

# Aircraft Ground Icing General Research Activities During the 2005-06 Winter



*Prepared for*  
**Transportation Development Centre**

*In cooperation with*

Civil Aviation  
Transport Canada

and

The Federal Aviation Administration  
William J. Hughes Technical Center

Prepared by



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# Aircraft Ground Icing General Research Activities During the 2005-06 Winter



*by*

**APS Aviation Inc.**



**October 2006  
Final Version 1.0**

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

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

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## 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 develop holdover time data for all newly-qualified de/anti-icing fluids;
- To evaluate whether holdover times should be developed for ice pellet conditions;
- To examine the effect of heated fluids on Type II, III, and IV fluid endurance times;
- To evaluate if it is appropriate to apply fluid with a -3°C buffer (fluid with a freeze point 3°C above the ambient temperature) for the 1<sup>st</sup> step of a two-step application;
- To evaluate weather data from previous winters to establish a range of conditions suitable for the evaluation of holdover time limits;
- To assist in the testing of flow of contaminated fluid from aircraft wings during takeoff;
- To validate the laboratory snow test protocol with Type II and IV fluids;
- To develop performance specifications for an integrated weather system that measures holdover time;
- To provide support for the development of a standard that evaluates remote on-ground ice detection systems;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests on non-aluminum plates; and
- To conduct endurance time tests in frost on various test surfaces.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2005-06 are documented in nine reports. The titles of the reports are as follows:

- TP 14712E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2005-06 Winter;
- TP 14713E Aircraft Deicing Research in Natural and Simulated Ice Pellet Conditions;
- TP 14714E Evaluation of Fluid Freeze Points in First-Step Application of Type I Fluids;
- TP 14715E Winter Weather Impact on Holdover Time Table Format (1995-2006);
- TP 14716E Falcon 20 Trials to Examine Fluid Removed from Aircraft During Takeoff with Ice Pellets;
- TP 14717E Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2005-06;
- TP 14718E Preliminary Endurance Time Testing in Simulated Ice Pellet Conditions;
- TP 14719E Aircraft Ground Icing General Research Activities During the 2005-06 Winter; and
- TP 14720E Effect of Heat on Fluid Endurance Times Using Composite Surfaces.

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

- *Implementation of Holdover Time Determination Systems;*
- *Effect of Heat on Endurance Times of Anti-Icing Fluids; and*
- *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions.*

This report, TP 14719E, has the following objective:

- To document the exploratory research and general activities carried out for the Transportation Development Centre during the winter of 2005-06.

## **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: George Balaban, Katrina Bell, Kim Bendickson, Stephanie Bendickson, Nicolas Blais, Michael Chaput, Sami Chebil, John D'Avirro, Jan Gorackowski, Chris McCormack, Rob Petermann, Marco Ruggi, Joey Tiano, Larry Turner, and David Youssef.

Special thanks are extended to Barry Myers, Frank Eyre, and Yagusha Bodnar, who on behalf of the Transportation Development Centre, have participated, contributed and provided guidance in the preparation of these documents.

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15. Supplementary Notes (Funding programs, titles of related publications, etc.) Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada (TC). These are available from the Transportation Development Centre (TDC). Nine reports (including this one) 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 exploratory research and general activities completed by APS Aviation Inc. (APS) related to aircraft ground deicing research in the winter of 2005-06. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2005-06, which are documented in separate reports. The seven activities included in this report are described below.  <ol style="list-style-type: none"> <li>1) Methodology to Re-Categorize Fluid Holdover Time Tables: A study was conducted to ascertain whether the number of holdover time (HOT) guideline tables could be reduced by producing a set of generic tables for Type II/IV fluids that would not change from year to year. Keeping the existing system was recommended. An alternate approach was also provided.</li> <li>2) Validity of 75/25 Endurance Time Test Protocol: Research was conducted to assess the accuracy of the current protocol for endurance time testing of fluid dilutions. Differences in viscosity were observed when fluids were put through simulated operational and endurance time testing processes. It was recommended that the lowest on-wing viscosity (LOWV) for dilutions be added to the HOT Guidelines.</li> <li>3) Endurance Times on Plates with Residual Ice: Previous testing has shown that in certain conditions, deicing technicians may not detect residual ice under fluid. Preliminary tests were conducted, and they suggest that endurance times of anti-icing fluids are reduced by the presence of residual ice.</li> <li>4) Tactile Inspection of Ice with the Use of Gloves: APS conducted tests to ascertain if the type of glove worn during post-deicing tactile checks impacts the ability to detect ice. Candidates were able to detect ice using all five gloves tested.</li> <li>5) Support for the Development of SAE AS5681: APS is supporting the development of Aerospace Standard (AS) 5681 by providing expert opinion and clerical support for the development of the standard on remote on-ground ice detection systems (ROGIDS).</li> <li>6) Holdover Time Guidelines Website: APS developed and implemented a website for the official Transport Canada (TC) 2006-07 HOT Guidelines.</li> <li>7) Test Procedures, Presentations, and Fluid Manufacturer Reports: An account of the test procedures, presentations, and fluid manufacturer reports that were produced for the 2005-06 test program is included in this report.</li> </ol>						
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15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.) Plusieurs rapports de recherche ont été produits au nom de Transports Canada (TC) sur les essais réalisés au cours des hivers antérieurs. Ceux-ci sont disponibles auprès du Centre de développement des transports (CDT). Neuf rapports (dont celui-ci) ont été produits dans le cadre du programme de recherche de cet hiver. On trouvera dans la préface l'objet de ces rapports. Les travaux décrits dans ce rapport ont été en partie coparrainés par la Federal Aviation Administration (FAA).				
16. Résumé Ce rapport fait état de la recherche exploratoire et 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 2005-2006. Les activités dont fait état ce rapport ont été effectuées en plus des projets de recherche principale menés pendant l'hiver 2005-2006, qui sont documentés dans des rapports distincts. Les sept activités qui font l'objet du présent rapport sont énumérées ci-dessous.  <ol style="list-style-type: none"> <li>1) Méthodologie pour classer à nouveau les tableaux de durées d'efficacité des liquides : Une étude a été menée pour déterminer si le nombre de tableaux de lignes directrices sur les durées d'efficacité pouvait être réduit en produisant un ensemble de tableaux génériques pour les liquides de type II et de type IV qui ne changeraient pas d'année en année. Il a été recommandé de conserver le système existant. Une autre approche a également été proposée.</li> <li>2) Validité du protocole d'essai sur les durées d'endurance à une dilution de 75/25 : Des recherches ont été menées pour évaluer la précision du protocole actuel pour les essais de durées d'endurance des dilutions de liquides. Des différences de viscosité ont été observées lorsque les liquides ont été soumis à des processus simulés d'essais opérationnels et de durées d'endurance. Il a été recommandé d'ajouter aux lignes directrices sur les durées d'efficacité les valeurs de viscosité les plus basses sur l'aile (LOWV) aux fins de dilution.</li> <li>3) Durées d'endurance sur plaques avec glace résiduelle : Des essais antérieurs ont révélé que dans certaines conditions, les techniciens en dégivrage pouvaient ne pas détecter la glace résiduelle présente sous le liquide. Des essais préliminaires ayant été menés suggèrent que les durées d'endurance des liquides antigivrants sont réduites par la présence de glace résiduelle.</li> <li>4) Inspection tactile de la glace à l'aide de gants : APS a mené des essais pour vérifier si le type de gant porté pendant les vérifications tactiles effectuées après le dégivrage influait sur la capacité de détecter la glace. Les candidats ont pu détecter la glace à l'aide des cinq gants mis à l'essai.</li> <li>5) Contribution à l'élaboration de la norme AS5681 de la SAE : APS contribue à l'élaboration de la norme aérospatiale (AS) 5681 en fournissant des avis d'experts et un soutien administratif pour la mise au point de la norme sur les systèmes de détection de glace au sol à distance (ROGIDS).</li> <li>6) Site Web des lignes directrices sur les durées d'efficacité : APS a conçu et mis en place un site Web présentant les lignes directrices officielles de Transports Canada (TC) sur les durées d'efficacité pour 2006-2007.</li> <li>7) Procédures d'essais, présentations et rapports des fabricants de fluides : Un certain nombre de procédures d'essais, de présentations et de rapports des fabricants de fluides ont été produits dans le cadre du programme d'activités de 2005-2006. Ceux-ci sont inclus dans le présent rapport.</li> </ol>				
17. Mots clés <b>Dégivrage, SAE, normes, durée d'efficacité, durées d'endurance, protocole d'essai, glace résiduelle, ROGIDS, gants</b>		18. Diffusion <b>Le Centre de développement des transports dispose d'un nombre limité d'exemplaires</b>		
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## EXECUTIVE SUMMARY

This report documents the exploratory research and general activities related to aircraft ground deicing research completed by APS Aviation Inc. (APS) in the winter of 2005-06 on behalf of the Transportation Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA). The seven activities documented in this report are described below and were carried out in addition to the main research projects completed in the winter of 2005-06, which are documented in separate reports.

### Methodology to Re-Categorize Fluid Holdover Time Tables (Section 2)

APS conducted an analysis of the existing Type II and Type IV fluid-specific holdover time (HOT) tables to group the fluids into several generic tables so that the fluid-specific tables could be eliminated. This would reduce the number of HOT tables published each year and address concerns in the industry that too many HOT tables exist.

The fluids were grouped based on their performance in the most used cells in the HOT tables. The advantages and disadvantages of implementing the proposed set of generic HOT tables were examined. It was recommended that the fluid-specific tables should continue to exist, as the amount of holdover time forfeited by implementing the new generic tables was deemed excessive and the changes would be difficult to implement at this stage of development.

### Validity of 75/25 Endurance Time Test Protocol (Section 3)

Concerns have arisen that the protocol used to measure endurance times of diluted anti-icing fluids may not produce values consistent with those experienced during actual operations. Research was conducted to assess the accuracy of the current protocol for fluid dilutions.

A significant difference was seen in the final viscosity of fluid that was diluted before it was sheared (operational process) and fluid diluted after it was sheared (testing process). This may have important implications, as endurance times of fluid used in operations may be shorter than the endurance times given in the HOT Guidelines. It is recommended that lowest on-wing viscosity (LOWV) values be provided for dilutions in the HOT Guidelines. It is suggested that when submitting fluid samples for holdover time testing in the future, manufacturers shear samples after they have been diluted.

#### **Endurance Times on Plates with Residual Ice (Section 4)**

Previous research has shown that, in certain conditions, deicing technicians cannot detect residual ice under fluid during post-deicing inspections. APS conducted preliminary testing to investigate how the presence of residual ice affects endurance times of anti-icing fluids. The preliminary tests suggest that endurance times of fluids are reduced by the presence of residual ice. It was recommended that more data be generated to solidify the analysis.

#### **Tactile Inspection of Ice with the Use of Gloves (Section 5)**

Testing in 2004-05 evaluated human tactile ability to detect ice on wings. It was found that test subjects could detect ice of any thickness on unpainted aluminum plates. One type of glove was used during these tests. It was later theorized that the type of glove worn by the test subjects may alter the results.

In 2005-06, tests were conducted with candidates using five types of gloves. In a very limited number of tests, all the candidates were able to detect ice regardless of the type of glove they wore. While the results showed that ice can be detected with gloves, it was concluded that the test methodology should be examined if future tests are required.

#### **Support for Development of SAE AS5681 (Section 6)**

The proposed Society of Automotive Engineers (SAE) Aerospace Standard (AS) 5681 specifies the minimum performance requirements of remote on-ground ice detection systems (ROGIDS). APS has supported the development of AS5681 by providing expert opinion and clerical support.

#### **Holdover Time Guidelines Website (Section 7)**

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. APS updated this website in July 2006 with the 2006-07 HOT Guidelines.

#### **Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 8)**

A number of test procedures, presentations, and fluid manufacturer reports were produced by APS for the 2005-06 test program. An account of these activities is included in this report.

## SOMMAIRE

Ce rapport fait état de la recherche exploratoire et 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 2005-2006, pour le compte du Centre de développement des transports (CDT) de Transports Canada (TC) et de la Federal Aviation Administration (FAA). Les sept activités dont fait état ce rapport sont décrites ci-dessous et ont été effectuées en plus des projets de recherche principale menés pendant l'hiver 2005-2006, qui sont documentés dans des rapports distincts.

### **Méthodologie pour classer à nouveau les tableaux de durées d'efficacité des liquides (Section 2)**

APS a effectué une analyse des tableaux existants de durées d'efficacité spécifiques aux liquides de type II et de type IV afin de regrouper les liquides en plusieurs tableaux génériques et d'éliminer les tableaux spécifiques aux liquides. Cela permettrait de réduire le nombre de tableaux de durées d'efficacité publiés chaque année et de répondre aux préoccupations du secteur concernant l'existence d'un trop grand nombre de tableaux de durées d'efficacité.

Les liquides ont été regroupés en fonction de leur rendement dans les cellules les plus utilisées des tableaux de durées d'endurance. Les avantages et les inconvénients de la mise en œuvre de l'ensemble proposé de tableaux génériques de durées d'endurance ont été examinés. Il a été recommandé que les tableaux spécifiques aux liquides continuent d'exister, car la quantité de durées d'efficacité perdues par la mise en œuvre des nouveaux tableaux génériques a été jugée excessive, et les changements seraient difficiles à appliquer à ce stade de développement.

### **Validité du protocole d'essai sur les durées d'endurance à une dilution de 75/25 (Section 3)**

Des préoccupations ont été soulevées quant au fait que le protocole utilisé pour mesurer les durées d'endurance des liquides antigivrants dilués peut ne pas produire de valeurs conformes à celles obtenues lors des opérations réelles. Des recherches ont été menées pour évaluer la précision du protocole actuel pour les essais de durées d'endurance des dilutions de liquides.

Une différence significative a été observée dans la viscosité finale du liquide dilué avant qu'il ne soit cisailé (processus opérationnel) et celle du liquide dilué après son cisaillement (processus d'essai). Cette observation peut avoir des conséquences importantes, car les durées d'endurance du liquide utilisé dans les opérations peuvent être plus courtes que celles figurant dans les lignes directrices. Il est recommandé d'indiquer dans le document directeur les valeurs de viscosité les plus basses sur l'aile (LOWV) aux fins de dilutions. Dans l'avenir, lors de la soumission d'échantillons de liquides à des essais de durées d'efficacité, il est suggéré aux fabricants de cisailier les échantillons après leur dilution.

#### **Durées d'endurance sur plaques avec glace résiduelle (Section 4)**

Des recherches antérieures ont montré que, dans certaines conditions, les techniciens en dégivrage pouvaient ne pas détecter la glace résiduelle présente sous le liquide lors d'inspections menées après le dégivrage. APS a mené des essais préliminaires pour étudier la façon dont la présence de glace résiduelle influe sur les durées d'endurance des liquides antigivrants. Les essais préliminaires suggèrent que les durées d'endurance des liquides sont réduites par la présence de glace résiduelle. Il a été recommandé que davantage de données soient recueillies pour solidifier l'analyse.

#### **Inspection tactile de la glace à l'aide de gants (Section 5)**

Des essais menés en 2004-2005 ont évalué la capacité tactile des humains à détecter la glace sur les ailes. On a constaté que les participants aux essais pouvaient détecter la glace de toute épaisseur sur des plaques d'aluminium non peintes. Un seul type de gants a été utilisé au cours de ces essais. Par la suite, on a formulé l'hypothèse selon laquelle le type de gants porté par les participants pouvait modifier les résultats.

En 2005-2006, des essais ont été effectués auprès de candidats utilisant cinq types de gants. Dans un nombre très limité de tests, tous les candidats ont pu détecter la glace, quel que soit le type de gants qu'ils portaient. Bien que les résultats aient montré que la glace pouvait être détectée avec des gants, on a conclu que la méthode d'essai devrait être examinée si de futurs essais s'avéraient nécessaires.

#### **Contribution à l'élaboration de la norme AS5681 de la SAE (Section 6)**

La norme aérospatiale (AS) 5681 proposée par la Society of Automotive Engineers (SAE) précise les exigences minimales de rendement des systèmes de détection de glace au sol à distance (ROGIDS). APS a contribué à l'élaboration de la norme AS5681 en fournissant des avis d'experts et un soutien administratif.

#### **Site Web des lignes directrices sur les durées d'efficacité (Section 7)**

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. En juillet 2006, APS a mis à jour ce site Web avec les lignes directrices sur les durées d'efficacité de 2006-2007.

#### **Procédures d'essais, présentations et rapports des fabricants de fluides (Section 8)**

APS a produit un certain nombre de procédures d'essais, de présentations et de rapports aux fabricants de fluides pour le programme d'essais de l'hiver 2005-2006. Le présent rapport contient une description de ces activités.

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## **GLOSSARY**

AMS	Aerospace Material Specification
APS	APS Aviation Inc.
AS	Aerospace Standard
CBAAC	Commercial and Business Aviation Advisory Circular
EG	Ethylene Glycol
FAA	Federal Aviation Administration
HOT	Holdover Time
LOWV	Lowest On-Wing Viscosity
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
OAT	Outside Air Temperature
PG	Propylene Glycol
ROGIDS	Remote On-Ground Ice Detection Systems
SAE	Society of Automotive Engineers
TC	Transport Canada
TCCA	Transport Canada Civil Aviation
TDC	Transport Development Centre
WSET	Water Spray Endurance Test
YUL	Montréal–Pierre Elliott Trudeau International Airport

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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.

The research program consisted of a number of major research projects and several exploratory research and general activities. Each of the major research projects is documented in a separate individual report. The exploratory research and general activities are documented in this report.

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

### 1.1 Exploratory Research

#### 1.1.1 Methodology to Re-Categorize Fluid Holdover Time Tables

Significant resources are required to produce fluid-specific holdover time (HOT) Guidelines for new fluids and modify the generic HOT Guidelines each year. As the guidelines increase in size and complexity, they also become more difficult to use.

APS examined the feasibility of reducing the number of HOT tables and limiting the changes that are made to them annually. This analysis is included in Section 2.

### **1.1.2 Validity of 75/25 Endurance Time Test Protocol**

Concerns have arisen that the protocol used to measure endurance times of diluted anti-icing fluids may not produce values consistent with those experienced during actual operations. These concerns have brought into question the validity of the current test protocol for diluted fluids and the accuracy of the diluted fluid values in the HOT Guidelines. Tests were conducted to explore this possibility. This topic is discussed in Section 3.

### **1.1.3 Endurance Times on Plates with Residual Ice**

Previous research has shown that, in certain conditions, deicing technicians cannot detect residual ice under fluid during post-deicing inspections. APS conducted preliminary tests on plates with residual ice to ascertain if the presence of residual ice affects endurance times. This topic is discussed in Section 4.

### **1.1.4 Tactile Inspection of Ice with the Use of Gloves**

In 2004-05, testing was performed to evaluate human visual and tactile ability to detect ice. It was determined that ice of any thickness could be detected on bare aluminum plates using a tactile check. Test subjects used only one type of glove during these tests. It was later theorized that the type of glove used may influence technicians' ability to detect ice. In 2005-06, APS repeated a limited number of tests. In these tests, candidates attempted to detect ice while wearing each of five types of gloves. This topic is discussed in Section 5.

## **1.2 General Activities**

### **1.2.1 Support for Development of SAE AS5681**

The proposed Society of Automotive Engineers (SAE) Aerospace Standard (AS) 5681 specifies the minimum performance requirements of remote on-ground ice detection systems (ROGIDS). APS has supported the development of AS5681 by providing expert opinion and clerical support for the development of the standard. This topic is discussed in Section 6.

### **1.2.2 Holdover Time Guidelines Website**

In July 2003, APS developed and implemented a website for the official TC HOT Guidelines. This was done to eliminate the discrepancies and potential safety risks associated with publishing the information in several locations, including websites and documents. In July 2006, APS updated the website with the new 2006-07 HOT Guidelines. This topic is discussed in Section 7.

### **1.2.3 Test Procedures, Presentations, and Fluid Manufacturer Reports for 2005-06**

Section 8 contains an account of the test procedures, presentations, and fluid manufacturer reports that were prepared by APS in 2005-06.

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## 2. METHODOLOGY TO RE-CATEGORIZE FLUID HOLDOVER TIME TABLES

Each year, as new Type II and Type IV products are introduced into the market, additional fluid-specific holdover time (HOT) tables are added to the HOT Guidelines, and the generic Type II and Type IV HOT tables are modified to encompass the new fluids. There are two significant disadvantages to this process. First, producing new tables and revising the existing tables require significant resources. Second, the guidelines become less user-friendly as they increase in size and complexity.

As one alternative to this process, this report explores the feasibility of implementing a new set of generic tables and eliminating fluid-specific tables.

### 2.1 Types of Fluid Guidelines

Two sets of guidelines currently exist in the aviation industry for anti-icing purposes: fluid-specific HOT Guidelines and generic fluid HOT Guidelines.

#### 2.1.1 Fluid-Specific Holdover Time Guidelines

Fluid-specific HOT Guidelines are tables that provide holdover time guidance to aircraft operators who know which fluid has been used on an aircraft. Usually used by seasoned pilots and operators, fluid-specific guidelines tell the operators the duration of time available for takeoff after an aircraft is de/anti-iced with a specific fluid. If a pilot is aware of the fluid that is being used, utilising the fluid-specific tables will extend the window of time available for takeoff since the fluid-specific tables portray the true capability of a specific product rather than the minimum/most conservative estimate of fluid holdover times. Major airlines also view the fluid-specific tables as a cost-efficient tool.

A total of 14 fluid-specific HOT Guidelines were published for the winter of 2005-06 (abbreviations used in subsequent figures are shown in parentheses) as follows:

- Type II Fluids:
  - Clariant Safewing MP II 2025 ECO (C-2025);
  - Kilfrost ABC-II Plus (ABC-II +);
  - Kilfrost ABC-2000 (K2000);
  - Octagon E Max II (E II); and
  - SPCA Ecowing 26 (S E26).

- Type IV Fluids:
  - Clariant Safewing MP IV 2001 (C-2001);
  - Clariant Safewing MP IV 2012 Protect (C-2012);
  - Clariant Safewing MP IV 2030 ECO (C-2030);
  - Kilfrost ABC-S (K-ABC-S);
  - Octagon Max-Flight (O-Max);
  - Octagon Max-Flight 04 (O-Max 04);
  - Octagon MaxFlo (O-MFlo);
  - SPCA AD-480 (S-480); and
  - Dow Chemical UCAR ADF/AAF Ultra + (Ultra +).

### 2.1.2 Generic Holdover Time Guidelines

Generic HOT Guidelines provide guidance in cases where the pilot or operator is not aware of the fluid being used. Unlike the fluid-specific guidelines, these tables encompass all fluids available on the market and therefore provide the lowest/most conservative time available for takeoff after de/anti-icing.

One generic HOT table is produced annually for each fluid type. Because fluid-specific tables are not produced for Type I or Type III fluids, any new Type I and Type III fluids must meet the standards set in their respective generic tables in order to qualify. As a result, the Type I and Type III generic guidelines rarely change.

The Type II and Type IV generic HOT Guidelines have been used in the industry for many years. The values represented in the Type II and Type IV generic guidelines are based on the lowest value obtained from holdover time tests conducted with all fluids of a specific type currently being used on the market. Each time a new Type II or Type IV fluid is introduced, the values in the generic HOT Guidelines are reassessed to include the new fluid's holdover times.

## 2.2 Issues with the Current Situation

### 2.2.1 Perpetual Changes to Generic Table Values

Each year, typically two or three new Type II/IV products are introduced to the market. Every new product that is introduced undergoes a series of holdover time tests. The results from the tests provide data to produce a fluid-specific table that is

added to the HOT Guidelines. In addition, if the product fails to generate values that are superior to those reported in the current generic HOT Guidelines, the times in the generic guidelines are reduced to include the new product. This practice has the effect of continually reducing the values represented in the generic HOT Guidelines.

However, when a product has not been commercially available for four years (and has not been re-qualified), it is removed from the generic HOT Guidelines analysis. If the fluid has the lowest holdover time in a cell, the value in that cell will increase with its removal. Fluids are removed much less frequently than fluids are added. Only five fluids have been removed from the generic analysis since the adoption of this rule in 2001. They include the following:

- Hoechst MP IV 1957;
- Dilute forms of Dow Chemical UCAR Ultra + ;
- SPCA AD-404;
- Clariant Safewing Four; and
- Clariant Safewing MP IV 1957.

The continual changes to the generic HOT Guidelines have long prompted discussion within the aviation industry that suggested freezing the generic Type II and Type IV HOT Guidelines. This would lock in the values of the generic guidelines and create a situation in which any new fluid introduced to the market would have to meet the minimum values set in either the Type II or Type IV generic tables.

**2.2.2 Similarity of Type II and Type IV Generic Tables**

Another issue with the current situation is the similarity of the Type II and Type IV generic HOT Guidelines. Fluids are classified as Type II or Type IV based on the outcome of a water spray endurance test (WSET). This is an endurance time test conducted in freezing rain at -5°C, at a rate of 5 g/dm<sup>2</sup>/h. The minimum WSET values for Type II and Type IV classification are given in Table 2.1.

**Table 2.1: Minimum WSET Endurance Times for Type II/IV Fluids**

Fluid Type	Fluid Dilution		
	100/0	75/25	50/50
Type II	30 minutes	20 minutes	5 minutes
Type IV	80 minutes	20 minutes	5 minutes

Source: SAE AMS 1428D.

Using the WSET to evaluate the overall holdover time performance of a fluid is not always reliable. There are several reasons for this. First, the Type II and Type IV WSET requirements differ only in the 100/0 dilution, and therefore the fluid is being evaluated on the performance of only one dilution. Second, the conditions under which the WSET is conducted do not directly correspond to any cell in the HOT Guidelines. Since fluids often perform stronger or weaker relative to each other in different conditions (especially common across precipitation types), their performance on the WSET may not be reflective of their overall holdover time performance. Therefore, although the WSET classifies fluids into stronger (Type IV) and weaker (Type II) performers, the classification may not be valid when looking at overall holdover time performance.

Furthermore, there is no rule preventing a fluid manufacturer from marketing a fluid that meets Type IV specifications as a Type II fluid.

The outcome of the current classification system is that the Type II and Type IV generic tables have very similar values (see Figure 2.1 to Figure 2.3). In fact, of the Type II and Type IV generic holdover time values derived from endurance time testing (i.e., in all precipitation types except frost), 38 percent are equal, 65 percent differ by 5 minutes or less, and 77 percent differ by 10 minutes or less.

