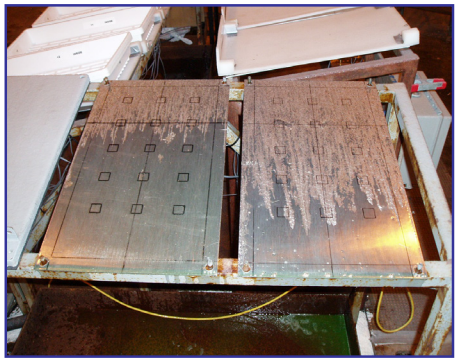
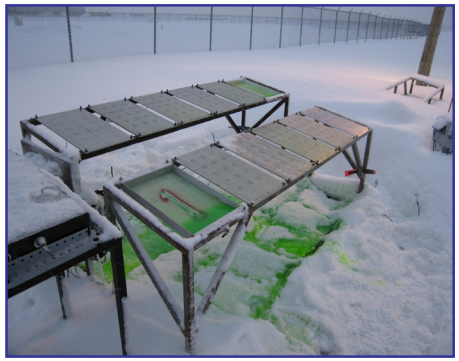
RESEARCH/ACTION PLAN FOR ENABLING USE OF ROGIDS AT END-OF-RUNWAY





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ISO 9001:2000

ROGIDS WORKING GROUP
JUNE 10/11, 2009

Presented by Stephanie Bendickson

OUTLINE

- Objectives
- Benefits of End-of-Runway ROGIDS
- Project Plan
  - Description of each step
  - Project timeline
- Summary
- Next Steps

2

OBJECTIVES

- Project Objective: To conduct research and develop guidance materials to allow ROGIDS to be used at end-of-runway
- Meeting Objective: To develop a research/action plan for enabling use of ROGIDS for inspections at end-of-runway

3

BENEFITS OF ROGIDS AT END-OF-RWY

- Potential operational advantages
  - Reduced turn-backs
  - Allow cargo carriers, high wing aircraft, aircraft requiring tactile checks, to conduct pre-takeoff contamination checks
- Potential improvements in safety
  - Reduce number of aircraft departing with contamination
  - Provide checks in changing conditions, wind speeds
  - Standardization of pilot contamination checks

4

PROGRAM STEPS

1. Initiate Program
2. Analysis of "Heldover" Time
3. Survey of Pilots to Determine Turn-backs
4. Tune ROGIDS to Plate Failures
5. Determine Visual Contamination Detection Abilities of Pilots

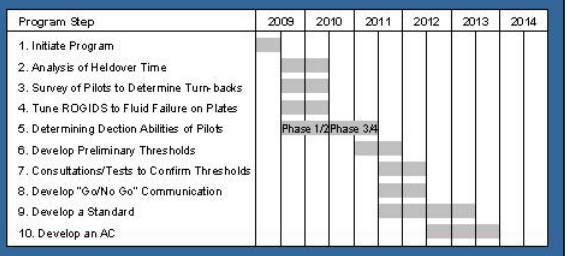
5

PROGRAM STEPS

6. Develop Preliminary Thresholds
7. Consultations and Tests to Confirm Thresholds
8. Develop Methodology to Communicate "Go/No Go" to Pilot
9. Develop a Standard
10. Develop an AC

6

TIMELINE



7

1. INITIATE PROGRAM

- PHASE 1: Review previous research
  - Aircraft Full-Scale Test Program for the 1996/97 Winter (TP 13130E)
  - Aircraft Full-Scale Test Program for the 1994/95 Winter (TP 12595E)
  - Ice Detection Sensor Capabilities for End-of-Runway Wing: Phase 2 evaluation (TP 13662E)
  - Development of Ice Samples for Comparison Study of Human and Sensor Capability to Detect Ice on Aircraft (TP 14450E)
  - Development of Ice Samples for Visual and Tactile Ice Detection Capability Tests (TP 14449E)
  - Contaminated Aircraft Take-off Tests for the 1998/99 Winter (TP 13479E)
  - Feasibility of Use of Ice Detection Sensors for End-of-Runway Wing Checks (TP 13481E)
  - Adhesion of Aircraft Anti-Icing Fluids on Aluminum Surfaces (TP 14377E)
- PHASE 2: Plan activities required (this presentation)

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2. ANALYSIS OF "HELDOVER" TIME

- Obtaining information from airports and/or airlines on usage of HOTs:
  - How long are aircraft on the ground prior to departure?
  - What % of HOT is used?
- End result of this step would be to help in setting the threshold for the cameras
- Threshold may be before or after HOT, based on actual operations

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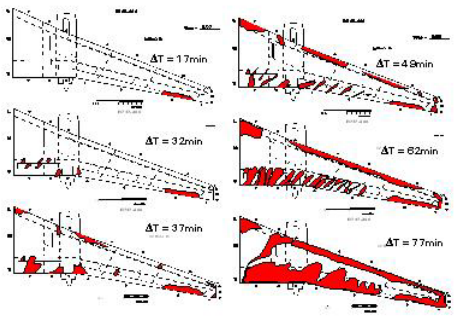
PROGRESSION OF FAILURE

(ID 2A) – B 737 (Ultra +, -3.2°C, ZR-)

HOT = 30 to 45 min (HOTDS = 41 min), plate fail = 42 min (R = 17 g/dm²/h)



3. SURVEY OF PILOTS TO DETERMINE TURN-BACKS

- Survey pilots in Canada and the United States to determine:
  - Number of times they turn-back due to expired holdover times
  - Number of times they turn-back due to detection of frozen contamination during pre-takeoff check
  - Number of times they turn back before HOT has expired
  - Where checks are conducted from

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4. TUNE ROGIDS TO PLATE FAILURES

- Determine appropriate conditions for tuning sensors to various fluid failure appearance on plates
  - This step completed by the working group
  - Purpose is to give guidelines on fluids, precipitation types, rates, etc.
- Conduct sensor tuning activity
  - This step is completed predominantly by the manufacturer(s)
  - Purpose is to determine if sensor can work on plate

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5. DETERMINE VISUAL CONTAMINATION DETECTION CAPABILITIES OF PILOTS

- PHASE 1: Human Factors development of test plan
  - Educate human factors experts
  - Provide problem description
  - Human factors experts determine test methodology and number of tests required to get proper statistical sampling
- PHASE 2: Develop method for producing stable specimens for various types of failure

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5. DETERMINE VISUAL CONTAMINATION DETECTION CAPABILITIES OF PILOTS

- PHASE 3: Conduct preliminary tests with small group of pilots to refine procedure
  - GIDS could be present during this stage, as a secondary objective
- PHASE 4: Conduct tests with large (50-100?) group of pilots

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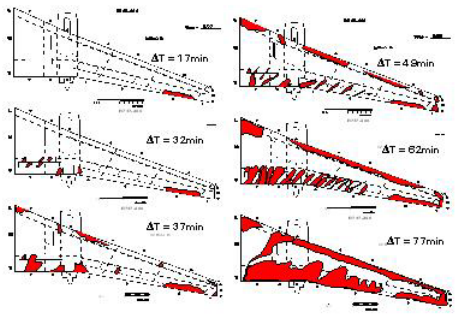
PROGRESSION OF FAILURE

(ID 24) – B 737 (Ultra +, -3.2°C, ZR-)

HOT = 30 to 45 min (HOTDS = 41 min), plate fail = 42 min (R = 17 g/dm²/h)



6. DEVELOP PRELIMINARY THRESHOLDS

- Analyze results to develop preliminary threshold(s)
  - Could potentially be multiple thresholds for different precipitation types, fluids, etc.

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7. CONSULTATIONS AND TESTS TO CONFIRM THRESHOLDS

- Examine threshold sensitivity to adherence (wind tunnel) to provide information/explanation to airframe manufactures
- Conduct consultations with airframe manufacturers to help define thresholds for sensors
- Conduct full-scale tests with ROGIDS in an outdoor environment to confirm threshold
- Correlate human factor tests with pilots on plates/airfoil to full-scale wing

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8. DEVELOP METHODOLOGY TO COMMUNICATE "GO/NO GO" TO PILOT

- Needs further development with workgroup
- Probably best done once program is underway

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9. DEVELOP A STANDARD

- Standard would provide the process for evaluating a specific ROGIDS for end-of-runway use
- SAE Aerospace Standard (AS)?

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10. DEVELOP AN AC

- Work with Transport Canada and the FAA to draft an Advisory Circular (AC)
- AC would provide:
  - Guidelines and recommendations for using ROGIDS at end-of-runway
  - Guidance for Regulators on how to obtain approval to use ROGIDS at end-of-runway

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TIMELINE

Program Step	2009	2010	2011	2012	2013	2014
1. Initiate Program						
2. Analysis of Heldover Time						
3. Survey of Pilots to Determine Turn-backs						
4. Tune ROGIDS to Fluid Failure on Plates						
5. Determining Dection Abilities of Pilots		Phase 1/2	Phase 3/4			
6. Develop Preliminary Thresholds						
7. Consultations/Tests to Confirm Thresholds						
8. Develop "Go/No Go" Communication						
9. Develop a Standard						
10. Develop an AC						

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SUMMARY

- To get ROGIDS approved for use at end-of-runway, a number of research and regulatory steps will need to be completed
- The process is expected to take 5 years
- Cost estimate?

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NEXT STEPS

- Currently working on Step 1
- Goal of today/tomorrow's meetings is to discuss and finalize the research plan and put it in motion

23

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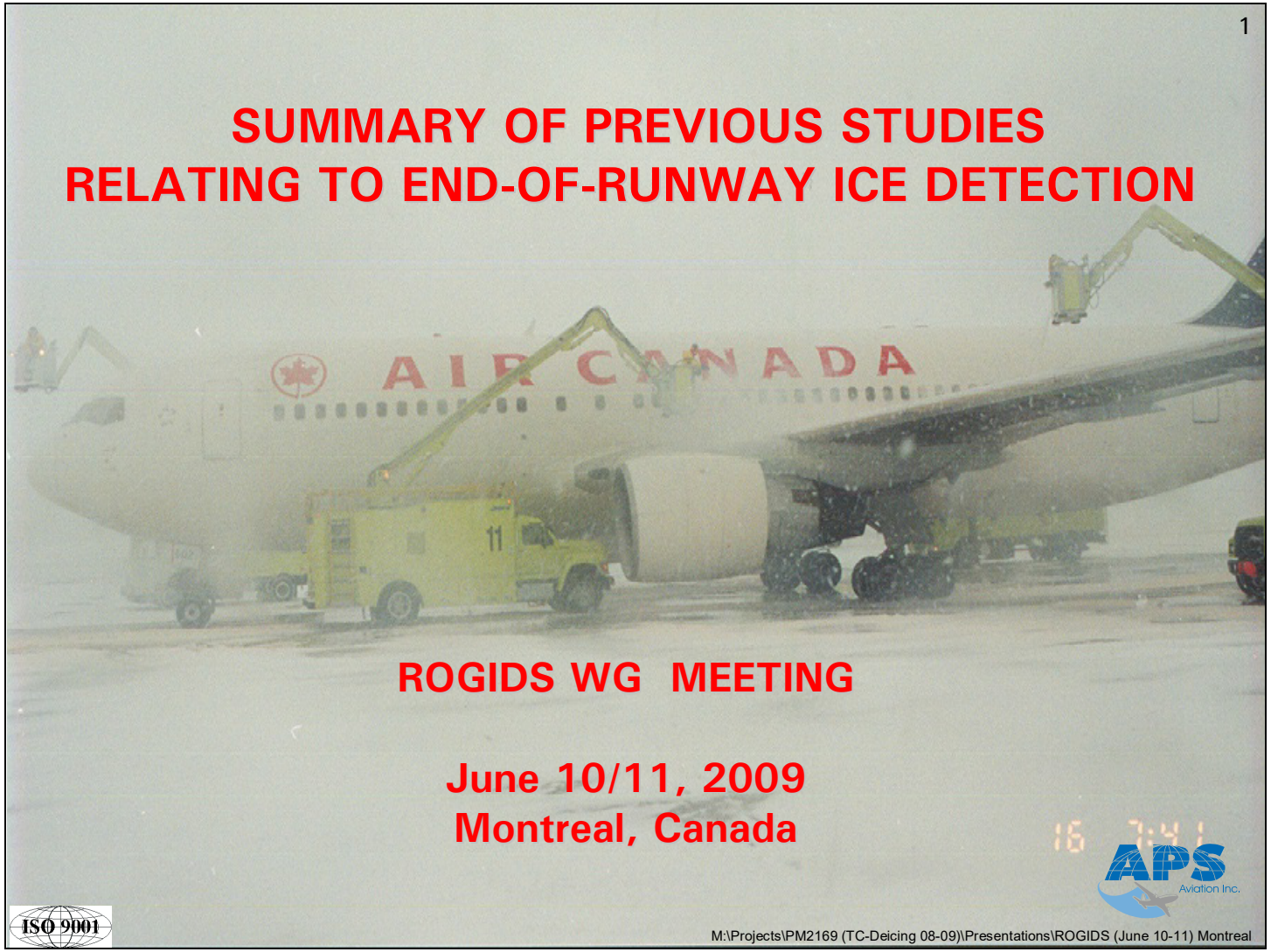

1
SUMMARY OF PREVIOUS STUDIES
RELATING TO END-OF-RUNWAY ICE DETECTION
AIR CANADA
11
ROGIDS WG MEETING
June 10/11, 2009
Montreal, Canada
ISO 9001
APS
Aviation Inc.
M:\Projects\PM2169 (TC-Deicing 08-09)\Presentations\ROGIDS (June 10-11) Montreal

2

VARIOUS APPLICATIONS OF REMOTE ICE DETECTION SENSORS

- At the Gate before or after Deicing
- At the Deicing Centre
- At the End of Runway prior to take-off
- Other applications

3

REMOTE ICE DETECTION SYSTEM FOR END-OF-RUNWAY

NEED FOR ASSISTANCE ON FLUID FAILURE IDENTIFICATION

- A potential application is to provide pilots with information on the condition of aircraft wings during snow or freezing precipitation, just prior to entering the departure runway.
- Tests have demonstrated that there is a need for assistance in identifying fluid contamination.

4

EXAMPLES SHOWING NEED FOR ASSISTANCE

Test Setup

NRC Falcon 20D

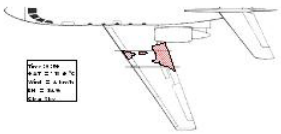
Test Area - Inboard of Fence

5

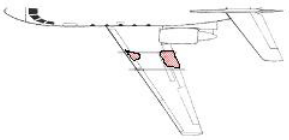
EXAMPLES SHOWING NEED FOR ASSISTANCE

Failure Pattern Before Takeoff, Run 2, Ultra +

Failure Pattern Reported by Outside Observer



Failure Pattern Reported by Experienced Cabin Observer



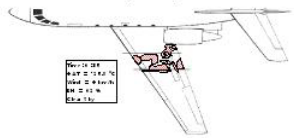
Failure Pattern Reported by Pilot

6

EXAMPLES SHOWING NEED FOR ASSISTANCE

Failure Pattern Before Takeoff, Run 5, Ultra +

Failure Pattern Reported by Outside Observer



Failure Pattern Reported by Experienced Cabin Observer

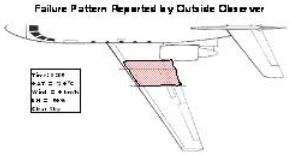
Failure Pattern Reported by Pilot

7

EXAMPLES SHOWING NEED FOR ASSISTANCE

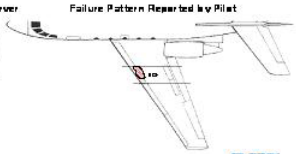
Failure Pattern Before Takeoff, Run 7, ABC-S

Failure Pattern Reported by Outside Observer



Failure Pattern Reported by Experienced Cabin Observer

Failure Pattern Reported by Pilot



EXAMPLES SHOWING NEED FOR ASSISTANCE

OBSERVATIONS

- Examples demonstrate a need for assistance
- Variability and inconsistencies of the fluid failure observations between the pilot, the cabin observer and the field observer is apparent.

KEY CHALLENGES

Principal challenges in developing an end-of-runway ROGIDS application include:

a) Determining the feasibility of locating a sensor where useful information can be obtained.

b) Confirming the sensitivity of the ice detection sensor, and ability to produce reliable results at end-of-runway locations.

c) Understanding and considering fluid and precipitation concerns.

d) Consideration of various wing types.

e) Developing a basis for sensor reading acceptance – contamination threshold defined as per tactile program?

f) Determining a method for communicating wing condition information to the Pilot.

KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

WINTER 1998/99

Study examined the feasibility of locating a Sensor near the end-of-runway.

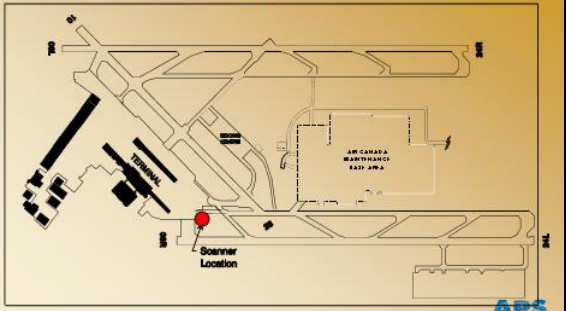
KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

BELL MICROWAVE TRUCK - 42' MAST

Sensor MOUNTING

KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

SCANNING AIRCRAFT AT END OF RUNWAY
DORVAL AIRPORT



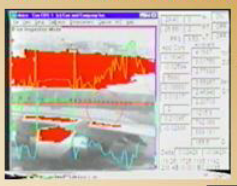
KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

SENSOR POSITION RELATIVE TO AIRCRAFT

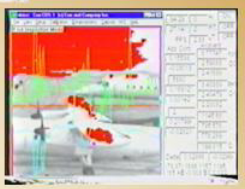
TAXING AIRCRAFT BEING SCANNED

14

KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR



747 LEADING EDGE



HIGH WING
TURBO PROP

15

KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

PRELIMINARY RESULTS

Trials at end of runway demonstrated that the sensor can be located in a position that is operationally acceptable, and where viable information can be obtained from a remote ice detection system.

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KEY CHALLENGE: a) LOCATING AN ICE DETECTION SENSOR

SOME CONSIDERATIONS FOR END-OF-RUNWAY SENSOR INSTALLATIONS AT AIRPORTS

- Which runways are used for departures during deicing operations?
  - How many scanning locations are required?
  - Can system be installed near the hold-for-takeoff clearance position?
- What are the imposed limits on space, taxiway separation clearances and obstacle limitations at the desired sites?
  - Are the runways shared for departures and arrivals during deicing operations?
- Should the sensor installations be permanent or mobile?; retractable or fixed height?; manned or remote?

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KEY CHALLENGE: b) SENSOR SENSITIVITY ISSUES

CONFIRMING THE SENSITIVITY OF THE ICE DETECTION SENSOR, AND ABILITY TO PRODUCE RELIABLE RESULTS AT THE END-OF-RUNWAY LOCATIONS.