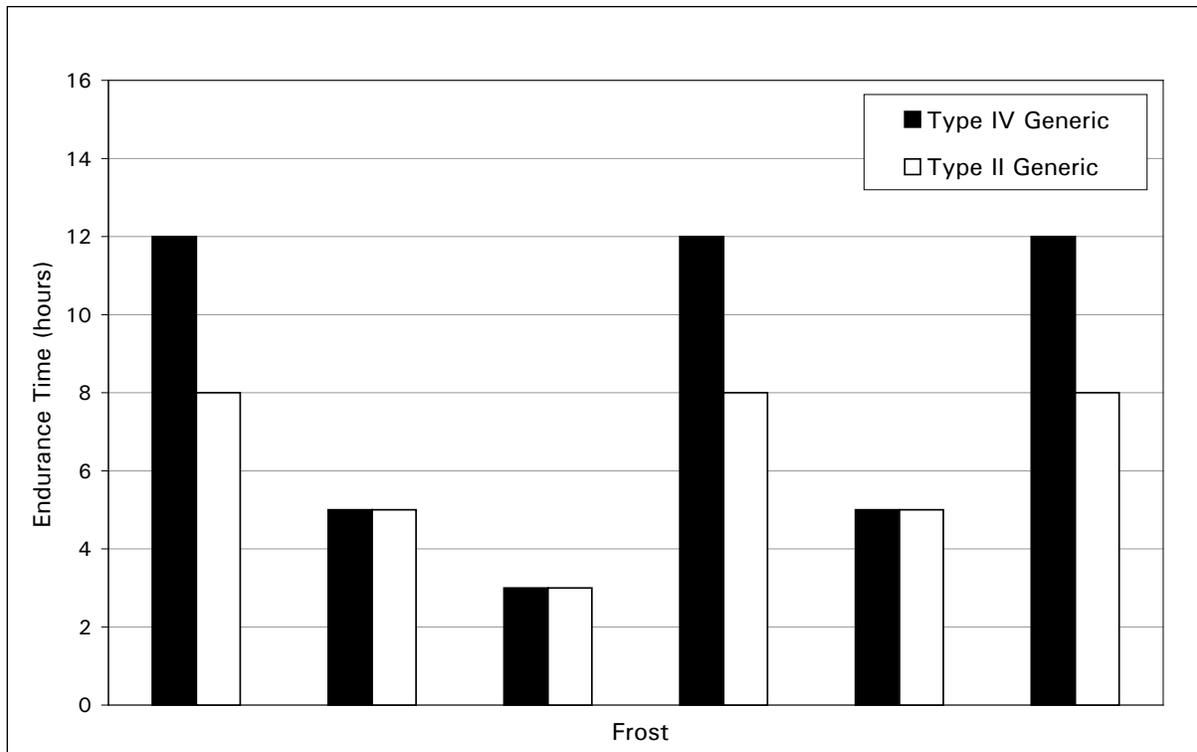


Figure 2.1: Generic Holdover Time Guideline Values in Frost

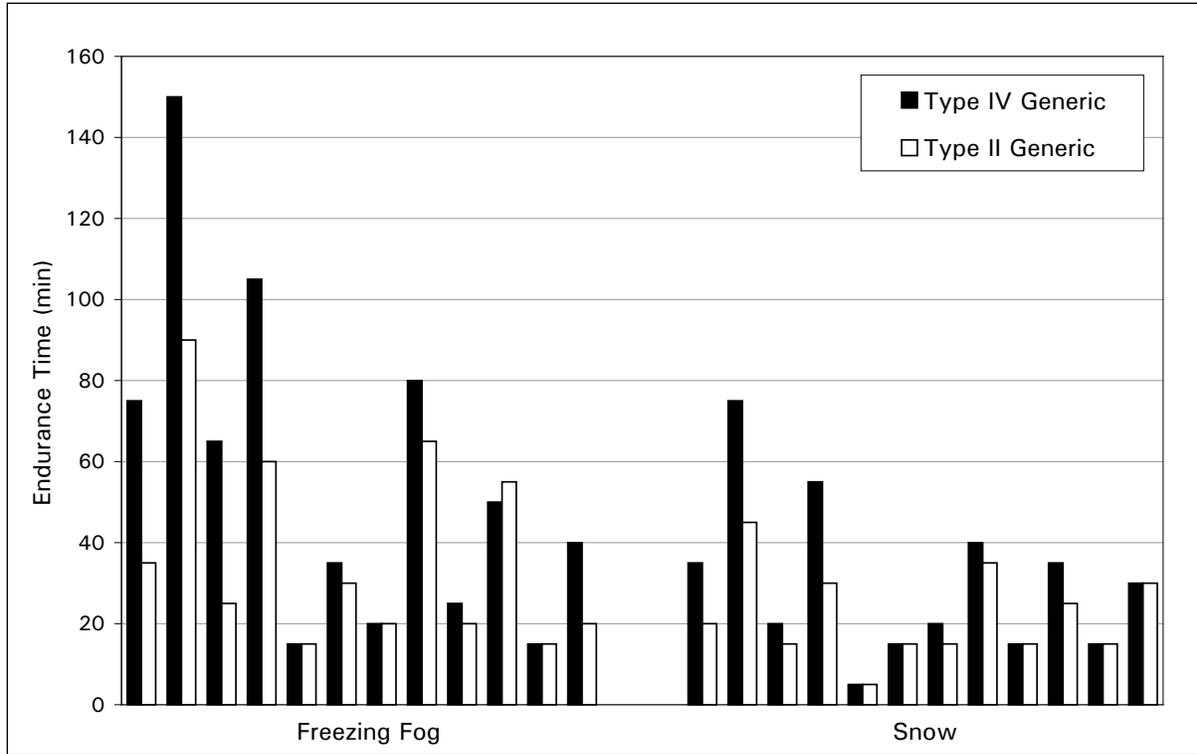


Figure 2.2: Generic Holdover Time Guideline Values in Freezing Fog and Snow

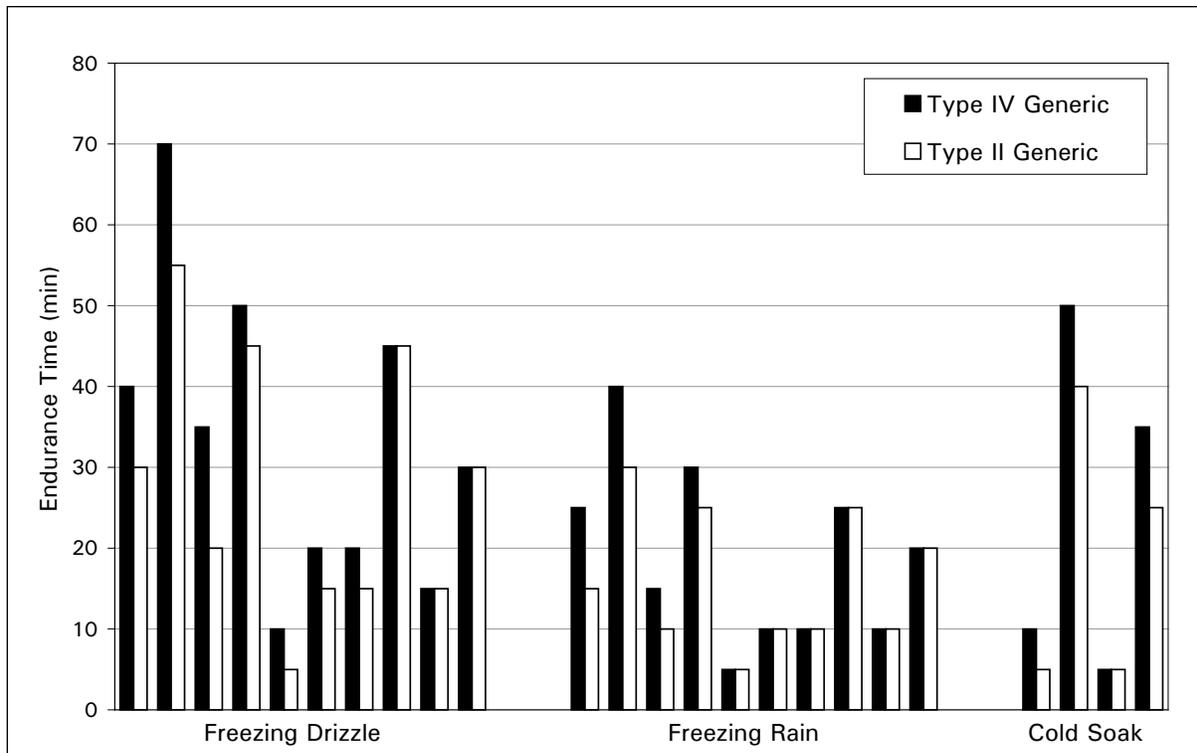


Figure 2.3: Generic Holdover Time Guideline Values in Freezing Drizzle, Freezing Rain, and Rain on Cold-Soaked Wing

## 2.3 Previous Work

This issue was previously examined in 2001 in the report entitled *Methodology to Re-Categorize Fluid Holdover Time Tables*, which was included as an appendix to the Transport Canada (TC) report, TP 13826E, *Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter* (1).

The report concluded that the Type II and Type IV fluids in use at the time could potentially be summarized into three generic tables, but that further analysis and industry consultation were required before the three proposed generic tables could be implemented. Since then, additional fluid-specific tables have been added for new fluids, bringing the total number to 14 for the winter of 2005-06.<sup>1</sup> The categorization of winter weather conditions has also changed, making it necessary to re-examine the data.

## 2.4 Objective

This report presents a thorough analysis of the data included in the 2005-06 fluid-specific HOT Guidelines. The primary objective is to find a methodology that reduces the number of HOT Guidelines tables and separates the high-performing fluids from the low-performing fluids.

## 2.5 Methodology and Data Review

### 2.5.1 Data Identification

HOT tables provide holdover times for neat and dilute fluids in specific weather conditions. These weather conditions are defined by precipitation type and outside air temperature (OAT). There are seven precipitation types: active frost, freezing fog, snow or snow grains, freezing drizzle, light freezing rain, rain on cold-soaked wing, and an “other” category for which values are not provided. There are three temperature ranges provided for frost, freezing fog, and snow; two for freezing drizzle and freezing rain; and one for rain on cold-soaked wing. The outcome of this categorization is a matrix of 30 cells.

With the exception of frost, two values are given in each cell: an upper limit holdover time value and a lower limit holdover time value. Only one data value is given in each frost cell. In total, 54 data values are given in each Type II and Type IV HOT table. In this report, the term “data cell” will refer to one of these 54 values. A sample HOT table is shown in Table 2.2.

---

<sup>1</sup> Five more tables were added for the winter of 2006-07; however, they did not exist when this analysis was conducted and therefore were not included in the analysis.

**Table 2.2: Sample Type II/IV Holdover Time Table**

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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	1:30 – 2:05	0:40 – 1:10	0:40 – 1:00	0:25 – 0:35	0:10 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:55 – 1:45	0:25 – 0:45	0:25 – 0:45	0:20 – 0:25	0:05 – 0:50	
		50/50	3:00	0:20 – 0:35	0:05 – 0:15	0:10 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45 – 1:50	0:35 – 1:00	0:35 – 1:05	0:20 – 0:35		
		75/25	5:00	0:40 – 1:20	0:25 – 0:45	0:30 – 0:40	0:15 – 0:25		
below -14 to -25	below 7 to -13	100/0	8:00	0:25 – 0:45	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.						

### 2.5.2 Data Extraction and Selection

The values given in the fluid-specific tables were extracted in the form of hours:minutes and converted to minutes. A log was developed that contains the 54 data points from each of the 14 fluid-specific tables. The log is given in Appendix B.

Attempting to group 14 data sets when each data set has 54 values is highly complex. Specialized mathematical software would be required to conduct the analysis using all of the data points. In a simplified approach, the number of values analysed from each table was reduced based on data cell usage and data cell variance across tables. This was possible because the majority of de/anti-icing operations occur in only a few of the 54 data cells and because high variance between fluids is not seen in all 54 data cells.

#### 2.5.2.1 Data Cell Usage

To determine the most used data cells, a database of de/anti-icing operation distributions was examined. The database, which can be found in Section 3 of the TC report, TP 14375E, *Winter Weather Impact on Holdover Time Table Format (1995-2004)* (2), was built on information gathered from a survey of international deicing operators. The database comprises 86,853 data points collected from 16 international cities over three winters, from 2000-01 to 2002-03. The distribution of operations by precipitation type and temperature is shown in Table 2.3.

Table 2.3 clearly shows that operations in frost and snow in the two warmer temperature ranges are the most used cells. They account for 88 percent of de/anti-icing operations.

**Table 2.3: Distribution of Anti-Icing Operations by Weather Condition**

Outside Air Temperature		Usage of Cells in Actual Operations <sup>1</sup>						
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Freezing Rain	RCSW	Other
-3 and above	27 and above	23.9%	1.6%	36.1%	2.4%	1.9%	1.0%	0.9%
below -3 to -14	below 27 to 7	7.3%	1.0%	19.2%	1.0%	0.8%	CAUTION: No holdover time guidelines exist	1.0%
below -14 to -25	below 7 to -13	0.5%	0.0%	1.5%				0.0%

<sup>1</sup> Transport Canada report TP 14375E, Winter Weather Impact on Holdover Time Table Format (1995-2004).

**2.5.2.2 Removal of Frost and “Other” Data Cells**

Frost data values are different from the other precipitation data values included in the HOT Guidelines. This is because fluid-specific holdover times in frost are not measured, and all fluid-specific guidelines include generic values in the frost cells. Thus, all Type II fluids have the same values in the frost column, and all Type IV fluids have the same values in the frost column. Because the frost values are not fluid-specific, they should not be included in an analysis attempting to group fluids based on fluid-specific attributes.

Data in the “other” precipitation column is not relevant to the analysis because data values are not given in this column in the HOT tables.

Therefore, the frost and “other” cells were removed from the analysis. The distribution of the remaining de/anti-icing operations is shown in Table 2.4.

**Table 2.4: Distribution of Anti-Icing Operations by Selected Weather Conditions**

Outside Air Temperature		Usage of Cells in Actual Operations <sup>1</sup>						
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Freezing Rain	RCSW	Other
-3 and above	27 and above	-	2.4%	54.3%	3.6%	2.9%	1.5%	
below -3 to -14	below 27 to 7	-	1.5%	28.9%	1.4%	1.3%	CAUTION: No holdover time guidelines exist	
below -14 to -25	below 7 to -13	-	0.0%	2.2%				

<sup>1</sup> Transport Canada report TP 14375E, Winter Weather Impact on Holdover Time Table Format (1995-2004).

### 2.5.2.3 Further Classification of Usage Data

Unfortunately, information on the usage of dilutions was not collected in the worldwide operations survey, nor is it known if the lower or upper holdover time limits are used. Therefore, the following assumptions were made to further classify the data:

- In conditions where three dilutions could potentially be used, dilutions were used with the following frequency:
  - 100/0: 80 percent;
  - 75/25: 15 percent; and
  - 50/50: 5 percent.
- In conditions where two dilutions could potentially be used, dilutions were used with the following frequency:
  - 100/0: 80 percent; and
  - 75/25: 20 percent.
- The upper holdover time limit was used 80 percent of the time, and the lower holdover time limit was used 20 percent of the time.

Based on these assumptions, the numbers in Table 2.4 were further divided. The data (see Table 2.5) reveals that six data cells account for 78 percent of table usage when the frost and other columns are excluded. The six data cells (bolded in Table 2.5) are as follows:

- Snow, -3°C and above, 100/0, high rate;
- Snow, -3°C and above, 100/0, low rate;
- Snow, -3°C and above, 75/25, low rate;
- Snow, below -3°C to -14°C, 100/0, high rate;
- Snow, below -3°C to -14°C, 100/0, low rate; and
- Snow, below -3°C to -14°C, 75/25, low rate.

### 2.5.2.4 Data Cell Variance

In addition to the usage of each data cell, it is also important to examine the variance in individual fluid values in each data cell. It is important to include data cells with high variance in the analysis, as these cells are important in differentiating the fluids from one another.

The standard deviation of the fluid-specific values in each data cell was calculated to measure the variance. A higher standard deviation indicates that the holdover times vary considerably between fluids in a data cell. The standard deviation statistics are given in Table 2.6.

**Table 2.5: Distribution of Anti-Icing Operations by Weather Condition, Fluid Dilution, and Precipitation Rate**

Outside Air Temperature		Fluid Conc.	Usage of Cells in Actual Operations <sup>1</sup>											
Degrees Celsius	Degrees Fahrenheit	Fluid/Water	Active Frost	Freezing Fog		Snow or Snow Grains		Freezing Drizzle		Freezing Rain		RCSW		Other
			n/a	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	n/a
-3 and above	27 and above	100/0	-	0.4%	1.5%	<b>8.7%</b>	<b>34.7%</b>	0.6%	2.3%	0.5%	1.9%	0.2%	0.9%	CAUTION: No holdover time guidelines exist
		75/25	-	0.1%	0.3%	1.6%	<b>6.5%</b>	0.1%	0.4%	0.1%	0.4%	0.1%	0.2%	
		50/50	-	0.0%	0.1%	0.5%	2.2%	0.0%	0.1%	0.0%	0.1%			
below -3 to -14	below 27 to 7	100/0	-	0.2%	1.0%	<b>4.6%</b>	<b>18.5%</b>	0.2%	0.9%	0.2%	0.8%			
		75/25	-	0.1%	0.2%	1.2%	<b>4.6%</b>	0.1%	0.2%	0.1%	0.2%			
below -14 to -25	below 7 to -13	100/0	-	0.0%	0.0%	0.4%	1.8%							

<sup>1</sup> Based on the following assumptions.  
 - 100/0, 75/25, 50/50 dilutions occur with this regularity: 80%, 15%, 5%.  
 - 100/0, 75/25 dilutions occur with this regularity: 80%, 20%.  
 - High rates are used 20%, low rates are used 80%.

**Table 2.6: Standard Deviations of Type II and Type IV Fluid Holdover Times**

Outside Air Temperature		Fluid Conc.	Standard Deviation of Type II and Type IV Holdover Times (minutes)											
Degrees Celsius	Degrees Fahrenheit	Fluid/Water	Active Frost	Freezing Fog		Snow or Snow Grains		Freezing Drizzle		Freezing Rain		RCSW		Other
			n/a	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	n/a
-3 and above	27 and above	100/0	-	32.4	38.4	15.1	19.8	22.3	20.5	13.1	16.3	4.5	20.5	CAUTION: No holdover time guidelines exist
		75/25	-	21.8	37.0	11.8	22.5	22.3	22.6	12.0	16.1	4.3	23.8	
		50/50	-	20.8	44.5	6.7	20.7	8.9	16.4	6.0	8.0			
below -3 to -14	below 27 to 7	100/0	-	11.8	27.4	8.7	14.4	10.3	18.5	7.1	7.3			
		75/25	-	6.7	19.9	7.1	12.5	8.4	16.2	3.0	4.3			
below -14 to -25	below 7 to -13	100/0	-	4.2	8.8	1.3	4.0							

2.5.2.5 Final Selection

The usage and variance measurements were incorporated into one analysis by multiplying the standard deviation by the occurrence percentage in each cell. The resulting statistic gives the propensity of the cell to be important in the grouping analysis.

The values are given in Table 2.7. It reveals that the four following data cells (bolded in Table 2.7) are key in grouping the fluids:

- Snow, -3°C and above, 100/0, high rate;
- Snow, -3°C and above, 100/0, low rate;
- Snow, -3°C and above, 75/25, low rate; and
- Snow, below -3°C to -14°C, 100/0, low rate.

**Table 2.7: Propensity of Data Cells to Be Important in Grouping Tables**

Outside Air Temperature		Fluid Conc.	Propensity of Cells to be Important in Calculating Table Groups (standard deviation x usage)											
Degrees Celsius	Degrees Fahrenheit	Fluid/Water	Active Frost	Freezing Fog		Snow or Snow Grains		Freezing Drizzle		Freezing Rain		RCSW		Other
			n/a	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	n/a
-3 and above	27 and above	100/0	-	0.13	0.60	<b>1.31</b>	<b>6.87</b>	0.13	0.47	0.06	0.31	0.01	0.19	CAUTION: No holdover time guidelines exist
		75/25	-	0.02	0.11	0.19	<b>1.47</b>	0.02	0.10	0.01	0.06	0.00	0.05	
		50/50	-	0.00	0.04	0.04	0.45	0.00	0.02	0.00	0.01			
below -3 to -14	below 27 to 7	100/0	-	0.03	0.26	0.40	<b>2.66</b>	0.02	0.17	0.01	0.06			
		75/25	-	0.00	0.05	0.08	0.58	0.01	0.04	0.00	0.01			
below -14 to -25	below 7 to -13	100/0	-	0.00	0.00	0.01	0.07							

2.6 Analysis

This subsection focuses on forming the best fluid groupings, and it analyses the outcome from both mathematical and practical perspectives.

### 2.6.1 Grouping Methodology

To meet the objectives of reducing the number of HOT tables and grouping fluids by performance, the methodology outlined below was determined.

1. Fluids are grouped according to similar endurance time performance.
2. In each group, the lowest fluid-specific value in each data cell becomes the group value in that cell.
3. A generic HOT table is constructed for each group with the group values; the number of groups gives the number of generic HOT tables.
4. New fluids introduced must meet the standard set by at least one of the new generic tables.

### 2.6.2 Formation of Fluid Groups

The values from the four important data cells identified in Subsection 2.5.2.5 were extracted from each fluid-specific HOT table and plotted on a line graph (see Figure 2.4).

Trial and error was then used to generate groupings based on similar values in the four important data cells. To select the best grouping, the total holdover time that is forfeited in the four important data cells when the group values are used in place of the fluid-specific values was calculated. This was done by calculating the difference between each fluid-specific value and its corresponding group value and then summing the differences for each fluid. The grouping with the smallest amount of time forfeited was considered to be the best grouping.

It should be noted that linear programming could also be used to determine the best grouping; however, it was not required at this time.

The best grouping is shown in Table 2.8. The four groups it includes are also plotted in Figure 2.5. The total holdover time forfeited by using this grouping is 450 minutes. The fluids included in each group are listed as follows:

- Group A – low performers:
  - Clariant Safewing MP II 2025 ECO;
  - Kilfrost ABC-2000;
  - Kilfrost ABC-II Plus;
  - SPCA Ecowing 26; and
  - Clariant Safewing MP IV 2012 Protect.

- Group B – average performers:
  - Octagon E Max II;
  - Dow Chemical UCAR ADF/AAF Ultra + ;
  - Octagon MaxFlo; and
  - SPCA AD-480.
- Group C – high performers:
  - Clariant Safewing MP IV 2030 ECO;
  - Octagon Max-Flight;
  - Kilfrost ABC-S; and
  - Clariant Safewing MP IV 2001.
- Group D – very high performers:
  - Octagon Max-Flight 04.

It should be noted that this categorization has grouped fluids based on endurance time performance only and not on fluid quality. While endurance time is one measure of fluid quality, there are many other measures that may be equally or more important in determining the quality of fluid.

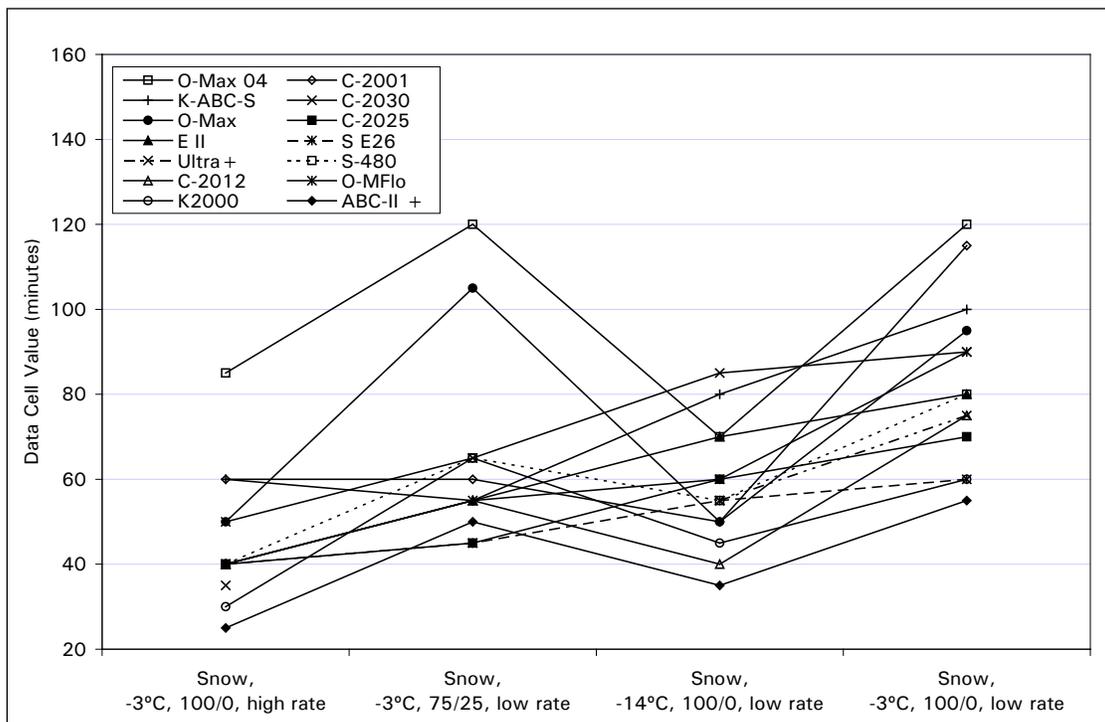
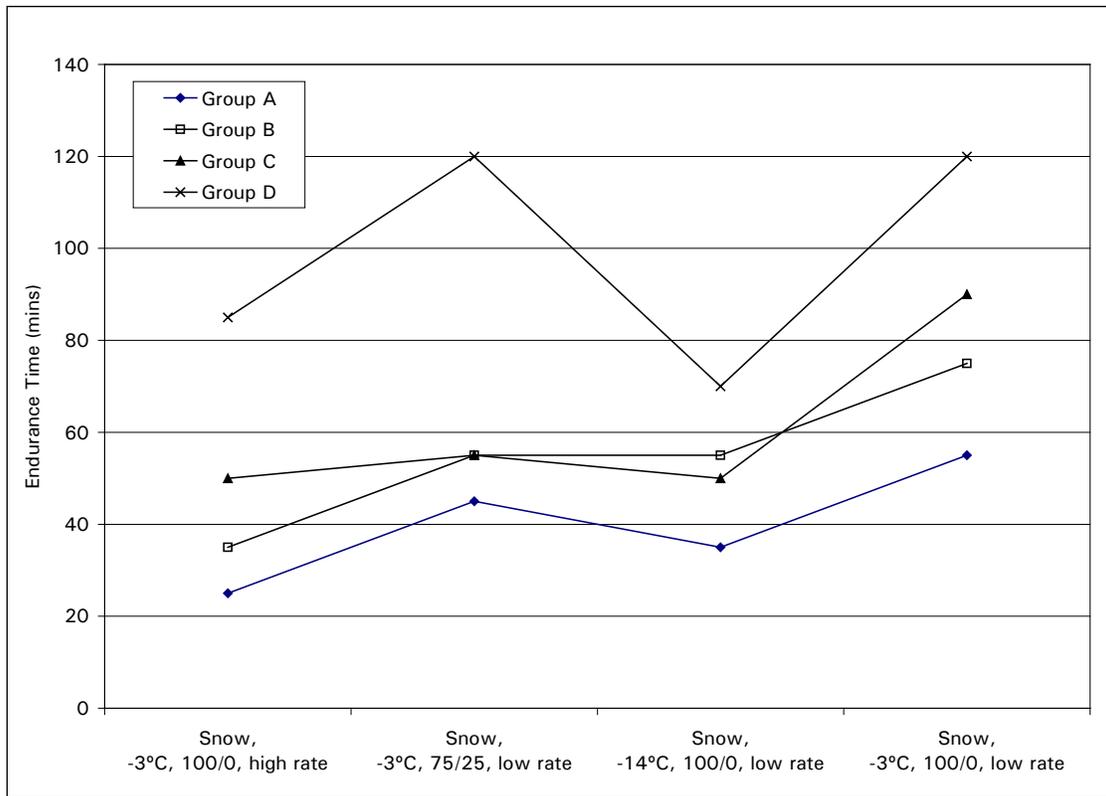