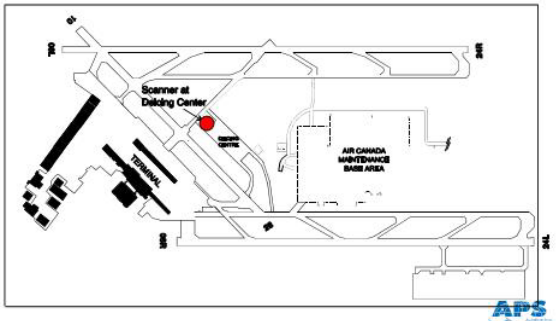
Winter 1999/2000 project to confirm the ice detection system accuracy for this application:

- Sensor set up at the Dorval central deicing facility
- Aircraft scanned just prior to being deiced
- Detail of contamination on wing was documented by an observer in the deicing bucket

18

KEY CHALLENGE: b) SENSOR SENSITIVITY ISSUES

SCANNING AIRCRAFT AT END OF RUNWAY
DORVAL AIRPORT



19

KEY CHALLENGE: b) SENSOR SENSITIVITY ISSUES

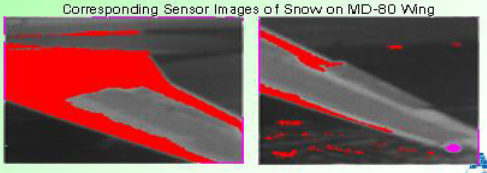
SETUP AT YUL CDF
February 16, 2000

KEY CHALLENGE: b) SENSOR SENSITIVITY ISSUES

20

Photo of Snow on MD-80 Wing – Prior to Deicing

Corresponding Sensor Images of Snow on MD-80 Wing



KEY CHALLENGE: b) SENSOR SENSITIVITY ISSUES

21

CHALLENGES

Ice detector must produce reliable and consistent contamination data regardless of:

- physical limitations imposed by the installation site or,
- the operating environment

SCANNING GEOMETRY IMPOSED BY INSTALLATION SITES

- Need to scan both wings: installation sites on opposite sides of aircraft may impose different scanning distances
- Scanning distances and viewing angles may be severe
- Sensitivity to distance and angle-of-viewing complicates the detection sensing
  - Detection of ice farther on wing (root) may be more challenging than ice on the wing tip
  - Detection of ice on higher wings (flatter angle) may be more challenging than on lower wings

OPERATING ENVIRONMENT

- Aircraft movement may affect ice-detection reliability
- Snow-covered tarmac may affect definition of contaminated wing perimeter
- Ambient lighting will vary and could impact on the sensing capability: This includes night, day and rapidly changing light conditions at dawn and dusk

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

22

Laboratory Test

- Document characteristics of failure of various fluids using different techniques

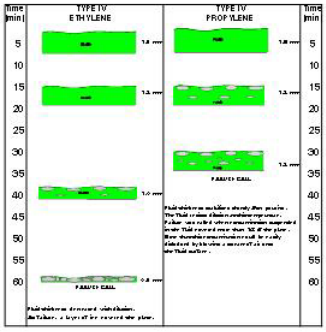
Field Test

- Determine whether different levels of contaminated fluid are sheared off during a simulated take-off run with a Falcon 20.

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

23

TYPE IV ETHYLENE vs TYPE IV PROPYLENE
SCHEMATIC OF FAILURE MECHANISM
FREEZING DRIZZLE: T = -10°C, Rate = 5g/dm²/hr



KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

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CONTAMINATED AIRCRAFT TAKE-OFF TRIALS
SAE TYPE IV ETHYLENE-BASED

Contamination Level 5% of area

Before Take-off Run

After Take-off Run

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

25

CONTAMINATED AIRCRAFT TAKE-OFF TRIALS
SAE TYPE IV PROPYLENE-BASED

Contamination Level 100%

Before Take-off Run

After Take-off Run

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

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CONTAMINATED AIRCRAFT TAKE-OFF TRIALS
During Take-off Run

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

27

PRELIMINARY RESULTS AND CHALLENGES

- Visual and sensor failure calls under different conditions were compared in the laboratory tests, allowing for ongoing refinement of sensor calibration.
- Type IV effect of temperature in freezing drizzle laboratory tests:
  - Mechanism of failure in ZD laboratory tests was not temperature dependent for ethylene glycol-based Type IV fluids.
  - Propylene glycol-based IV fluids failed due to ice bridging at lower temperatures and due to dilution at higher temperatures.
- The Falcon 20 trials further demonstrated the differences in fluid failure mechanism of propylene and ethylene Type IV Fluids. Future tests with the Falcon 20 will examine the effects of snow precipitation on fluid failure.
- The outcome of the work done in this area will aid in the decision making process.

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

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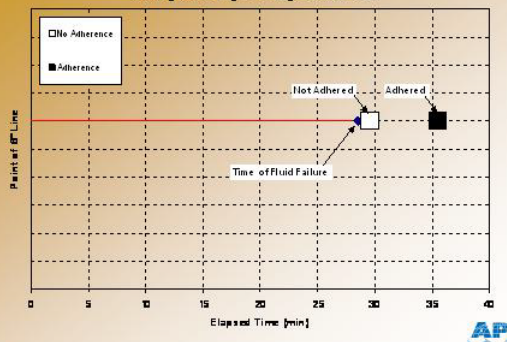
TIME OF ADHESION VERSUS FAILURE TIME

Test Objectives

- to document the instances in which fluid adhesion occurs
- to determine the extent of the safety buffer between endurance time and adhesion time

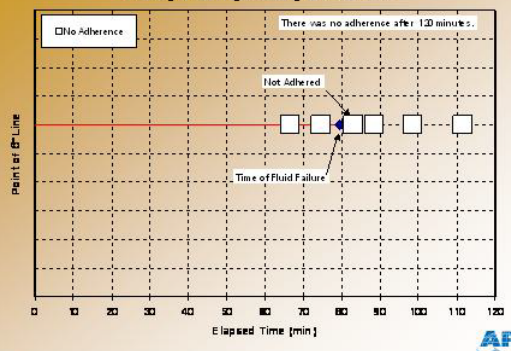
28

ADHERENCE OCCURRENCE - TYPE IV FLUID (ETHYLENE)
Freezing Drizzle / Light Freezing Rain, OAT -10°C



30

ADHERENCE OCCURRENCE - TYPE IV FLUID (PROPYLENE)
Freezing Drizzle / Light Freezing Rain, OAT -10°C



31

Table 4.2: Safety Buffer for Tests Conducted with Type II/III/IV Fluids

OAT	Approximate Safety Buffers Under Various Weather Conditions						
°C	Frost	Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
above						1.2 [1]	
0 to -3		1.3 [2]	No Adh. [11]* 6.1 [4]**	1.3 [4]	1.4 [10]		
below -3 to -14		1.1 [1]	No Adh. [15]***	1.3 [9]	1.3 [6]		
below -14 to -25		No Adh. [2]					
below -25							

32

KEY CHALLENGE: c) FLUID AND PRECIPITATION CONCERNS

TIME OF ADHESION VERSUS FAILURE TIME

SNOW

Independent of fluid type, ambient temperature and rate of precipitation, failures in snow conditions were not prone to adhesion to the test surface.

33

WIND TUNNEL TESTS

34

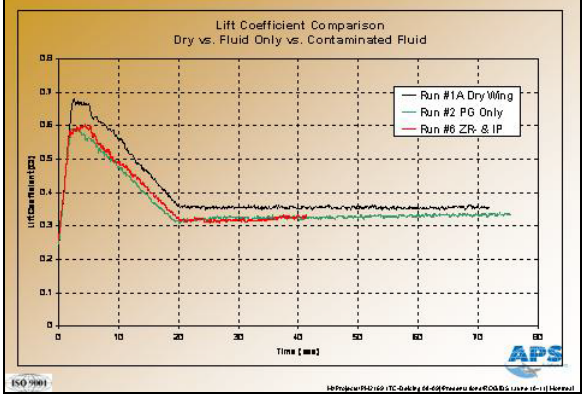
35

Test #11
Type IV PG, ZR-&IP- 20+5 g/dm²/h, 40 min,
OAT-2°C, Wing -4°C

Click for Photos

36

Lift Coefficient Comparison

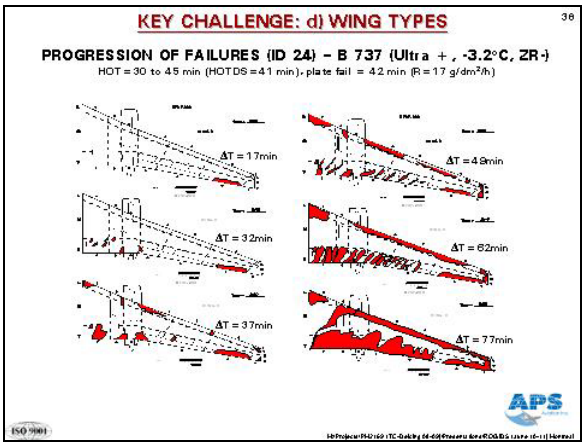


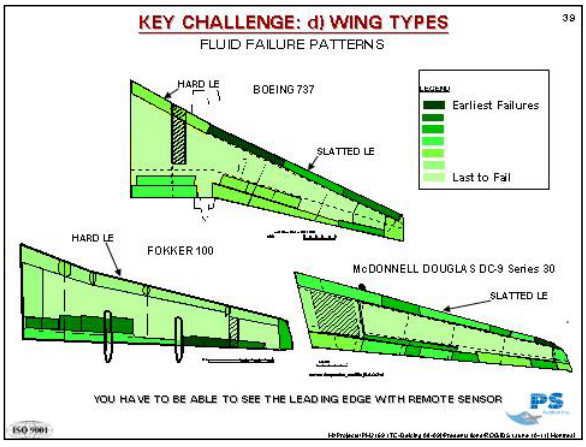
37

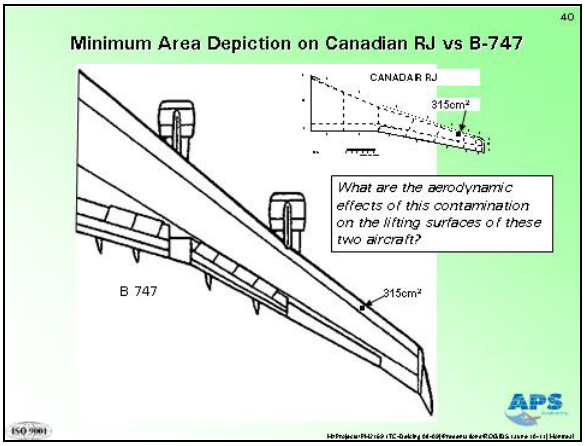
KEY CHALLENGE: d) VARIOUS WING TYPES

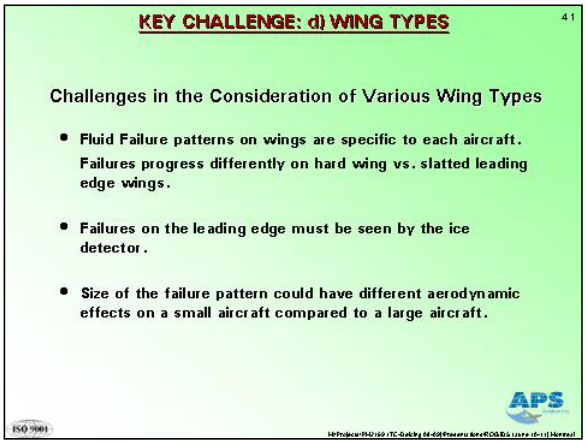
OBJECTIVES OF FULL SCALE WING FLUID FAILURE TESTS

- to determine the influence of different variables on the progression of anti-icing fluid failure on aircraft wings under freezing precipitation


KEY CHALLENGE: d) WING TYPES
36
PROGRESSION OF FAILURES (ID 24) – B 737 (Ultra +, -3.2°C, ZR-)
HOT = 30 to 45 min (HOTDS = 41 min), plate fail = 42 min (R = 17 g/dm²/h)
ΔT = 17min
ΔT = 48min
ΔT = 32min
ΔT = 62min
ΔT = 37min
ΔT = 77min
APS
ISO 9001


KEY CHALLENGE: d) WING TYPES
39
FLUID FAILURE PATTERNS
HARD LE
BOEING 737
SLATTED LE
Earliest Failures
Last to Fail
HARD LE
FOKKER 100
McDONNELL DOUGLAS DC-9 Series 30
SLATTED LE
YOU HAVE TO BE ABLE TO SEE THE LEADING EDGE WITH REMOTE SENSOR
APS
ISO 9001


40
Minimum Area Depiction on Canadian RJ vs B-747
CANADAIR RJ
315cm²
What are the aerodynamic effects of this contamination on the lifting surfaces of these two aircraft?
B 747
315cm²
APS
ISO 9001


KEY CHALLENGE: d) WING TYPES
41
Challenges in the Consideration of Various Wing Types
Fluid Failure patterns on wings are specific to each aircraft. Failures progress differently on hard wing vs. slatted leading edge wings.
Failures on the leading edge must be seen by the ice detector.
Size of the failure pattern could have different aerodynamic effects on a small aircraft compared to a large aircraft.
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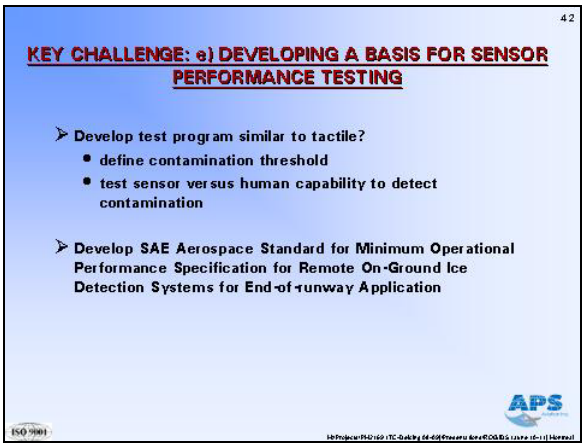
42
KEY CHALLENGE: e) DEVELOPING A BASIS FOR SENSOR PERFORMANCE TESTING
Develop test program similar to tactile?
define contamination threshold
test sensor versus human capability to detect contamination
Develop SAE Aerospace Standard for Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems for End-of-runway Application
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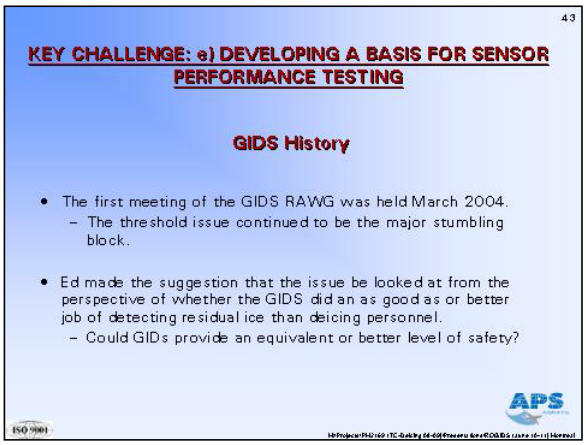
43
KEY CHALLENGE: e) DEVELOPING A BASIS FOR SENSOR PERFORMANCE TESTING
GIDS History
The first meeting of the GIDS RAWG was held March 2004.
– The threshold issue continued to be the major stumbling block.
Ed made the suggestion that the issue be looked at from the perspective of whether the GIDS did an as good as or better job of detecting residual ice than deicing personnel.
– Could GIDs provide an equivalent or better level of safety?
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KEY CHALLENGE: e) DEVELOPING A BASIS FOR SENSOR PERFORMANCE TESTING
GIDS History
• The FAA Flight Safety Branch and the TC Transportation Development Center decide to move forward and collaborate on a GIDS vs Deicers research project.
• As the first GIDS application will be for post-deicing inspections, the research was focused in this area.
• Early on, the WG realized we needed help from human factors experts.
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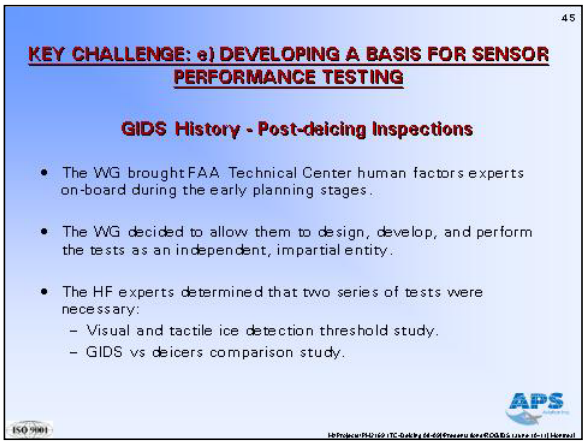
45
KEY CHALLENGE: e) DEVELOPING A BASIS FOR SENSOR PERFORMANCE TESTING
GIDS History - Post-deicing Inspections
• The WG brought FAA Technical Center human factors experts on-board during the early planning stages.
• The WG decided to allow them to design, develop, and perform the tests as an independent, impartial entity.
• The HF experts determined that two series of tests were necessary:
– Visual and tactile ice detection threshold study.
– GIDS vs deicers comparison study.
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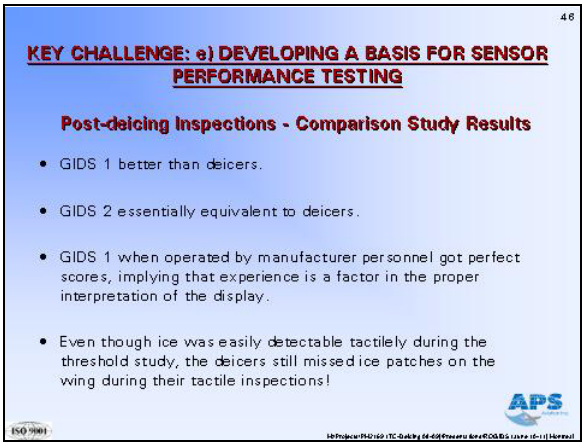
46
KEY CHALLENGE: e) DEVELOPING A BASIS FOR SENSOR PERFORMANCE TESTING
Post-deicing Inspections - Comparison Study Results
• GIDS 1 better than deicers.
• GIDS 2 essentially equivalent to deicers.
• GIDS 1 when operated by manufacturer personnel got perfect scores, implying that experience is a factor in the proper interpretation of the display.
• Even though ice was easily detectable tactilely during the threshold study, the deicers still missed ice patches on the wing during their tactile inspections!
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ISO 9001

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Anti-icing Fluids Applied in Aircraft Hangars: Effect of Delayed Exposure to Precipitation on Fluid Endurance Time

APS Aviation Inc.

ISO 9001:2000

SCOUIC October 6, 2009

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

OUTLINE

- Background
- Current Guidance Material
- APS Test Program
- Test Results
- Recommendations

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BACKGROUND

- Some operators anti-ice aircraft inside aircraft hangars
- The anti-iced aircraft may wait in the hangar for some time before being exposed to precipitation
- When does the holdover time "clock" start?
  - When the anti-icing fluid application begins?
  - When the aircraft is first exposed to precipitation?

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2008-09 GUIDANCE MATERIAL
FAA

N 8900.55 §6.a.(2)(f).1.1

HOTs start as soon as the anti-icing step begins

AC135-17 / AC135-16 / AC120-60B

Holdover time begins when the final application of deicing/anti-icing fluid commences and expires when the deicing/anti-icing fluid applied to the aircraft loses its effectiveness.

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2008-09 GUIDANCE MATERIAL
Transport Canada

TP 14052 §11.1.1 (Holdover Time Guidelines – General)

The time that fluid remains effective is the time from first application of anti-icing fluid on a clean wing until such time as ice crystals form or remain in the fluid creating a surface roughness.

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2008-09 GUIDANCE MATERIAL
Transport Canada

TP 14052 §10.11 (Applying Type IV Fluid in a Hangar)

The period of time after Type IV 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 the frozen precipitation. The HOT available from a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature.

The air operator is advised to consult with the fluid manufacturer for guidance on using their fluids under these conditions. A minimum of a fluid thickness measurement may be required, dependent upon the circumstances, to ensure that the predicted fluid HOT protection is available.

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APS PRELIMINARY TEST PROGRAM

- APS conducted a preliminary test program (limited tests)
- Objective: to compare endurance times (ETs) of anti-icing fluids applied in hangars to ETs of anti-icing fluids applied outdoors
- Since fluid HOTs are established using a protocol that simulates outdoor operations, if hangar ETs are shorter than outdoor ETs we can conclude that starting the HOT clock at first exposure to precipitation poses a safety concern

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STANDARD VS. HANGAR OPERATIONS

- Standard Operation
  - Aircraft temperature near OAT
  - Fluid temperature near OAT
  - Immediate exposure to precipitation
- Hangar Operation
  - Aircraft temperature near 20°C
  - Fluid temperature near 20°C or near OAT
  - Delayed exposure to precipitation

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SIMULATING STANDARD / HANGAR OPERATIONS

- Standard Operation simulated by:
  - Using test surfaces at OAT
  - Using fluids at OAT
  - Exposing to precipitation immediately
- Hangar Operation simulated by:
  - Using test surfaces at 20°C
  - Using fluids at 20°C or OAT
  - Exposing to precipitation after a delay of 15 minutes or 60 minutes

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TEST TYPES

Chart Symbol	Test Type	Surface Temp	Fluid Temp	Time to Exposure
	Standard	OAT	OAT	0 mins
	Hangar 1	20°C	20°C	15 mins
	Hangar 2	20°C	20°C	60 mins
	Hangar 3	20°C	OAT	60 mins

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APS PRELIMINARY TEST PROGRAM

- 11 runs were conducted
- Each run consisted of:
  - 1 "standard" test used to establish the fluid HOT in the condition
  - 2-3 "hangar" tests used to measure the ETs of fluids applied in different types of hangar operations
- Runs conducted with differing fluids, precipitation types, precipitation rates and OATs

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RUN CONDITIONS

Run #	Fluid Type	Fluid Dilution	OAT (°C)	Precipitation Type	Precip. Rate (g/dm²/h)
1	Type IV	100	-1	Snow	10
2	Type III	100	-1	Snow	12
3	Type II	100	-4	Snow	14
4	Type IV	100	-10	Light Freezing Rain	13
5	Type II	100	-3	Light Freezing Rain	13
6	Type IV	100	-10	Freezing Drizzle	13
7	Type II	100	-3	Freezing Drizzle	5
8	Type IV	100	-3	Light Freezing Rain	25
9	Type IV	100	-10	Light Freezing Rain	25
10	Type IV	100	-3	Freezing Drizzle	13
11	Type IV	100	-10	Freezing Drizzle	5

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TEST PROCEDURE

- All test surfaces were exposed to precipitation at the same time
- Fluid applied in advance for tests with delayed exposure to precipitation
- ET "clock" started at first exposure to precipitation for all tests

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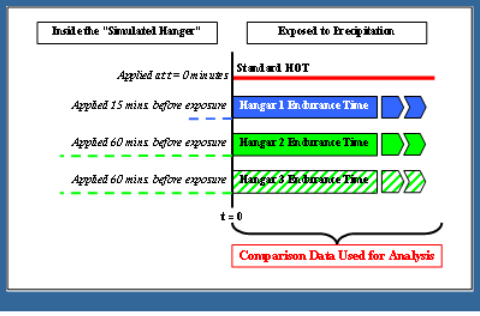
TEST PROCEDURE



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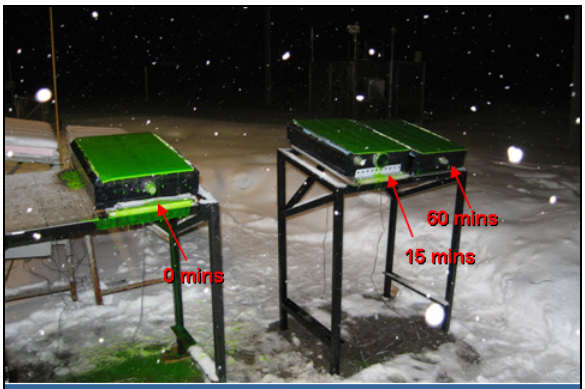
TEST PROCEDURE

TEST PROCEDURE



TEST PROCEDURE

TEST TYPES

Chart Symbol	Test Type	Surface Temp	Fluid Temp	Time to Exposure
	Standard	OAT	OAT	0 mins
	Hangar 1	20°C	20°C	15 mins
	Hangar 2	20°C	20°C	60 mins
	Hangar 3	20°C	OAT	60 mins

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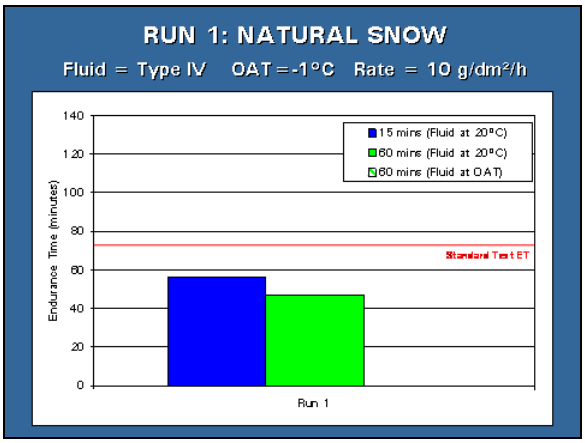
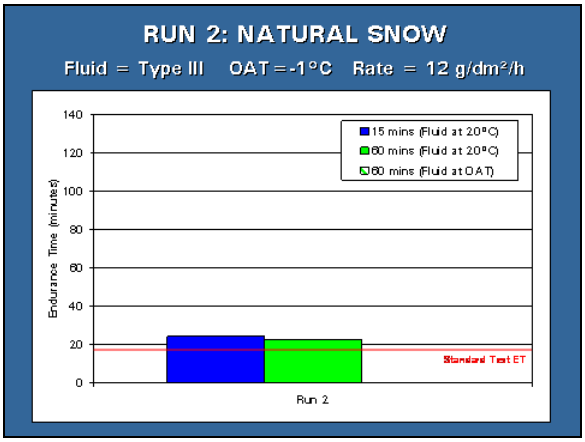
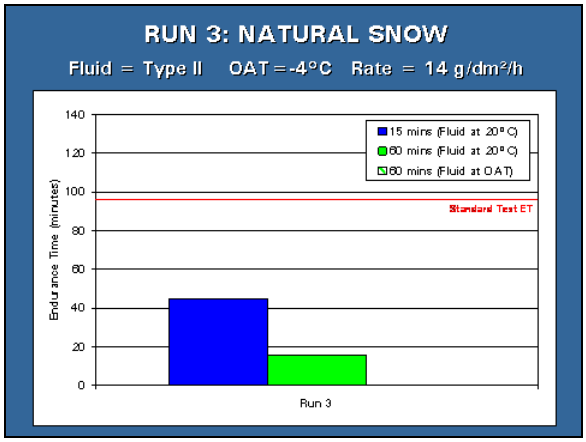
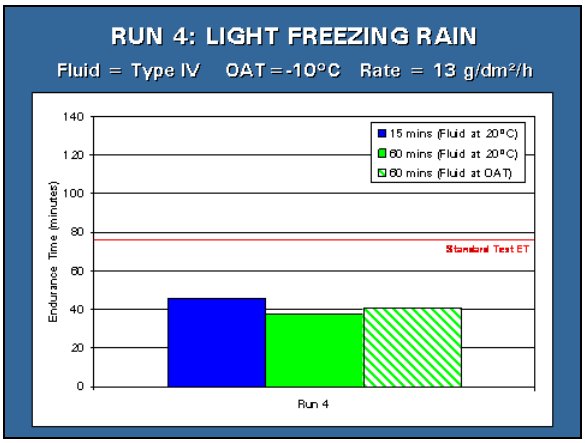
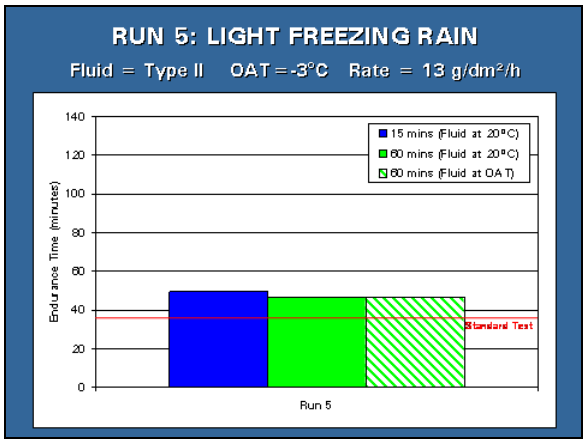

RUN 1: NATURAL SNOW
Fluid = Type IV OAT = -1°C Rate = 10 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 1

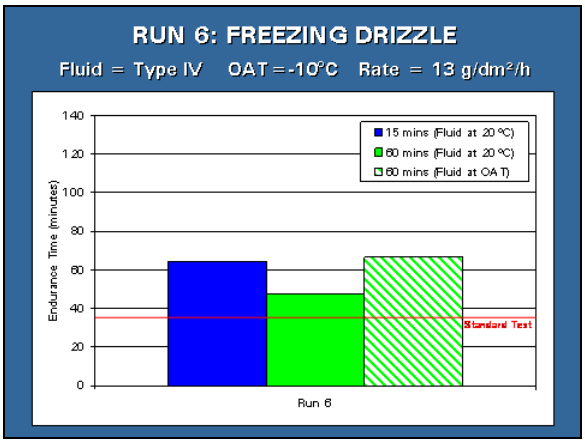
60 mins
15 mins
0 mins
RUN 1

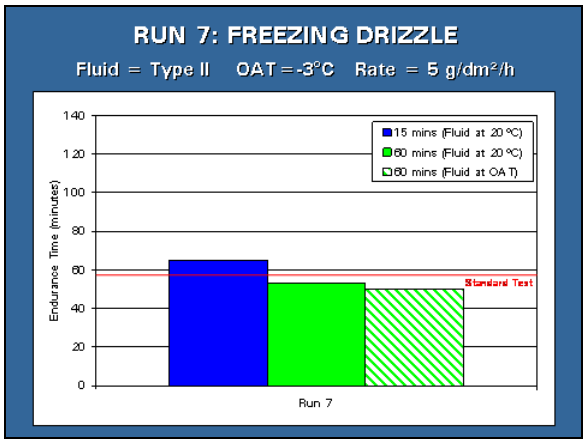

RUN 2: NATURAL SNOW
Fluid = Type III OAT = -1°C Rate = 12 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 2

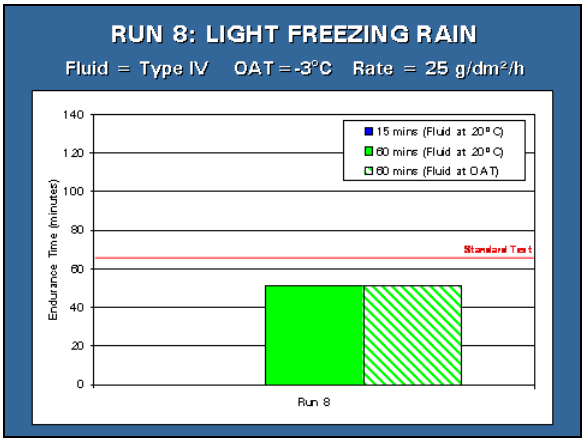

RUN 3: NATURAL SNOW
Fluid = Type II OAT = -4°C Rate = 14 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 3

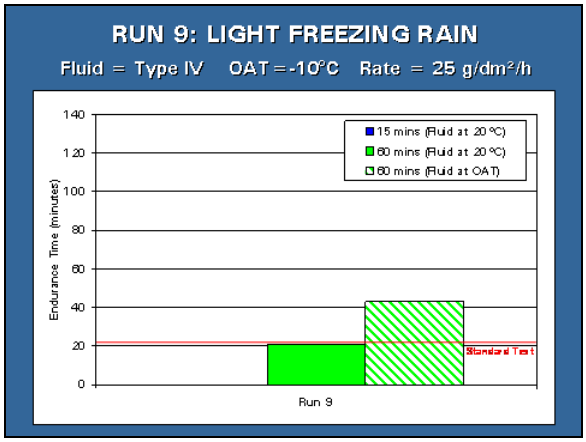

RUN 4: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -10°C Rate = 13 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test ET
Run 4

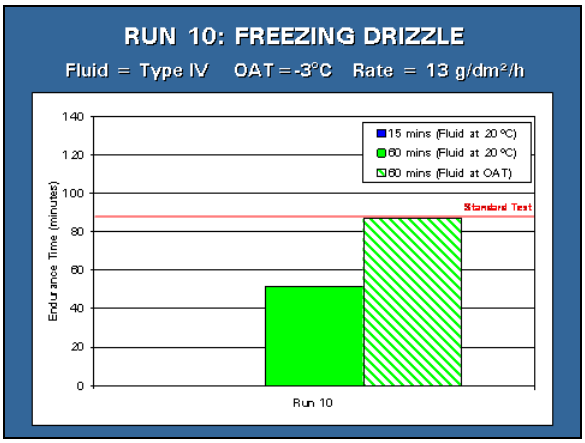

RUN 5: LIGHT FREEZING RAIN
Fluid = Type II OAT = -3°C Rate = 13 g/dm²/h
15 mins (Fluid at 20°C)
60 mins (Fluid at 20°C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 5

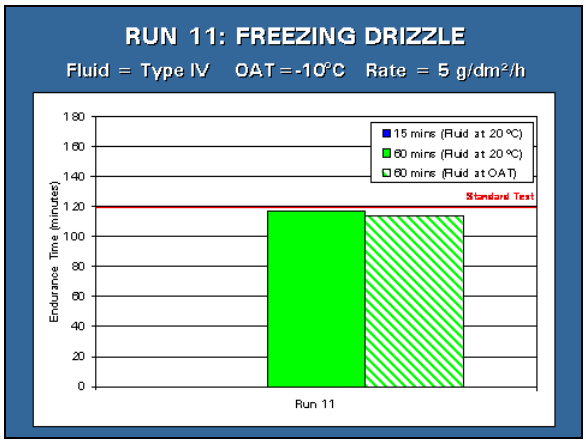

RUN 6: FREEZING DRIZZLE
Fluid = Type IV OAT = -10°C Rate = 13 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 6


RUN 7: FREEZING DRIZZLE
Fluid = Type II OAT = -3°C Rate = 5 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 7


RUN 8: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -3°C Rate = 25 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 8


RUN 9: LIGHT FREEZING RAIN
Fluid = Type IV OAT = -10°C Rate = 25 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 9


RUN 10: FREEZING DRIZZLE
Fluid = Type IV OAT = -3°C Rate = 13 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 10


RUN 11: FREEZING DRIZZLE
Fluid = Type IV OAT = -10°C Rate = 5 g/dm²/h
15 mins (Fluid at 20 °C)
60 mins (Fluid at 20 °C)
60 mins (Fluid at OAT)
Endurance Time (minutes)
Standard Test
Run 11

OBSERVATIONS

- Limited results indicate that ETs of fluids applied in hangars and allowed to sit before being exposed to precipitation are often shorter than HOTs
  - This is likely due to a number of factors including fluid thickness and fluid temperature
  - These factors also add to variability in the results obtained
- The only safe approach is to start the HOT "clock" when fluid application begins, not when the fluid is first exposed to precipitation

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2009-10 GUIDANCE MATERIAL

Transport Canada

TP 14052 §10.11 (Applying Type IV Fluid in a Hangar)

There are operational conditions when Air Operators may choose to anti-ice their aircraft while the aircraft remains 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 Type IV 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 upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to frozen precipitation.

APS Aviation Inc. 33

2009-10 GUIDANCE MATERIAL

Transport Canada

TP 14052 §10.11 (Applying Type IV Fluid in a Hangar)

There are operational conditions when Air Operators may choose to anti-ice their aircraft while the aircraft remains in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

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POTENTIAL FUTURE WORK

- Discussion with operators to investigate the impact of the current change to the guidance material on hanger anti-icing operations
  - *Does this change affect operations?*
- Future work could look at potential solution to assist operators when pre anti-icing. Areas of research could include:
  - **Exposure delay time**
    - *How long will the fluid typically be on the aircraft prior to leaving the hangar ?*
  - **Potential development of reduced HOT's for hangar anti-icing operations**
    - *Selection of representative fluids: Type II, III, IV? Neat or diluted?*
    - *Guidance requirement for Type I fluid?*
    - *What is the fluid temperature (cold or warm)?*

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HOLDOVER TIME GUIDELINES UPDATE

FOR 2009-10 WINTER OPERATIONS

APS Aviation Inc.

ISO-9001:2000

TC SCOUIC MEETING
TORONTO – OCTOBER 6, 2009

PRESENTED BY MICHAEL CHAPUT

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

OUTLINE

- Changes to HOT Guidelines for 2009-10
  - Type I
  - Type II
  - Type III
  - Type IV
- Changes to the HOT Table Format
  - Removal of the "below -25°C" Row
  - Separate Frost Table
  - Guidance for "Light Snow Mixed with Light Rain"

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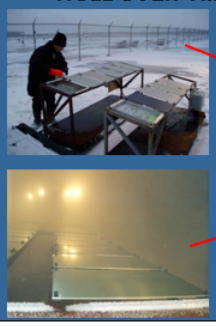
FLUID ENDURANCE TIME TESTING AND HOLDOVER TIME TABLE DEVELOPMENT



SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration (Mixed Fluid/Water, nominal volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[2]	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[4]
-3 and above	27 and above	100/0	1:15 – 2:30	0:25 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:30 – 0:50	0:15 – 0:30	0:05 – 0:45	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:25 – 1:25	0:20 – 0:45	0:20 – 0:45[5]	0:10 – 0:20[5]	CAUTION: No holdover time guidelines exist	
		75/25	0:20 – 0:50	0:10 – 0:30	0:15 – 0:30[5]	0:10 – 0:20[5]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	0:15 – 0:40[7]	0:15 – 0:30[7]				

NOTES

1. Based on the lowest holdover times of the fluids listed in Table 5-4.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. These holdover times only apply to outside air temperatures (OAT) at or below -10°C (14°F) under freezing drizzle and light freezing rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6. Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTION

- 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 loss 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 deicing/anti-icing do not provide in-flight icing protection.