Figure 2.4: Important Data Cell Values of Type II and Type IV Fluids

**Table 2.8: Preliminary Group Endurance Time Values**

Data Cell	Group A	Group B	Group C	Group D
Snow, -3°C, 100/0, High Rate	25 minutes	35 minutes	50 minutes	85 minutes
Snow, -3°C, 75/25, Low Rate	45 minutes	55 minutes	55 minutes	120 minutes
Snow, -14°C, 100/0, Low Rate	35 minutes	55 minutes	50 minutes	70 minutes
Snow, -3°C, 100/0, Low Rate	55 minutes	75 minutes	90 minutes	120 minutes



**Figure 2.5: Preliminary Group Endurance Time Values**

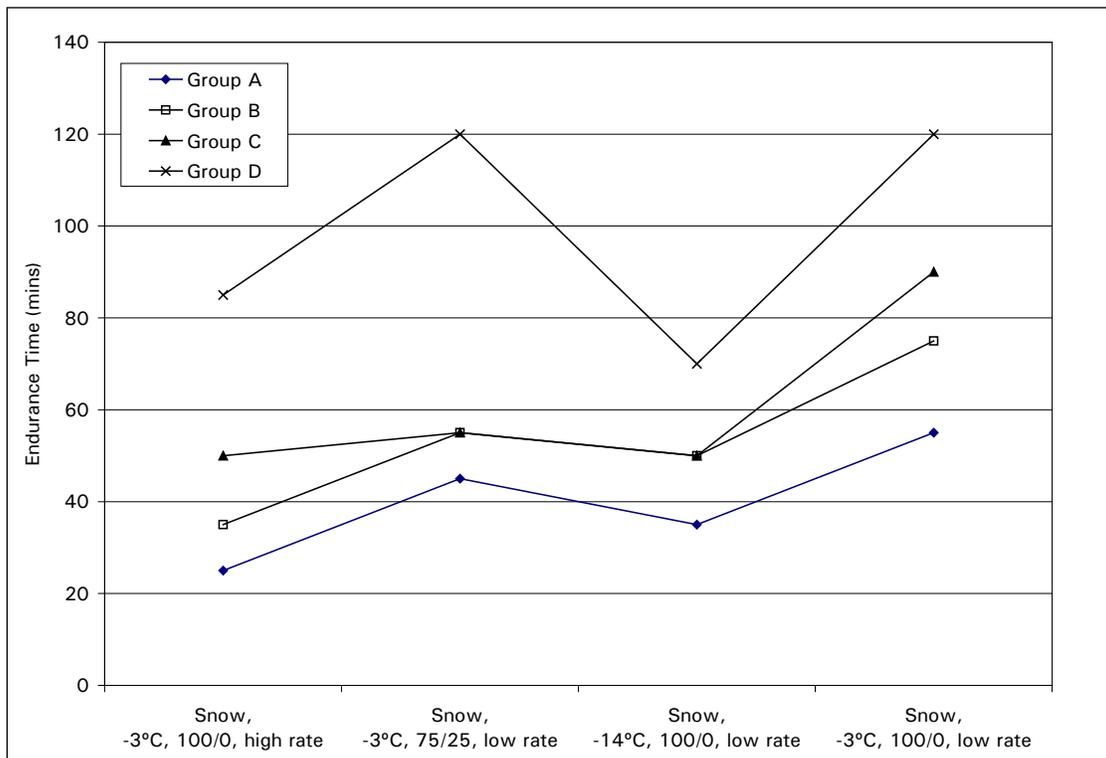
### 2.6.3 Revisions to Preliminary Grouping to Create Successive Groups

One of the objectives of this project (see Subsection 2.4) is to segregate low-performing fluids from high-performing fluids. To attain this objective, each group in the grouping must have successively longer endurance time values in each data cell (i.e., Group A value < Group B value < Group C value < Group D value).

As can be seen in Table 2.8 and Figure 2.5, this requirement is met in most cases in the preliminary grouping. There is, however, one exception. The Group B endurance time value in the *Snow, -14°C, 100/0, Low Rate* data cell is 55 minutes, which is 5 minutes longer than the Group C value of 50 minutes. In order to meet the project objective, the Group B value has to be reduced to 50 minutes. The consequence of making this change is that the holdover time forfeited increases from 450 to 470 minutes. The final group data values are shown in Table 2.9 and Figure 2.6. The groups are shown individually in Figure 2.7 to Figure 2.10.

**Table 2.9: Final Group Endurance Time Values**

Data Cell	Group A	Group B	Group C	Group D
Snow, -3°C, 100/0, High Rate	25 minutes	35 minutes	50 minutes	85 minutes
Snow, -3°C, 75/25, Low Rate	45 minutes	55 minutes	55 minutes	120 minutes
Snow, -14°C, 100/0, Low Rate	35 minutes	50 minutes	50 minutes	70 minutes
Snow, -3°C, 100/0, Low Rate	55 minutes	75 minutes	90 minutes	120 minutes



**Figure 2.6: Final Group Endurance Time Values**

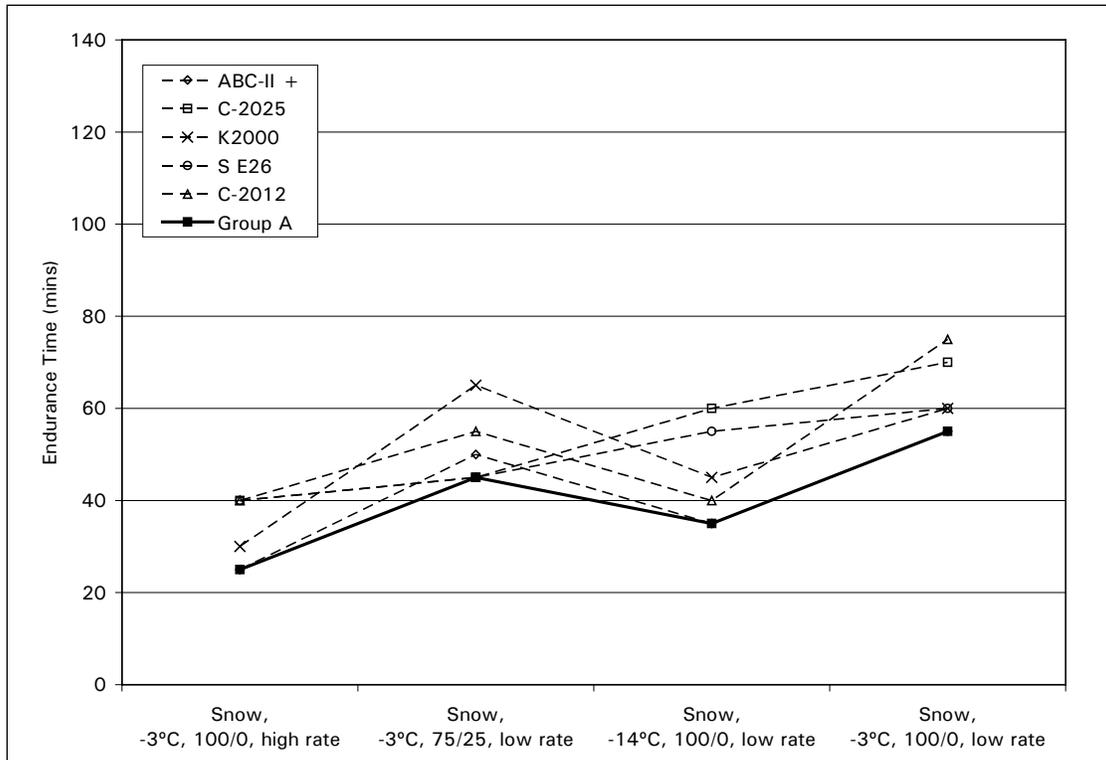


Figure 2.7: Group A Endurance Time Values

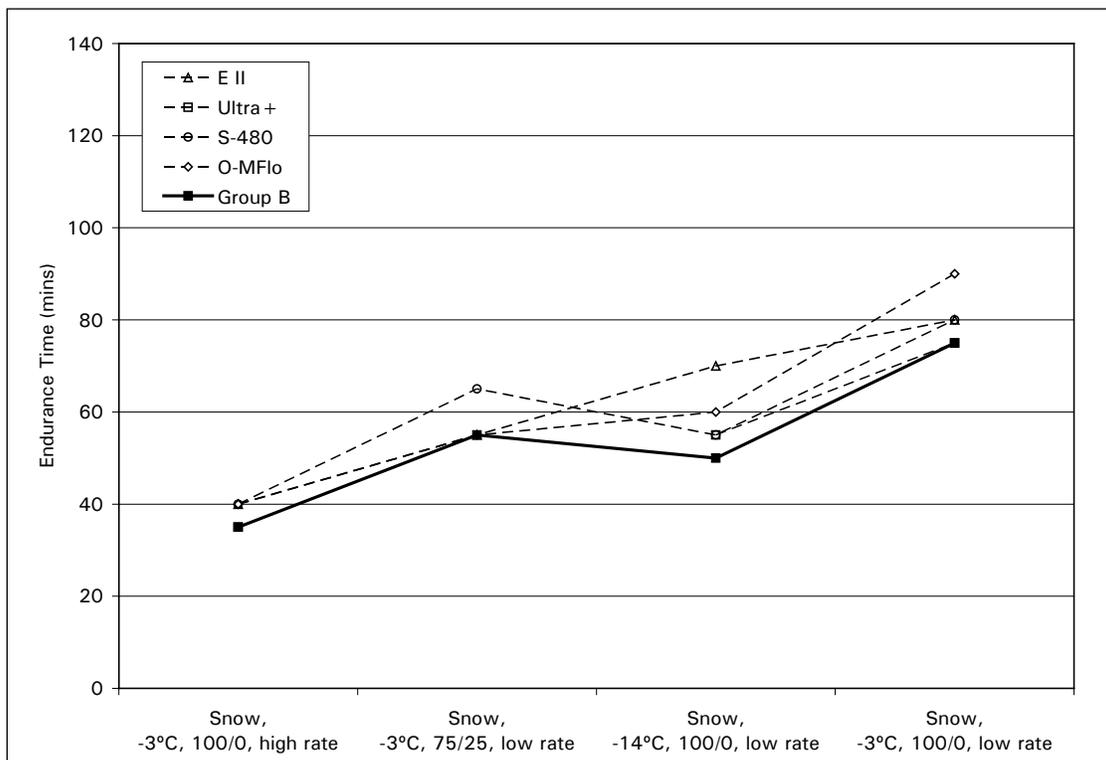


Figure 2.8: Group B Endurance Time Values

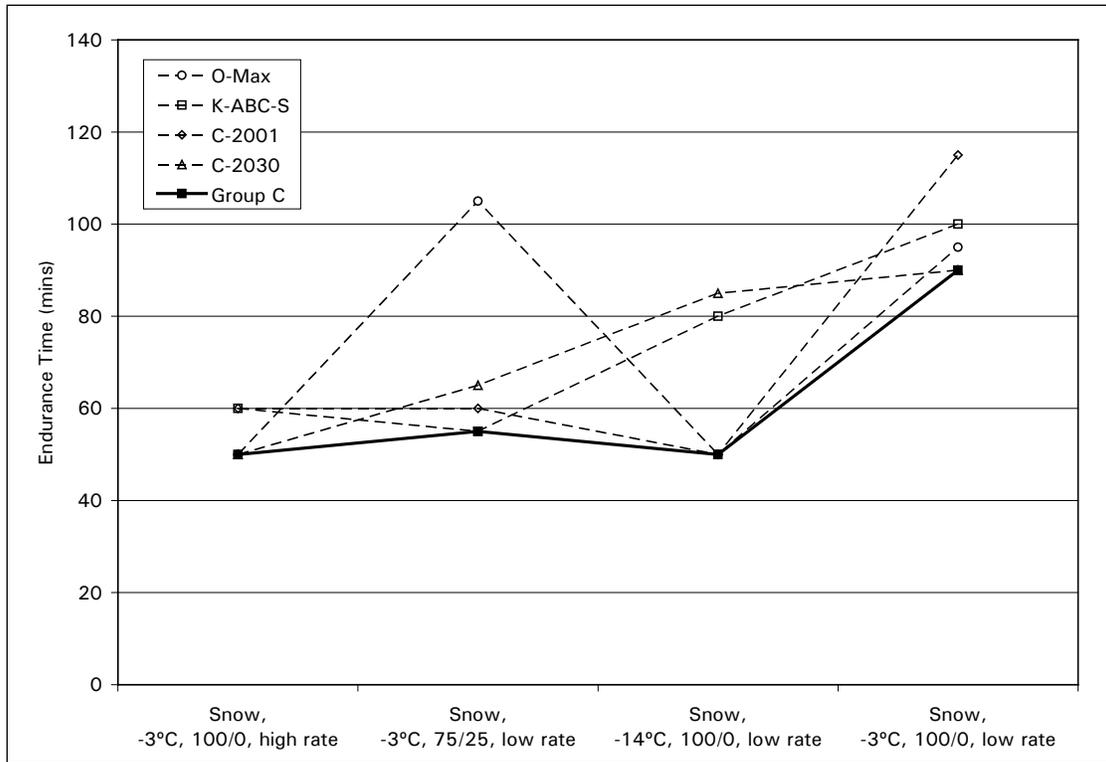


Figure 2.9: Group C Endurance Time Values

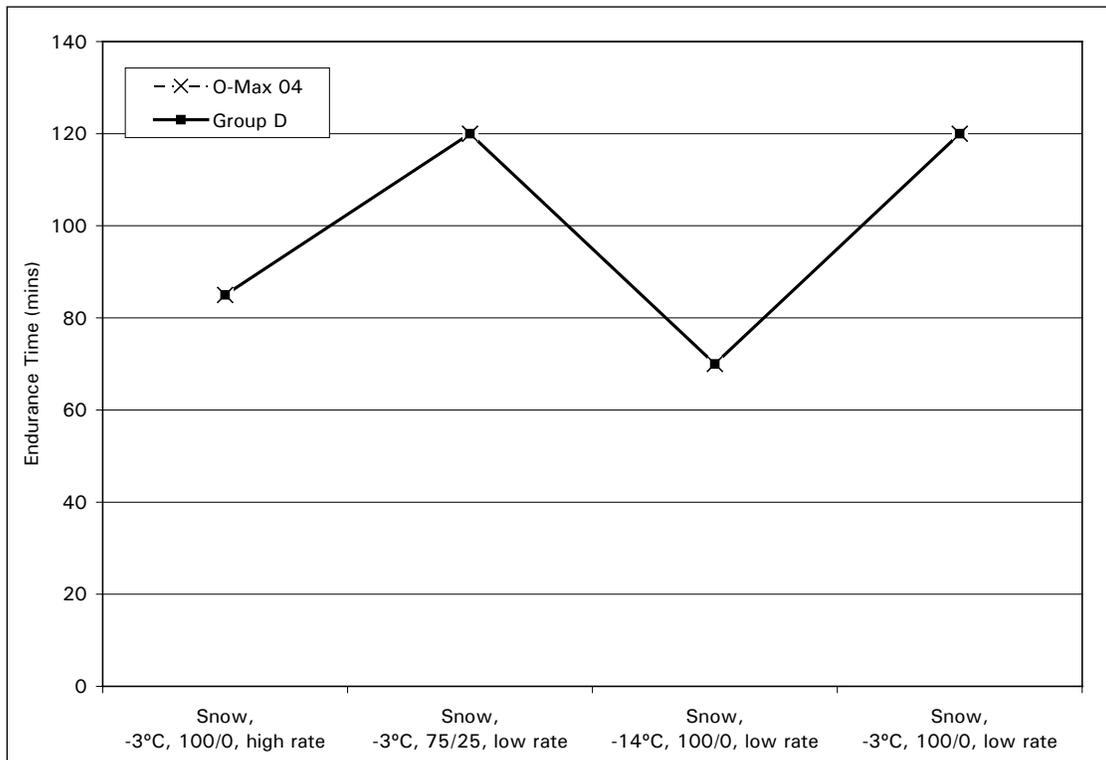


Figure 2.10: Group D Endurance Time Values

### 2.6.4 Proposed New Generic Tables

The four proposed new generic tables are shown in Table 2.10 to Table 2.13. Note that values are only given in the four data cells used in the analysis.

**Table 2.10: Generic Holdover Time Table “A”**

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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			0:25 – 0:55				CAUTION: No holdover time guidelines exist
		75/25			– 0:45				
		50/50							
below -3 to -14	below 27 to 7	100/0			– 0:35				
		75/25							
below -14 to -25	below 7 to -13	100/0							
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.						

**Table 2.11: Generic Holdover Time Table “B”**

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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			0:35 – 1:15				CAUTION: No holdover time guidelines exist
		75/25			– 0:55				
		50/50							
below -3 to -14	below 27 to 7	100/0			– 0:50				
		75/25							
below -14 to -25	below 7 to -13	100/0							
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.						

**Table 2.12: Generic Holdover Time Table “C”**

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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			0:50 – 1:30				CAUTION: No holdover time guidelines exist
		75/25			– 0:55				
		50/50							
below -3 to -14	below 27 to 7	100/0			– 0:50				
		75/25							
below -14 to -25	below 7 to -13	100/0							
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.						

**Table 2.13: Generic Holdover Time Table “D”**

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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			1:15 – 2:00			CAUTION: No holdover time guidelines exist	
		75/25			– 2:00				
		50/50							
below -3 to -14	below 27 to 7	100/0			– 1:10				
		75/25							
below -14 to -25	below 7 to -13	100/0							
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.						

**2.6.5 Mathematical Evaluation of Grouping**

Although this fluid grouping is the best possible given the imposed limitations, mathematically it is not a good representation of the data. There are significant sacrifices made (470 minutes) in holdover time to meet the imposed limitations. In addition, the groupings are not “best-fit” curves of the fluids within, as they must be the lowest value of all the fluids in the group due to safety concerns. Finally, there is not a clear pattern in the formation of the curves given by the groups; therefore, the group curves do not accurately portray the curves of the fluids.

However, given the restrictions in creating the groups, these groups are a reasonable outcome. The key issue is no longer whether the grouping is a good mathematical evaluation, but whether it is worth forfeiting 470 minutes of holdover time to reduce the number of HOT tables.

### 2.6.6 Practical Evaluation of Grouping

In addition to the mathematical evaluation, the grouping also needs to be evaluated from a practical perspective.

#### 2.6.6.1 Holdover Time Forfeited

The holdover time forfeited by eliminating the fluid-specific tables and introducing the four new generic tables is 470 minutes. In the four weather conditions and 14 fluids examined in this analysis (56 cells total), this translates to 30 percent of data cells losing no holdover time per departure, 25 percent losing 5 minutes per departure, 27 percent losing 10 to 15 minutes per departure, and 18 percent losing 20 minutes or more. These are significant losses.

#### 2.6.6.2 User Friendliness

From a user’s viewpoint, the grouping should be arranged logically. The creation of successive groups from low-performing to high-performing is the best way to do this. However, users may not find it logical that the group values do not increase proportionately in each data cell (i.e., that Group B values are not always 25 percent greater than Group A values). Instead, the increases appear to be random (see Table 2.14).

**Table 2.14: Data Value Increases**

Data Cell	Group B Increase over Group A	Group C Increase over Group B	Group D Increase over Group C
Snow, -3°C, 100/0, High Rate	40%	43%	70%
Snow, -3°C, 75/25, Low Rate	22%	0%	118%
Snow, -14°C, 100/0, Low Rate	43%	0%	40%
Snow, -3°C, 100/0, Low Rate	36%	20%	33%

All of the group curves have the same shape, which is also logical for users; however, most individual fluid curves do not have this shape, which may cause confusion. This is also a drawback for manufacturers, as fluids with differently shaped curves will be penalized more than fluids that follow the shape of the group curves. A good example of this phenomenon is Clariant Safewing 2030, whose fluid-specific values differ substantially from its Group C values.

### **2.6.6.3 *Opposition to Change***

Although the idea of reducing the number of HOT Guidelines has been debated in the industry for many years, significant opposition to proposed changes is expected. The primary reason for the opposition is that almost all fluids would have reduced holdover times in some data cells when the new generic tables replace the existing fluid-specific tables. Some fluids would have reduced holdover times in all conditions.

As recently as 2001, when this issue was first examined, the possibility of eliminating fluid-specific guidelines existed. However, since that time, the industry has changed significantly with the introduction of many more fluids. Holdover times are one of the key characteristics that distinguish one fluid from the next, and manufacturers market their fluids based on their holdover time performance. If generic tables were implemented, many of these fluids would lose their holdover time advantages over other fluids.

The recent elimination of the above 0°C temperature range in the Type II and Type IV guidelines illustrates that even minor changes face strong opposition. The change caused several fluids to lose 5 minutes in one cell. The opposition to this change has been so strong that the reinstatement of the above 0°C row has been considered. This example shows that opposition to making more dramatic changes, such as the elimination of fluid-specific guidelines, may not be possible with the market in its current state.

### **2.6.7 Advantages and Disadvantages to Stakeholders**

The following subsections outline the advantages and disadvantages that may be experienced by the various stakeholders should the industry and the regulating bodies proceed with this new approach. These advantages and disadvantages will exist regardless of the method used to segregate the fluids; therefore, weaknesses with the current analysis method will not be considered.

### *2.6.7.1 Operators*

Listed below are the advantages to the operators.

- Reducing the number of fluid-specific tables reduces possible confusion and the probability of error.
- No decision is required as to the choice of table to use (fluid-specific or generic).
- If a small aircraft operator typically uses generic tables, the new generic tables increase the holdover time available. This is because the new set of tables provides longer times for fluids that belong to the higher-performing categories.
- The major loss experienced in holdover time when choosing generic fluid HOT tables instead of fluid-specific tables is greatly diminished.

Listed below are the disadvantages to the operators.

- There will be losses in holdover times, which will vary by fluid.
- When using the new set of tables, operators would be required to know the fluid being used in order to identify the table that must be used. When using the current generic tables, an operator is only required to know whether a Type II or Type IV fluid is being used.

### *2.6.7.2 Fluid Manufacturers*

Listed below are the advantages to the fluid manufacturers.

- Stronger-performing fluids will be recognized, and weaker-performing fluids will continue to be available on the market.

Listed below are the disadvantages to the fluid manufacturers.

- Many fluids will lose their market advantage of longer holdover times in specific cells. Manufacturers will resultantly lose a strong marketing tool.
- When developing a new fluid, manufacturers will not know which category the new fluid will fall into until all endurance time tests are completed.

### **2.6.7.3 Regulators**

Listed below are the advantages to the regulators.

- The concern over too many fluid-specific tables will be removed.
- The concern over the lowering and perpetually changing generic tables will be removed.
- An added safety buffer will be introduced, as holdover times for specific fluids will be reduced in many cells.
- New tables will not need to be introduced for new fluids on the market, and only minimal changes will need to be made to the generic guidelines each year.

Listed below are the disadvantages to the regulators.

- The introduction of a new set of tables will require time, effort, and a scientific approach that will be valid and sustainable in the long term.
- Opposition from the industry will have to be overcome.
- The actual holdover times will be longer than the holdover times given in the tables for many fluids. This will cause pilots to disbelieve the performance of the fluids, and the credibility of the HOT Guidelines will be jeopardized.

## **2.7 Application of Approach to New Fluids**

As stated in Subsection 2.6.1, if this approach is adopted, all new fluids introduced will have to meet the standard set by at least one of the new generic tables. To illustrate this requirement, the five Type II/IV fluids newly qualified for the winter of 2006-07 will be examined.

Two Type II fluids and three Type IV fluids were qualified for the winter of 2006-07 as follows:

- Type II:
  - Clariant Safewing MP II Flight; and
  - Kilfrost ABC-TF2.
- Type IV:
  - Clariant Safewing MP IV Launch;
  - Kilfrost ABC-S PLUS; and
  - Dow Chemical UCAR Endurance EG106.

The endurance time data for the five new fluids in the relevant data cells is given in Table 2.15. The minimum holdover times for inclusion in the proposed fluid groups are given in Table 2.16.

**Table 2.15: Data for Type II/IV Fluids Introduced in 2006-07**

	Snow, -3°C, 100/0, High Rate	Snow, -14°C, 100/0, Low Rate	Snow, -3°C, 100/0, Low Rate	Snow, -3°C, 75/25, Low Rate
<b>Clariant Safewing MP II Flight</b>	60 minutes	65 minutes	95 minutes	80 minutes
<b>Kilfrost ABC-TF2</b>	20 minutes	35 minutes	45 minutes	30 minutes
<b>Clariant Safewing MP IV Launch</b>	60 minutes	65 minutes	95 minutes	80 minutes
<b>Kilfrost ABC-S PLUS</b>	45 minutes	60 minutes	85 minutes	55 minutes
<b>Dow Chemical UCAR Endurance EG106</b>	40 minutes	65 minutes	80 minutes	n/a

**Table 2.16: Minimum Endurance Times for Proposed Fluid Types**

	Snow, -3°C, 100/0, High Rate	Snow, -14°C, 100/0, Low Rate	Snow, -3°C, 100/0, Low Rate	Snow, -3°C, 75/25, Low Rate
<b>Type A</b>	25 minutes	35 minutes	55 minutes	45 minutes
<b>Type B</b>	35 minutes	50 minutes	75 minutes	55 minutes
<b>Type C</b>	50 minutes	50 minutes	90 minutes	55 minutes
<b>Type D</b>	85 minutes	70 minutes	120 minutes	120 minutes

The data is displayed graphically, along with the four proposed generic fluid groups, in Figure 2.11 to Figure 2.15. These figures show that Kilfrost ABC-S PLUS and Dow Chemical UCAR Endurance EG106 would be qualified as Type B fluids; Clariant Safewing MP IV Launch and Clariant Safewing MP II Flight would be qualified as Type C fluids; and Kilfrost ABC-TF2 would not meet qualification requirements.<sup>2</sup>

<sup>2</sup> The analysis to determine the Type II generic holdover time values also takes “grandfathered” fluids into consideration. Many of the cells in the Type II generic snow column are given by the grandfathered fluids, which have shorter (sometimes significantly) holdover times than all currently qualified fluids. Kilfrost ABC-TF2 was not tested in snow in 2005-06 and therefore was given Type II generic values in the snow column. For this reason, it meets the holdover time requirements of a Type II fluid, but not of the lowest-performing fluid type (Type A) of the fluid groups proposed in this analysis.