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SUMMARY OF CHANGES TO HOT GUIDELINES

For Winter 2009-10 Operations

TYPE I

FAA/TC TYPE I HOT GUIDELINES 2009-10

FAA Type I Holdover Time Guidelines

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains			Freezing Drizzle[3]	Light Freezing Rain[3]	Rain on Cold Soaked Wing[3,4]	Other[3]
			Very Light***	Light **	Moderate**				
-3 and above	27 and above	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	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	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07			
below -10	below 14	0:05-0:09	0:07-0:09	0:04-0:07	0:02-0:04				

NO CHANGES

SAE Type I Fluid Holdover Time Guidelines for Winter 2009-10

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	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				

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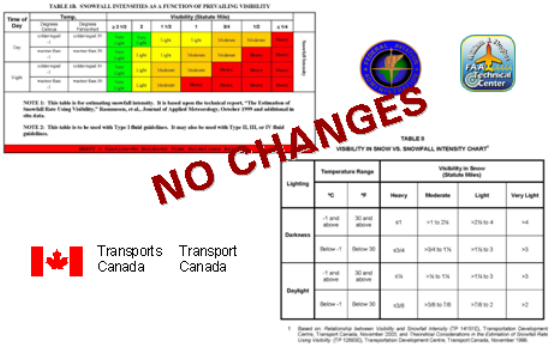
FAA/TC VISIBILITY TABLES 2009-10



NO CHANGES

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TYPE II

TYPE II
NEW FLUIDS

- Aviation Shaanxi Cleanwing II will be commercialized in winter 2009-10
- A fluid-specific HOT table has been added to the Type II guidelines for Aviation Shaanxi Cleanwing II

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TYPE II
INCLUSION OF TYPE IV DATA

- Freezing Fog, 75/25, below -3°C to -14°C, upper value
  - One Type IV fluid has a shorter HOT than the generic Type II value
  - As Type IV fluids also qualify as Type II fluids, Type II generic value must be reduced
  - Value will be reduced from **0:55** to **0:50**

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TYPE II
REMOVAL OF OBSOLETE DATA

- As per AS 5718 § 5.12.3, fluid-specific data becomes obsolete 4 years after the fluid qualification expires and is not re-certified
  - Fluid-specific HOT table is removed
  - Fluid-specific data is removed from the generic analysis
- Kilfrost ABC-II PLUS meets these requirements in 2009
  - Increases to three generic Type II HOTs
  - Changes detailed on next slide

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CHANGES TO GENERIC TYPE II HOT GUIDELINES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 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	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35	0:15 – 0:30[5]				

FAA/TC TYPE II HOT GUIDELINES 2009-10

FAA Type II Holdover Time Guidelines

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	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1,4]	Other[2]
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40	
		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	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	***0:20-0:45	***0:10-0:25	CAUTION: No holdover time guidelines exist	
		75/25	0:25-0:50	0:10-0:20	***0:15-0:30	***0:05-0:15		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:15-0:35	0:15-0:30				

SAE Type II Fluid Holdover Time Guidelines for Winter 2009-10

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 or Snow Grains[4]	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 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	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

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TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2009-10

1) ABAX ECOWING 26
2) AVIATION SHAANXI HI-TECH CLEANWING II **(NEW)**
3) CLARIANT SAFEWING MP II 2025 ECO
4) CLARIANT SAFEWING MP II FLIGHT
5) KILFROST ABC-2000
6) KILFROST ABC-K PLUS
7) NEWAVE AEROCHEMICAL FCY-2
8) OCTAGON E-MAX II

REMOVED: KILFROST ABC-II PLUS
AVIATION XI'AN HI-TECH KHF-II*

**Removed from TC guidelines following Charleston meeting- was removed from FAA guidelines in 2008*

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TYPE III

FAA/TC TYPE III HOT GUIDELINES 2009-10

FAA Type III Holdover Time Guidelines

Outside Air Temperature		Type III 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			Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1,4]	Other[2]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:20 – 0:40	0:35 – 0:45	0:20 – 0:35	0:10 – 0:20	0:10 – 0:20	0:08 – 0:10	0:05 – 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		
		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	0:06 – 0:30	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) [illegible] and the criteria (LOUT) are met. Consider the use of SAE Type I when Type III fluid cannot be used.

NO CHANGES

SAE Type III Fluid Holdover Time Guidelines for Winter 2009-10

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 or Snow Grains			Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	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		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10	CAUTION: No holdover time guidelines exist	
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

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TYPE IV

TYPE IV
NEW FLUIDS/OBSOLETE DATA

- ABAX Ecowing AD-49 and Kilfrost ABC-4^{sustain} will be commercialized for the winter of 2009-10
  - New fluid-specific tables will be added for both fluids
  - One reduction will be made to generic HOT guidelines
- Process for the removal of obsolete data is the same as for Type II fluids
  - No Type IV data becomes obsolete in 2009
  - No changes required

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CHANGES TO GENERIC TYPE IV HOT GUIDELINES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[4]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[3]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[5]	0:10 – 0:25[5]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[5]	0:10 – 0:20[5]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

FAA/TC TYPE IV HOT GUIDELINES 2009-10

FAA Type IV Holdover Time Guidelines

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	Freezing Drizzle[2]	Light Freezing Rain[2]	Rain on Cold Soaked Wing[2]	Other[2]
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25	CAUTION: No holdover time guidelines exist	
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

SAE Type IV Fluid Holdover Time Guidelines for Winter 2009-10

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 or Snow Grains[4]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[5]	0:10 – 0:25[5]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[5]	0:10 – 0:20[5]		
below -14 to -25 or LOUT[6]	below 7 to -13 or LOUT[6]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

Transport Canada

TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2009-10

1) ABAX AD-480
2) ABAX AD-49 (NEW)
3) CLARIANT SAFEWING MP IV 2001
4) CLARIANT SAFEWING MP IV 2012 PROTECT
5) CLARIANT SAFEWING MP IV LAUNCH
6) DOW UCAR ULTRA +
7) DOW UCAR ENDURANCE EG106
8) DOW UCAR FLIGHTGUARD AD-480
9) KILFROST ABC-S
10) KILFROST ABC-S PLUS
11) KILFROST ABC-4^{sustain} (NEW)
12) LYONDELL ARCTIC SHIELD
13) OCTAGON MAX-FLIGHT
14) OCTAGON MAX-FLIGHT 04
15) OCTAGON MAXFLO

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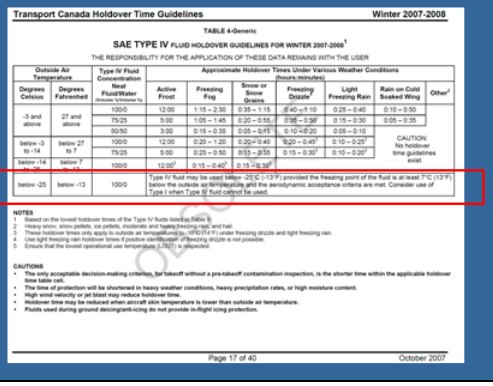
SUMMARY OF CHANGES TO HOT FORMAT

For Winter 2009-10 Operations

REMOVAL OF "BELOW -25°C" ROW



Transport Canada Holdover Time Guidelines — Winter 2007-2008

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008[1]

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

Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[3]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[5]	0:10 – 0:25[5]	CAUTION: No holdover time guidelines exist	
		75/25	5:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[5]	0:10 – 0:20[5]		
below -14 to -25	below 7 to -13	100/0	12:00[6]	0:15 – 0:40[5]	0:15 – 0:30[5]				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature, and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

NOTES

1. Based on the lowest holdover times of the Type IV fluids listed in Table 1.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. These holdover times only apply to outside air temperatures at or below 0°C (14°F) under freezing drizzle and light freezing rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Ensure that the lowest operational use temperature (LOUT) is respected.

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 deicing/anti-icing do not provide in-flight icing protection.

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REMOVAL OF "BELOW -25°C" ROW

- Comparative endurance time testing was conducted
- Results did not demonstrate significant differences in endurance times for -25°C vs. -28.5°C tests
- Based on the current generation of fluids (LOUT of approx -28.5°C), the current -25°C HOT's could be used down to the fluid LOUT's

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REMOVAL OF "BELOW -25°C" ROW

- Recommended to eliminate "below -25°C" row
- Lower temperature range changed to "below -14 to -25°C or LOUT"
- Changes applicable to Type II and IV

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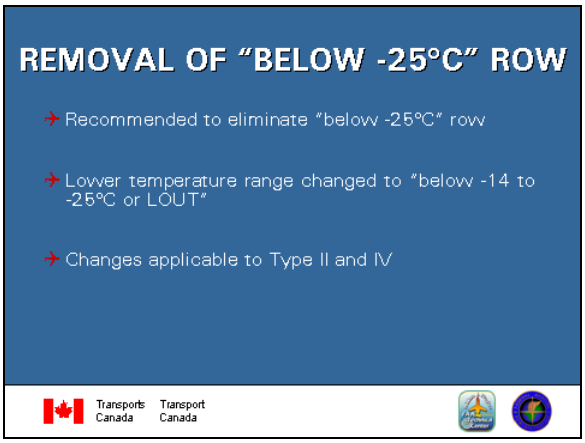
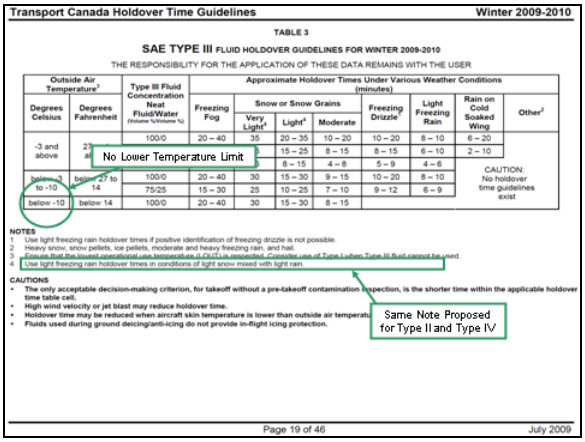
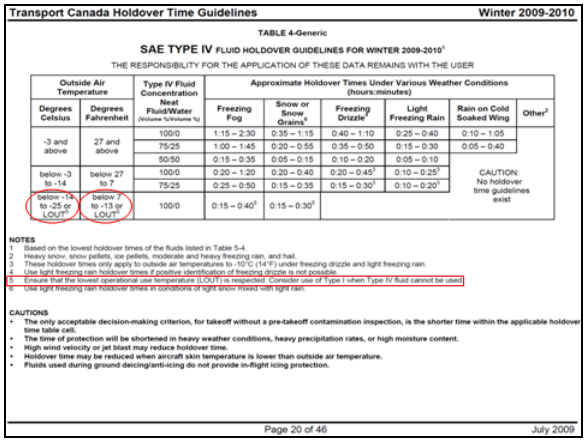
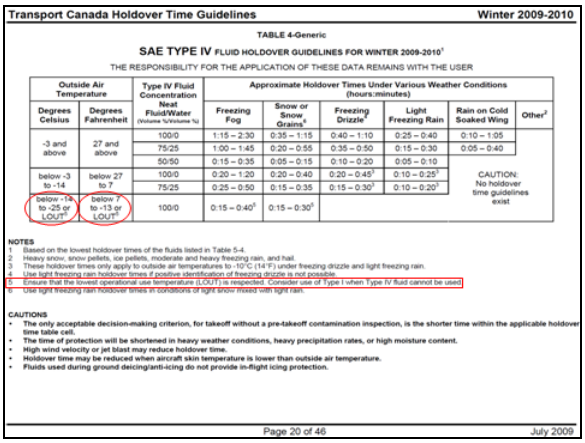
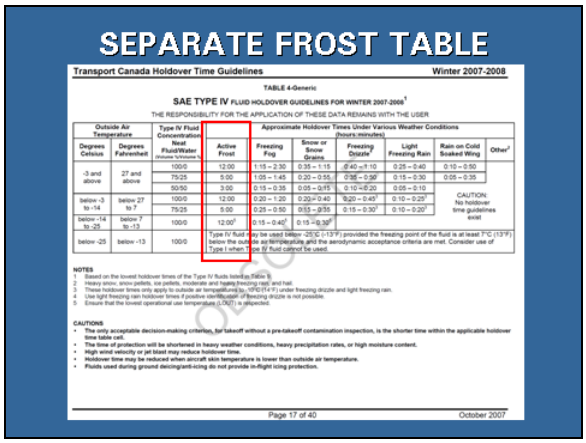








SEPARATE FROST TABLE



SEPARATE FROST TABLE

- Historically generic HOT's have been used for "Active Frost" conditions
- Endurance time testing was conducted to substantiate the generic HOT's in natural frost conditions
- Reduced Endurance Times were observed for Type II and Type IV fluid in Frost Conditions
  - Due to fluid freeze point issues

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SEPARATE FROST TABLE

- A separate frost HOT table was recommended to issue necessary changes to the frost values and to to minimize operational impacts
  - Temperature breakdowns were modified
- Frost HOT's have been removed from the generic and fluid-specific tables

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Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	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 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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LIGHT SNOW MIXED WITH LIGHT RAIN

- Comparative endurance time was conducted
- ET for "light snow mixed with light rain" was always slightly longer compared to "light freezing rain"
- Both conditions showed similar failure characteristics
  - i.e. adherence and erosion of the fluid layer

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LIGHT SNOW MIXED WITH LIGHT RAIN

- "Light freezing rain" holdover times seem a good conservative approach for "light snow mixed with light rain"
  - In accordance with AEA recommendation
- A footnote has been included in all tables

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Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[4]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[5]	Light[5]	Moderate	Freezing Drizzle[6]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 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.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

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TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 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	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[3]	0:15 – 0:30[3]				

NOTES
1. Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6. Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains			Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	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		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10	CAUTION: No holdover time guidelines exist	
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES
1. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4. Use light freezing rain holdover times in conditions of light snow mixed with light 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.**
- **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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

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 or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[3]	0:15 – 0:30[3]				

NOTES
1. Based on the lowest holdover times of the fluids listed in Table 5-4.
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6. Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

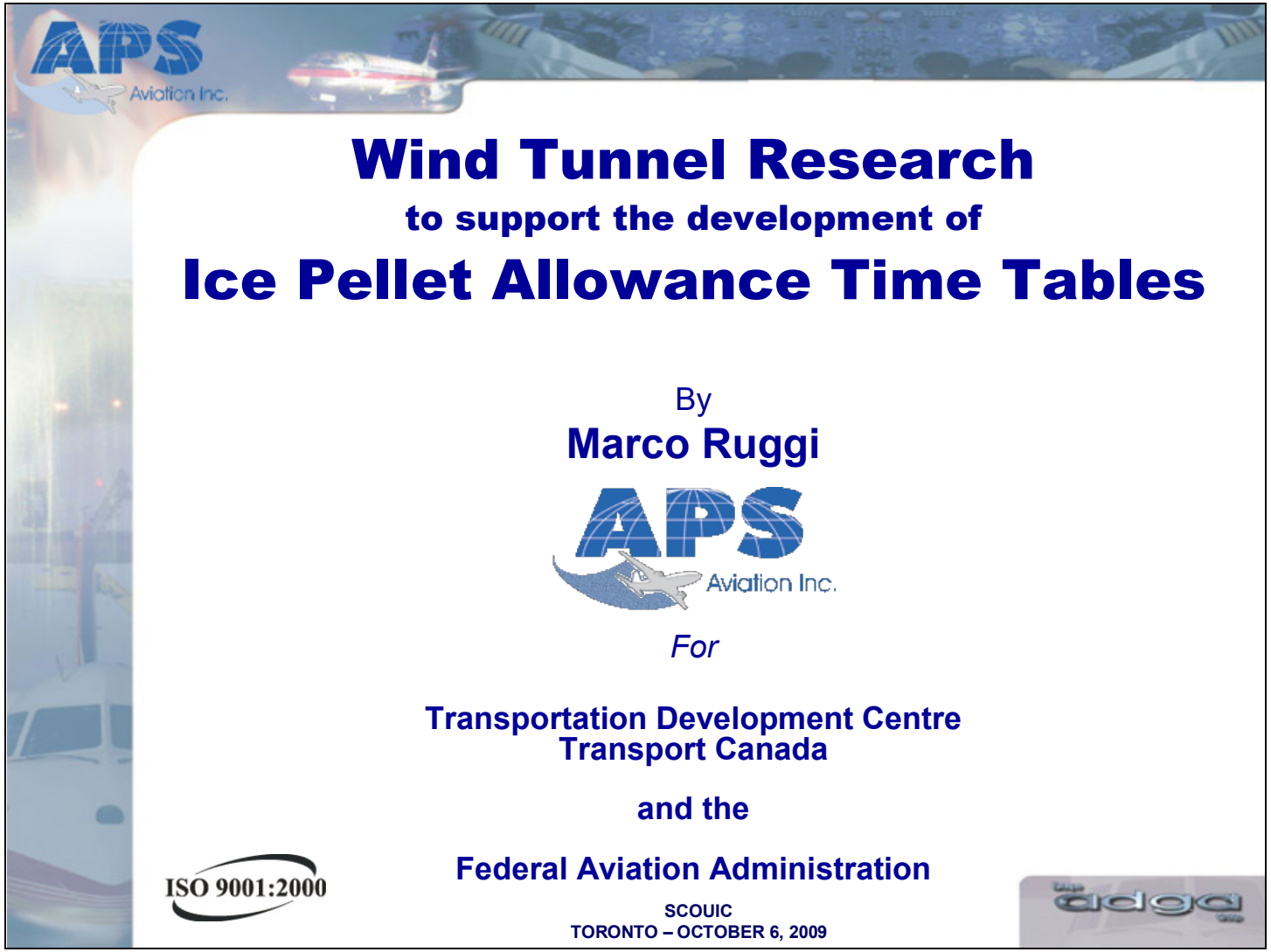
TC HOLDOVER TIME GUIDANCE MATERIAL

Transports Canada Transport Canada

http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm

Guidance for Aircraft Ground Icing Operations – TP14052

Transports Canada Transport Canada


APS
Aviation Inc.
Wind Tunnel Research
to support the development of
Ice Pellet Allowance Time Tables
By
Marco Ruggi
APS
Aviation Inc.
For
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration
SCOUIC
TORONTO – OCTOBER 6, 2009
ISO 9001:2000
adga

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE II, III, IV LOW SPEED
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

Background

- Recent industry need to provide aircraft operators with guidance material for ice pellet conditions
- Ongoing research has been conducted during the winters of 2004-05 to 2008-09
- Work consisted of
  - Flat plate testing
  - Full scale aircraft tests
  - Wind tunnel testing

Ice Pellet Guidance

- 2005-06 Guidelines
  - FAA notices for No Takeoff in Ice Pellets
- 2006-07 Guidelines
  - FAA Preliminary 25 minute Allowance Time
- 2007-08 Guidelines
  - TC and FAA Ice Pellet Allowance Time Table
- 2008-09 Guidelines
  - No Changes
- ***2009-10 Guidelines***
  - ***Updated table discussed in this presentation***

Background

- Guidance material was followed by a list of conditions and restrictions which include
  - Type IV Neat Fluid Only
  - Rotation speed of 100 knots or greater
- Industry requested additional guidance material for operations with
  - Low rotation speed aircraft
  - Type III fluid

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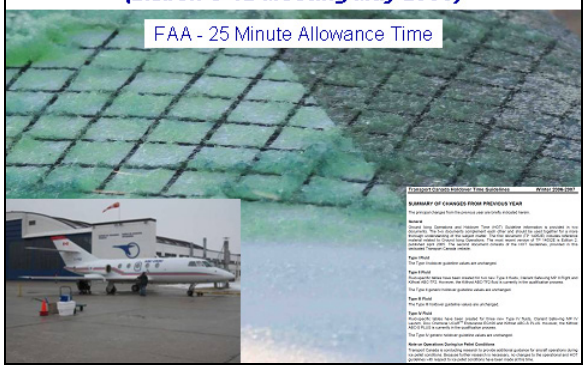
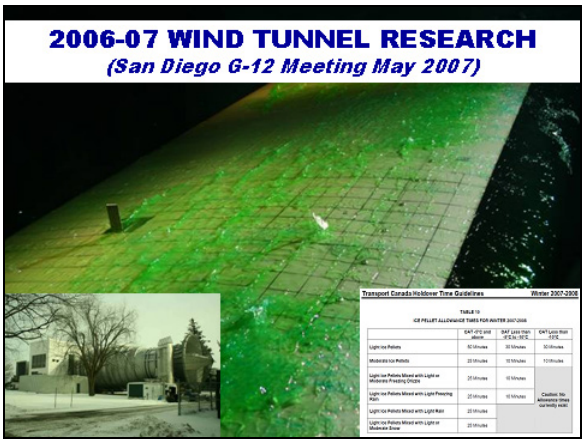
2005-06 FALCON 20 RESEARCH

(Lisbon G-12 Meeting May 2006)

FAA - 25 Minute Allowance Time



2006-07 WIND TUNNEL RESEARCH
(San Diego G-12 Meeting May 2007)



2007-08 F20 AND T-33 RESEARCH
(Warsaw G-12 Meeting May 2008)

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2008-09 Wind Tunnel Test Plan

- Primary Research Objectives
  - Validation of Current Allowance Times
  - Expansion of Allowance Times
    - Low Rotation Speed
    - SN/IP at lower temperatures
    - Different Fluid Types
- Secondary Research Objectives
  - S++, Frost, Inadequate Application, Composite Materials, R-&SN, R&IP-, Surface Roughness

Summary of Test Runs

Objective	# of Runs
Secondary Research Objectives	29
Baseline/Dry	24
Type IV High Speed	24
Type IV Low Speed	17
Type III Low Speed	11
Type II Low Speed	2
Total	***107***

2008-09 RESEARCH TEAM

OUTLINE

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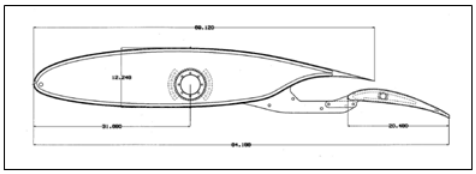
Test Methodology

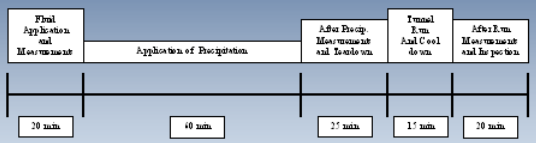
- NASA LS(1)-0417 Wing Section was used for testing
  - Fowler Flap fixed at 15°



Wind Tunnel Test Profile

- Typical wind tunnel test profile:
  - Initial wing angle of attack 0°
  - 0 to V_R in 30-35 seconds
  - At V_R, Pitch wing to Θ_{MAX}° (2.7° per second)
  - Pitch wing back to 4° (0.25° per second)
  - Hold wing at 4° for 1 minute and stop test
- V_R = 80 knots (low speed) or 100 knots (high speed)
- Θ_{MAX}° = 8°,12°, 16°, and 20°

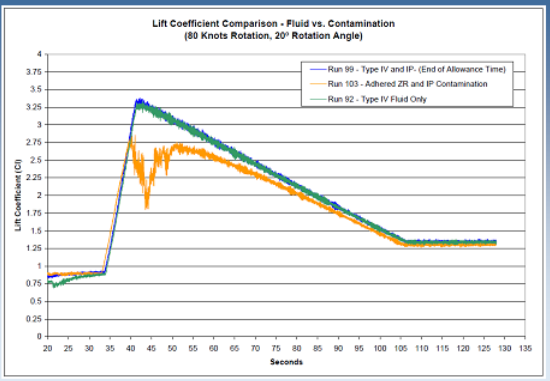
Sample Run Timeline



Test Methodology

- Test results were evaluated based on:
  - Aerodynamic performance (lift coefficient data)
    - Provided by NRC
  - Visual contamination ratings (fluid flow off)
    - By observers and with high speed photography
- Measured parameters included:
  - Fluid brix
  - Fluid thickness
  - Skin temperature

Effect of Contamination



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Type IV High Speed

- 24 tests were conducted
- Objectives:
  - To validate current allowance times
  - To potentially expand current allowance times
    - Mixed IP and SN below -5ºC

Type IV High Speed

- Results
  - Current allowance times were validated
    - Data at colder temps still recommended for IP and IP-
  - Allowance times were expanded for
    - IP/SN and IP/R_{mod}
- Changes to HOT Guidelines
  - Updated Type IV High Speed Allowance Time table
- Recommendation
  - Additional testing at colder temperatures

New Type IV High Speed

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes		10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle			Caution: No allowance times currently exist
Light Ice Pellet… Rain		10 minutes	
Light Ice Pellets …	25 minutes		
Light Ice Pellets Mi… with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

Published

Example: Validation Test Light Ice Pellets

- Current IP- Allowance:
  - 50 minutes for Above -5ºC
- Test Conditions:
  - Type IV PG Neat
  - IP 25 g/dm²/h for 50 min
  - OAT -9°C
  - High Speed, 8° Rotation

Old Type IV High Speed Table

TABLE 10
ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		

Test #21 (P45)

Validation Test

ABC-S Plus, IP 25 g/dm²/h, 50 min, -9°C,

High Speed, 8° Rotation

Example: Validation Test Light Ice Pellets

- Test #21 Results:
  - Visual contamination ratings were good
    - Acceptable level of visual contamination at start of test
    - Leading edge clean at rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - **Good Successful Run**

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ***ICE PELLET ALLOWANCE TIME RESEARCH***
  - TYPE IV HIGH SPEED
  - ***TYPE II, III, IV LOW SPEED***
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

Type IV Low Speed Results

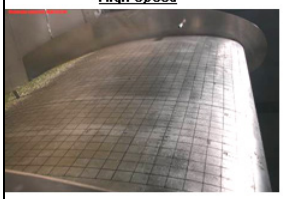
- Type IV Low Speed
  - Preliminary Allowance times were only developed for a limited number of cells
    - Issues with low speed fluid flow-off.
  - Additional testing is required
  - In addition, Type IV fluids are generally not certified (or do not qualify) for low speed takeoff
  - Aero acceptance tests for Type IV fluid must be modified before allowance times can be published.

High Speed TIV vs. Low Speed Type IV

Test #21(HS) vs. Test #86(LS)
ABC-S Plus, IP- 25 g/dm²/h, 50 min, -9°C

Before Rotation
High Speed vs. Low Speed

High Speed



Low Speed

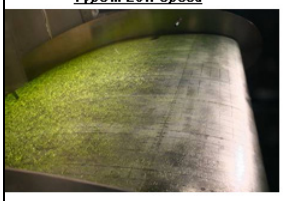
Type III Low Speed Results

- Type III Low Speed
  - Testing was conducted as a secondary objective
    - Only a limited amount of data was collected
  - A comprehensive preliminary allowance time table was developed
  - Publication of the guidelines has been postponed until further data is collected.

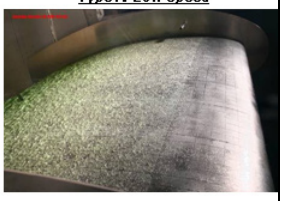
Low Speed TIII vs. Low Speed Type IV

Test #101(LS) vs. Test #86(LS)
Before Rotation
Low Speed TIII vs. Low Speed Type IV

Type III Low Speed



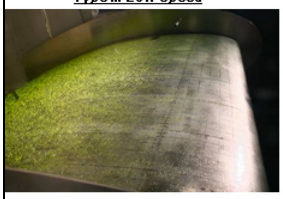
Type IV Low Speed



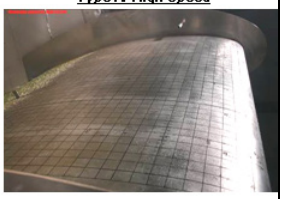
Low Speed TIII vs. High Speed Type IV

Test #101(LS) vs. Test #21(HS)
Before Rotation
Low Speed TIII vs. High Speed Type IV

Type III Low Speed



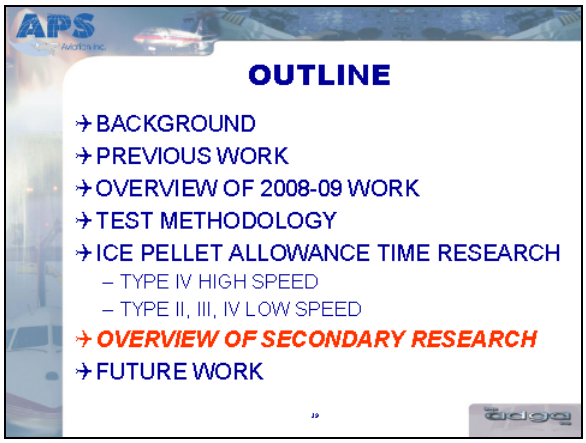
Type IV High Speed



Type II Results

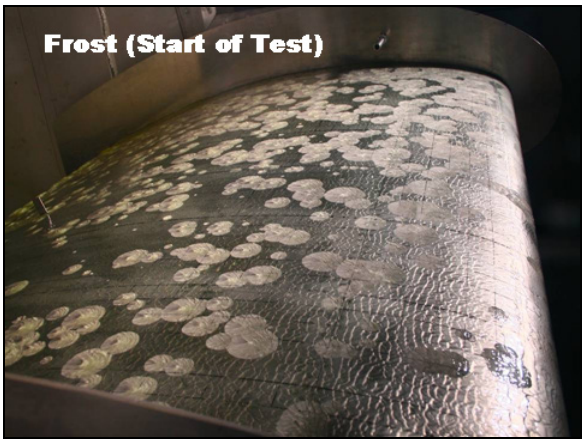
- Type II
  - Conducted as a low priority objective
    - Only two tests were conducted
  - Results were positive
  - Further testing is required to compile a comprehensive table

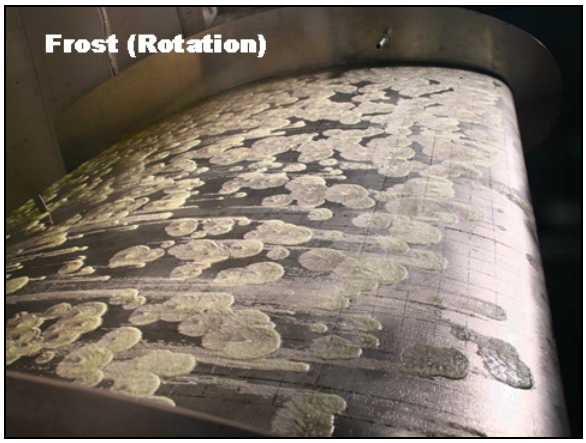
Published
In Development
In Development
In Development

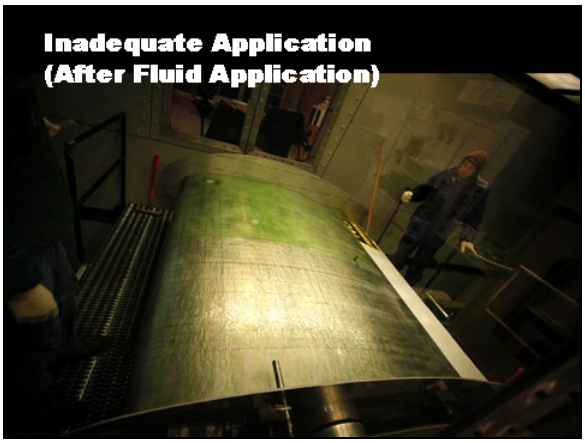

APS
OUTLINE
BACKGROUND
PREVIOUS WORK
OVERVIEW OF 2008-09 WORK
TEST METHODOLOGY
ICE PELLET ALLOWANCE TIME RESEARCH
– TYPE IV HIGH SPEED
– TYPE II, III, IV LOW SPEED
OVERVIEW OF SECONDARY RESEARCH
FUTURE WORK

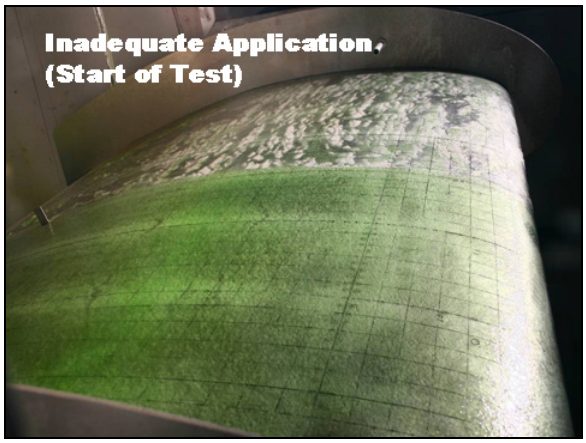
Heavy Snow (Start of Test)

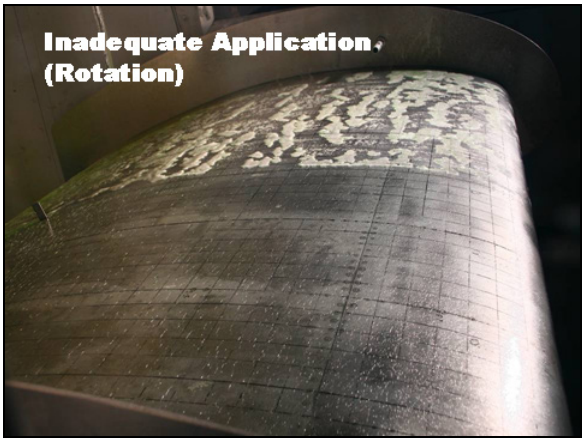
Heavy Snow (Rotation)


Frost (Start of Test)

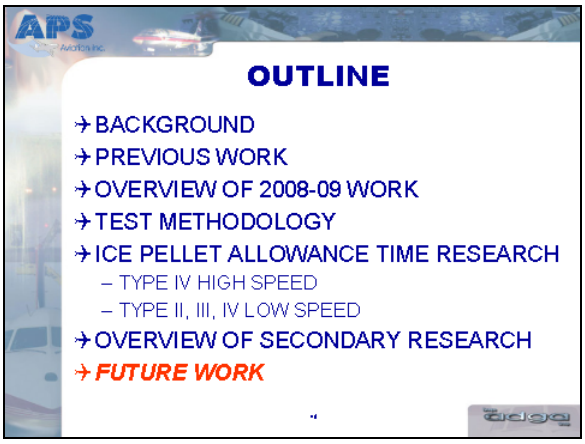

Frost (Rotation)


Inadequate Application
(After Fluid Application)


Inadequate Application
(Start of Test)


Inadequate Application
(Rotation)

Effects of Surface Roughness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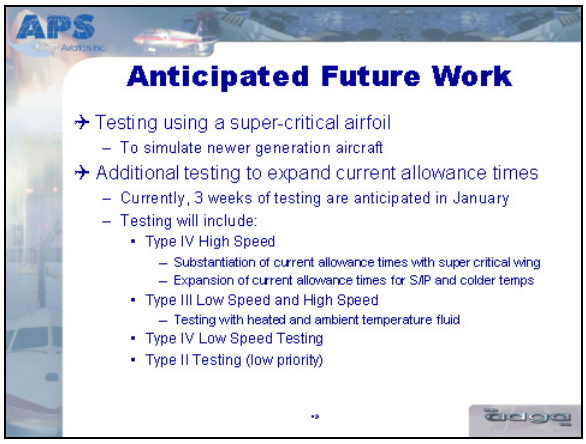
APS
Anticipated Future Work
Testing using a super-critical airfoil
– To simulate newer generation aircraft
Additional testing to expand current allowance times
– Currently, 3 weeks of testing are anticipated in January
– Testing will include:
Type IV High Speed
– Substantiation of current allowance times with super critical wing
– Expansion of current allowance times for S/P and colder temps
Type III Low Speed and High Speed
– Testing with heated and ambient temperature fluid
Type IV Low Speed Testing
Type II Testing (low priority)

APS
Aviation Inc
Additional Areas of Research
In previous years, additional wind tunnel research has been geared towards industry needs
Inadequate fluid application, simulated frost, heavy snow, etc.
Potential areas of future research include:
Ice detection (ROGIDS)
Effect of wing ice phobic coatings
Reduced Type I ET's on composite wings
Fluid flow off in heavy snow conditions
Aerodynamic fluid failure vs. HOT defined failure
Additional industry suggestions???
adga

APS
Aviation Inc.
Marco Ruggi
mruggi@adga.ca

APPENDIX J

PROCEDURE:
EVALUATION OF ENDURANCE TIME VALUES FOR INDOOR (AIRCRAFT HANGAR) ANTI-ICING APPLICATIONS

CM2169.001

PROCEDURE:
EVALUATION OF ENDURANCE TIME VALUES FOR INDOOR (AIRCRAFT HANGER) ANTI-ICING APPLICATIONS

Winter 2008-09

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: for David Youssef

Reviewed by: John D'Avirro

March 10, 2009
Final Version 1.1

EVALUATION OF HOLDOVER TIME VALUES FOR INDOOR (AIRCRAFT HANGER) ANTI-ICING APPLICATIONS

Winter 2008-09

1. BACKGROUND

In recent years, indoor application of anti-icing fluid on aircraft has been an important topic of industry discussion. It is understood that many fixed based operators is to anti-ice an aircraft when it is still parked inside the aircraft hanger. Often this aircraft has been in the hanger for a long enough period of time that the skin temperature and fuel temperature is equal to the ambient indoor temperature.

The holdover time of a given fluid is calculated as beginning with the final application of the anti-icing fluid, and as expiring when the fluid is no longer effective. Once an aircraft is anti-iced inside a hanger there is an elapsed period of time from the end of fluid application to precipitation exposure. This elapsed time may be due to a delay in aircraft readiness, or more simply the time to marshal the aircraft outside of the hanger.

Questions have been raised concerning the effect this elapsed period may have on the endurance time of Type II, III, and IV fluids.

2. OBJECTIVE

The objective of this project is to investigate the effect indoor (aircraft hanger) anti-icing has upon endurance times. In order to achieve this objective, a series of tests will be performed using five representative anti-icing fluids, on both standard aluminum plates and standard cold-soak boxes.

Focus will be set upon investigating the effect any lapse time between end of anti-icing and exposure to precipitation has upon endurance times.

This procedure will investigate the above objectives in a natural snow setting. Upon analysis of the results, further testing may be completed in simulated freezing precipitation conditions.