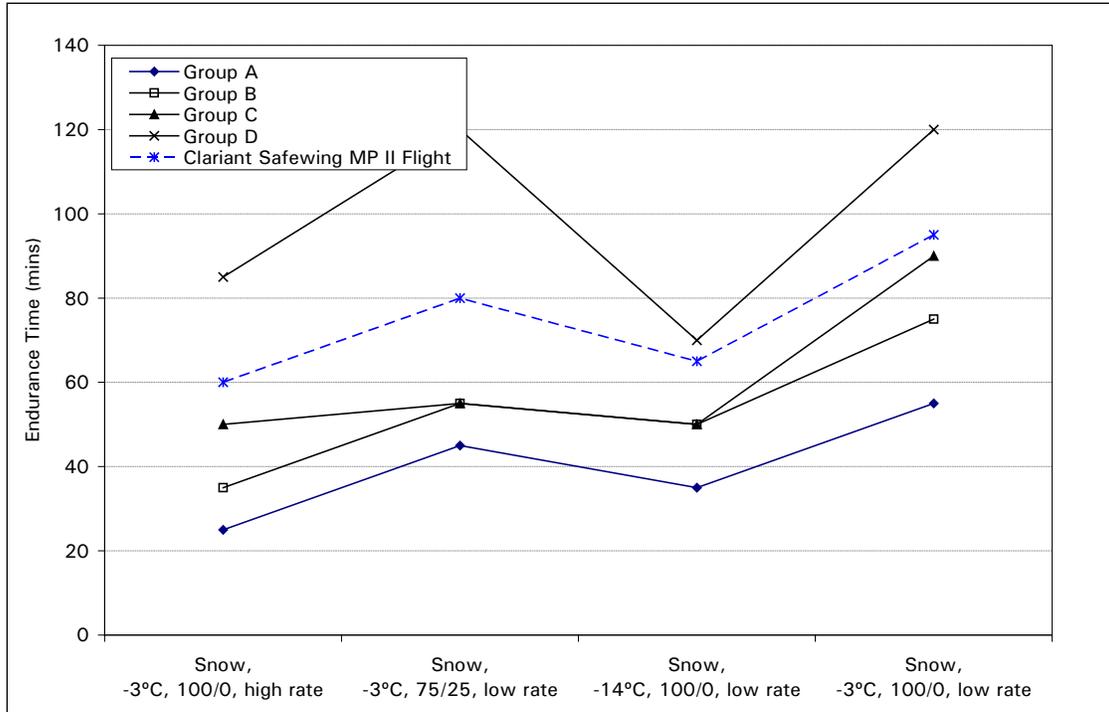


Figure 2.11: Clariant Safewing MP II Flight

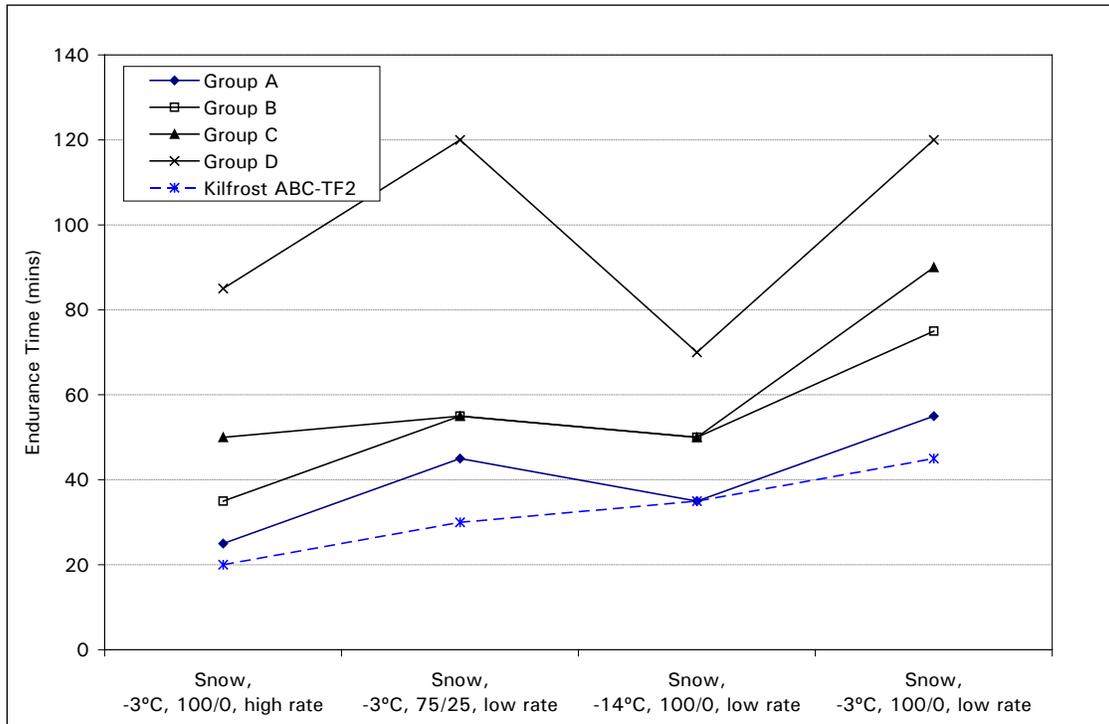


Figure 2.12: Kilfrost ABC-TF2

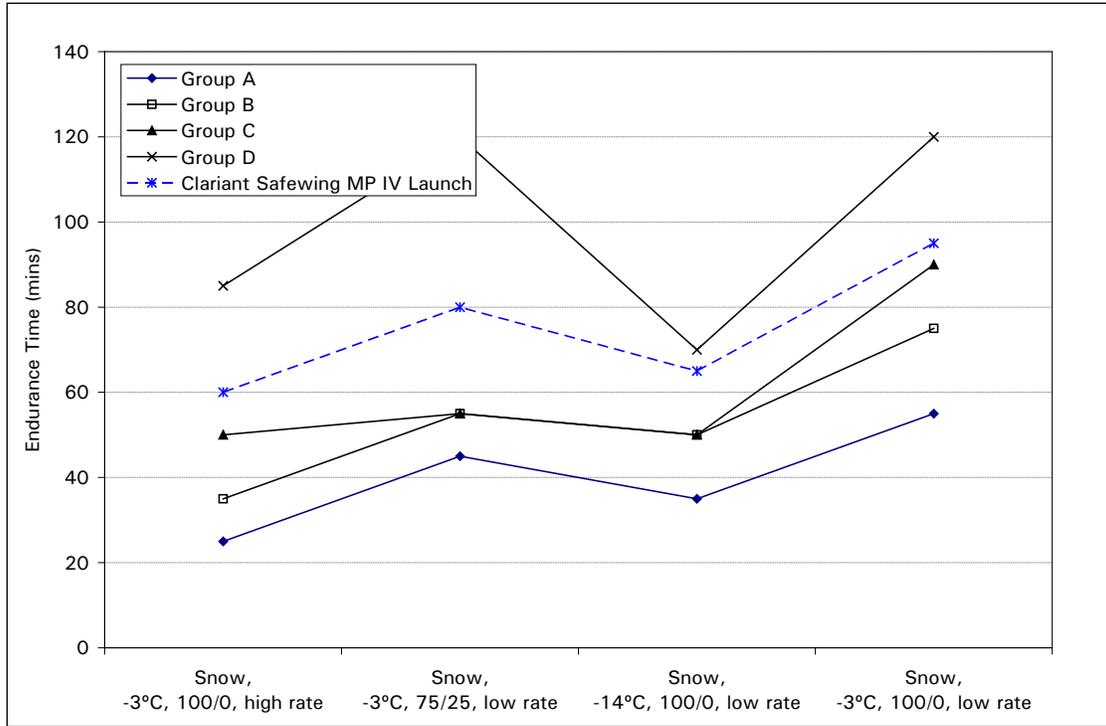


Figure 2.13: Clariant Safewing MP IV Launch

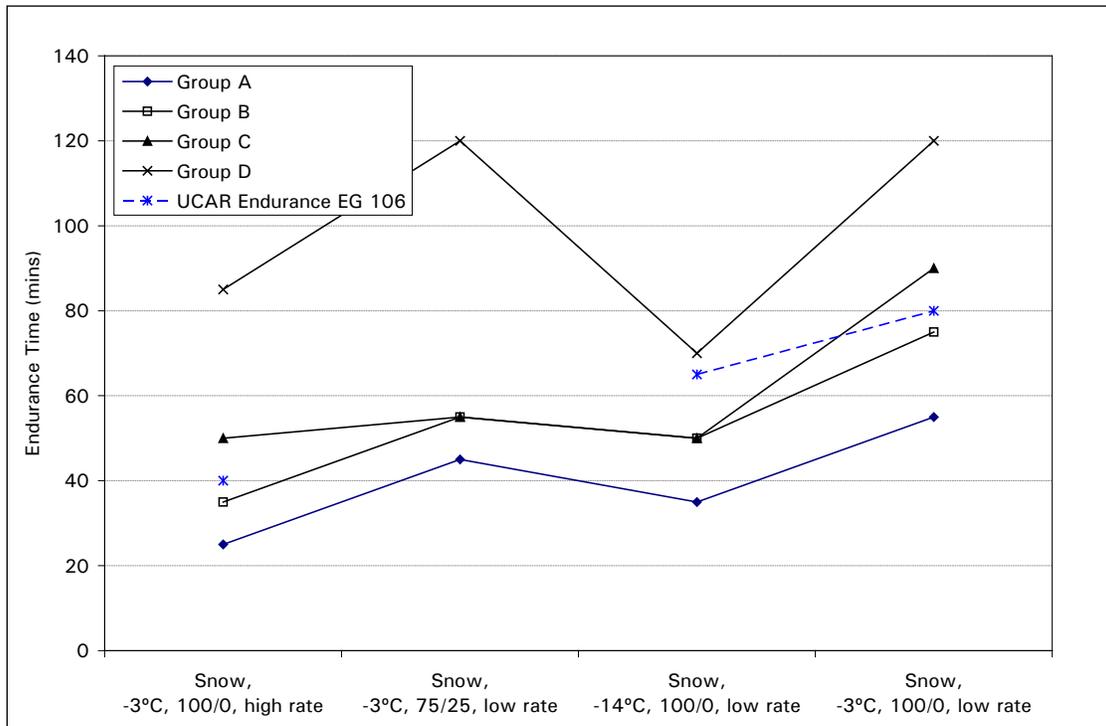


Figure 2.14: Dow Chemical UCAR Endurance EG106

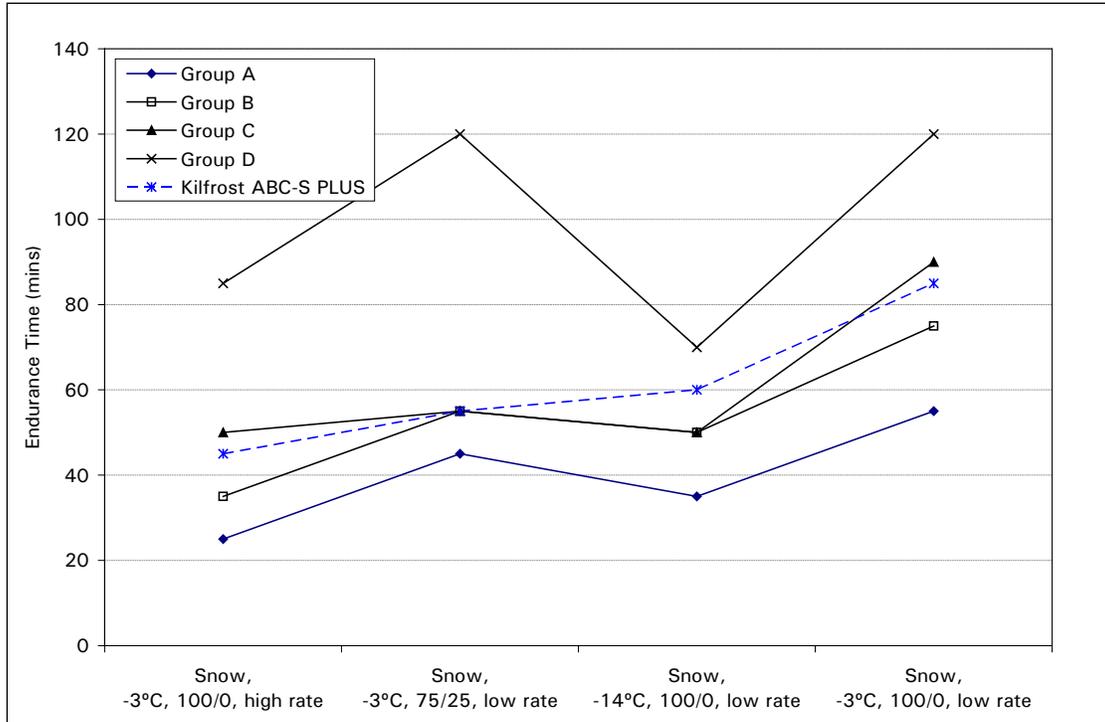


Figure 2.15: Kilfrost ABC-S PLUS

## 2.8 Conclusions and Recommendations

Although the analysis was based on a simplified method and incorporated only four of 54 data cells, these four cells represent 68 percent of usage of the HOT Guidelines. In addition, the methodology used to group the fluids met the project objectives by producing a method by which to reduce the number of HOT Guidelines with a set of successive tables.

However, there are significant disadvantages to using the groupings given in this report to produce new generic tables, including the following:

- The restrictions imposed on the analysis and the differently shaped fluid curves mean that the groups are not the best mathematical summary of the data;
- There are significant losses of holdover time in a number of cells for many fluids;
- Fluid manufacturers and users will be reluctant to accept losses in holdover times; and
- The Aerospace Material Specification (AMS) fluid specifications would need to be changed to reflect new groupings. This would be met with some opposition and would likely take a long time, as it would need to be balloted.

It is therefore recommended that the new generic tables proposed in this report not be implemented and that the current fluid-specific tables continue to exist.

However, it is also recommended that the adequacy of the current Type II/IV fluid classification test should be examined. As snow is the precipitation type under which most de/anti-icing operations occur, a snow endurance time test would be more representative in evaluating fluid performance than the existing WSET. This recommendation would have to be put forward to the community for further discussion and evaluation, as changing the classification system may require the re-classification of existing fluids.

## **2.9 Alternate Approach for Future Consideration**

There are many other approaches that could be taken for completing this analysis. One approach that merits consideration is keeping the fluid-specific tables but inserting generic values in some of the lesser-used cells. This approach would not reduce the number of tables in the HOT Guidelines, but it would reduce the amount of endurance time testing required for new fluids.

Fluid-specific tables would continue to exist; however, generic values would be used in the majority of cells – fluid-specific values would only be used in the cells that have usage of greater than two percent according to the worldwide operations survey.

Table 2.17 shows cell usage by weather condition and fluid dilution (precipitation rate will not be considered, as it would not make sense to have a generic value as the lower/upper value in a cell and a fluid-specific value as the upper/lower value). Cells with usage greater than two percent are shown in bold and include the following:

- All snow cells;
- Freezing drizzle, 100/0, -3°C and above; and
- Freezing rain, 100/0, -3°C and above.

The disadvantage of this method is that there are still many HOT tables. However, there are several major advantages: holdover time is forfeited in only a very small percentage of operations; significant resources will be saved by testing in limited conditions only; and the tables will be simplified because only some of the cells will change from table to table.

The fluid-specific tables included in the 2006-07 HOT Guidelines are shown modified using this approach in Table 2.18 to Table 2.36.

**Table 2.17: Distribution of Anti-Icing Operations by Weather Condition and Fluid Dilution**

Outside Air Temperature		Fluid Conc.	Usage of Cells in Actual Operations <sup>1</sup>						
Degrees Celsius	Degrees Fahrenheit	Fluid/Water	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Freezing Rain	RCSW	Other
-3 and above	27 and above	100/0	-	1.9%	43.4%	2.8%	2.3%	1.2%	CAUTION: No holdover time guidelines exist
		75/25	-	0.4%	8.1%	0.5%	0.4%	0.3%	
		50/50	-	0.1%	2.7%	0.2%	0.1%		
below -3 to -14	below 27 to 7	100/0	-	1.2%	23.1%	1.2%	1.0%		
		75/25	-	0.3%	5.8%	0.3%	0.3%		
below -14 to -25	below 7 to -13	100/0	-	0.0%	2.2%				

<sup>1</sup> Based on the following assumptions.

- 100/0, 75/25, 50/50 dilutions occur with this regularity: 80%, 15%, 5%.
- 100/0, 75/25 dilutions occur with this regularity: 80%, 20%.

**Table 2.18: Alternate Type II Fluid-Specific Table – Clariant Safewing MP II 2025**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:40 – 1:10</b>	<b>0:40 – 1:00</b>	<b>0:25 – 0:35</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:25 – 0:45</b>	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	<b>0:05 – 0:15</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:35 – 1:00</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:25 – 0:45</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.19: Alternate Type II Fluid-Specific Table – Clariant Safewing MP II Flight**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>1:00 – 1:35</b>	<b>1:20 – 2:00</b>	<b>0:45 – 1:25</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:40 – 1:20</b>	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	<b>0:10 – 0:25</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:40 – 1:05</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:20 – 0:40</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.20: Alternate Type II Fluid-Specific Table – Kilfrost ABC 2000**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:30 – 1:00</b>	<b>0:55 – 1:35</b>	<b>0:40 – 0:50</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:30 – 1:05</b>	0:20 – 0:45	0:10 – 0:25		
		50/50	3:00	0:15 – 0:30	<b>0:15 – 0:30</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:25 – 0:45</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:25 – 0:50</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.21: Alternate Type II Fluid-Specific Table – Kilfrost ABC II Plus**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:25 – 0:55</b>	<b>0:35 – 1:10</b>	<b>0:30 – 0:40</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:25 – 0:50</b>	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	<b>0:15 – 0:35</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:15 – 0:35</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:15 – 0:35</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.22: Alternate Type II Fluid-Specific Table – Kilfrost ABC-TF2**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:20 – 0:45</b>	<b>0:40 – 1:20</b>	<b>0:30 – 0:45</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:15 – 0:30</b>	0:20 – 0:45	0:10 – 0:25		
		50/50	3:00	0:15 – 0:30	<b>0:05 – 0:15</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:15 – 0:35</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:15 – 0:25</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.23: Alternate Type II Fluid-Specific Table – Octagon E Max II**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:40 – 1:20</b>	<b>0:45 – 1:35</b>	<b>0:30 – 0:40</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:25 – 0:55</b>	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	3:00	0:15 – 0:30	<b>0:10 – 0:25</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:35 – 1:10</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:25 – 0:50</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.24: Alternate Type II Fluid-Specific Table – SPCA Ecowing 26**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	8:00	0:35 – 1:30	<b>0:40 – 1:00</b>	<b>0:50 – 1:35</b>	<b>0:40 – 0:50</b>	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 – 1:00	<b>0:25 – 0:45</b>	0:20 – 0:45	0:10 – 0:25		
		50/50	3:00	0:15 – 0:30	<b>0:10 – 0:20</b>	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	<b>0:35 – 0:55</b>	0:15 – 0:45	0:10 – 0:25		
		75/25	5:00	0:20 – 0:55	<b>0:25 – 0:40</b>	0:15 – 0:30	0:10 – 0:20		
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.						

**Table 2.25: Alternate Type IV Fluid-Specific Table – Clariant Safewing MP IV 2001**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>1:00 – 1:55</b>	<b>0:55 – 1:55</b>	<b>0:40 – 1:00</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:35 – 1:00</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:10 – 0:20</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:30 – 0:50</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:20 – 0:35</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.26: Alternate Type IV Fluid-Specific Table – Clariant MP IV 2012 Protect**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:40 – 1:15	0:40 – 1:10	0:25 – 0:45	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	0:25 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	0:15 – 0:25	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	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	0:20 – 0:40	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.27: Alternate Type IV Fluid-Specific Table – Clariant MP IV 2030 ECO**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:50 – 1:30	0:55 – 2:00	0:40 – 0:50	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	0:35 – 1:05	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	0:15 – 0:25	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:45 – 1:25	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	0:35 – 1:05	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.28: Alternate Type IV Fluid-Specific Table – Clariant Safewing MP IV Launch**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>1:00 – 1:35</b>	<b>1:30 – 2:00</b>	<b>1:00 – 1:40</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:40 – 1:20</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:10 – 0:25</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:40 – 1:05</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:20 – 0:40</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.29: Alternate Type IV Fluid-Specific Table – Dow Chemical UCAR™ ADF/AAF Ultra +**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:35 – 1:15</b>	<b>0:45 – 1:35</b>	<b>0:25 – 0:40</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:25 – 0:55</b>	0:20 – 0:45	0:10 – 0:25		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:15 – 0:40	<b>0:20 – 0:45</b>				
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.						

**Table 2.30: Alternate Type IV Fluid-Specific Table – Dow Chemical UCAR™ Endurance EG106**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:40 – 1:20</b>	<b>1:10 – 2:00</b>	<b>0:50 – 1:15</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00						
		50/50	3:00						
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:30 – 1:05</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00						
below -14 to -25	below 7 to -13	100/0	12:00	0:15 – 0:40	<b>0:15 – 0:30</b>				
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.						

**Table 2.31: Alternate Type IV Fluid-Specific Table – Kilfrost ABC-S**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>1:00 – 1:40</b>	<b>1:20 – 1:50</b>	<b>1:00 – 1:25</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:30 – 0:55</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:05 – 0:15</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:45 – 1:20</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:25 – 0:50</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.32: Alternate Type IV Fluid-Specific Table – Kilfrost ABC-S PLUS**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:45 – 1:25</b>	<b>1:15 – 1:55</b>	<b>0:50 – 1:10</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:25 – 0:55</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:05 – 0:15</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:35 – 1:00</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:25 – 0:50</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.33: Alternate Type IV Fluid-Specific Table – Octagon Max-Flight**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:50 – 1:35</b>	<b>0:55 – 2:00</b>	<b>0:35 – 1:00</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:45 – 1:45</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:25 – 1:15</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:25 – 0:50</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:20 – 0:50</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.34: Alternate Type IV Fluid-Specific Table – Octagon Max-Flight 04**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>1:25 – 2:00</b>	<b>2:00 – 2:00</b>	<b>1:10 – 1:30</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>1:05 – 2:00</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:25 – 1:15</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:35 – 1:10</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:40 – 1:20</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.35: Alternate Type IV Fluid-Specific Table – Octagon MaxFlo**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:40 – 1:30</b>	<b>1:20 – 2:00</b>	<b>0:30 – 1:00</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:20 – 0:55</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:05 – 0:15</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:25 – 1:00</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:15 – 0:40</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**Table 2.36: Alternate Type IV Fluid-Specific Table – SPCA AD-480**

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	Light Freezing Rain	Rain on Cold-Soaked Wing	Other
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	<b>0:40 – 1:20</b>	<b>0:50 – 1:30</b>	<b>0:35 – 0:55</b>	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	<b>0:30 – 1:05</b>	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	3:00	0:15 – 0:35	<b>0:10 – 0:20</b>	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	<b>0:30 – 0:55</b>	0:20 – 0:45	0:10 – 0:25		
		75/25	5:00	0:25 – 0:50	<b>0:20 – 0:45</b>	0:15 – 0:30	0:10 – 0:20		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

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### 3. VALIDITY OF 75/25 ENDURANCE TIME TEST PROTOCOL

Concerns have arisen that the protocol used to measure endurance times of diluted anti-icing fluids may not produce values consistent with those experienced during actual operations. These concerns have brought into question the validity of the current test protocol for diluted fluids and the accuracy of the diluted fluid values in the holdover time (HOT) Guidelines.

#### 3.1 Background

It has been found that, in general, endurance times decrease when fluid viscosity decreases. Thus, anything that causes a change in the viscosity of a fluid can also change its endurance times.

One variable known to reduce fluid viscosity in propylene glycol (PG)-based fluids is de/anti-icing application equipment. The equipment shears fluid as it is applied to aircraft, causing the applied fluid to become less viscous than the original fluid. As a result, the endurance time of the applied fluid can be shorter than that of the fluid delivered by the manufacturer.

In order to ensure values given in the HOT Guidelines reflect endurance times of applied fluids, fluid samples submitted for holdover time testing are mechanically sheared to reduce fluid viscosity. The method of shearing varies from manufacturer to manufacturer, but the process is the same: manufacturers shear a batch of neat fluid, dilute portions of it to 75/25 and 50/50 (glycol/hard water), and then send samples of all three concentrations to APS Aviation Inc. (APS) for testing.

Until recently, it was thought that this test process adequately replicated the operational process. Although fluid dilution occurs at a different time in the test process than in actual operations — fluid is diluted prior to being sheared in operations and after being sheared in the test process — it was thought not to matter. However, recent research on viscosity and shearing has questioned this assumption.

Research has shown that the more viscous a fluid is, the more susceptible it is to shearing. If two samples of the same fluid, one with a higher viscosity and one with a lower viscosity, are subjected to the same shearing, the higher viscosity fluid will experience a larger percentage decrease in viscosity than the lower viscosity fluid. Many fluids have higher viscosities in 75/25 dilution than in neat dilution. Therefore, if a fluid is sheared after it has been diluted to 75/25, it may experience a higher percentage decrease in viscosity than a fluid sheared in neat dilution and then diluted to 75/25.

Since fluids tested for endurance times are sheared before dilution, and fluids in operations are sheared after dilution, the final viscosities of test fluids may be different than viscosities of fluids applied to aircraft. If test fluid viscosities are lower than operational viscosities, operators may have less holdover time than is indicated in the HOT Guidelines. In this scenario, the test protocol for diluted fluids needs to be evaluated as a potential safety issue exists.

### 3.2 Previous Work

Initial research on this topic was conducted in 2004-05 and is documented in the Transport Canada (TC) report, TP 14451E, *Aircraft Ground Icing General Research Activities During the 2004-05 Winter* (3).

In 2004-05, tests were conducted with two Type IV PG-based fluids: one research fluid and one commercial fluid. The research fluid was put through two processes. The first sample was sheared and then diluted to 75/25. The second sample was diluted to 75/25 and then sheared. The final viscosities of both samples were measured and found to be similar (see Figure 3.1).