3. PROCEDURE

3.1 Natural Snow Testing

Endurance time tests will be conducted outdoors with the various fluids at the P. E. Trudeau International Airport test site. A six-position stand will be required for this testing. This is demonstrated in Figure 3.1. Position one will be used as the baseline for endurance times test and position six will have a rate pan that will be used for measuring the rate of precipitation during each test. The other four positions will simulate an elapsed time between anti-icing and exposure to precipitation. To simulate hangar fluid application, the standard cold soak boxes will be used to simulate heated Type I fluid application representing leading edge. Thermal equivalents will be used for the tests.

All positions will be exposed to precipitation at the same time; however the time of fluid application will vary. In other words, the three boxes that are kept inside will be poured at varying times before being put outside.

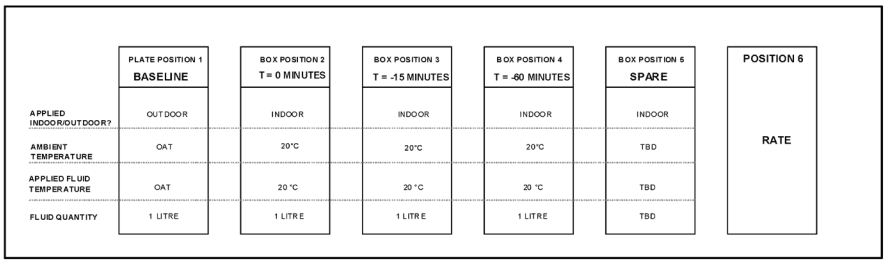

Figure 3.1: Six-Position Test Stand Set-up

3.1.1 In Advance of Testing

Certain tasks must be completed in advance of testing. Table 3.1 outlines these tasks.

Table 3.1: Tasks to be Completed in Advance of Testing

TIME	TASK	INSTRUCTIONS
T = Day Before Testing	PREPARATION OF 3 INDOOR BOXES. PREPARATION OF FLUID TO BE TESTED	• Place 4 Cold Soak Boxes indoors with fill caps removed for at least 12 hours before testing
		• Prepare all fluid to be applied at indoor ambient temperature, and leave indoors. • For all fluid to be applied at outdoor ambient temperature, leave outdoors.
T = 2 hours before testing	INDOOR STAND PREPARATION	• Bring inside one 3-position stands complete with wooden board holders and collection pans. In the event that the spare position is utilized, bring in a 1-position stand to compensate. • Level to 10° and place CSW boxes on top.
T = 1 hour before testing	OUTDOOR STAND PREPARATION	• Level to 10°

3.1.2 Test Procedure

As mentioned at the beginning of this section, all positions will be exposed to precipitation at the same time; however the time of fluid application will vary.

Table 3.2 outlines in chronological order the tasks of this testing.

Table 3.2: Test Procedure

Indoor Application

TIME	TASK	INSTRUCTIONS
T = 60 Minutes before exposure to Precipitation	APPLY FLUID TO BOX POSITION 4	• Pour 1 litre of 20°C Fluid onto box position 4
T = 15 Minutes before exposure to Precipitation	APPLY FLUID TO BOX POSITION 3	• Pour 1 litre of 20°C Fluid onto box position 3
T = 2 Minute before exposure to Precipitation	APPLY FLUID TO BOX POSITION 2	• Pour 1 litre of 20°C Fluid onto box position 2
T = 1 Minute before exposure to Precipitation	BRING BOX POSITIONS 2,3 AND 4 AND PLACE ON STAND	

← BRING BOX POSITION 2,3, AND 4 OUTSIDE AND PLACE ON STAND →

Outdoor Application

TIME	TASK	INSTRUCTIONS
T = 0 Minutes before exposure to Precipitation	APPLY FLUID TO PLATE POSITION 1	• Pour 1 litre of OAT Fluid onto Plate position 1

3.2 Freezing Precipitation Testing

This research will also be completed in freezing precipitation conditions, as part of the overall program of tests completed at the National Research Council Climactic Engineering Facility (NRC) in Ottawa. For more details, see the related project procedure: Overall Program of Tests at NRC, March-April 2009.

4. MEASUREMENTS

4.1 Rate Measurements

Rate measurements will be taken according to Standard Holdover Time testing practices.

4.2 Fluid Thickness and Brix (Refractive Index)

To assist in analyzing the results, fluid thickness and Brix will be measured on all of the tests conducted. These measurements will be taken upon application of fluid, and at 15 minute intervals throughout the test.

4.3 Plate Temperature

Plate Temperature will be measured at 15 minute intervals throughout the test. The selected tests from section 4.2 will be subject to plate temperature measurements.

5. TEST PLAN

A test plan has been compiled for Type II/III/IV fluids and is included in Attachment I. A total of five runs are anticipated for this project. An additional test plan for simulated freezing precipitation testing will be completed and incorporated into the Overall Program of tests procedure for NRC March - April 2009.

6. EQUIPMENT

The standard endurance time testing equipment from the procedure*, Test Requirements for Natural Precipitation Flat Plate Testing* (see Version 1.0 from December 23, 2004, located in Appendix B of TP14443E), will be used.

7. FLUIDS

The following fluids will be used for these tests:

Type II: Clariant MPII Flight
Xi'An CleanWing

Type III: Clariant MPIII 2031

Type IV: DOW EG-106 Endurance
ABAX TYPE IV F394

8. PERSONNEL

Two personnel will be required to conduct these tests. One individual will be responsible to measure endurance times, and the remaining individual will prepare fluids, assist with fluid application, collect rates, and record measurements.

9. DATA FORMS

These tests will require the end condition data form which is included as Attachment II. Attachment III depicts the data form to be used for recording Brix and thickness measurements.

10. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

- Pathways, stairs and test areas are to be cleared of snow regularly;
- Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;
- Warm clothing is to be worn by all personnel to prevent frostbite;
- Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;
- If fluid comes into contact with skin, rinse hands under running water; and
- If fluid comes into contact with eyes, flush with the portable eye wash station located inside the main trailer.

ATTACHMENT I: MATRIX OF OUTDOOR TESTS

Run #	Fluid Type	Fluid Brand	Dilution
1	II	Clariant MPII Flight	Neat
2	II	Xi'An Cleanwing	Neat
3	III	Clariant MPIII 2031	Neat
4	IV	DOW EG-106 Endurance	Neat
5	IV	ABAX TYPE IV F394	Neat

Note: All tests shall be run at rates greater than 4 g/dm^2/h

ATTACHMENT II: END CONDITION FORM FOR ENDURANCE TIME TESTING

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

LOCATION: **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

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

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 2°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

AMBIENT TEMPERATURE: _____ °C

COMMENTS:

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

FAILURES CALLED BY: _____

LEADER / MANAGER: _____

ATTACHMENT III: FLUID BRIX, FLUID THICKNESS, AND PLATE TEMPERATURE 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	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.	TIME	Brix	Thickness	Plate Temp.

APPENDIX K

TRANSPORT CANADA AND FEDERAL AVIATION ADMINISTRATION
HOLDOVER TIME GUIDELINES
WINTER 2009-2010

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2009-2010

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2009-2010

Original Issue, July 2009

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 the 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/CivilAviation/commerce/HoldoverTime/menu.htm.

REVISION	*DATE*	*DESCRIPTION OF CHANGES*	*AFFECTED PAGES*	*AUTHOR*

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

SUMMARY OF CHANGES FROM PREVIOUS YEAR

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

Type I Fluid

- The Type I holdover time guideline values are unchanged; however, the Type I active frost holdover times have been moved to the new active frost holdover time table (see below).

Type II Fluid

- A fluid-specific table has been created for one new Type II fluid, Aviation Shaanxi Hi-Tech Cleanwing II. The addition of this fluid did not impact the generic holdover times.
- Aviation Xi'an Hi-Tech KHF-II has been removed from the Type II guidelines due to ongoing concerns with fluid viscosity. The manufacturer had indicated intentions to requalify the fluid at a higher viscosity; however, the related aerodynamic test results were not provided to Transport Canada. The removal of this fluid did not impact the Type II generic holdover times.
- Kilfrost ABC-II Plus has been removed from the Type II guidelines as per the protocol for removing obsolete data. Removal of this fluid resulted in three increases to the Type II generic holdover times: two in freezing fog and one in freezing drizzle.
- All Type IV fluids also qualify as Type II fluids and therefore the Type II generic holdover times are the lowest holdover times of all Type II and Type IV fluids. A reduction has been made to one Type II generic freezing fog value as a result of a Type IV fluid having a shorter holdover time than any Type II fluid.
- The Type II active frost holdover times have been moved from the Type II holdover time tables to the new active frost holdover time table (see below).
- The *below -25°C* row has been removed from all Type II holdover time tables. In its place, the *below -14 to -25°C* row has been modified to *below -14 to -25°C or LOUT.* Unless the user verifies a lowest operational use temperature (LOUT) below -25°C, the holdover times apply down to -25°C only.

Type III Fluid

- The Type III holdover time guideline values are unchanged; however, the Type III active frost holdover times have been moved to the new active frost holdover time table (see below).

Type IV Fluid

- Fluid-specific tables have been created for two new Type IV fluids: ABAX Ecowing AD-49 and Kilfrost ABC-4^{sustain}. Kilfrost ABC-4^{sustain} is currently in the qualification process. The addition of ABAX Ecowing AD-49 did not impact the generic holdover times; the addition of Kilfrost ABC-4^{sustain} caused one reduction to the generic holdover times, in freezing fog.
- The Type IV active frost holdover times have been moved from the Type IV holdover time tables to the new active frost holdover time table (see below).
- The *below -25°C* row has been removed from all Type IV holdover time tables. In its place, the *below -14 to -25°C* row has been modified to *below -14 to -25°C or LOUT.* Unless the user verifies a lowest operational use temperature (LOUT) below -25°C, the holdover times apply down to -25°C only.

Transport Canada Holdover Time Guidelines Winter 2009-2010

Holdover Times in Active Frost Conditions

- The active frost holdover times have been moved from the generic and fluid-specific tables to a new active frost holdover time table. Type I and Type III active frost holdover times remain the same; reductions have been made to some Type II and Type IV values as a result of several years of research indicating lower values are required.

Holdover Times in Light Snow Mixed with Light Rain

- Recent tests have shown that light freezing rain holdover times can be used in conditions of light snow mixed with light rain. A note to this effect has been added to all Type I, Type II, Type III and Type IV holdover time tables.

Operations during Ice Pellet Conditions

- Further research has been conducted this year to expand and modify the guidance material for operations during ice pellet conditions. Specifically, changes have been made to include guidance for operations in light ice pellets mixed with moderate rain and to expand the guidance for operations in light ice pellets mixed with light or moderate snow.

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 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 remains 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 Type IV 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 upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to 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 and SAE Type II, III and IV fluids described in tables 6 & 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 SAE document AS 5681.

Air Operators and/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/CivilAviation/IMSdoc/ACs/600/602-001.htm

Transport Canada Holdover Time Guidelines Winter 2009-2010

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 fluid Types I, II, III, and IV.

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 decision-making criteria, 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 Paragraph 11.1.8 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) Snow Pellets; b) Hail; c) Moderate and Heavy Freezing Rain; and d) Heavy Snow.

Notes: 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.

Add Paragraph 11.1.12: Type I HOT Guidelines for Aircraft with Critical Surfaces Constructed Using Composite Materials

Preliminary research has shown that for aircraft with large portions of critical surfaces constructed using composite materials, Type I fluid holdover times could be shorter by up to 30% as compared to the current holdover times. Further testing is expected to develop Type I holdover times specific for aircraft with critical surfaces constructed using composite materials.

Replace Paragraph 12.1.2 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.

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2009-2010

Table 0	Active Frost Holdover Guidelines
Table 1	SAE Type I Fluid Holdover Guidelines
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-2025	Clariant Type II Fluid Holdover Guidelines Safewing MP II 2025 ECO
Table 2-C-Flight	Clariant Type II Fluid Holdover Guidelines Safewing MP II Flight
Table 2-K-ABC-2000	Kilfrost Type II Fluid Holdover Guidelines ABC-2000
Table 2-K-ABC-K+	Kilfrost Type II Fluid Holdover Guidelines ABC-K PLUS
Table 2-N-FCY-2	Newave Aerochemical Type II Fluid Holdover Guidelines FCY-2
Table 2-O-EM-II	Octagon Type II Fluid Holdover Guidelines E Max II
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-2001	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2001
Table 4-C-2012	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2012 Protect
Table 4-C-Launch	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV Launch
Table 4-D-ULTRA+	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ ADF/AAF ULTRA+
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-K-ABC-4^{sustain}	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 PLUS	Kilfrost Type IV Fluid Holdover Guidelines ABC-S PLUS
Table 4-L-ARCTIC Shield	Lyondell Type IV Fluid Holdover Guidelines ARCTIC Shield™
Table 4-O-MF	Octagon Type IV Fluid Holdover Guidelines Max-Flight
Table 4-O-MF-04	Octagon Type IV Fluid Holdover Guidelines Max-Flight 04
Table 4-O-MFLO	Octagon Type IV Fluid Holdover Guidelines MaxFlo
Table 5	Currently Qualified Fluids
Table 6	SAE Type I Deicing Fluid Application Procedures
Table 7	SAE Type II, Type III and Type IV Anti-Icing Fluid Application Procedures
Table 8	Visibility in Snow vs. Snowfall Intensity Chart
Table 9	Lowest On-Wing Viscosity Values for Anti-Icing Fluids
Table 10	Ice Pellet Allowance Times

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	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 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS

- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	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 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 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.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 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	0:05 – 0:15	0:05 – 0:10	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[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-A-E26

ABAX TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ECOWING 26

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10[3]	0:15 – 0:35[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50[3]	0:15 – 0:25[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:25 – 0:45[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-AS-CLEANWING II

AVIATION SHAANXI HI-TECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
CLEANWING II

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 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[3]	0:20 – 0:25[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:40 – 1:45	0:25 – 0:45	0:35 – 0:40[3]	0:20 – 0:25[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:50[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-C-2025

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
SAFEWING MP II 2025 ECO

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:30 – 2:05	0:40 – 1:10	0:40 – 1:00	0:25 – 0:35	0:10 – 1:15	
		75/25	0:55 – 1:45	0:25 – 0:45	0:25 – 0:45	0:20 – 0:25	0:05 – 0:50	
		50/50	0:20 – 0:35	0:05 – 0:15	0:10 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:35 – 1:00	0:35 – 1:05[3]	0:20 – 0:35[3]		
		75/25	0:40 – 1:20	0:25 – 0:45	0:30 – 0:40[3]	0:15 – 0:25[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:25 – 0:45[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-C-Flight

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
SAFEWING MP II FLIGHT

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	2:30 – 4:00	0:40 – 1:20	1:15 – 2:00	0:30 – 0:55	0:05 – 1:20	
		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[3]	0:25 – 0:45[3]		
		75/25	0:40 – 1:10	0:20 – 0:40	0:25 – 1:10[3]	0:30 – 0:40[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:30 – 0:50[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-K-ABC-2000

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ABC-2000

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 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[3]	0:10 – 0:30[3]		
		75/25	0:35 – 1:15	0:25 – 0:50	0:25 – 0:55[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:45[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-K-ABC-K+

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ABC-K PLUS

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 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[3]	0:15 – 0:35[3]		
		75/25	0:25 – 1:25	0:35 – 1:05	0:20 – 0:55[3]	0:05 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:30 – 0:55[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-N-FCY-2

NEWAVE AEROCHEMICAL TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
FCY-2

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:25	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:05 – 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	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45[3]	0:15 – 0:20[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:25 – 0:35[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-O-EM-II

OCTAGON TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
E MAX II

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	2:05 – 3:45	0:40 – 1:20	0:45 – 1:35	0:30 – 0:40	0:15 – 1:30	
		75/25	1:25 – 2:50	0:25 – 0:55	0:40 – 1:10	0:20 – 0:30	0:10 – 1:05	
		50/50	0:30 – 0:55	0:10 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:50 – 1:45	0:35 – 1:10	0:35 – 1:00[3]	0:20 – 0:30[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:20	0:25 – 0:50	0:35 – 1:05[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:35[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains			Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	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	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light 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.**
- **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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-A-AD-480

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
AD-480

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:10 – 0:20	0:15 – 0:25	0:05 – 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[3]	0:15 – 0:30[3]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below -7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-A-Ecowing AD-49

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ECOWING AD-49

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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[3]	0:20 – 0:25[3]		
		75/25	0:30 – 1:10	1:20 – 1:40	0:15 – 1:05[3]	0:15 – 0:25[3]		
below -14 to -25 or LOUT[5]	below -7 to -13 or LOUT[5]	100/0	0:25 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-C-2001

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
SAFEWING MP IV 2001

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:20 – 3:20	1:00 – 1:55	0:55 – 1:55	0:40 – 1:00	0:15 – 2:00	
		75/25	1:20 – 2:00	0:35 – 1:00	0:35 – 1:10	0:25 – 0:35	0:10 – 1:25	
		50/50	0:15 – 0:40	0:10 – 0:20	0:10 – 0:20	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:35	0:30 – 0:50	0:55 – 1:35[3]	0:30 – 0:45[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:00	0:20 – 0:35	0:40 – 1:10[3]	0:20 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:45[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-C-2012

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
SAFEWING MP IV 2012 PROTECT

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:40 – 1:15	0:40 – 1:10	0:25 – 0:45	0:10 – 1:05	
		75/25	1:10 – 2:05	0:25 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:25 – 0:45	0:15 – 0:25	0:15 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:45	0:20 – 0:40	0:25 – 0:45[3]	0:15 – 0:25[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:25 – 1:05	0:20 – 0:40	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:45[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-C-Launch

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
SAFEWING MP IV LAUNCH

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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[3]	0:25 – 0:45[3]	CAUTION: No holdover time guidelines exist	
		75/25	0:40 – 1:20	0:45 – 1:25	0:25 – 1:10[3]	0:25 – 0:45[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:30 – 0:50[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-D-ULTRA+

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
UCAR™ ADF/AAF ULTRA+

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:35 – 3:35	0:35 – 1:15	0:45 – 1:35	0:25 – 0:40	0:10 – 1:20	
		75/25					CAUTION: No holdover time guidelines exist	
		50/50						
below -3 to -14	below 27 to 7	100/0	1:25 – 3:00	0:25 – 0:55	0:45 – 1:25[3]	0:30 – 0:45[3]		
		75/25						
below -14 to -24	below 7 to -11	100/0	0:40 – 2:10[5]	0:20 – 0:45[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-E106

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
UCAR™ ENDURANCE EG106

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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[3]	0:45 – 1:10[3]		
		75/25						
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:30 – 1:05[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-D-AD-480

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
UCAR™ FLIGHTGUARD AD-480

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:10 – 0:20	0:15 – 0:25	0:05 – 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[3]	0:15 – 0:30[3]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-K-ABC-4^{sustain}

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ABC-4^{sustain}

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 0:15	0:10 – 0:20	0:05 – 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[3]	1:05 – 1:25[3]		
		75/25	0:35 – 2:10	0:30 – 0:55	0:25 – 1:20[3]	0:15 – 0:40[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:40 – 1:00[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-K-ABC-S

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ABC-S

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 0:15	0:15 – 0:20	0:05 – 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[3]	0:10 – 0:30[3]		
		75/25	0:25 – 1:00	0:25 – 0:50	0:20 – 1:10[3]	0:10 – 0:35[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-K-ABC-S PLUS