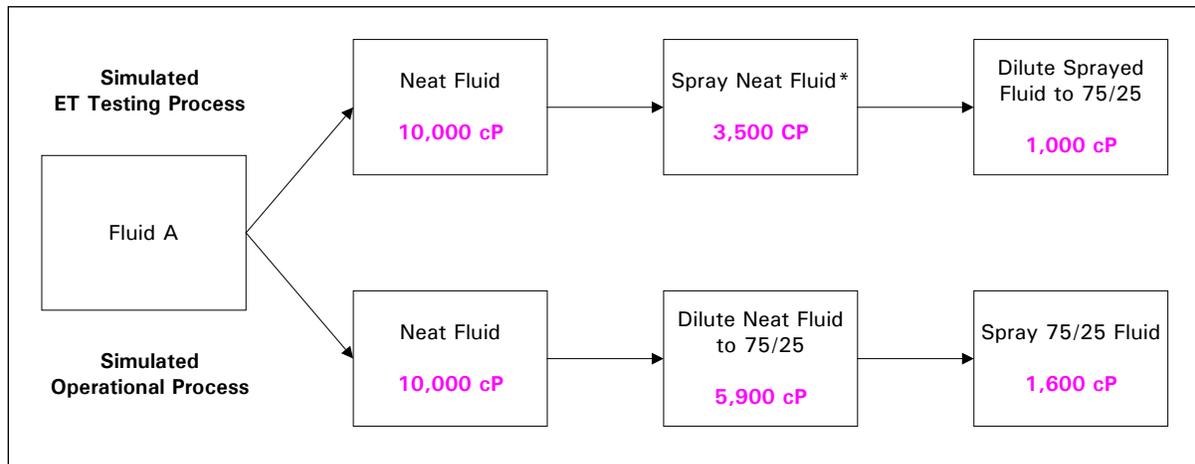


Figure 3.1: 2004-05 Test Results – Research Fluid

The commercial fluid was put through only one process due to a limited amount of fluid being available. A neat sample was diluted and then sheared before having its viscosity measured. The results are shown in Figure 3.2.

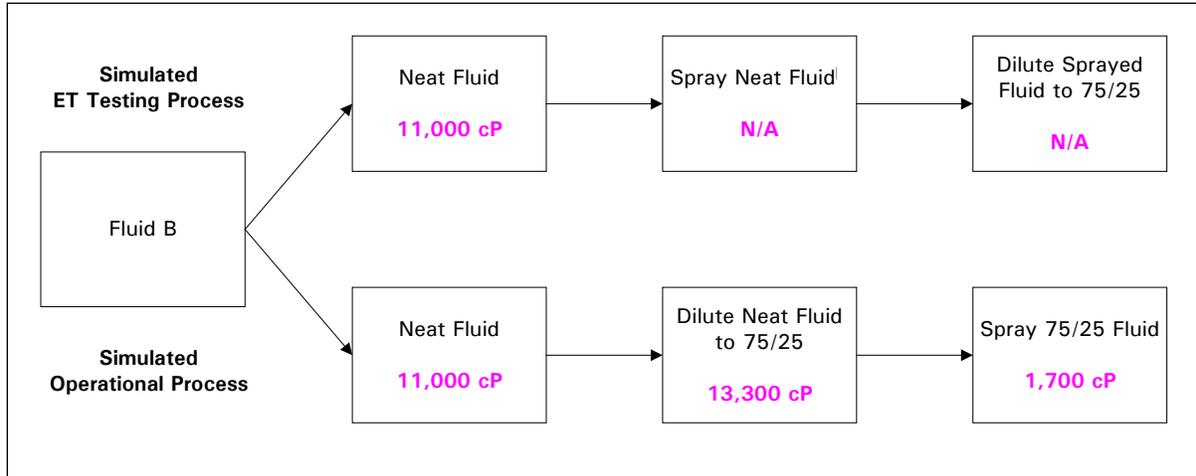


Figure 3.2: 2004-05 Test Results – Commercial Fluid

The conclusion from this testing was that, in the case of the research fluid, operational fluid viscosity is similar to test fluid viscosity. Therefore, operational holdover times are equivalent to those given in the HOT Guidelines, and there is no need to change the endurance time test protocol for diluted fluids.

However, the results from testing with the research fluid could not be generalized to other fluids for the two following reasons:

1. The fluid tested was not qualified; and
2. The fluid tested was less viscous in 75/25 dilution than in 100/0 dilution, and it is hypothesized that a different result would be seen with a fluid more viscous in 75/25 dilution than in 100/0 dilution.

Further research was recommended before general conclusions could be drawn. Specifically, it was recommended that the tests be repeated with a fluid more viscous in 75/25 dilution than in 100/0 dilution.

### 3.3 Objectives

The objectives for research carried out in the winter of 2005-06 were to repeat the tests conducted in 2004-05 with a qualified Type IV PG-based fluid, to determine the validity of the 75/25 endurance time test protocol, and to recommend changes to the protocol if necessary.

### 3.4 Fluids

One Type IV fluid was acquired for testing. The fluid, a PG-based anti-icing fluid, was the commercial fluid tested in the winter of 2004-05 and reported in Figure 3.2. The fluid is more viscous in 75/25 concentration than in 100/0 concentration. To protect the identity of the fluid and the fluid manufacturer, the fluid has been coded and will be referred to as “Fluid B” throughout this report.

### 3.5 Procedure

Tests were conducted using the procedure developed for testing the validity of the 75/25 endurance time test protocol in the winter of 2004-05. A copy of the procedure is included in Appendix C. A summary of the procedure follows.

The Type IV fluid was put through two processes: a simulated operational process and a simulated endurance time test process. The two test processes are illustrated in Figure 3.3.

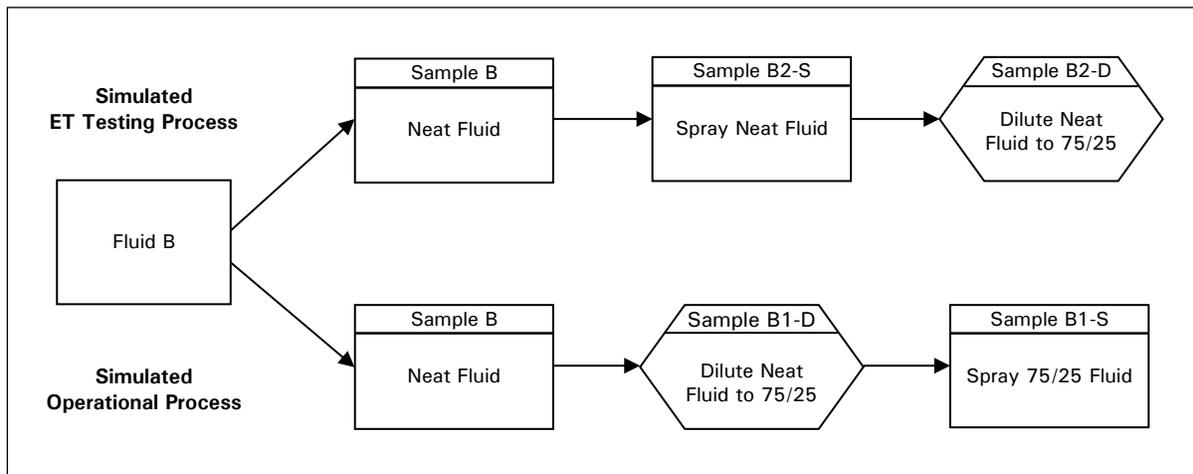


Figure 3.3: Flowchart for Testing

#### 3.5.1 Simulated Operational Process

In the simulated operational process (see lower path in Figure 3.3), neat fluid was diluted to 75/25 and then sprayed onto a JetStar wing using the TC mobile sprayer (see Photo 3.1 to Photo 3.3). The TC mobile sprayer was designed to replicate de/anti-icing equipment used in an operational environment. A sample was then collected from the wing using a squeegee (see Photo 3.4). Care was taken not to shear the fluid during collection. The sample was returned to the APS laboratory for viscosity measurement.

### 3.5.2 Simulated Endurance Time Test Process

In the simulated endurance time test process (see upper path in Figure 3.3), neat fluid was sprayed onto the wing using the TC mobile sprayer. In this process, the sprayer replicated the mechanical shearing that endurance time test samples are subjected to by fluid manufacturers. A sample was collected from the wing and returned to the APS laboratory. Once in the laboratory, the sample was diluted to 75/25 and its viscosity was measured.

### 3.5.3 Viscosity Measurement Procedure

Standard viscosity measurement protocol was followed to measure sample viscosities. The viscosity measurement parameters used for these tests were spindle 34, small sample adaptor (10 mL), 20°C, 0.3 rpm, and 10 minutes.

## 3.6 Test Conditions

Tests were conducted outdoors at the APS test site located at the Montréal–Pierre Elliott Trudeau International Airport (YUL). The tests took place on December 29, 2005. Skies were cloudy and the outside air temperature (OAT) was approximately 0°C.

## 3.7 Data and Analysis

Samples were collected at each step in the test processes. The samples were brought back to the APS laboratory, where their viscosities were measured. The viscosity and Brix measurements of each sample are given in Table 3.1.

**Table 3.1: Viscosity and Brix of Samples**

Sample Code	Sample Description	Viscosity (mPa.s)	Brix (°)
B	Neat	10,400	36.00
B2-S	Neat sprayed	6,400	35.75
B2-D	Neat sprayed, diluted to 75/25	12,200	28.00
B1-D	Diluted (75/25)	15,100	28.50
B1-S	Diluted (75/25), sprayed	5,300	27.25

The results are shown graphically in Figure 3.4. The viscosity of the fluid put through the simulated endurance time testing process was 6,900 mPa.s greater than the fluid put through the simulated endurance time testing process.

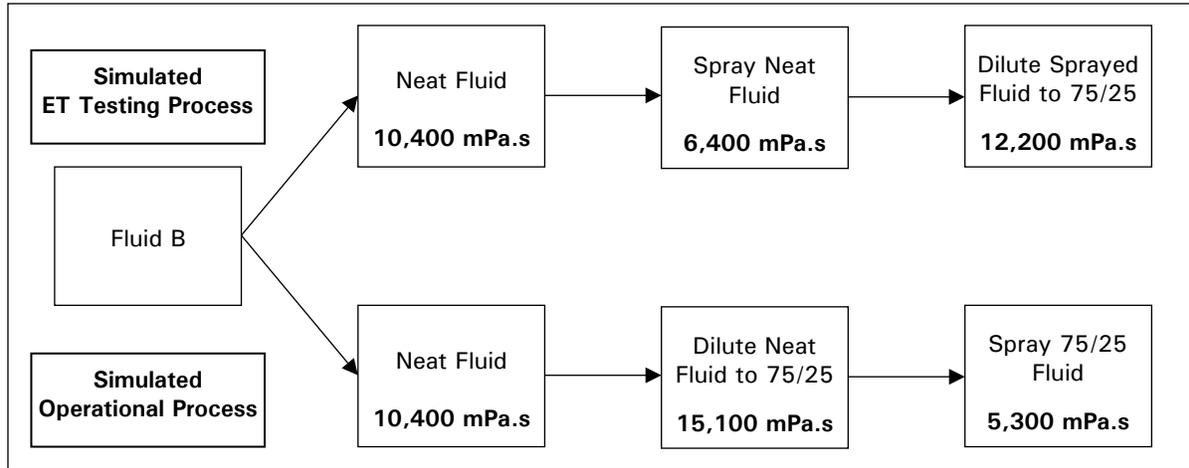


Figure 3.4: 2005-06 Test Results

### 3.7.1 Comparison to 2004-05 Results

Simulated operational process tests were also completed with Fluid B in the winter of 2004-05. No conclusions could be made at that time because simulated endurance time testing process data was not collected. However, the data can now be used to validate the tests conducted with Fluid B in 2005-06. The comparative results are given in Table 3.2.

Table 3.2: Simulated Operational Process Results

Winter	Fluid	Sample Viscosity (mPa.s)		
		Neat Fluid	75/25 Virgin	75/25 Sprayed
2005-06	Fluid B	10,400	15,100	5,300
2004-05	Fluid B	11,000	13,300	1,700

The initial fluid viscosities are similar. The final viscosities, however, differ by 3,600 mPa.s. Although different, both are substantially lower than the final viscosity of the simulated endurance time testing process (12,200 mPa.s), and both lead to the conclusion that subjecting Fluid B to shearing prior to dilution will result in lower on-wing viscosities than shearing it after dilution.

### 3.8 Conclusions

A significant difference was seen in the final viscosity of Fluid B depending on the process that was followed. The final viscosity was significantly lower when the fluid was diluted before it was sheared (operational process) than when it was diluted after it was sheared (testing process). This may have important implications, as endurance times of the fluid used in operations may be shorter than those measured during endurance time testing and given in the HOT Guidelines. If so, the current test protocol may not be valid given that lowest on-wing viscosity (LOWV) values are not given for dilutions in the existing HOT Guidelines.

### 3.9 Recommendations

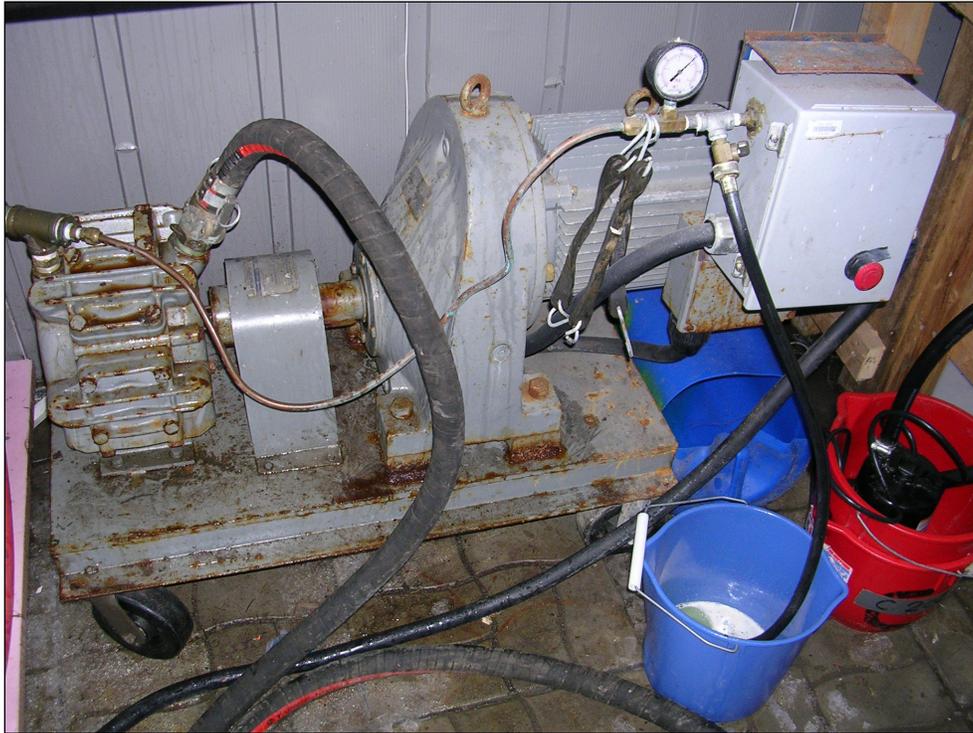
The conclusions indicate that the current dilution test protocol may not be producing holdover times consistent with those experienced in operations. The most obvious solution to this problem is to change the current protocol for diluted fluids. However, changing the protocol would require retesting all 19 fluids currently qualified for use in diluted form, which would require a significant investment of time and resources. As an alternate method of ensuring that operational holdover times for diluted fluids meet the values given in the HOT Guidelines, the below is recommended.

- LOWV values for dilute fluids should be added to the HOT Guidelines. This would ensure fluids with substandard viscosities are not used in operations.
- Fluid manufactures should be asked to provide LOWV values for dilutions of their currently qualified fluids.
- Operators should be made aware of the importance of testing each fluid dilution with individual equipment to ensure the LOWV values are met.

It is suggested that when fluid manufacturers submit fluid samples for holdover time testing in the future, they should dilute and then shear individual samples rather than shearing a large batch of neat fluid and then making dilution samples.

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**Photo 3.1: TC Mobile Sprayer**



**Photo 3.2: TC Mobile Sprayer Nozzle**



**Photo 3.3: Applying Fluid to JetStar Wing Using TC Mobile Sprayer**



**Photo 3.4: Collecting Sample from JetStar Wing**



## 4. ENDURANCE TIMES ON PLATES WITH RESIDUAL ICE

In collaboration with the Federal Aviation Administration (FAA), Transport Canada (TC) has studied human visual and tactile ice detection capabilities under aircraft post-deicing conditions. These tests showed conclusively that, under certain conditions, deicing technicians performing post-deicing inspections cannot detect residual ice underneath deicing fluid on an aircraft wing. It is therefore evident that, in some conditions, aircraft could be anti-iced with cold anti-icing fluid while ice is still present.

### 4.1 Objective

The objective of this project was to investigate how endurance times of anti-icing fluids are affected by the presence of residual ice (i.e., ice inadvertently left on wings after deicing).

### 4.2 Procedure

The detailed test procedure is included in Appendix D. Testing was conducted during two separate snow events. The procedure varied slightly for the two events.

At the first event, two runs (#1 and #2) were conducted:

1. A standard baseline test and a full coverage residual ice test; and
2. A standard baseline test and two residual ice tests (a full coverage plate and a plate with an ice patch of 315 cm<sup>2</sup>).

At the second event, one run (#3) was conducted:

3. A standard baseline test and two residual ice tests (a full coverage plate and a plate with an ice patch of 315 cm<sup>2</sup>).

Initial ice thickness for all runs was between 0.5 mm and 0.7 mm.

### 4.3 Data

Data was collected during two snow events: January 5 and January 9, 2006.

The first two runs took place on January 5, 2006, at an outside air temperature (OAT) of -3°C. The fluid tested was Clariant Safewing MP II 2025, which is a propylene glycol (PG)-based Type II fluid. It has a holdover time greater than 70 minutes in this condition (based on a rate of 10 g/dm<sup>2</sup>/h).

The third run took place on January 9, 2006, at an OAT of -3°C. The fluid tested was Dow Chemical UCAR Ultra+, which is an ethylene glycol (EG)-based Type IV fluid. It has a holdover time between 35 and 75 minutes in this condition (based on rates between 10 and 25 g/dm<sup>2</sup>/h).

In each of the runs, fluid was applied to both a baseline plate with no ice and a plate fully covered in ice. In the second and third runs, fluid was also applied to a third plate, which was partially covered in ice. This plate had an ice patch of 315 cm<sup>2</sup>.

The test data is shown in Table 4.1.

**Table 4.1: Residual Ice Data**

		Ice on Plate		
		No Ice (Baseline)	Full Coverage	315 cm <sup>2</sup>
Run 1	Endurance Time	DNF (140 min)*	18.5 min	-
	Fluid Thickness at 21 Minutes	0.7 mm	No fluid	-
	Average Rate	1.5 g/dm <sup>2</sup> /h	3.4 g/dm <sup>2</sup> /h	-
Run 2	Endurance Time	DNF (80 min)*	20 min	DNF (80 min)*
	Fluid Thickness at 6 Minutes	1.0 mm	0.5 mm	1.0 mm
	Fluid Thickness at 20 Minutes	0.6 mm	No fluid	0.6 mm
	Average Rate	0.6 g/dm <sup>2</sup> /h	0.8 g/dm <sup>2</sup> /h	0.6 g/dm <sup>2</sup> /h
Run 3	Endurance Time	DNF (100 min)*	7 min	11 min
	Average Rate	7.7 g/dm <sup>2</sup> /h	9.4 g/dm <sup>2</sup> /h	9.2 g/dm <sup>2</sup> /h

\*DNF (xx min) = the fluid had not failed when the test was stopped after the time indicated in parentheses.

#### 4.4 Analysis and Observations

In Run 1, the plate fully covered in ice failed after 18.5 minutes. The baseline plate lasted significantly longer: 140 minutes. A partially covered plate was not tested in Run 1.

In Run 2, fluid failure on the full coverage plate occurred 20 minutes after application. At that time, the standard plate was not close to failure. The partially covered plate was close to failure; however, the test was stopped due to a diminishing rate of precipitation. The endurance time of the fluid was significantly lower with the presence of residual ice.

In Run 3, the full coverage plate failed after 7 minutes, and the partially covered plate failed after 11 minutes. It was speculated that this was due to a fluid feed from the upper portions of the test plate. The standard plate had not failed when the test was stopped after 100 minutes due to a lack of snow.

Photo 4.1 was taken of Run 3 at 10 minutes after fluid application. The left plate is the baseline plate, the middle plate is the partially covered plate, and the right plate is the fully covered plate. The photo clearly shows that the two plates with residual ice have greatly diminished in fluid thickness.

Photo 4.2 was taken 7 minutes later (at 17 minutes after fluid application) and shows further contamination on the residual ice plates.

Close observation of the photos shows that the condition of the plates with residual ice is "rough." Furthermore, Photo 4.2 shows that the "rough" area on the partially covered plate (the middle plate) is larger (see bottom of plate) than the 315 cm<sup>2</sup> of ice that it began with.

## **4.5 Conclusions**

Preliminary testing suggests that endurance times of anti-icing fluids are reduced by the presence of residual ice. This is likely due to the reduced thickness of fluid on ice-covered surfaces, which is a result of the smoothness of an icy surface.

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**Photo 4.1: Run 3 – Test Plates 10 Minutes After Application**



**Photo 4.2: Run 3 – Test Plates 17 Minutes After Application**



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## 5. TACTILE INSPECTION OF ICE WITH THE USE OF GLOVES

In collaboration with the Federal Aviation Administration (FAA), Transport Canada (TC) is studying human visual and tactile capabilities to detect ice under aircraft post-deicing conditions.

### 5.1 Background

In 2004-05, testing was performed to evaluate human visual and tactile ability to detect ice on wings. Tests were conducted in a cold chamber using a procedure in which two samples, one with ice and one without ice, were presented to a group of participants. The participants were asked to indicate on which of the two samples they could detect ice. To evaluate tactile ability, participants were blindfolded while they completed the task. While blindfolded, participants were able to detect ice of any thickness on aluminum plates almost without error. This work is documented in the TC report, TP 14449E, *Development of Ice Samples for Visual and Tactile Ice Detection Capability Tests* (4).

In 2005-06, it was hypothesized that tactile ability to detect ice may be influenced by the type of glove that is worn. Since only one glove type was used in the 2004-05 tactile testing but many glove types are used in the field, further tests were recommended to determine if glove type can influence tactile ability to detect ice.

### 5.2 Objective

The objective of testing in 2005-06 was to investigate if wearing different types of gloves influences the ability to detect ice. Five sets of commercially available gloves were tested. Funding for this project was limited; therefore, only a preliminary investigation with very limited tests was completed.

### 5.3 Description of Gloves

Five sets of commercially available gloves were selected for the study based on their variability in materials. Details of the gloves are given in Table 5.1. Photos of the gloves are provided at the end of this section (see Photo 5.1 to Photo 5.5).

**Table 5.1: Description of Gloves**

Glove Number	Manufacturer	Glove Type	Product Number	Description
1	Midwest Glove Company®	Red PVC Coated	710	<ul style="list-style-type: none"> <li>• Red PVC coated</li> <li>• Cotton jersey lining</li> <li>• Smooth non-slip finish</li> <li>• Wing thumb and knit cuff</li> </ul>
2	Horizon®	Acrylic Pile Lining	757 006K	<ul style="list-style-type: none"> <li>• Acrylic pile lining</li> <li>• Knitted acrylic fabric lining</li> <li>• Lofted similar to natural sheared wool</li> <li>• Outside: 55% nitrile, 45% cotton</li> </ul>
3	Horizon®	Rubber Palm Work Glove	75R26YPC	<ul style="list-style-type: none"> <li>• Lining: 40% cotton</li> <li>• Outside: 60% rubber</li> </ul>
4	Horizon®	Lined Acrylic	CA07695 RN83575	<ul style="list-style-type: none"> <li>• Lofted similar to wool</li> <li>• Outside: 70% cowhide, 30% cotton</li> </ul>
5	Horizon®	Liquid Protection Glove	754056	<ul style="list-style-type: none"> <li>• Outside: 80% polyvinyl, 20% cotton</li> </ul>

## 5.4 Procedure

The detailed test procedure is included in Appendix E. Testing was completed on two occasions: a dry run was conducted on February 17, 2006, and a run with fluid was conducted on February 23, 2006.

### 5.4.1 Occasion 1 (Dry Run)

Two standard aluminum test plates were used in these tests. The first plate was left untouched to simulate a bare wing surface free of any contamination. The second plate was treated with approximately 0.6 mm of ice to simulate a thin layer of contamination on the wing surface.

Three candidates were blindfolded and, using a “forced-choice” methodology, were asked to indicate on which of the two plates they could detect ice. The test was repeated five times, with the candidates wearing a different type of glove each time. The testing is shown in Photo 5.6.

### 5.4.2 Occasion 2 (With Fluid)

The procedure used on the second occasion was the same as the one used on the first occasion. However, on this occasion, fluid was applied to both the uncontaminated and contaminated test plates to simulate the possibility of ice being present after fluid application.

### 5.4.3 Test Location

Tests were conducted inside a refrigerated truck located at the APS Aviation Inc. (APS) test site at the Montréal–Pierre Elliott Trudeau International Airport (YUL). The refrigerated truck was cooled to  $-4^{\circ}\text{C}$  on the first occasion and  $-5^{\circ}\text{C}$  on the second occasion.

### 5.4.4 Data Form

One data form was required for the tests. It is included in the test procedure in Appendix E.

### 5.4.5 Description of Candidates

APS personnel were used as candidates in this study. On the first occasion, two research assistants (Candidates 1 and 2) and a photographer (Candidate 3) participated. The research assistants, while knowledgeable about endurance time testing and fluid failure, had not previously attempted to tactilely detect ice on aircraft or aluminum test plates. The photographer had never actively participated in endurance time or ice detection testing.

On the second occasion, two research assistants, one who participated in the first occasion and one who did not, and a manager were the candidates. The manager had over 10 years of experience in endurance time testing but had not previously attempted to detect ice while blindfolded.

## 5.5 Data and Observations

All subjects were able to detect which plates were contaminated with ice on both occasions. Table 5.2 details the test results.