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ABC-S PLUS

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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[3]	0:20 – 0:30[3]		
		75/25	0:45 – 1:50	0:35 – 1:00	0:20 – 1:10[3]	0:15 – 0:25[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:40 – 1:00[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-L-ARCTIC Shield

LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
ARCTIC SHIELD™

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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	0:05 – 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[3]	0:25 – 0:30[3]		
		75/25	0:50 – 1:45	0:35 – 0:55	0:30 – 1:15[3]	0:25 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:25 – 0:45[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-O-MF

OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
MAX-FLIGHT

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	2:40 – 4:00	0:50 – 1:35	0:55 – 2:00	0:35 – 1:00	0:15 – 1:15	
		75/25	2:05 – 3:15	0:45 – 1:45	1:15 – 2:00	0:35 – 1:10	0:10 – 0:40	
		50/50	0:55 – 1:45	0:25 – 1:15	0:35 – 1:00	0:15 – 0:30	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50 – 2:30	0:25 – 0:50	0:25 – 1:10[3]	0:20 – 0:40[3]		
		75/25	0:30 – 1:05	0:20 – 0:50	0:20 – 1:00[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:45[5]	0:15 – 0:30[5]				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-O-MF-04

OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
MAX-FLIGHT 04

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-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[3]	0:20 – 0:40[3]		
		75/25	0:30 – 1:05	0:40 – 1:20	0:20 – 1:00[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:20 – 0:45[5]	0:15 – 0:30[5]				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

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TABLE 4-O-MFLO

OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
MAXFLO

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

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 or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	2:20 – 3:35	0:40 – 1:30	1:20 – 2:00	0:30 – 1:00	0:10 – 2:00	
		75/25	1:25 – 2:00	0:20 – 0:55	0:40 – 1:05	0:20 – 0:35	0:05 – 1:15	
		50/50	0:20 – 0:40	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	1:10 – 2:20	0:25 – 1:00	0:35 – 1:45[3]	0:30 – 0:50[3]		
		75/25	0:40 – 1:25	0:15 – 0:40	0:35 – 1:15[3]	0:15 – 0:30[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:30 – 1:00[5]	0:15 – 0:30[5]			CAUTION: No holdover time guidelines exist	

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light 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 deicing/anti-icing do not provide in-flight icing protection.**

TABLE 5
CURRENTLY QUALIFIED FLUIDS (2009-2010)

Table 5-1: Qualified Type I Anti-icing Fluids[1] [2]			
#	**COMPANY NAME**	**FLUID NAME**	**EXPIRY (Y-M-D)**
1-1	ABAX Industries	ABAX DE-950	12-06-25
1-2	ABAX Industries	ABAX DE-950 Colorless	12-06-26
1-3	Arcton Ltd.	Arctica DG ready-to-use	13-04-08
1-4	Aviation Xi'an Hi-Tech Physical Co. Ltd.	KHF-1	11-09-20
1-5	*Battelle Memorial Institute*	*D^3: Degradable by Design™ ADF1006A*	*08-01-13*[3]
1-6	Beijing Wangye Aviation Chemical Product Co.	KLA-1	11-09-20
1-7	*Beijing Wangye Aviation Chemical Product Co.*	*YJF-1*	*09-02-23*[3]
1-8	*Clariant Produkte (Deutschland) GmbH*	*Clariant Safewing MP I 1938 TF*	*08-08-21*[3]
1-9	*Clariant Produkte (Deutschland) GmbH*	*Clariant Safewing MP I 1938 TF PreMix 60% i.e. ready-to-use (multiple location)*	*07-09-14*[3]
1-10	Clariant Produkte (Deutschland) GmbH	Clariant Safewing MP I 1938 ECO (80)	12-06-10
1-11	Clariant Produkte (Deutschland) GmbH	Clariant Safewing MP I 1938 ECO (80) PreMix 55% i.e. ready-to-use	13-05-20
1-12	Clariant Produkte (Deutschland) GmbH	Clariant Safewing MP I 1938 ECO	12-06-10
1-13	Clariant Produkte (Deutschland) GmbH	Clariant Safewing EG I 1996	12-06-10
1-14	Clariant Produkte (Deutschland) GmbH	Clariant Safewing EG I 1996 (88)	11-07-06
1-15	Clariant Produkte (Deutschland) GmbH	Safewing MPI ECO PLUS (80)	11-03-20
1-16	*Chemical Specialists Development Inc.*	*Prist Wing De-Icer*	*08-05-17*[3]
1-17	Dow Chemical Company	Dow UCAR™ Aircraft Deicing Fluid Concentrate	11-09-10
1-18	Dow Chemical Company	Dow UCAR™ ADF XL54	13-01-21
1-19	Dow Chemical Company	Dow UCAR™ PG Aircraft Deicing Fluid	12-02-05
1-20	Dow Chemical Company	Dow UCAR™ PG ADF Dilute 55/45	12-02-05
1-21	*HOC Industries*	*SafeTemp I ES*	*07-10-27*[3]
1-22	HOC Industries	SafeTemp ES Plus	11-10-04
1-23	*Inland Technologies Inc.*	*Inland Duragly-P ready to use*	*05-09-11*[3]
1-24	*Inland Technologies Inc.*	*Inland Duragly-E ready to use*	*05-10-20*[3]
1-25	Kilfrost Limited	Kilfrost DF Plus	11-09-27
1-26	Kilfrost Limited	Kilfrost DF Plus (80)	12-07-21
1-27	Kilfrost Limited	Kilfrost DF Plus (88)	11-09-27
1-28	Kilfrost Limited	Kilfrost DFsustain™	13-02-10
1-29	*Lyondell Chemical Company*	*ARCOPlus*	*08-02-14*[3]
1-30	*Lyondell Chemical Company*	*ARCTIC Plus™*	*08-04-10*[3]
1-31	Newave Aerochemical Co. Ltd.	FCY-1A	11-08-21
1-32	Octagon Process Inc.	EcoFlo	13-07-06
1-33	Octagon Process Inc.	Octaflo EF	11-07-11
1-34	Octagon Process Inc.	Octaflo EG	13-06-10
1-35	*Viterbo S.A.*	*Jarkleer SAE Type I*	*07-01-20*[3]

[1] Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Québec à Chicoutimi. Web site: http://www.uqac.ca/amil/index.htm. The expiry date was determined based upon the earliest qualification date of the High Speed Aerodynamic Test or Water Spray Endurance Test.
For other specification requirements for Type I fluids, see SAE AMS 1424 (latest version). Fluids that successfully qualify after the issuance of this list will appear in a later update.

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

[3] Fluids listed in italics have expired and will be removed from this listing four years after expiry.

[4] Currently in qualification/re-qualification process.

TABLE 5 (cont.)

CURRENTLY QUALIFIED FLUIDS (2009-2010)

Table 5-2: Qualified[1] Type II Anti-icing Fluids			
#	**COMPANY NAME**	**FLUID NAME**	**EXPIRY (Y-M-D)**
2-1	ABAX Industries	Ecowing 26	09-08-21[3]
2-2	Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	11-02-19
2-3	Clariant Produkte (Deutschland) GmbH	Safewing MP II 1951	11-05-20
2-4	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP II 2025 ECO*	*08-06-28*[2]
2-5	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	10-06-16
2-6	Kilfrost Limited	ABC-3	10-06-11
2-7	Kilfrost Limited	ABC-2000	10-07-21
2-8	Kilfrost Limited	ABC-K PLUS	10-07-10
2-9	Newave Aerochemical Co. Ltd.	FCY-2	11-05-27
2-10	*Octagon Process Inc.*	*E Max II*	*08-10-31*[2]

Table 5-3: Qualified[1] Type III Anti-icing Fluids			
#	**COMPANY NAME**	**FLUID NAME**	**EXPIRY (Y-M-D)**
3-1	Clariant Produkte (Deutschland) GmbH	Clariant Safewing MP III 2031 ECO	09-05-08[3] 11-06-08[4]
	CAUTION: The lowest operational use temperature (LOUT) is -16.5°C (2°F) for aircraft with rotation speeds less than 100 knots or -29°C (-20°F) for aircraft with higher rotation speeds.		

Table 5-4: Qualified[1] Type IV Anti-icing Fluids			
#	**COMPANY NAME**	**FLUID NAME**	**EXPIRY (Y-M-D)**
4-1	ABAX Industries	AD-480	09-07-30[3]
4-2	ABAX Industries	Ecowing AD-49	10-12-12
4-3	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP IV 2001*	*08-06-26*[2]
4-4	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP IV 2012 Protect*	*07-07-12*[2]
4-5	Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	10-06-18
4-6	*Dow Chemical Company*	*UCAR™ ADF/AAF ULTRA+*	*08-08-21*[2]
4-7	Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	09-09-04[3]
4-8	Dow Chemical Company	UCAR™ FlightGuard AD-480	10-04-30
4-9	*Ely Chemical Company*	*Octagon Max-Flight*	*06-07-06*[2]
4-10	Kilfrost Limited	ABC-4^{sustain}	Y-M-D[3]
4-11	Kilfrost Limited	ABC-S	11-07-06
4-12	Kilfrost Limited	ABC-S PLUS	11-06-01
4-13	Lyondell Chemical Company	ARCTIC Shield™	10-05-21
4-14	*Octagon Process Inc.*	*Max-Flight*	*06-07-06*[2]
4-15	Octagon Process Inc.	Max-Flight 04	10-04-29
4-16	Octagon Process Inc.	MaxFlo	07-03-24[3]

[1] Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Québec à Chicoutimi. Web site: http://www.uqac.ca/amil/index.htm. The expiry date was determined based upon the earliest qualification date of the High Speed Aerodynamic Test or Water Spray Endurance Test, unless otherwise noted.
For other specification requirements for Type II, III or IV fluids, see SAE AMS 1428 (latest version). Fluids that successfully qualify 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 qualification/re-qualification process.

[4] Expiry date based upon the Low Speed Aerodynamic Test.

TABLE 6

SAE TYPE I DEICING 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 Deicing/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.

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 snow conditions, 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. 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 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 Deicing/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.
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 (Statute Miles)			
	ºC	ºF	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 30	≤3/4	>3/4 to 1½	>1½ to 3	>3
Daylight	-1 and above	30 and above	≤½	>½ to 1½	>1½ to 3	>3
	Below -1	Below 30	≤3/8	>3/8 to 7/8	>7/8 to 2	>2

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 fluid Types I, II, III, and IV.

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 ANTI-ICING FLUIDS
(See Table 9 endnotes)

Table 9-1: 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 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 2025 ECO	100/0	5 500 [b]	5 750 [g]
	75/25	10 000 [b]	10 000 [g]
	50/50	3 000 [b]	3 250 [g]
Clariant Safewing MP II Flight	100/0	3 340 [g]	3 340 [g]
	75/25	17 500 [g]	17 500 [g]
	50/50	11 500 [g]	11 500 [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]
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]
Octagon E Max II	100/0	13 520 [d]	13 520 [g]
	75/25	11 400 [g]	11 400 [g]
	50/50	2 820 [g]	2 820 [g]

Table 9-2: 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 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS

(See Table 9 endnotes)

Table 9-3: Type IV 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 Safewing MP IV 2001	100/0	18 000 [b]	18 000 [c]
	75/25	8 000 [b]	11 500 [g]
	50/50	1 200 [b]	1 750 [g]
Clariant Safewing MP IV 2012 Protect	100/0	7 800 [b]	7 250 [g]
	75/25	17 800 [b]	17 700 [c]
	50/50	4 500 [b]	4 250 [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]
Dow UCAR™ ADF/AAF ULTRA+	100/0	36 000 [f]	28 000 [c]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
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]
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]
See next page for additional Type IV fluids			

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS

(See Table 9 endnotes)

Table 9-3: Type IV Anti-Icing Fluids (cont.)			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Octagon Max-Flight	100/0	5 540 [d]	5 540 [g]
	75/25	15 000 [g]	15 000 [g]
	50/50	5 200 [g]	5 200 [g]
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]
Octagon MaxFlo	100/0	8 670 [g]	8 670 [g]
	75/25	8 200 [g]	8 200 [g]
	50/50	2 200 [g]	2 200 [g]

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 20ºC, 0.3 rpm, for 15 minutes 0 seconds.

c Brookfield Spindle LV2-disc with guard leg, 150 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.

d Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20ºC, 0.3 rpm, for 33 minutes 20 seconds.

e Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20ºC, 0.3 rpm, for 30 minutes 0 seconds.

f Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 0ºC, 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 20ºC, 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.

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.

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

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 the aerodynamic surfaces during takeoff.

3) The allowance times were developed based on this aerodynamic testing and are contained in Table 10.

4) 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 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;

   e) If the takeoff is not accomplished within the applicable allowance time in Table 10, 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 limits of the applicable allowance time in Table 10 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, under conditions of light ice pellets mixed with light freezing rain, the OAT must not decrease during the 90-minute period.

5) 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 up to 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 no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action up to 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 that no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action up to 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 2009-2010

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

FAA
HOLDOVER TIME GUIDLEINES
WINTER 2009-2010

OFFICIAL FAA HOLDOVER TIME TABLES AND ALLOWANCE TIMES

WINTER 2009-2010

The information contained in this document is the FAA official guidance, Holdover Tables, and Allowance Times for use the Winter 2009 – 2010. This is advance information that will be included in the formal FAA Winter 2009 – 2010 Update that will be published later this year.

Questions concerning FAA Aircraft Ground De/anti-icing requirements or Flight Standards policies should be addressed to jerry.c.ostronic@faa.gov or 412-886-2580 Ext 332.

Questions on the technical content of the holdover time tables should be addressed to warren.underwood@faa.gov or 404-832-4766.

Questions on grammatical corrections or web access issues should be addressed to kevin.west@faa.gov or 202-267-8002

SUMMARY OF CHANGES FROM 2008-2009

TYPE I FLUIDS **Lyondell ARCTIC Plus®** has been removed from the list of qualified Type I fluids (Table 7), at the request of Lyondell Chemical Company due to recertification concerns, and their subsequent recall of this product. Lyondell ARTIC Plus fluid is the only Lyondell fluid affected by this by this notice and the Lyondell recall. For information on the recall and replacement of Lyondell ARTIC Plus fluid contact Lyondell directly at 800-321-7000. The Type I fluid holdover time (HOT) table values are unchanged. Frost holdover times have been moved to a new frost only table, Table 0, FAA Guidelines for Active Frost Holdover Times.

TYPE II FLUIDS One new Type II fluid, **Aviation Shaanxi Hi-Tech Cleanwing II**, has been added to the list of qualified Type II fluids. The addition of this fluid did not cause any of the values to change in the Type II generic HOT table, Table 2. A brand specific table has been added for this new fluid, Table 2B. Kilfrost ABC II Plus was removed due to being out of production for four years. This action resulted in times in three cells being increased in the generic Type II holdover time table, two in freezing fog, and a cell in freezing drizzle. Frost holdover times have been moved to a new frost only table, Table 0, FAA Guidelines for Active Frost Holdover Times. The below -25°C row has been removed from all Type II holdover time tables. In its place the below -14 to -25 °C row has been modified to "below -14 to -25 or LOUT." Unless the fluid manufacturer provides the user a lower operational use temperature (LOUT), the holdover times apply down to -25 °C only.

TYPE III FLUIDS The Type III fluid HOT table values are unchanged. Frost holdover times have been moved to a new frost only table, Table 0, FAA Guidelines for Active Frost Holdover Times.

TYPE IV FLUIDS Two new Type IV fluids, **ABAX Ecowing AD-49** and **Kilfrost ABC-4^{sustain}** have been added to the list of qualified Type IV fluids. The addition of Ecowing AD-49 did not change any of the values in the generic Type IV holdover time table, Table 4; however, the addition of Kilfrost ABC-4^{sustain} caused a reduction in one cell in the generic Type IV holdover time table in freezing fog. Frost holdover times have been moved to a new frost only table, Table 0, FAA Guidelines for Active Frost Holdover Times. The below -25°C row has been removed from all Type IV holdover time tables. In its place the below -14 to -25 °C row has been modified to read "below -14 to -25 or LOUT." Unless the fluid manufacturer provides the user a lower operational use temperature (LOUT) , the holdover times apply down to -25 °C only. There is one exception; Dow Ultra+ fluid has a LOUT of -24° C.

ACTIVE FROST HOLDOVER TIMES The holdover times for active frost conditions have been moved from the individual generic and fluid brand specific holdover tables to a new active frost table, Table 0. The holdover times for Type I, and Type III fluids are identical to the values from previous years, however, research over the last decade indicated concerns about Type II, and Type IV fluid failures during active frost, especially at lower temperatures. As a result of this research, some of the times for these fluids have been reduced. Type II, III, and IV fluids have an application limit of -25 °C due to radiational cooling of aircraft surfaces to temperatures colder that the actual outside air temperature (OAT) in active frost conditions.

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HOLDOVER TIMES IN LIGHT SNOW MIXED WITH LIGHT RAIN Recent tests have shown that in conditions of light snow mixed with light rain, the light freezing rain holdover times can be used. Accordingly a note has been added to all of the applicable holdover tables indicating this use.

USE OF FAA SNOW INTENSITY TABLE In previous years the use of the FAA Snow Intensity Table was only required for Type I fluid holdover times and strongly recommended for use with Type II, III, and IV fluids as well. In the FAA Winter Notice for 2007 – 2008 the FAA proposed the required use of the FAA Snow Intensity Table for all fluid Types which was widely criticized by industry. Because of this criticism the FAA did not require the use of the FAA Snow Intensity Table for Types II, III, and IV fluids pending a more detailed review of the data supporting its use.

The FAA has collected and reviewed data for more than 7000 catch pan collection samples in comparison to both the Federal Metrological Handbook (FMH-1) visibility table currently used by weather observers and ASOS to report snowfall intensity and the FAA Snow Intensity Table. The analysis of this large amount of data clearly indicates that the FAA Snow Intensity Table is far more accurate in estimating snowfall intensity using visibility than the FMH-1 Table. Much of this improved accuracy is do to the accounting for night vs. day and temperature variations in the FAA Snow Intensity Table which is not taken into account in the FMH-1 Table.

The snow catch pans used for gathering the comparison data were placed on a 10 degree slope to account for similar slopes of many aircraft airfoil surfaces. The use of the 10 degree slope catch pans is the same method used in evaluating anti-icing fluid endurance times (as per SAE specifications) and therefore provides a direct relationship between the determination of snowfall intensity using the FAA Snow Intensity Table and the appropriate holdover time of the anti-icing fluid.

For these reasons the FAA is now requiring the use of the FAA Snow Intensity Table to determine appropriate holdover times in snowfall conditions (Table 1B, page 8 of the attached document) for all Types of anti-icing fluid (Type I, II, III, and IV). Because the FAA Snow Intensity Table, like the FMH-1 Table, uses visibility to determine snowfall intensities, if the visibility is being reduced by snow along with other forms of obscuration such as fog, haze, smoke, and etc. the FAA Snow Intensity Table need not be used to estimate the snow fall intensity for holdover time 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 ASOS, the FMH-1 Table may be used.

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	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 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is not exceeded.