**Table 5.2: Results of Gloves Testing**

		ABILITY TO DETECT ICE (YES/NO)				
		Glove #1	Glove #2	Glove #3	Glove #4	Glove #5
<b>Occasion 1 (Dry Run)</b>	<b>Candidate 1</b>	Yes	Yes	Yes	Yes	Yes
	<b>Candidate 2</b>	Yes	Yes	Yes	Yes	Yes
	<b>Candidate 3</b>	Yes	Yes	Yes	Yes	Yes
<b>Occasion 2 (With Fluid)</b>	<b>Candidate 1</b>	Yes	Yes	Yes	Yes	Yes
	<b>Candidate 4</b>	Yes	Yes	Yes	Yes	Yes
	<b>Candidate 5</b>	Yes	Yes	Yes	Yes	Yes

## 5.6 Conclusions and Recommendations

The results of these preliminary tests indicate that ice can be detected using any type of glove. If the use of gloves is mandated due to health and safety concerns, further testing would be merited and should be done on a larger scale. If this is the case, it is recommended that, prior to any further testing being carried out, an investigation into the test methodology be completed to ascertain the best method of evaluating true human ability.

One methodology that may give more realistic results is to provide candidates with samples one at a time. Contaminated and uncontaminated samples would be presented randomly. This would eliminate the forced-choice aspect of the 2005-06 methodology and may reduce candidates' ability to make correct guesses.

Photo 5.1: Glove #1 – Midwest Glove Company® Red PVC Coated Glove



Photo 5.2: Glove #2 – Horizon® Acrylic Glove



Photo 5.3: Glove #3 – Horizon® Rubber Palm Work Glove



Photo 5.4: Glove #4 – Horizon® Lined Acrylic Glove



Photo 5.5: Glove #5 – Horizon® Liquid Protection Glove



Photo 5.6: Dry Run Testing



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## 6. SUPPORT FOR DEVELOPMENT OF SAE AS5681

Human factor tests, documented in the Federal Aviation Administration (FAA) report, DOT/FAA/TC-06/21, *Human Visual and Tactile Ice Detection Capabilities under Aircraft Post Deicing Conditions* (5), have demonstrated that the ability to detect ice can be somewhat difficult with both visual and tactile detection. It has been determined that, under certain circumstances, remote on-ground ice detection systems (ROGIDS) can be more reliable than human visual or tactile ice detection.

The proposed Society of Automotive Engineers (SAE) Aerospace Standard (AS) 5681 specifies the minimum performance requirements of ROGIDS. As a ground-based system, the main objective of ROGIDS is to allow flight crews and deicing technicians to determine whether frozen contamination is present on aircraft surfaces. Therefore, ROGIDS are intended to be used during aircraft ground operations to provide information about the condition of the monitored aircraft surfaces.

In collaboration with regulatory authorities, APS Aviation Inc. (APS) is supporting the development of AS5681 by providing expert opinion and clerical support for the development of this standard.

### 6.1 Development of Standard

APS has been an ongoing contributor to the development of AS5681 through continued support at all industry meetings. Below is a list of the relevant meetings.

- Pre-Meeting: *Fall 2005, Atlantic City, Regulatory Approval Working Group Meeting*: Decision made to set up a focus group to revise AS5116B (now AS5681) to incorporate findings from recent human factors research (see DOT/FAA/TC-06/21 [5]).
- Meeting 1: *March 28-30, 2006, Montreal*: Updated previous specifications from Section 1 to the beginning of Section 6.
- Meeting 2: *April 25-27, 2006, Montreal*: Continued development of Section 6 and development of tests to be conducted (Appendix A).
- Meeting 3: *May 21-25, 2006, Lisbon, SAE G-12 Aircraft Ground Deicing Committee Meetings*: No progress on document. Discussions focused on ice detection in general for the SAE G-12 committee.
- Meeting 4: *June 20-22, 2006, Ottawa*: Further development of Section 6.
- Meeting 5: *October 2-5, 2006, Atlantic City*: Next planned meeting.

## 6.2 Current Version of Standard

The July 2006 version of the ROGIDS standard, which has been formatted by APS, is included for reference purposes in Appendix F.

## 7. HOLDOVER TIME GUIDELINES WEBSITE

### 7.1 Background

The development and use of holdover time (HOT) tables have made 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 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:

1. The Transport Canada Civil Aviation (TCCA) Commercial and Business Aviation Advisory Circular (CBAAC) document;
2. The TCCA website; and
3. 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. The formatting of website contents in different computer languages can easily lead to errors in content and format. Translations 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 in order 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.

### 7.2 Changes to the Website

Each July since 2003, APS has published the HOT Guidelines for the upcoming winter on the website. In July 2006, the 2006-07 HOT Guidelines were published on the website and replaced the 2005-06 HOT Guidelines, which were archived on the site. Appendix G contains the 2006-07 HOT Guidelines as they appear in English on the website. As has been done in other 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 14712E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2005-06 Winter* (6).

The changes made to the 2006-07 HOT Guidelines include the following:

- Addition of three new Type IV fluids: Clariant Safewing MP IV Launch, Dow Chemical UCAR Endurance EG106, and Kilfrost ABC-S PLUS; and
- Addition of two new Type II fluids: Clariant Safewing MP II Flight and Kilfrost ABC-TF2.

In order for the changes to be approved, APS is required to obtain approval from both TC and the TDC. Figure 7.1 shows the form used for this purpose.

### **7.3 Future Responsibilities**

APS has undertaken the responsibility to ensure that the website is operational, in terms of Internet availability, for a one-year period. In the summer of 2007, APS intends to update the website with new data from Winter 2006-07 testing and publish the 2007-08 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: _____
Barry Myers Senior Development Officer Transportation Development Centre	Douglas Ingold Specialist Flight Technical 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/Nicoara Moc)
3. APS will acquire the necessary signatures or email confirmations
4. APS will submit changes to its IT department after approval is received<sup>1</sup>

<sup>1</sup> The website files are located on a secure server with restricted access. This access is limited to the APS IT department.

**Figure 7.1: HOT Guideline Change Form**

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## 8. 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 2005-06.

### 8.1 Procedures

Several procedures were developed to guide and support the research team in the methodology for conducting tests. Table 8.1 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.

### 8.2 Presentations

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

In 2005-06, the following meetings were held:

1. Standing Committee Meeting, Ottawa, Canada, September 2005;
2. DND Icing Operations Standing Committee Meeting, Ottawa, Canada, October 2005;
3. SAE G-12 HOT Subcommittee and HOT Working Group Meetings, Montreal, Canada, November 2005; and
4. SAE G-12 HOT Subcommittee and FAA/TC Pre-HOT Meetings, Lisbon, Portugal, May 2006.

The presentations given by APS at each of these meetings are listed in the following subsections. Copies of the presentations are contained in Appendix H.

### **8.2.1 Standing Committee Meeting, Ottawa, Canada, September 2005**

One presentation was prepared for the Standing Committee for Operations Under Icing Conditions meeting held in Ottawa on September 21, 2005:

1. Aircraft De/Anti-Icing Fluid Holdover Time Update for the 2005-06 Season.

### **8.2.2 DND Icing Operations Standing Committee Meeting, Ottawa, Canada, October 2005**

One presentation was prepared for the DND Icing Operations Standing Committee meeting held in Ottawa on October 12, 2005:

1. Testing of Aircraft Ground De/Anti-Icing Fluids.

### **8.2.3 SAE G-12 HOT Subcommittee and HOT Working Group Meetings, Montreal, Canada, November 2005**

Two presentations were prepared for the SAE G-12 HOT Subcommittee and HOT Working Group meetings held in Montreal on November 3, 2005:

1. Holdover Time Table Format Changes; and
2. Endurance Time Testing in Simulated Ice Pellet Conditions.

### **8.2.4 SAE G-12 HOT Subcommittee and FAA/TC Pre-HOT Meetings, Lisbon, Portugal, May 2006**

A total of 10 presentations were prepared for the SAE G-12 HOT Subcommittee and FAA/TC Pre-HOT meetings held in Lisbon from May 22 to May 24, 2006. The meeting(s) at which each presentation was made are noted in parentheses:

1. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type I (Pre-HOT and HOT Subcommittee);
2. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type II (Pre-HOT and HOT Subcommittee);
3. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type III (Pre-HOT and HOT Subcommittee);
4. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type IV (Pre-HOT and HOT Subcommittee);

5. Aircraft Deicing Research in Simulated Ice Pellet Conditions (Pre-HOT and HOT Subcommittee);
6. Results from Testing of Fluid Freeze Point Buffer – SAE Type I Fluids in a First-Step Deicing Application (Pre-HOT);
7. Aircraft Ground Deicing Fluid Endurance Times in Snow Pellet Conditions (Pre-HOT);
8. Preliminary Aircraft Ground Deicing Research Using Composite Materials (Pre-HOT);
9. Holdover Times for Heavy Snow (Pre-HOT and HOT Subcommittee); and
10. Development of Holdover Time Determination Systems (Pre-HOT and HOT Subcommittee).

### **8.3 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 2005-06, seven fluids were tested. APS prepared a report for each fluid and provided these reports directly to the fluid manufacturers. Reports were prepared for the following:

- Battelle D3: Degradable by Design Deicer™ 1006A (Type I);
- Clariant Safewing MP II Flight (Type II);
- Clariant Safewing MP IV Launch (Type IV);
- Dow Chemical UCAR Endurance EG106 (Type IV);
- Kilfrost ABC-S PLUS (Type IV);
- Kilfrost ABC-TF2 (Type II); and
- Kilfrost P1792-1 (Type II).

The reports for the fluids that are expected to be qualified (six of the seven) have also been included as appendices to TP 14712E (6).

**Table 8.1: List of Procedures for Winter 2005-06**

Program Element #	ID#	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
1.0	1.1	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Simulated Freezing Precipitation Flat Plate Testing	15-Jan-04	1.0	HOT
1.0	1.2	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing	23-Dec-04	1.0	HOT
1.0	1.3	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Overall Program of Tests at NRC, April 2006	31-Mar-06	1.0	HOT
1.0	1.4	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval	27-Feb-06	1.0	HOT
1.0	1.5	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Additional Program of Tests at NRC, April 2006	24-Apr-06	1.0	HOT
2.0	2.1	Endurance Time Testing in Frost	Exp. Program – Endurance Time Testing in Frost with Type I, II, III, and IV Fluids	13-Nov-03	1.0	Frost
3.0	3.1	Endurance Time Testing of Non-Aluminum Plates	Indoor Endurance Time Testing on Non-Aluminum Plates	28-Mar-06	1.0	Composite
3.0	3.2	Endurance Time Testing of Non-Aluminum Plates	Outdoor Endurance Time Testing on Non-Aluminum Plates	13-Jan-06	1.0	Composite
4.0	4.1	Effect of Heat on Neat and Diluted Type II/IV Endurance Times	JetStar Test Wing Type II/III/IV Leading Edge Temperature Profiles	1-Nov-05	1.0	Heat
4.0	4.2	Effect of Heat on Neat and Diluted Type II/IV Endurance Times	Effect of Heat on Endurance Times of Anti-Icing Fluids	4-Nov-05	1.0	Heat
5.0	5.1	Inclusion of Ice Pellets in HOT Guidelines	Endurance Time Testing in Natural Ice Pellets	19-Dec-05	1.0	Ice Pellets
5.0	5.3	Inclusion of Ice Pellets in HOT Guidelines	Video Documentation of Pilot’s Perspective in Ice Pellets	12-Dec-05	1.0	Ice Pellets
5.0	5.4	Inclusion of Ice Pellets in HOT Guidelines	Photography of Ice Pellets on Black Felt	22-Dec-05	3.0	Ice Pellets

**Table 8.1: List of Procedures for Winter 2005-06 (cont'd)**

Program Element #	ID#	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
5.0	5.5	Inclusion of Ice Pellets in HOT Guidelines	Adhesion of Type II/III/IV Fluids in Ice Pellets	23-Jan-06	1.1	Ice Pellets
5.0	5.6	Inclusion of Ice Pellets in HOT Guidelines	Documentation of Falcon 20 Pilot's Perspective in Simulated Ice Pellets	20-Feb-06	1.0	Ice Pellets
6.0	6.1	Validity of 75/25 Hot Test Protocol (Spraying vs. Pouring)	Comparison of Viscosities of Diluted Fluids (75/25) Before and After Spraying	21-Mar-06	1.0	General and Exploratory
7.0	7.1	Study of -3°C Buffer on the First Step Application	Comparison of Negative 3°C Buffer to 0°C and +10°C Buffer Type I	15-Dec-05	1.0	-3°C Buffer
12.0	12.3	Standards for Measuring HOTs	Fluid Endurance Time Testing with Artificial Snow	13-Feb-06	1.0	NCAR
17.0	17.1	Flows of Contaminated Fluid from Aircraft Wings During Takeoff	Falcon 20 Trials to Examine Fluid Removed from Aircraft During Takeoff with Ice Pellets	13-Mar-06	3.0	Falcon 20
17.0	17.2	Flows of Contaminated Fluid from Aircraft Wings During Takeoff	Wind Tunnel Tests to Examine Fluid Removed from Aircraft During Takeoff with Ice Pellets	14-Mar-06	1.0	Falcon 20
17.0	17.3	Flows of Contaminated Fluid from Aircraft Wings During Takeoff	Photo Documentation of Falcon 20 Pilot's Perspective in Simulated Ice Pellets	20-Feb-06	1.0	Ice Pellets
18.0	18.1	Continuation of Human Factor Tactile Tests: Field Validation & Protocol & Standard for Tactile Method	Preliminary Tactile Testing for Use of Gloves	12-Jan-05	1.0	General and Exploratory
18.0	18.2	Continuation of Human Factor Tactile Tests: Field Validation & Protocol & Standard for Tactile Method	Endurance Times for Plates with Residual Ice	22-Dec-05	2.0	General and Exploratory
20.0	20.1	Video Documentation of Frost Formations, Ice Pellets, and Snow	Photographic Documentation of Frost Formations	See TP 14452E – Appendix B		General and Exploratory
20.0	20.2	Video Documentation of Frost Formations, Ice Pellets, and Snow	Melting Time Indoors; Video Documentation of Simulated Snow and Ice Pellets Melting in Fluid	12-Dec-05	1.0	Ice Pellets
20.0	20.3	Video Documentation of Frost Formations, Ice Pellets, and Snow	Melting Time Outdoors: Video Documentation of Simulated Snow and Ice Pellets Dissolving in Fluid	13-Dec-05	1.0	Ice Pellets

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## REFERENCES

1. Campbell, R., Chaput, M., *Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2001, TP 13826E, 250.
2. Moc, N., *Winter Weather Impact on Holdover Time Table Format (1995-2004)*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2004, TP 14375E, 68.
3. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2004-05 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2005, TP 14451E, XX (to be published).
4. Moc, M., *Development of Ice Samples for Visual and Tactile Ice Detection Capability Tests*, APS Aviation Inc., Transportation Development Centre, Montreal, September 2005, TP 14449E, 46.
5. Bender, K., D'Avirro, J., Eyre, F., Marcil, I., Pugacz, E., Sierra Jr., E. A., *Human Visual and Tactile Ice Detection Capabilities under Aircraft Post Deicing Conditions*, FAA, February 2006, DOT/FAA/TC-06/21, 113. Retrieved from <http://www.tc.faa.gov/its/worldpac/techrpt/tc06-21.pdf>.
6. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2005-06 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2006, TP 14712E, 62.

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**APPENDIX A**

**TRANSPORTATION DEVELOPMENT CENTRE  
WORK STATEMENT EXCERPT:  
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2005-06**



**TRANSPORTATION DEVELOPMENT CENTRE  
WORK STATEMENT EXCERPT:  
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2005-06**

**5.2 FLUID PERFORMANCE RESEARCH**

**5.2.6 Validity of 75/25 HOT Test Protocol (Spraying vs. Pouring)**

- a) Acquire the appropriate fluids for testing;
- b) Review procedure developed for testing in 2004-05;
- c) Conduct tests at the Dorval test site;
- d) Analyse results; and
- e) Report findings to TC/FAA.

**5.2.10 HOT Table Guidelines; a Future Perspective**

- a) Review the previous report TP 13826E and current HOT table usage data;
- b) Develop potential scenarios for the new HOT tables; and
- c) Prepare a report.

**5.2.11 SAE Standards for Measuring Holdover Times**

- a) Provide support to modifying and updating the SAE Aerospace Recommended Practice (ARP) 5485;
- b) Further develop, advance and ballot the new SAE ARP5945 for Type I fluids;
- c) Develop or acquire viscosities for Clariant Type III, Clariant 1951, and Kilfrost ABC-3, and for the dilutions of all other fluids. Provide this information to FAA and TC for their consideration for inclusion in the table of viscosities;
- d) Prepare presentation of all changes agreed upon by the HOT Working Group meeting and deliver at the next SAE G-12 HOT Subcommittee meeting;
- e) 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;
- f) Support the development of the inclusion of results from compatibility and environmental tests of Aerospace Material Specification (AMS) 1424 and AMS1428 in the TC/FAA list of approved fluids;

- g) Support activities of SAE G-12 Field Viscosity Working Group; and
- h) Support round robin testing of new viscometer with all certified fluids to ensure safe levels.

## 5.5 SENSORS RESEARCH

### 5.5.1 Support for Human Factor Tactile Tests, and for Means of Implementing Changes Arising from Test Findings

- a) Participate in the activities of the SAE G-12 Subcommittee for Ice Detection, the SAE Regulatory Approval Process Working Group, and the TC "Ground Ice Detection System (GIDS) Implementation Team" (Ref: RDIMS 554519v5) including:
  - i. Address the issue of the visual threshold for detection of frozen contamination on aircraft surfaces;
  - ii. Address the issue of the comparative capabilities of human visual inspection and remote sensor inspection for the detection of frozen contamination on aircraft surfaces;
  - iii. Report on the conduct of tests at the PMG cold chambers during 2005 to examine human visual capabilities and remote sensor capabilities for the detection of frozen contamination on aircraft surfaces. Draw conclusions and develop recommendations as to the suitability of remote sensors to support or replace human inspection of aircraft surfaces immediately following deicing;
  - iv. Review Remote GIDS reliability issues including implications of Transport Canada Hardware and Software Issue papers;
  - v. Chair the SAE Ice Detection Subcommittee Working Group to develop a Standard for Remote On-Ground Ground Ice Detection Sensors (RGIDS);
  - vi. Prepare and coordinate an updated draft Standard for On-Board Aircraft Point and Remote Ground Ice Detection Systems (OGIDS). Coordinate with EUROCAE activities; and
  - vii. Conduct tests to evaluate the effect that residual ice has on the endurance of deicing fluids. Investigate human ice detection by surveying the effectiveness of different types of operator's gloves that can be used in industry. As part of ongoing education, participate in many pertinent human factor conferences, SAE tactile workgroups and meetings.

## 5.7 RESEARCH INFORMATION DISSEMINATION

### 5.7.1 Provision of Support Services and other Activities

- a) Provide support services to assist the Transport Development Centre (TDC) with testing, refining data and reporting;
- b) Present findings and prepare reports on each activity described herein; and
- c) Provide support to address other issues that may emerge as having greater priority during the course of the winter season, which could be pursued on direction from TDC. Potential issues are listed below:
  - i. Review of the usage of infrared heat with Type I and Type II/IV fluids;
  - ii. Dispersion of fluids on airport surfaces;
  - iii. Hot water deicing;
  - iv. Infrared system development for northern climates;
  - v. Ice phobic materials (effect on Type IV fluids);
  - vi. Support development of SAE Standards for Electronic Message Boards (EMB); and
  - vii. Participate at the workgroup meetings for the development of the EMB standards.

### 5.7.2 Web Site for HOT Guidelines Tables

- a) Ensure the 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 and post the new HOT Guidelines in summer of 2006 for use in winter of 2006-07.

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**APPENDIX B**

**LOG OF FLUID-SPECIFIC TYPE II AND TYPE IV HOLDOVER TIME DATA**



**Table B-1: Type II and Type IV Fluid-Specific Holdover Times**

Precip. Type	Temp. (°C)	Dil.	Rate	Type II Fluids				Type IV Fluids										AVG (min)	STDEV (min)		
				ABC-II+	C-2025	E II	K2000	S E26	O-Max	KABCS	Ultra+	S-480	C-2001	O-Max4	C-2012	C-2030	O-MFlo				
Frost	≥ -3	100/0	n/a	480	480	480	480	480	720	720	720	720	720	720	720	720	720	720	634	119	
		75/25	n/a	300	300	300	300	300	300	300	300	n/a	300	300	300	300	300	300	300	300	0
		50/50	n/a	180	180	180	180	180	180	180	180	n/a	180	180	180	180	180	180	180	180	0
	-3 to -14	100/0	n/a	480	480	480	480	480	720	720	720	720	720	720	720	720	720	720	720	634	119
		75/25	n/a	300	300	300	300	300	300	300	300	n/a	300	300	300	300	300	300	300	300	0
	-14 to -25	100/0	n/a	480	480	480	480	480	720	720	720	720	720	720	720	720	720	720	720	634	119
Freezing Fog	≥ -3	100/0	H	70	90	125	90	85	160	155	95	120	80	160	75	115	140	111	32		
			L	145	125	225	185	155	240	240	215	210	200	240	150	200	215	196	38		
		75/25	H	70	55	85	100	65	125	65	n/a	90	80	125	70	75	85	84	22		
			L	145	105	170	210	115	195	105	n/a	165	120	195	125	125	120	146	37		
		50/50	H	15	20	30	60	30	55	20	n/a	30	15	55	25	30	20	35	21		
			L	45	35	55	130	45	105	35	n/a	45	40	105	45	45	40	68	44		
	-3 to -14	100/0	H	30	45	50	35	45	50	45	85	20	45	50	45	50	70	45	12		
			L	65	110	105	85	135	150	125	180	80	95	150	95	120	140	112	27		
		75/25	H	20	40	30	35	35	30	25	n/a	25	30	30	25	40	40	32	7		
			L	55	80	80	75	75	65	60	n/a	50	60	65	65	90	85	74	20		
	-14 to -25	100/0	H	15	25	20	20	25	20	20	40	15	20	20	20	25	30	21	4		
			L	20	45	35	45	45	45	40	130	40	45	45	45	45	60	43	9		
Snow	≥ -3	100/0	H	25	40	40	30	40	50	60	35	40	60	85	40	50	40	45	15		
			L	55	70	80	60	60	95	100	75	80	115	120	75	90	90	83	20		
		75/25	H	25	25	25	30	25	45	30	n/a	30	35	65	25	35	20	32	12		
			L	50	45	55	65	45	105	55	n/a	65	60	120	55	65	55	65	22		
		50/50	H	15	5	10	15	10	25	5	n/a	10	10	25	15	15	5	13	7		
			L	35	15	25	30	20	75	15	n/a	20	20	75	25	25	15	30	21		
	-3 to -14	100/0	H	15	35	35	25	35	25	45	25	30	30	35	20	45	25	30	9		
			L	35	60	70	45	55	50	80	55	55	50	70	40	85	60	58	14		
		75/25	H	15	25	25	25	25	20	25	n/a	20	20	40	20	35	15	24	7		
			L	35	45	50	50	40	50	50	n/a	45	35	80	40	65	40	48	13		
-14 to -25	100/0	H	15	15	15	15	15	15	15	20	15	15	15	15	15	15	15	1			
		L	30	30	30	30	30	30	30	30	45	30	30	30	30	30	30	31	4		

**Table B-1: Type II and Type IV Fluid-Specific Holdover Times (cont'd)**

Precip. Type	Temp. (°C)	Dil.	Rate	Type II Fluids				Type IV Fluids										AVG (min)	STDEV (min)
				ABC-II +	C-2025	E II	K2000	S E26	O-Max	KABCS	Ultra +	S-480	C-2001	O-Max4	C-2012	C-2030	O-MFlo		
Freezing Drizzle	≥ -3	100/0	H	35	40	45	55	50	55	80	45	50	55	120	40	55	80	58	22
			L	70	60	95	95	95	120	110	95	90	115	120	70	120	120	98	21
		75/25	H	30	25	40	45	45	75	45	n/a	50	35	110	35	40	40	47	22
			L	60	45	70	75	65	120	70	n/a	75	70	120	50	65	65	73	23
		50/50	H	5	10	15	15	15	35	15	n/a	15	10	35	15	15	10	16	9
			L	25	15	30	25	25	60	20	n/a	25	20	70	20	25	20	29	16
	-3 to -14	100/0	H	15	35	35	25	30	25	20	45	25	55	25	25	30	35	30	10
			L	45	65	60	50	70	70	60	85	80	95	90	45	70	105	71	18
		75/25	H	15	30	35	25	20	20	20	n/a	25	40	20	15	35	35	26	8
			L	30	40	65	55	50	60	70	n/a	65	70	60	30	80	75	58	16
Freezing Rain	≥ -3	100/0	H	30	25	30	40	40	35	60	25	35	40	70	25	40	30	38	13
			L	40	35	40	50	50	60	85	40	55	60	90	45	50	60	54	16
		75/25	H	20	20	20	40	25	35	35	n/a	30	25	60	15	25	20	28	12
			L	40	25	30	50	35	70	50	n/a	45	35	80	30	35	35	43	16
		50/50	H	5	5	10	5	5	15	5	n/a	5	5	25	5	5	5	8	6
			L	15	10	15	15	10	30	10	n/a	15	15	35	10	10	10	15	8
	-3 to -14	100/0	H	10	20	20	10	15	20	10	30	15	30	20	15	20	30	19	7
			L	30	35	30	30	35	40	30	45	30	45	40	25	35	50	36	7
		75/25	H	10	15	15	10	15	15	10	n/a	15	20	15	10	15	15	14	3
			L	20	25	30	30	25	30	35	n/a	30	30	30	20	30	30	28	4
Cold-Soaked Wing	≥ -3	100/0	H	5	10	15	15	20	15	20	10	15	15	20	10	15	10	14	4
			L	60	75	90	70	85	75	75	80	95	120	120	65	100	120	88	21
		75/25	H	5	5	10	15	10	10	10	n/a	10	10	20	5	10	5	10	4
			L	50	50	65	100	60	40	50	n/a	75	85	120	40	60	75	67	24

## **APPENDIX C**

### **EXPERIMENTAL PROCEDURE COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING**



CM1892.001 (04-05)

**EXPERIMENTAL PROCEDURE  
COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25)  
BEFORE AND AFTER SPRAYING**

Winter 2004-05

Prepared for

**Transportation Development Centre  
Transport Canada**

Prepared by: Stephanie Bendickson

Reviewed by: John D'Avirro



March 21, 2005  
Version 1.0

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**COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING**

---

**EXPERIMENTAL PROCEDURE  
COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25)  
AND AFTER SPRAYING**

Winter 2004-05

**1. BACKGROUND**

Concerns have arisen that the protocol used to measure endurance times of diluted anti-icing fluids may not produce values consistent with those experienced during actual operations. These concerns have brought into question the accuracy of the current diluted fluid values in the holdover time guidelines and the current test protocol.

The goal of endurance time testing is to determine the length of time, after application, a fluid will remain uncontaminated in winter precipitation. In general, it has been found that the more viscous the fluid the longer the endurance time, especially in warmer temperatures. During the application process fluids are subjected to shearing by the application equipment. This shearing reduces the viscosity of the fluid, rendering the applied fluid less viscous than the original fluid.

To replicate the shearing of the fluid caused during application, fluid manufacturers mechanically shear fluid samples before they are sent to APS Aviation Inc. (APS) for endurance time testing. The method of shearing varies from manufacturer to manufacturer, but all manufacturers shear a batch of neat fluid and then dilute portions of it to 75/25 and 50/50 dilutions.

It has been shown that the more viscous a fluid is, the more susceptible it is to shearing. In other words, if two samples of the same fluid, one with a higher viscosity and one with a lower viscosity, are subjected to the same shearing, the higher viscosity fluid will experience a larger percentage decrease in viscosity.

It has been theorized that because fluids submitted for endurance time testing are sheared *prior* to dilution and fluids that are used on aircraft are sheared *after* dilution, the endurance times of fluids tested for endurance times are different from the endurance times of fluids used in operations.

**2. OBJECTIVE**

The objective of these tests is to determine if fluids sheared before they are diluted have the same viscosity as fluids sheared after they are diluted. The measurement of viscosities will be used as an indicator of endurance times.

---

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Version 1.0, March 2005

2 of 6

**COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING**

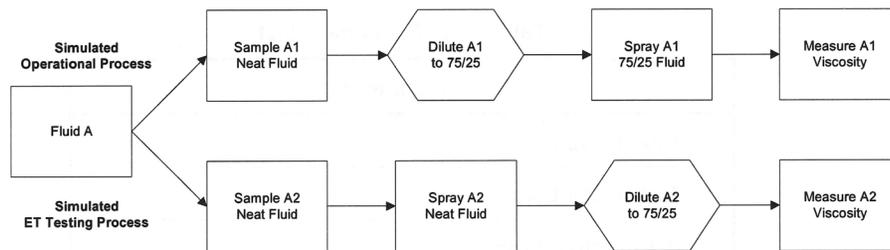
If the viscosities are different, it will have implications for holdover time testing protocol. Currently, fluids are sheared and then mixed for holdover time testing, but in operations, fluids are provided mixed to users and then sheared when they are applied.

**3. PROCEDURE**

Samples of several Type IV fluids will be sprayed using the mobile sprayer. Samples of the sprayed fluid will be collected and returned to the APS laboratory where their viscosities will be measured.

These tests will examine fluids diluted to 75/25 (glycol/hard water). To replicate the operational type and timing of shearing, a sample of each neat fluid will be diluted to 75/25 prior to spraying. To replicate the endurance time testing type and timing of shearing, a sample of the same neat fluid will be sprayed and then diluted to 75/25. The two test processes are illustrated in Figure 3.1.

The viscosity of the fluids will be measured at each step in the process when possible. The key viscosity measurement will be the viscosity of the final samples.



**Figure 3.1: Flowchart for Testing**

**4. FLUIDS**

Two fluids will be tested: Homeoil Type IV and Octagon Max-Flight. Each fluid will be sprayed in neat dilution and diluted to 75/25 and sprayed.

**5. PERSONNEL**

Two individuals are required for the spray tests. One individual is required to conduct the viscosity tests.

COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING**6. TEST PLAN**

The test plan for spray tests is given in Table 6.1.

**Table 6.1: Test Plan**

Test #	Fluid	Dilution	Notes
1	Octagon Max-Flight	100/0	
2	Octagon Max-Flight	75/25	Dilute neat sample
3	Homeoil Type IV	100/0	
4	Homeoil Type IV	75/25	Dilute neat sample

**7. EQUIPMENT**

Table 7.1 lists the equipment required.

**Table 7.1: Equipment List**

Equipment
Mobile Sprayer
Collection Barrel
1 L Sample Bottles
Brookfield Viscometer and Temperature Bath

**8. DATA FORMS**

A data form has been created for the spray tests and is given in Figure 8.1. The APS viscosity log book will be used to record the results of the viscosity tests.

**COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING**

Date: \_\_\_\_\_

Temperature: \_\_\_\_\_

Weather: \_\_\_\_\_

Wind: \_\_\_\_\_

Test No.	Fluid	Dilution	Time of Application	Comments

Performed By: \_\_\_\_\_

Written By: \_\_\_\_\_

**Figure 8.1: Spray Test Data Form**

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Version 1.0, March 2005

COMPARISON OF VISCOSITIES OF DILUTED FLUIDS (75/25) BEFORE AND AFTER SPRAYING

## 9. SAFETY PRECAUTIONS

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

- 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.

**APPENDIX D**

**PROCEDURE:  
ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE**



CM (TC-Deicing 05-06)

**PROCEDURE  
ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE**

Winter 2005-06

Prepared for

**Transportation Development Centre  
Transport Canada**

Prepared by: David Youssef

Reviewed by: John D'Avirro



December 22, 2005  
Version 2.0

## ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE

### 1. BACKGROUND

Transport Canada (TC), in collaboration with the Federal Aviation Administration (FAA), has studied human visual and tactile ice detection capabilities under aircraft post-deicing conditions. This helped evaluate new systems and devices used to detect ice. Ground ice detection systems (GIDS) are new technologies that are being developed to assist ice checkers perform their duties. A Ground Ice Detection System Regulatory Approval Working Group (GIDS RAWG), under the auspices of the SAE G-12 Ice Detection Sub-Committee, was formed to find ways to meet this objective.

The above-mentioned Human Factors tests showed conclusively that under certain conditions deicers performing post-deicing inspections could not determine whether or not there was any residual ice below the deicing fluid on an aircraft wing. It is therefore evident that the aircraft could subsequently be anti-iced with cold anti-icing fluid and still have ice present (at the time of anti-icing fluid application).

### 2. OBJECTIVES

The objective of this test is to investigate how the presence of residual ice at the time of post-deicing inspection can affect the endurance time (ET) of given fluids.

### 3. TEST PLAN

There will be 2 to 3 runs conducted with residual ice, depending on time constraints. The fluid to be used will be Ultra+ Type IV, with a total of 3 baseline tests and 2 residual ice tests, conducted simultaneously (see Figure 3.1).

### 4. SETUP

The setup will be an addition to the standard holdover time testing conducted outdoors in snow conditions. The tests with residual ice will consist of four plates (two with an ice patch of 315 cm<sup>2</sup>, and two with full ice coverage of the

ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE

plate). The residual ice for both tests will be between 0.5 mm and 1 mm thick. Figure 3.1 shows the setup for this test.

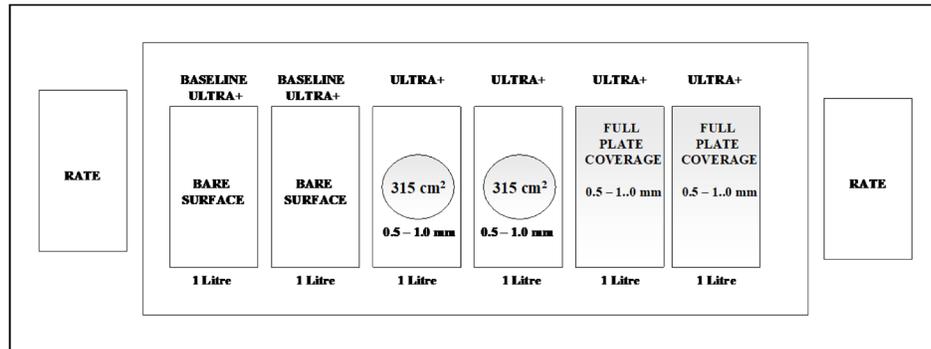


Figure 3.1: Plan of Test Runs

**5. PROCEDURE**

1. Prepare residual ice plates as in Figure 3.1; and
2. Conduct tests according to Standard Endurance time testing procedure for snow.

**6. PERSONNEL**

Two APS employees will be used to conduct this test; one to oversee the production of the ice disks and measure snow intensity, and one to pour fluid and determine failure.

**7. EQUIPMENT**

The same equipment that is used for the Endurance Time Testing at the outdoor test site will be used for this test. Any additional equipment needed for the production of ice patches will be used.

*ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE*

---

## **8. DATA FORMS**

The data forms are included in Attachments I and II. Attachment I shows the data form developed for the end-condition tester. Attachment II shows the data form for the meteo/precipitation rate.

**ENDURANCE TIMES FOR PLATES WITH RESIDUAL ICE**

**ATTACHMENT I  
End Condition Data Form**

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

<b>LOCATION:</b>	<b>DATE:</b>	<b>RUN NUMBER:</b>	<b>STAND # :</b>
------------------	--------------	--------------------	------------------

**TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)**

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)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
<b>FLUID NAME/DILUTION</b>						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

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)

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
<b>FLUID NAME/DILUTION</b>						
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: \_\_\_\_\_

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**APPENDIX E**

**PROCEDURE:  
PRELIMINARY TACTILE TESTING FOR USE OF GLOVES**



CM2020.001 (05-06)

**PROCEDURE  
PRELIMINARY TACTILE TESTING FOR USE OF GLOVES**

Winter 2005-06

Prepared for

**Transportation Development Centre  
Transport Canada**

Prepared by: David Youssef

Reviewed by: John D'Avirro



January 12, 2006  
Version 1.0

*PRELIMINARY TACTILE TESTING FOR USE OF GLOVES*

---

**PROCEDURE: PRELIMINARY TACTILE TESTING FOR USE OF GLOVES**

**1. BACKGROUND**

Human Factors tests showed conclusively that under certain conditions deicers performing post-deicing inspections could not determine whether or not there was any residual ice below the deicing fluid on an aircraft wing. It is therefore evident that the aircraft could subsequently be anti-iced with cold anti-icing fluid and still have ice present (at the time of anti-icing fluid application).

The ability to detect the presence of residual ice through "touch" is also very become important. In most cases, deicers will use gloves as a means of protection during deicing.

**2. OBJECTIVES**

The objective of this procedure is to provide preliminary research into the use of gloves during ice detection. In addition to this, research will be carried out to study different types of gloves and how they may obstruct the detection of residual ice.

**3. TEST PLAN**

Preliminary testing will be completed on one occasion, either in a cold chamber, or in a refrigerated truck.

**4. SETUP**

The setup will consist of two standard test plates. The first will be free of contamination, and the second will have full coverage residual ice between 0.5 and 1 mm thick.

PRELIMINARY TACTILE TESTING FOR USE OF GLOVES

---

## 5. PROCEDURE

Gloves will be selected based on the materials used to construct the glove, absorbency, thickness, and the presence of a liner. Between 4-5 types of gloves will be tested in total.

Testing will be completed with two or three individuals with masked vision. These individuals will be asked to determine which plate has residual ice.

## 6. DATA FORMS

A general data form will be used to record the results for each tester (see Attachment I).

**ATTACHMENT I  
USE OF GLOVES WHEN DETECTING RESIDUAL ICE**

DATE: \_\_\_\_\_ ICE THICKNESS: \_\_\_\_\_

TESTER: \_\_\_\_\_ OAT: \_\_\_\_\_

LOCATION: \_\_\_\_\_

**Detection of Ice**

	Description of Glove	Detection of Ice (Yes/No)
Glove Type #1		
Glove Type #2		
Glove Type #3		
Glove Type #4		
Glove Type #5		

**Comments**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Test Leader \_\_\_\_\_

Signature \_\_\_\_\_

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Version 1.0, January 2006

**APPENDIX F**

**DRAFT AEROSPACE STANDARD 5681:  
MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR REMOTE  
ON-GROUND ICE DETECTION SYSTEMS  
JULY 24, 2006**





SAE AS5681 Draft

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**SAE AS5681 Draft****1. SCOPE (SAE STYLE?)**

This SAE Aerospace Standard (AS)/Minimum Operational Performance Specification (MOPS) specifies the minimum performance requirements of Remote On-Ground Ice Detection Systems (ROGIDS). These systems are ground-based. They provide information for indication as to whether frozen contamination is present on airplane surfaces.

Chapter 1 provides information required to understand the need for the ROGIDS characteristics and tests defined in the remaining chapters. It describes typical ROGIDS applications and operational objectives and is the basis for the performance criteria stated in Chapter 3 through Chapter 5. Definitions essential to the proper understanding of this document are provided in Chapter 1.

Chapter 3 contains general design requirements for a remote on-ground ice detection system to be used during ground operations.

Chapter 4 contains the Minimum Operational Performance Requirements for the ROGIDS, defining performance under icing conditions likely to be encountered during ground operations.

Chapter 5 describes environmental test conditions providing laboratory means of testing the overall performance characteristics of the ROGIDS under conditions which may be encountered in actual operations.

Chapter 6 describes recommended test procedures for demonstrating compliance with Chapters 3 and 4.

Chapter 7 contains the Minimum Operational Performance Requirements for ROGIDS. Tests are included for operational conditions where performance cannot be adequately determined under controlled test conditions.

**1.1 Applications of This Document:**

Compliance with this AS/MOPS ensures that the ROGIDS will satisfactorily perform its intended functions as given by Subsection 1.2 during airplane ground operations.

Compliance with this AS/MOPS does not necessarily constitute compliance with regulatory requirements. Any application of this document in whole or in part is the sole responsibility of the appropriate regulatory agencies.

The measured values of the ROGIDS performance characteristics may be a function of the method of measurement. Therefore, controlled test conditions and methods of testing are recommended in this document.

**Mandating and Recommendation Phrases:****a. "Shall"**

The use of the word "Shall" indicates a mandated criterion; i.e., compliance with the particular procedure or specification is mandatory and no alternative may be applied.

**b. "Should"**

The use of the word "Should" (and phrases such as "It is recommended that...", etc.) indicates that although the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester can provide information or data to adequately support and justify the alternative.

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## 1.2 Safety

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, this procedure does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes, and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

## 1.3 Functional Description of System

ROGIDS are intended to be used during airplane ground operations to inform the ground crew and/or the flight crew and/or a relevant system about the condition of monitored airplane surfaces.

The ROGIDS may, when approved, provide a functional alternative to the visual and tactile checks required by regulatory agencies, including the European Aviation Safety Agency (EASA), the United States Federal Aviation Administration (FAA) and Transport Canada Civil Aviation (TCCA), to determine the condition of airplane critical surfaces under operating conditions involving freezing contamination.

A ROGIDS may be used as a means of compliance with the operating rules applicable to airplane ground icing conditions, including pre-deicing check, post-deicing check and/or any applicable regulatory pre-takeoff checks.

- The ROGIDS function is to detect frozen contaminants (ice, frost, snow and/or slush) on airplane surfaces.

ROGIDS make a remote measurement of a monitored surface, and may be hand held, pedestal or truck mounted.

## 1.4 The ROGIDS shall include

- a. At least one sensor that is directly or indirectly sensitive to the physical phenomena of airplane icing during weather conditions consistent with ground icing operations.
- b. A processing unit to perform signal processing. The unit may either be integrated with or separate from the sensor(s).
- c. A device to provide information to the flight and/or ground crew.

## 2. REFERENCES

## 2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

**SAE AS5681 Draft**

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org)

AMJ 25.1309

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

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

ARP4256 Design Objectives for Liquid Crystal Displays for Part 25 (Transport) ARP4737 Airplane Deicing/Anti-icing Methods with Fluids for Large Transport Airplanes

ARP5485 Endurance Time Tests For Aircraft Deicing/Anti-icing Fluids SAE Type II, Type III and Type IV

ARP5945 TBD

SAE J1211 Recommended Environmental Practices for Electronic Equipment Design

2.1.2 EUROCAE/RTCA or EUROCAE/SAE Publications

EUROCAE Documents (ED) available from EUROCAE, 17, rue Hamelin 75783 PARIS, Cedex 16, France, Tel: +33 1 45 05 71 88, [eurocae@compuserve.com](mailto:eurocae@compuserve.com)

RTCA documents (DO) available from RTCA, One McPherson Square, 1225 K Street N.W., Suite 500, Washington, DC 20005.

ED-14/RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

ED-12/RTCA DO-178 Software Considerations in Airborne Systems and Equipment Certification

ED-80/RTCA DO-254 Design Assurance Guidance for Airborne Electric Hardware

RTCA/DO-216 Minimum General Specification for Ground-Based Electronic Equipment

2.1.3 JAA/FAA Publications

JAA/JAR documents available from JAA, Saturnusstraat 8-10 PO Box 3000 2130 KA Hoofddorp The Netherlands, Tel: +31 23 5679 764, [publications@jaa.nl](mailto:publications@jaa.nl), [www.jaa.nl](http://www.jaa.nl)

FAA/FAR/AC documents available from Federal Aviation Administration 800 Independence Avenue, SW Washington, DC 20591, Tel: 1-866-TELL-FAA (1-866-835-5322), [www.faa.gov/regulations\\_policies/faa\\_regulations/](http://www.faa.gov/regulations_policies/faa_regulations/)

AC 00-34A Aircraft Ground Handling and Servicing

AC 20-117 Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing

AC 25.1309

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AC 120-58	Pilot Guide for Large Aircraft Ground Deicing
AC 120-60	Ground Deicing and Anti-Icing Program
AC 135-16	Ground Deicing & Anti-Icing Training & Checking
AC 135-17	Pilot Guide - Small Aircraft Ground Deicing
AC 150/5300-14	Design of Aircraft Deicing Facilities
DOT/FAA/TC-06/20	Comparison of Human Ice Detection Capabilities and Ground Ice Detection System Performance under Post Deicing Conditions
DOT/FAA/TC-06/21	Human Visual and Tactile Ice Detection Capabilities under Aircraft Post Deicing Conditions
FAA Aircraft Icing Handbook	
FAR Part 91	General Operating and Flight Rules
FAR Part 121	Certification and Operations: Domestic Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft
FAR Part 125	Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More
FAR Part 129	Operations: Foreign Air Carriers and Foreign Operators of U.S.- Registered Aircraft Engaged in Common Carriage
FAR part 135	Air Taxi Operators and Commercial Operators
FAR 21.607(d)	
HF-STD-001	FAA Human Factors Design Standard
JAA/Leaflet #4 to JAR/OPS1 Ice and Other Contaminants Procedures	
JAR-1	Definitions and Abbreviations
JAR TSO	Joint Technical Standard Orders
JAR/OPS 1, [2]	Commercial Air Transportation (Aeroplanes)
2.1.4 Transport Canada Publications	
Available fom Transport Canada, Tower C, Place de Ville, 330 Sparks Street Ottawa, Ontario K1A 0N5, Tel: ???, www.tc.gc.ca	
TP XXX (APS Reports)	
TC-CASS 622.11	Commercial Air Service Standard - Ground Icing Operations Standard
TC CAR 602.11	Canadian Aviation Regulation - Aircraft Icing

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2.1.5 CEN/IEC/ISO Publications

CEN/EN documents available from CEN, 36, rue de Stassart B-1050 Brussels, Tel: +32 2 550 0811, infodesk@cenorm.be

IEC documents available from International Electrotechnical Commission, 3, rue de Varrembe, P.O. Box 131, 1211 Geneva 20, Switzerland, Tel: +44-22-919-02-11, www.iec.ch

ISO documents available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org

CEN 50081-2            Electromagnetic compatibility - Generic emission standard - Part 2: Industrial environment

CEN 12312 part 6      Deicing/Anti-icing equipment. A/C Ground support equipment requirements

EN 50020              Electrical apparatus for potentially explosive atmospheres, intrinsic safety "I"

CEN 50082-2           Electromagnetic compatibility - Generic immunity standard - Part 2: Industrial environment

IEC 0079 Part 11      Electrical apparatus for potentially explosive atmospheres, intrinsic safety

ISO 11077              Aerospace deicing/anti-icing vehicle requirements

2.1.6 ARINC Publications

Available from ARINC, 2551 Riva Road, Annapolis, MD 21401, www.arinc.com

ARINC-415              Operational and Technical Guidelines on Failure Warning and Functional Test

ARINC-604              Guidance for Design and Use of Built-in Test equipment (BITE)

2.1.7 Weather Related Publications

WMO documents available from World Meteorological Organization, P.O. Box 2300, CH-1211, Geneva 2, Switzerland, Tel: 617 227 2425, wmopubs@ametsoc.org

World Meteorological Organization Aerodrome Reports and Forecasts (Doc No. 782, revised 1 Jan 1996)

2.2 Definitions and Abbreviations

2.2.1 Definitions

ANTI-ICING: A precautionary procedure that provides protection of an airplane against the formation of frost or ice and accumulation of snow or slush on treated surfaces of the airplane for a limited period of time.

CLEAR ICE: Clear ice can occur inflight or on the ground. It forms at temperatures at or below 0oC, with a high concentration of large supercooled water droplets. [It can also form as a result of the deicing process.] Clear ice is hard, and appears as a smooth and glassy coating that can be very difficult to detect without a tactile inspection. Clear ice may not be seen during a walkaround, particularly if the wing

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is wet or during nighttime time operations. Clear ice adheres firmly to surfaces, and is difficult to remove, requiring special care during de/anti-icing.

DEICING: A procedure by which frost, ice, snow or slush is removed from the airplane in order to provide clean surfaces.

FALSE NEGATIVE: An indication of absence of frozen contamination when frozen contamination is present on the reference surface.

FALSE POSITIVE: An indication of the presence of frozen contamination when no frozen contamination is present on the reference surface.

DE/ANTI-ICING FLUID FAILURE: Possibly indicated by the presence of frozen contamination in or on the de/anti-icing fluid, surface freezing or snow accumulation, random snow accumulation and/or dulling of surface reflectivity caused by the gradual deterioration of the de/anti-icing fluid.

FROZEN CONTAMINATION/CONTAMINANTS: For the purpose of this AS/MOPS: frost, ice, snow, slush.

MONITORED SURFACE: The surface of concern regarding ice hazard.

ROGIDS: A system that makes a remote measurement of a monitored surface to determine whether frozen contamination is present.

SYSTEM: A combination of components which are inter-connected to perform one or more functions.

VISUAL PATTERN OF CONTAMINATION: Area and location of visible frozen contamination in or on or under the de/anti-icing fluid.

Descriptors of this frozen contamination may be, but are not limited to:

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

WEATHER CONDITIONS: See Subsection 2.1.7.

2.2.2 Abbreviations

AC	Advisory Circular (FAA)
AMJ	Advisory Material Joint (JAA)
ARINC	Aeronautical Radio, Inc.
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
BITE	Built In Test Equipment

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CEN	Comité Européen de Normalisation . European for Standardisation. Europäisches Komitee für Normung.
EASA	European Aviation Safety Agency
EN	Norme Européenne. European Standard. Europäische Norm.
EUROCAE	The European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration (USA )
FAR	Federal Aviation Regulations (USA)
FOD	Foreign Object Damage
FPD	Freezing Point Depressant; used to qualify the nature of de/anti-icing fluids
GIDS	Ground Ice Detection System
IEC	International Electricity Committee
ISO	International Organization for Standardization
JAA	Joint Aviation Authorities (in Europe)
JAR	Joint Aviation Requirements (Europe)
LRU	Line Replaceable Unit
min	Minute
MOPS	Minimum Operational Performance Specification
MTBF	Mean Time Between Failure
OAT	Outside Air Temperature
ROGIDS	Remote On-Ground Ice Detection System
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers (USA originated)
T.C. - CAR	Transport Canada - Civil Aviation Requirements
T.C	Transport Canada (The Canadian Civil Aviation Authority)

**3. GENERAL DESIGN REQUIREMENTS**

**3.1 Introduction**

This chapter identifies general design considerations for ROGIDS.

**SAE AS5681 Draft****3.2 Complex Hardware and Software Design**

The design of complex hardware such as large scale integrated circuits shall follow the guidelines specified in document EUROCAE ED-80/RTCA DO-254. The hardware criticality level will depend on the particular ROGIDS function and application.

3.2.1 Software design shall follow the guidelines specified in document EUROCAE ED-12/RTCA DO-178". The software criticality level will depend on the particular ROGIDS function and application.

**3.3 Technical Requirements****3.3.1 Materials**

Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in the ROGIDS.

**3.3.2 Workmanship**

Workmanship shall be such as to minimize degradation of service performance and reliability. All components shall be fitted properly and firmly in their appropriate positions. All electrical connections shall be mechanically secured and electrically sound. Care shall be given to neatness and thoroughness of soldering, wiring, welding, brazing, surface treatments, painting, screwed and bolted assemblies, marking of parts and assemblies, and elimination of burrs and sharp edges.

**3.3.3 Electrical Bonding and Grounding**

The ROGIDS grounding system shall provide for separation of AC power, DC power, chassis ground and signal ground(s). Optionally, signal ground(s) may be "referenced" to chassis ground. Wire shields shall not be used as a signal return.

On non-conductive enclosures, controls or metal parts which may be touched shall be bonded to ground. Case ground shall not be used for electrical power returns. Materials, surface preparation and finishes for electric bonding surfaces shall be compatible with preservation of adequate electrical conductivity over the life of the ROGIDS. The maximum resistance across any bonding or grounding junction shall be 0.25  $\Omega$ , as manufactured.

**3.3.4 Interchangeability**

All major components having the same part number, shall be interchangeable with each other physically and functionally.

**3.3.5 Marking**

Permanently and legibly mark each major component with the following information:

1. Name and address of the manufacturer.
2. The name, type, part number or model designation of the component.
3. The serial number, or the date of manufacture of the component or both.

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If the component includes software, the part number shall either include hardware and software identification, or use separate part numbers for hardware and software identification. The part number must uniquely identify the hardware and software design, including modification status.

### 3.4 Minimum Structural Requirements

#### 3.4.1 Exposure During Normal Operations

ROGIDS parts exposed to the external environment should be designed to withstand the temperature, pressure, chemical and/or radiation environment associated with deicing/anti-icing conditions. GIDS parts exposed to the external environment should be designed to withstand impact from ice particles shed from the airplane and remain functional.

### 3.5 Foreign Object Damage (FOD)

The ROGIDS should be constructed so that in the normal operating environment parts do not become loose in service and create a FOD hazard.

### 3.6 Human Factors

Design of any ROGIDS should include consideration of the applicable human factors enumerated in FAA Human Factors Design Standard, HF-STD-001. As a minimum, each design shall consider the following factors:

#### 3.6.1 Installation

Mounting location is dependent on local factors. For truck mounted units this includes truck type, cab type, and optional equipment installed.

Mounting of the ROGIDS must not interfere with the primary de/anti-icing functions of the truck. The mounting location of the sensor must be such that it can obtain a clear scan of aircraft surfaces to be monitored. The ROGIDS display must be mounted in a location easily visible to the operator responsible for checking the monitored surface during or after de/anti-icing operations.

#### 3.6.2 Hazards

If the ROGIDS can produce a hazard to personnel or property then a warning label shall be prominently provided on or close to the unit. The ROGIDS shall not produce toxic fumes under any fault conditions. Except for small parts that would not significantly contribute to the propagation of fire, all materials used must be self-extinguishing.