CAUTIONS

Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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FAA TYPE I HOLDOVER TIME GUIDELINES

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I 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		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
			Very Light◆◆	Light ◆◆	Moderate◆◆				
-3 and above	27 and above	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	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	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	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, snow pellets, ice pellets, moderate and heavy freezing rain, hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

◆◆ TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M^2 (≈ 2 GALS/100FT^2) MUST BE APPLIED TO DEICED SURFACES
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.

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

Concentrations in % volume

<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.</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 snow conditions, 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. 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 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 1B. SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY

Time of Day	Temp.		Visibility (Statute Mile)							Snowfall Intensity
	Degrees Celsius	Degrees Fahrenheit	≥ 2 1/2	2	1 1/2	1	3/4	1/2	≤ 1/4	
Day	colder/equal -1	colder/equal 30	Very Light	Very Light	Light	Light	Moderate	Moderate	**Heavy**	
	warmer than -1	warmer than 30	Very Light	Light	Light	Moderate	Moderate	**Heavy**	**Heavy**	
Night	colder/equal -1	colder/equal 30	Very Light	Light	Moderate	Moderate	**Heavy**	**Heavy**	**Heavy**	
	warmer than -1	warmer than 30	Very Light	Light	Moderate	**Heavy**	**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.

HEAVY = Caution—No Holdover Time Guidelines Exist

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FAA TYPE II HOLDOVER TIME GUIDELINES

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	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	0:05-0:40	
		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	0:05-0:15	0:05-0:10		
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	CAUTION: No holdover time guidelines exist	
		75/25	0:25-0:50	0:10-0:20	***0:15-0:30	***0: 05-0: 15		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:15-0:35	0:15-0:30				

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

* 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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 2A. FAA GUIDELINES FOR HOLDOVER TIMES ABAX ECOWING 26 TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/ Snow Grains	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	0:05-0:10	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 to LOUT	below 7 to -13 to LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 2B. FAA GUIDELINES FOR HOLDOVER TIMES AVIATION SHAANXI HI-TECH 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	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	0:05-0:50	
		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	***0:20-0:25		
		75/25	0:40-1:45	0:25-0:45	***0:35-0:40	***0:20-0:25		
below -14 to -25 or LOUT	below 7 to -13 to LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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 SHANNXI HI-TECH TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT

August 2009

TABLE 2C. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP II 2025 ECO 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:30-2:05	0:40-1:10	0:40-1:00	0:25-0:35	0:10-1:15	
		75/25	0:55-1:45	0:25-0:45	0:25-0:45	0:20-0:25	0:05-0:50	
		50/50	0:20-0:35	0:05-0:15	0:10-0:15	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-1:50	0:35-1:00	***0:35-1:05	***0:20-0:35		
		75/25	0:40-1:20	0:25-0:45	***0:30-0:40	***0:15-0:25		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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 II 2025 ECO TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 2D. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP II FLIGHT TYPE II FLUID MIXTURESAS 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	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	
		75/25	2:30-4:00	0:40-1:20	1:15-2:00	0:30-0:55	0:05-1:20	
		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	***0:25-0:45		
		75/25	0:40-1:10	0:20-0:40	***0:25-1:10	***0:30-0:40		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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 II FLIGHT TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

August 2009

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	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	
		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	0:05-0:15	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	***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 -25 or LOUT	Below 7 to -13 or 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 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.

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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	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	0:05-0:15	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	***0:05-0:30		
below	below 7 to -13	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 2G. 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	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	0:05-0:45	
		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	0:05-0:10	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	***0:15-0:20		
		75/25	0:30-1:05	0:10-0:20	***0:15-0:30	***0:05-0:15		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 2H. FAA GUIDELINES FOR HOLDOVER TIMES OCTAGON E-MAX 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	2:05-3:45	0:40-1:20	0:45-1:35	0:30-0:40	0:15-1:30	
		75/25	1:25-2:50	0:25-0:55	0:40-1:10	0:20-0:30	0:10-1:05	
		50/50	0:30-0:55	0:10-0:25	0:15-0:30	0:10-0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-1:45	0:35-1:10	***0:35-1:00	***0:20-0:30		
		75/25	0:30-1:20	0:25-0:50	***0:35-1:05	***0:15-0:30		
below -14 TO -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20-0:35	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)
‡ Snow pellets, ice pellets, heavy snow, 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.
- OCTAGON E-MAX TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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FAA TYPE III HOLDOVER TIME GUIDELINE

TABLE 3. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE III FLUID MIXTURE AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE.

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	**Degrees Fahrenheit**	**Type III Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Freezing Fog**	**Snow/Snow Grains**			**Freezing Drizzle***	**Light Freezing Rain†**	**Rain on Cold Soaked Wing****	**Other‡**
				Very Light	**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		
		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	CAUTION: No holdover time guidelines exist			

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.

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

‡ Snow pellets, ice pellets, heavy snow, 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.

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FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
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)
‡ Snow pellets, ice pellets, heavy snow, 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 IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4A. FAA GUIDELINES FOR HOLDOVER TIMES ABAX AD-480 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/ Snow Grains	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	0:10-0:20	0:15-0:25	0:05-0:15	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 -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 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4B. FAA GUIDELINES FOR HOLDOVER TIMES ABAX ECOWING AD-49 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/ Snow Grains	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	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	***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 -25 or LOUT	below 7 to -13 or LOUT	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 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4C. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV 2001 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:20-3:20	1:00-1:55	0:55-1:55	0:40-1:00	0:15-2:00	
		75/25	1:20-2:00	0:35-1:00	0:35-1:10	0:25-0:35	0:10-1:25	
		50/50	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-1:35	0:30-0:50	***0:55-1:35	***0:30-0:45		
		75/25	0:30-1:00	0:20-0:35	***0:40-1:10	***0:20-0:30		
below -14 to -25 or LOUT	Below 7 to -13 or 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 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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 2001 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4D. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV 2012 PROTECT 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:40-1:15	0:40-1:10	0:25-0:45	0:10-1:05	
		75/25	1:10-2:05	0:25-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-1:45	0:20-0:40	***0:25-0:45	***0:15-0:25		
		75/25	0:25-1:05	0:20-0:40	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or 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 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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 2012 PROTECT TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4E. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV LAUNCH 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	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	
		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	CAUTION: No holdover time guidelines exist	
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 -25 or LOUT	below 7 to -13 or LOUT	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 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4F. FAA GUIDELINES FOR HOLDOVER TIMES DOW UCAR™ ULTRA+ ADF/AAF 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.

<table>
<tr><th colspan="2">Outside Air Temperature</th><th rowspan="2">Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)</th><th colspan="6">Approximate Holdover Times Under Various Weather Conditions (hours: minutes)</th></tr>
<tr><th>Degrees Celsius</th><th>Degrees Fahrenheit</th><th>Freezing Fog</th><th>Snow/ Snow Grains</th><th>Freezing Drizzle*</th><th>Light Freezing Rain†</th><th>Rain on Cold Soaked Wing**</th><th>Other‡</th></tr>
<tr><td rowspan="3">-3 and above</td><td rowspan="3">27 and above</td><td>100/0</td><td>1:35-3:35</td><td>0:35-1:15</td><td>0:45-1:35</td><td>0:25-0:40</td><td>0:10-1:20</td><td></td></tr>
<tr><td>75/25</td><td></td><td></td><td></td><td></td><td rowspan="3">CAUTION:
No holdover time guidelines exist</td><td rowspan="3"></td></tr>
<tr><td>50/50</td><td></td><td></td><td></td><td></td></tr>
<tr><td>below -3 to -14</td><td>below 27 to 7</td><td>100/0</td><td>1:25-3:00</td><td>0:25-0:55</td><td>***0:45-1:25</td><td>***0:30-0:45</td></tr>
<tr><td></td><td></td><td>75/25</td><td></td><td></td><td></td><td></td></tr>
<tr><td>below -14 to -24 or LOUT</td><td>below 7 to -12 or LOUT</td><td>100/0</td><td>0:40-2:10</td><td>0:20-0:45</td><td colspan="4"></td></tr>
</table>

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)
‡ Snow pellets, ice pellets, heavy snow, 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 ULTRA+ TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4G. FAA GUIDELINES FOR HOLDOVER TIMES 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.

<table>
<tr><th colspan="2">Outside Air Temperature</th><th rowspan="2">Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)</th><th colspan="6">Approximate Holdover Times Under Various Weather Conditions (hours: minutes)</th></tr>
<tr><th>Degrees Celsius</th><th>Degrees Fahrenheit</th><th>Freezing Fog</th><th>Snow/ Snow Grains</th><th>Freezing Drizzle*</th><th>Light Freezing Rain†</th><th>Rain on Cold Soaked Wing**</th><th>Other‡</th></tr>
<tr><td rowspan="3">-3 and above</td><td rowspan="3">27 and above</td><td>100/0</td><td>2:05-3:10</td><td>0:40-1:20</td><td>1:10-2:00</td><td>0:50-1:15</td><td>0:20-2:00</td><td></td></tr>
<tr><td>75/25</td><td></td><td></td><td></td><td></td><td rowspan="3">CAUTION:
No holdover time guidelines exist</td><td></td></tr>
<tr><td>50/50</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>below -3 to -14</td><td>below 27 to 7</td><td>100/0</td><td>1:50-3:20</td><td>0:30-1:05</td><td>***0:55-1:50</td><td>***0:45-1:10</td><td></td></tr>
<tr><td></td><td></td><td>75/25</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>below -14 to -25 or LOUT</td><td>below 7 to -13 or LOUT</td><td>100/0</td><td>0:30-1:05</td><td>0:15-0:30</td><td colspan="4"></td></tr>
</table>

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)
‡ Snow pellets, ice pellets, heavy snow, 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 EG 106 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4H. FAA GUIDELINES FOR HOLDOVER TIMES DOW 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	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	0:10-0:20	0:15-0:25	0:05-0:15	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 -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 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4I. 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	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	
		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	0:05-0:15	0:15-0:20	0:05-0:10	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	***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 -25 or LOUT	below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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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	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	0:05-0:15	0:10-0:20	0:05-0:10	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 -25 or LOUT	below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4K. 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	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 -25 or LOUT	below 7 to -13 or LOUT	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)
‡ Snow pellets, ice pellets, heavy snow, 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.

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TABLE 4L. 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	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	0:05-1:20	
		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 -25 or LOUT	below 7 to -13 or LOUT	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 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.
- LYONDELL ARCTIC SHIELD TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4M. FAA GUIDELINES FOR HOLDOVER TIMES OCTAGON MAX-FLIGHT 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	2:40-4:00	0:50-1:35	0:55-2:00	0:35-1:00	0:15-1:15	
		75/25	2:05-3:15	0:45-1:45	1:15-2:00	0:35-1:10	0:10-0:40	
		50/50	0:55-1:45	0:25-1:15	0:35-1:00	0:15-0:30	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-2:30	0:25-0:50	***0:25-1:10	***0:20-0:40		
		75/25	0:30-1:05	0:20-0:50	***0:20-1:00	***0:15-0:30		
below -14 to -25 or LOUT	below 7 to -13 or 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 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.
- OCTAGON MAX-FLIGHT TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4N. FAA GUIDELINES FOR HOLDOVER TIMES 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	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	0:40-1:20	***0:20-1:00	***0:15-0:30		
below -14 to -25 or LOUT	below 7 to -13 or 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 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Snow pellets, ice pellets, heavy snow, 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.
- OCTAGON MAX-FLIGHT 04 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 4O. FAA GUIDELINES FOR HOLDOVER TIMES OCTAGON MAXFLO 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	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	2:20-3:35	0:40-1:30	1:20-2:00	0:30-1:00	0:10-2:00	
		75/25	1:25-2:00	0:20-0:55	0:40-1:05	0:20-0:35	0:05-1:15	
		50/50	0:20-0:40	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:10-2:20	0:25-1:00	***0:35-1:45	***0:30-0:50		
		75/25	0:40-1:25	0:15-0:40	***0:35-1:15	***0:15-0:30		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30-1:00	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)
‡ Snow pellets, ice pellets, heavy snow, 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.
- OCTAGON MAXFLO TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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TABLE 5. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE II, TYPE III, AND TYPE IV FLUID MIXTURES MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

Concentrations in % Volume

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing[1, 2]
-3 °C (27 °F) and above	50/50 Heated[3] Types II, III or IV	Heated water or a heated mix of Type I, II, III	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	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.

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 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.**

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TABLE 6

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS
(See Page 37 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 (SPCA) 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
	50/50	10,150 [c]	10,200 [g]
Clariant Safewing MP II 2025 ECO	100/0	5,500 [b]	5,750 [g]
	75/25	10,000 [b]	10,000 [g]
	50/50	3,000 [b]	3,250 [g]
Clariant Safewing MP II Flight	100/0	3,340 [g]	3,340 [g]
	75/25	17,500 [g]	17,500 [g]
	50/50	11,500 [g]	11,500 [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]
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]
Octagon E Max II	100/0	13,520 [d]	13,520 [g]
	75/25	11,400 [g]	11,400 [g]
	50/50	2,820 [g]	2,820 [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 (SPCA) 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 Safewing MP IV 2001	100/0	18,000 [b]	18,000 [c]
	75/25	8,000 [b]	11,500 [g]
	50/50	1,200 [b]	1,750 [g]
Clariant Safewing MP IV 2012 Protect	100/0	7,800 [b]	7,250 [g]
	75/25	17,800 [b]	17,700 [c]
	50/50	4,500 [b]	4,250 [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]
Dow UCAR ADF/AAF ULTRA+	100/0	36,000 [f]	28,000 [c]
	75/25	Dilution Not Applicable	Dilution Not
	50/50	Dilution Not Applicable	Dilution Not
Dow UCAR Endurance EG106	100/0	24,850 [f]	2,230 [g]
	75/25	Dilution Not Applicable	Dilution Not
	50/50	Dilution Not Applicable	Dilution Not
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]
*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]	4,700 [c]
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]

* Qualification pending completion of certain AMS1428 testing requirements.

Table 6.3 Type IV Anti-Icing Fluids (Continued)			
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]
Octagon Max-Flight	100/0	5,540 [d]	5,540 [g]
	75/25	15,000 [g]	15,000 [g]
	50/50	5,200 [g]	5,200 [g]
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]
Octagon MaxFlo	100/0	8,670 [g]	8,670 [g]
	75/25	8,200 [g]	8,200 [g]
	50/50	2,200 [g]	2,200 [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.

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.

TABLE 7. LIST OF QUALIFIED (1) DEICING/ANTI-ICING FLUIDS-WINTER 2009-2010
Qualified Type I Deicing/Anti-Icing Fluids

Company Name	Fluid Name
ABAX Industries (formerly SPCA)	ABAX DE-950
ABAX Industries (formerly SPCA)	ABAX DE-950 Colorless
Arkton Ltd.	Artica DG Ready to Use
Aviation Xi'an High-Tech	KHF-1
Battelle	D^3: Degradable by Design Deicer™ ADF 1006A
Beijing Wangye Aviation Chem. Prod. Co.	KLA-1
Beijing Wangye Aviation Chem. Prod. Co	YJF-1
Chemical Specialists and Development	Prist Wing Deicer
Clariant GmbH	Safewing MPI 1938 TF
Clariant GmbH	Safewing MPI 1938 TF Pre-mix 60%
Clariant GmbH	Safewing MP I 1938 ECO (80)
Clariant GmbH	Safewing MP I 1938 ECO (80) Pre-mix 55%
Clariant GmbH	Safewing MP I 1938 ECO
Clariant GmbH	Safewing EG I 1996
Clariant GmbH	Safewing EG I 1996 (88)
Clariant GmbH	Safewing MP I ECO PLUS (80)
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
HOC Industries	SafeTemp I ES
HOC Industries	SafeTemp I ES Plus
Inland Technologies	Duragly - P ready to use
Inland Technologies	Duragly - E ready to use
Kilfrost	Kilfrost DF PLUS
Kilfrost	Kilfrost DF PLUS (80)
Kilfrost	Kilfrost DF PLUS (88)®
Kilfrost	Kilfrost DF^{SUSTAIN} ™
Lyondell Chemical Company	ARCOPlus®
Newave Aerochemical Company	FCY-1A
Octagon Process	EcoFlo
Octagon Process	Octaflo EF
Octagon Process	Octaflo EG
Viterbo S.A.	Jarkleer SAE Type I

TABLE 7. LIST OF QUALIFIED [1] DEICING/ANTI-ICING FLUIDS-WINTER 2009-2010

Qualified Type II Deicing/Anti-Icing Fluids

Company Name	Fluid Name
ABAX Industries	ABAX Ecowing 26
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II
Clariant GmbH	Safewing MP II 1951
Clariant GmbH	Safewing MP II 2025 ECO
Clariant GmbH	Safewing MP II Flight
Kilfrost	Kilfrost ABC-3
Kilfrost	Kilfrost ABC-2000
Kilfrost	Kilfrost ABC-K PLUS
Newave Aerochemical Technology	FCY-2
Octagon Process	E-Max

Qualified Type III Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant GmbH	Safewing MP III 2031 ECO

Qualified Type IV Deicing/Anti-Icing Fluids

Company Name	Fluid Name
ABAX Industries	ABAX AD-480
ABAX Industries	ABAX Ecowing AD-49
Clariant GmbH	Safewing MP IV 2001
Clariant GmbH	Safewing MP IV 2012 Protect
Clariant GmbH	Safewing MP IV Launch
Dow Chemical Company	UCAR™ ADF/AAF ULTRA+
Dow Chemical Company	UCAR™ Endurance EG106
Dow Chemical Company	UCAR™ FlightGuard AD-480
Kilfrost	[2]Kilfrost ABC-4 SUSTAIN
Kilfrost	Kilfrost ABC-S
Kilfrost	Kilfrost ABC-S Plus
Lyondell Chemical Company	ARCTIC Shield™
Octagon Process	Max-Flight
Octagon Process	Max-Flight 04
Octagon Process	MaxFlo

[1] Qualified indicates that the fluid has been qualified solely to the requirements of the applicable SAE anti-icing and aerodynamic performance specifications in effect at the time of certification, as conducted by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, Web site: http://www.uqac.ca/amil/index.htm. For other specification requirements for Type I fluids, see SAE AMS 1424 (latest version) and for SAE Types II, III, and IV fluids, see SAE AMS 1428 (latest version).

[2] Qualification pending completion of certain tests described in SAE AMS 1428.

ICE PELLET ALLOWANCE TIMES
2009-2010

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 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 the winter season of 2008-2009 which further expanded the ice pellet allowance times under specified conditions. Guidance is 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.

Operations in Light and Moderate Ice Pellets and Light Ice Pellets mixed with other forms of precipitation.

(1) 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.

(2) 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. 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-1. 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, and the OAT has remained constant or increased from the temperature on which the allowance time was based, 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.

Examples: a) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0^0C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that the OAT remains constant or increases and that no precipitation restarts after the allowance time of 10:50 the aircraft may takeoff without any further action up to 11:30.

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b) 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 10:15 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.

c) 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.

(3) 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:

(a) 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.

(b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid.

(c) 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.

(d) 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 provided the temperature on which the allowance time was based remains constant or increases.

(e) 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.

(f) 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.

(g) If the temperature decreases below the temperature on which the allowance time was based,

1. 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.

2. 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 1

ICE PELLET ALLOWANCE TIMES

2009 - 2010

	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
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
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		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		