#### 3.6.3 Interface Design

The display design shall:

- a. Utilize natural and meaningful symbology that is readily understood.
- b. Provide information that is immediately discernible. Results provided by the system shall be readily interpretable by a trained operator.
- c. Provide a clear indication when the ROGIDS is inoperative.

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- d. In the event that the display does not encompass the entire surface to be checked, the interface shall be designed in a way that allows the operator to clearly identify the location of the area displayed in relation to the overall wing (or other entire surface to be checked). This is to ensure that no part of the surface to be checked has been omitted or erroneously duplicated. This text to be re-worded by Frank Teti.

**3.7 Safety Requirements****3.7.1 Design for Performance Safety**

A structured safety assessment shall be conducted to evaluate the failure modes and their effects on system operation.

The intent is to ensure that ground and flight crew are not presented with misleading information (false negatives), generated by system malfunctions, which would allow dispatch and take-off of an aircraft with contamination on the critical surfaces within the performance defined in Chapter 4 & 5 of this AS.

System malfunctions may include:

- a. Malfunctions that are readily detected by the trained operator.
- b. Malfunctions not detectable by the trained operator.

The system safety shall address malfunctions not detectable by the trained operator.

Acceptable structured assessment procedures include but are not limited to:

- a. System Safety Assessment
- b. Functional Hazard Assessment
- c. Failure Modes and Effects Analysis
- d. Fault Tree Analysis

Appropriate software and hardware design assurance levels shall be selected based on a structured safety assessment process.

ROGIDS must be designed, installed, operated, and maintained according to applicable safety standards defined by the authority having jurisdiction.

**3.7.2 Failure Analysis**

Undetected failure rate and MTBF of the ROGIDS shall be determined by failure analysis in accordance with AMJ 25.1309 or AC 25.1309.

The failure analysis shall include False Negatives. [Doug and Dennis to fix]

**3.7.3 Detection Reliability**

The detection reliability is the capability to recognize frozen contamination when frozen contamination is present on the monitored surface. The detection reliability can be influenced by the physical measurement principle and the position of the sensor(s).

The detection reliability shall be included in the failure analysis. [Doug and Dennis to Fix]

NOTE: Chapters 6 and 7 define test procedures that demonstrate detection capability of the system.

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3.8 ROGIDS Operation

3.8.1 ROGIDS Controls

The operation of ROGIDS controls in all possible positions, combinations and sequences, shall not be detrimental to the continued normal operation of the ROGIDS.

ROGIDS controls which are not intended to be adjusted in normal operation shall not be readily accessible to the ground crew.

3.8.2 Data Processing

Following acquisition, the processing and interpretation of data by the ROGIDS shall be automatic.

The system shall be designed in such a manner as to preclude the display of invalid output data.

3.8.3 Built In Test Equipment (BITE)

The ROGIDS shall include a confidence (BITE) test. The test function shall be automatic during operation.

The Built-In Test Equipment (BITE) shall ensure the safety objectives and the reliability requirements as defined in Subsection 3.7. BITE shall provide a clear indication of detected GIDS failures to the operator.

3.8.4 Nuisance Alarms

Nuisance alarms should be minimized.

3.8.5 Operating Weather Conditions

The ROGIDS shall perform its intended function during weather conditions consistent with ground icing operations. [Look for possible appropriate references.]

3.9 Qualification Tests

3.9.1 Responsibility for Testing

The manufacturer of the product shall be responsible for performing and documenting all required tests specified in Chapters 5, 6 and 7 to demonstrate compliance with this AS/MOPS.

The manufacturer shall confer with the regulatory agency to determine those tests that need to be witnessed or performed by the regulatory agency or other acceptable entity.

If a manufacturer intends to seek regulatory approval for a limited application of an ROGIDS (e.g., sensors for cold-soak icing only) then the manufacturer is responsible for choosing the tests specified in Chapter 6 and 7 that are appropriate for demonstrating compliance with that subset of the MOPS. Such limitations shall be documented in accordance with Subsection 3.10.4. According to Paragraphs 6.1.1 and 7.1.1, a test plan and test procedures shall be prepared, and may be submitted to the appropriate authorities for review. Any deviation in the prepared test procedures with this standard shall be highlighted and justified.

3.9.2 Test Article

The tests shall be conducted with one or more ROGIDS that are in full conformity with production build. If the tested item incorporates features that are still experimental or in the development stage, any tests

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involving the non-production features shall be repeated later on a production item, or evidence presented to substantiate that the test results are valid for the production instrument.

As a minimum performance requirement, the test articles shall complete all tests without maintenance and without necessity to re-calibrate the test articles.

3.10 Reports and Declarations

3.10.1 Summary Test Report

The ROGIDS manufacturer shall prepare a summary report declaring the following:

- a. The part number and serial number, which identifies the ROGIDS as tested, and revision number if applicable.
- b. A statement of all performance tests that have been successfully completed.
- c. A specific statement for each performance test that was not performed or not successfully completed.
- d. A specific statement for each declared or identified operational ROGIDS limitation.
- e. The summary report shall include the support data, see Appendix B paragraph B.4.5.5?
- f. An environmental Qualification Form, in accordance with EUROCAE ED-14/RTCA DO-160, indicating which environmental tests were conducted and where applicable, the resulting environmental category of the ROGIDS.
- g. Compliance with Requirements of EUROCAE ED-12/RTCA DO-178 and submission of supporting data.

3.10.2 Substantiating Test Data/Analysis

The ROGIDS manufacturer shall compile and make available for review all the following:

- a. A description of the test facility and test procedures used.
- b. The test results and technical data which substantiate the declarations of Subsection 3.10.1.
- c. The processing cycle and/or refresh rate of the ROGIDS from data acquisition to final display.
- d. Failure modes and effects analysis.

The foregoing information shall be referenced to the appropriate sections of this AS/MOPS.

3.10.3 Operating Procedures

A set of operating procedures for each specific ROGIDS shall be developed.

3.10.4 Operational limitations

The manufacturer shall document and clearly identify all operational limitations identified during the tests specified in this document.

These limitations shall be stated in the Summary report.

**SAE AS5681 Draft****4. MINIMUM PERFORMANCE SPECIFICATION**

This chapter defines the minimum performance criteria that shall be used for the design of ROGIDS described in Subsections 1.3 and 1.4. Chapter 7 defines the performance and validation methods for the ROGIDS when installed.

**4.1 Frozen Contamination Detection**

Under the operating weather conditions referred to in Subsection 3.8.5, ROGIDS shall be able to detect and annunciate the presence of clear ice during pre-and post deicing operations.

ROGIDS performance standards for detection of frost, snow and slush have not been defined. Issues related to detection of frost are addressed in appendix (X). It is anticipated that issues related to the detection of snow and/or slush may be addressed in future versions of this document.

**4.1.1 Detection Threshold**

The ROGIDS detection threshold shall ensure the detection of clear ice of 0.5 mm thickness or less, continuously distributed over an area of 315 cm<sup>2</sup>, or less.

**4.1.2 Frozen Contamination Above the Detection Threshold**

If frozen contamination on the monitored surface is in excess of the detection threshold, the ROGIDS shall indicate its presence.

**4.2 Monitored Surface Finish, illumination conditions, and ROGIDS Performance**

The ROGIDS performance shall not be affected by the material, the surface finish and/or surface treatment of the monitored surface.

The performance of the ROGIDS shall not be affected by the transition between two or more surface finishes and/or illumination conditions.

**5. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS****5.1 Introduction**

- a. The environmental test conditions and performance criteria described in this section provide a laboratory means of determining the overall performance characteristics of the ROGIDS under conditions representative of those which may be encountered in actual operation.
- b. Unless otherwise specified, the test procedures applicable to the determination of an ROGIDS performance under environmental test conditions are contained in EUROCAE ED-14/RTCA DO-160. For each test, the manufacturer must choose an appropriate category based on the expected application of the ROGIDS.
- c. Some of the environmental tests contained in this section do not have to be performed unless the manufacturer wishes to qualify the ROGIDS for that particular environmental condition; these tests are identified by the phrase "If Required". If the manufacturer wishes to qualify the ROGIDS to these additional environmental conditions, then the "If Required" tests shall be performed.

**5.2 Environmental Testing**

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The following tests determine whether the ROGIDS can withstand the effects of the following environmental test conditions and applicable test procedures described in document EUROCAE ED-14D/RTCA DO-160D.

The functional tests, defined in EUROCAE ED-14D/RTCA DO-160D, will be performed in relationship to the identified ROGIDS categories. The acceptance criteria during the environmental tests is detection of ice of 0.5mm thickness and an area of 315cm<sup>2</sup>, and absence of system dysfunction. The ROGIDS manufacturer shall provide sufficient functional test data to show compliance of the equipment before, during and after the various tests detailed in Table 1.

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TABLE 1 - TITLE?

Test #	CONDITIONS	DOCUMENTS SECTION	COMPLIANCE REQUIREMENTS	COMMENTS
1	Survival Low Temperature	ED-14/ DO160D 4.5.1	§ 5.2	Category B2 (-55 °C)
2	Operating Low Temperature	ED-14/ DO160D 4.5.1	§ 5.2	Category B2 limited to -40 °C for GIDS parts exposed to external environment
3	Survival High Temperature	ED-14/ DO160D 4.5.2	§ 5.2	Category B2 (+70 °C)
4	Operating High Temperature	ED-14/ DO160D 4.5.2	§ 5.2	Category B2 limited to +20 °C for GIDS parts exposed to external environment
9	Temperature Variation	ED-14/ DO160D 5.0	§ 5.2	Category C
6	Altitude	ED-14/ DO160D 4.6.1	§ 5.2	If required. 13,000 ft max.
10	Humidity	ED-14/ DO160D 6.0	§ 5.2	Category A for equipment parts not exposed to external environment. Category B for GIDS parts exposed to external environment.
11	Operational Shock	SAE J1211 4.8	§ 5.2	Shipping, handling and installation
13	Vibration	SAE J1211 4.7	§ 5.2	
14	Explosion	ED-14/ DO160D 9.0	(Non applicable)	Category X

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TABLE 1 (Continued): - TITLE?

Test #	CONDITIONS	DOCUMENTS SECTION	COMPLIANCE REQUIREMENTS	COMMENTS
15	Waterproofness	ED-14/ DO160D 10.3	§ 5.2	Category S for GIDS parts exposed to external environment.
16	De/anti-icing fluids Susceptibility	ED-14/ DO160D 11.4	Shall sustain De/anti-icing fluids (other fluids if required)	Applicable to GIDS exposed to de/anti-icing fluid projections.
17	Sand and Dust	SAE J1211 4.5	(if required)	Dust, sand and gravel bombardment
18	Fungus	ED-14/ DO160D 13.0	(if required)	Conduct test on components only
19	Salt Spray	ED-14/ DO160D 14.0	(if required)	
20	Magnetic effect	ED-14/ DO160D 15.0	(Non applicable)	Category X
21	Power input	DO 216 § 3.2.1.2.5	§ 5.2	If applicable
22	Voltage spike	DO 216 § 3.2.1.5	§ 5.2	If applicable
23	Audio Frequency Susceptibility	ED-14/ DO160D 18.0	§ 5.2	
24	Induced Signal Susceptibility	EN 50082-2	§ 5.2	
25	Radio Frequency Susceptibility	EN 50082-2	§ 5.2	
26	Radio Frequency Emission	EN 50081-2	§ 5.2	
29	Icing	ED-14/ DO160D 24.0	Ensure that all mechanical devices operate satisfactorily.	Category A
30	Electrostatic Discharge	ED-14/ DO160D 25.0	(if required)	

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## 6. PERFORMANCE TEST PROCEDURES

## 6.1 General

## 6.1.1 Test Plan, Procedures, and Reports

A test plan and test procedures shall be prepared, and shall be submitted to the appropriate regulatory agencies for review and approval. The test plan shall clearly identify the pass/failure criteria. Any deviation in the prepared test procedures with this standard shall be highlighted and justified.

A report of test results shall be prepared in accordance with Subsection 3.10 'Reports and Declarations'.

## 6.1.2 Power Input Voltage

Unless otherwise specified, all tests shall be conducted at the designed power input voltage. The input voltage shall be measured at the equipment input terminals.

## 6.1.3 Power Input Frequency

In the case of equipment designed for operation from an AC power source of essentially constant frequency, tests shall be conducted at the designed input frequency.

## 6.1.4 Ambient Conditions

Unless otherwise specified, all tests shall be conducted under conditions of ambient room temperature, pressure, and humidity, as defined in document EUROCAE ED-14/RTCA DO-160, Paragraph 3.5.

## 6.1.5 Warm-up Period

All tests shall be conducted after the warm-up period specified by the manufacturer.

## 6.1.6 Test Procedures

- a. The following test procedures are considered to be a satisfactory means of establishing compliance with the performance specifications of Chapters 4 and 5.
- b. Alternative procedures, acceptable to the regulatory agencies, which provide equivalent information may be used. In such cases, the procedures described in this chapter shall be used as reference criteria for evaluation of such alternative procedures.
- c. All test procedures shall be documented. Where physical facility limitations exist which influence the set-up and conduct of the tests, these limitations shall be noted.

## 6.2 Pass/Fail Criteria

TBD, SN-B/F4, SN-D/F4

## 6.3 Purpose of the Tests

The purpose of the tests is to demonstrate that the ROGIDS complies with the minimum performance specifications for the detection of clear ice with and/or without FPD fluids and under visibility conditions as specified in Appendix B.

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The tests for ROGIDS address three applications:

- a. Detection of Clear Ice Before Deicing
- b. Detection of Residual Clear Ice After Deicing
- c. Detection of Residual Clear Ice After Deicing with Obscured Visibility

#### 6.4 Test Equipment Required

For more details on equipment requirements refer to Appendix B. Conduct tests using:

- Flat test plates representative of airplane surface materials and finishes (Appendix B, Table B1 and Figure B1).
- Deicing and anti-icing fluids meeting SAE specifications (AMS 1424 and AMS 1428).
- Artificial precipitation in a temperature-controlled climatic chamber.

For test purposes, the following surfaces have been selected: polished, unpolished, painted white and painted red aluminum; painted red and painted white reinforced fibre. This test equipment ensures demonstration of ROGIDS performance under representative operational conditions.

Alternative procedures which provide equivalent information but which require different test equipment may be used (see Paragraph 6.1.6, item b). This includes tests conducted under natural conditions.

#### 6.5 Detailed Test Procedures

The tests given in this section, which are summarized in Appendix A and detailed in Appendices B and C, are required to demonstrate the capability of the ROGIDS to perform the functions as described in Paragraph 1.3.

To demonstrate the capability to identify clear ice, the selected laboratory precipitation conditions are considered to be consistent with natural icing conditions.

Test conditions, including methods to generate, control and validate precipitation conditions, are given in Appendix B.

These test conditions have been adapted from and use the same principles as laboratory test procedures to establish Endurance Times for airplane deicing/anti-icing fluids (SAE Types I, II, III, and IV). These test procedures are described in SAE ARP5485 and SAE ARP5945.

##### 6.5.1 Test Procedure for Detection of Clear Ice Before Deicing

For more details on procedure requirements refer to Appendix B.

The tests in Appendix A, Table 1, shall be conducted to demonstrate the capability of a ROGIDS to identify clear ice on an untreated surface.

- a. Ensure the plates as defined in Appendix B are clean and dry; the ambient air temperature is recommended to be less than or equal to -5°C.
- b. Develop a layer of clear ice on each plate. Ensure the ice has a maximum thickness of 0.5 mm and a maximum area of 315 cm<sup>2</sup>.

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- c. After subjecting the ROGIDS to the detection of the clear ice, measure and record the ice thickness. Record any false positive indication on the area of the plate not covered by ice.
- d. Tests shall be completed under all the illumination conditions defined in Appendix C and detailed in the test matrix given in Appendix A. The illumination conditions that will be considered include daylight, night-time illumination and a condition with shadows on the test plate.
- e. Tests shall be completed with the ROGIDS placed at two positions:
  - 1. Far - One ROGIDS at manufacturers specified minimum operational sight angle and maximum distance.
  - 2. Near - One ROGIDS at manufacturers specified minimum distance and maximum operational sight angle.
- f. False Positive Tests: Once each clear ice test is complete, a plate without ice will be placed above the original plate and tests shall be carried out with the far and near ROGIDS.

## 6.5.1.1 Appendix A, Table 1 – Pass/Fail Criteria

## a. False negatives

For each test in test set one (pre-deicing) the ROGIDS shall always correctly detect and indicate the presence of ice on each half or quadrant of the ice sample irrespective of:

- 1. The plate finish under the ice
- 2. Illumination of ice sample
- 3. Sensor location (near, far)

## b. False positives

For each clean plate test in test set 1 the ROGIDS shall not indicate the presence of ice on more than xx% of the test series irrespective of:

- 1. The plate finish
- 2. Illumination of plate
- 3. Sensor location (near, far)

## 6.5.1.2 Test Reporting

The test procedures, ice thickness and area measurements, sensor sight angles and distances, and detection results for each test conducted shall be documented.

## 6.5.2 Test Procedure for Detection of Residual Clear Ice After Deicing

For more details on procedure requirements refer to Appendix B.

The tests in Appendix A, Table 2, shall be conducted to demonstrate the capability of a ROGIDS to identify residual clear ice beneath a de/anti-icing fluid layer. For these tests ethylene and propylene glycol based Type I, II, III and IV de/anti-icing fluids shall be used. If the ROGIDS is intended to be used with other glycol based fluids (e.g. diethylene) or non-glycol based fluids, then additional tests with these fluids will be required.

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- a. Ensure the plates as defined in Appendix B are clean and dry; the ambient air temperature is recommended to be less than or equal to  $-5^{\circ}\text{C}$ .
- b. Develop a layer of clear ice on each plate. Ensure the ice has a maximum thickness of 0.5 mm and a maximum area of 315  $\text{cm}^2$  after the de/anti-icing fluid has been applied. For this test the plates shall be horizontal in order to ensure a consistent and representative de/anti-icing fluid thickness over the clear ice.
- c. In addition to these tests, a reduced set of tests with thick clear ice above the detection threshold described in Subsection 4.1.1 shall be conducted using clear ice with a thickness of  $10\text{mm} \pm 1\text{mm}$ .
- d. Prior to application of the fluid, ensure that the ROGIDS is capable of detecting the clear ice. Measure and record the ice thickness.
- e. Apply the appropriate fluid as listed in Appendix A, Table 2. The procedure for the application of the fluid is as follows:
  1. For Type I fluid, the amount of fluid needed is such that a thickness of  $0.1\text{mm} \pm 0.05\text{mm}$  is achieved. A retainer placed on the plate may be used to ensure that the required thickness is achieved.
  2. For Type III fluid, the amount of fluid needed is such that a thickness of  $1.0\text{mm} \pm 0.2\text{mm}$  is achieved.
  3. For Type II or Type IV fluid, the amount of fluid needed is such that a thickness of  $3\text{mm} \pm 0.5\text{mm}$  is achieved.
- f. Perform the test.
- g. After each test case, measure and record the fluid and residual ice thicknesses.

CAUTION: The fluid will dissolve the ice; therefore minimize the time between the fluid application and the measurement of the residual ice thickness.
- h. Tests shall be completed under the night-time illumination conditions that are defined in Appendix C and listed in the test matrix given in Appendix A, Table 2. In the event that the tests in Appendix A Table 3 are not performed, the tests in Appendix A, Table 2 must be repeated using both daylight and shadow illumination conditions.
- i. Tests shall be completed with the ROGIDS placed at two positions:
  1. Far - One ROGIDS at manufacturers specified minimum operational sight angle and maximum distance.
  2. Near - One ROGIDS at manufacturers specified minimum distance and maximum operational sight angle.
- j. False positive tests: Tests will only be carried out for the Type I and Type IV propylene fluids. Once each of the 12 Type I and Type IV clear ice tests is complete, a plate without ice will be placed above the original plate and tests shall be carried out with the far and near ROGIDS.

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## 6.5.2.1 Appendix A, Table 2 – Pass/Fail Criteria

## a. False negatives

For each test in test set 2 (post-deicing) the ROGIDS shall always correctly detect and indicate the presence of ice on each half or quadrant of the ice sample irrespective of:

1. The plate finish under the ice
2. Illumination of ice sample
3. Sensor location (near, far)
4. Ice thickness
5. Fluid type

## b. False positives

For each clean plate test in test set 2 the ROGIDS shall not indicate the presence of ice on more than xx% of the test series irrespective of:

1. The plate finish
2. Illumination of plate
3. Sensor location (near, far)
4. Fluid type

## 6.5.2.2 Test Reporting

The test procedures, ice thickness and area measurements, fluid name, fluid thickness, sensor sight angles and distances, and detection results for each test conducted shall be documented.

## 6.5.3 Test Procedure for Detection of Residual Clear Ice After Deicing with Obscured Visibility

For more details on procedure requirements refer to Appendix B.

The tests in Appendix A, Table 3, shall be conducted to demonstrate the capability of a ROGIDS to identify residual clear ice beneath a de/anti-icing fluid layer under the visibility conditions specified in Appendix B. For these tests, propylene glycol based Type I and IV de/anti-icing fluids will be used.

Conduct tests with the following precipitation conditions:

- Freezing fog with visual interference equivalent to a field visibility of 100 m.
  - Freezing drizzle between the plates and the sensor(s), and encompassing the sensor field of view.
  - Rain between the plates and the sensor(s), and encompassing the sensor field of view.
  - Freezing rain between the plates and the sensor(s), and encompassing the sensor field of view.
  - This particular set of tests does not need to be completed if the more challenging set of tests in the rain condition was satisfactory.
  - Snow between the plates and the sensor(s), and encompassing the sensor field of view.
- a. Ensure the plates as defined in Appendix B are clean; the ambient air temperature is recommended to be less than or equal to -5°C.

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- b. Develop a layer of clear ice on each plate. Ensure the ice has a maximum thickness of 0.5 mm and a maximum area of 315 cm<sup>2</sup> after the de/anti-icing fluid has been applied. For this test the plates shall be horizontal in order to ensure a consistent and representative de/anti-icing fluid thickness over the clear ice.
- c. Create the precipitation conditions that will obscure the visibility between the sensor and the surface to be inspected for ice.
- d. Prior to application of the fluid, ensure that the ROGIDS is capable of detecting the clear ice. Measure and record the ice thickness.
- e. Apply the appropriate fluids (Type IV propylene over Type I propylene over ice) as listed in Appendix A table 3. The procedure for the application of the fluid is as follows: For Type I fluid, the amount of fluid needed is such that a thickness of 0.1mm ± 0.05mm is achieved. A retainer placed on the plate may be used to ensure that the required thickness is achieved. Immediately following the Type I fluid application, apply 3mm ± 0.5 mm of Type IV fluid over the Type I fluid.
- f. Perform the test.
- g. After each test case, measure and record the total fluid and residual ice thicknesses.

CAUTION: The fluids will dissolve the ice, therefore minimize the time between the fluid application and the measurement of the residual ice thickness Tests shall be completed under all the illumination conditions defined in Appendix C and listed in the test matrix in Appendix A table 3. The illumination conditions that shall be considered include daylight, nighttime illumination and a condition with shadows on the test plate.

- h. Tests shall be completed with the ROGIDS placed at the far position- the manufacturers specified minimum operational sight angle and maximum distance.
- i. False positive tests: The 15 tests in shadow shall be repeated on plates without ice. Once each clear ice test in shadow is complete, a plate without ice will be placed above the original plate and tests shall be carried out with the far and near ROGIDS.

#### 6.5.3.1 Appendix A, Table 3 – Pass/Fail Criteria

##### a. False negatives

For each test in test set 3 (post-deicing with precipitation) the ROGIDS shall always correctly detect and indicate the presence of ice on each half or quadrant of the ice sample irrespective of:

1. The plate finish under the ice
2. Illumination of ice sample
3. Sensor location (near, far)
4. Fluid types
5. Temperature
6. Precipitation

##### b. False positives

For each clean plate test in test set 3 the ROGIDS shall not indicate the presence of ice on more than xx% of the test series irrespective of:

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1. The plate finish
2. Illumination of plate.
3. Sensor location (near, far)
4. Fluid types
5. Temperature
6. Precipitation.

**6.5.3.2 Test Reporting**

The test procedures, ice thickness and area measurements, combined fluid thickness, fluid names, sensor sight angle and distance, visibility conditions, precipitation characteristics, and detection results for each test conducted shall be documented.

**7. INSTALLED EQUIPMENT PERFORMANCE:****7.1 Introduction**

This chapter specifies the minimum acceptable level of performance and test procedures for verifying the performance of the ROGIDS when installed. This chapter does not specify means to show compliance with regulatory requirements. Installed performance criteria are generally the same as those contained in Chapter 4, which were verified through laboratory and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be verified after installation. The installed performance limits specified below take these situations into consideration.

**7.1.1 Test Plan, Procedures and Reports**

A test plan and test procedures shall be prepared, and may be submitted to the appropriate authorities for review. Any deviation in the prepared test procedures with this standard shall be highlighted and justified. A report of test results shall be prepared in accordance with Subsection 3.9.

Except where tests are obviously GO/NO GO in character (e.g., the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded.

**7.2 Installed Equipment Requirements****7.2.1 General****7.2.1.1 Installation**

The ROGIDS shall be compatible with the physical and environmental conditions present in the installed location. Installation of the equipment should permit ease of access for maintenance and testing. It shall be physically impossible to install the ROGIDS improperly.

**7.2.1.2 Display Visibility**

The user(s) shall have an unobstructed view of the displayed data when in the normal operating position. Display intensity shall be adequate for data interpretation under all relevant operating conditions.

**7.2.1.3 Controls Accessibility**

Controls shall be readily accessible from the user's normal operating position.

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7.2.1.4 Failure Protection

Any probable failure of the ROGIDS shall not degrade the normal operation of any other equipment or systems.

Failure of interfaced equipment or systems shall not degrade the safe operation of the ROGIDS. The validity of signals from interfaced equipment or systems shall be considered in the BITE as defined in Subsection 3.8.3.

7.2.1.5 Interference Effects

The ROGIDS shall not be the source of harmful interference and shall not be adversely affected by interference from other equipment or systems.

7.2.1.6 Documentation

Documentation provided with installed systems shall incorporate the operating procedures defined in accordance with Subsection 3.10.3.

If any operational limitations (see Subsection 3.10.4) are applicable to the ROGIDS, these limitations shall clearly be stated in the documentation provided with the system.

7.2.2 Technical

7.2.2.1 Power Source

The ROGIDS shall meet its performance criteria when supplied with the manufacturer's specified electrical power.

7.2.2.2 Protection against inadvertent turnoff should be provided.

7.2.2.3 Thermal Compatibility

7.2.2.4 The thermal characteristics of the GIDS shall not affect its ability to accurately perform its intended function.

7.2.2.5 Intrinsic Safety

The requirements of EN 50020 or IEC 0079 Part 11 or any local requirements apply to ROGIDS where installation locations could be made hazardous by the presence of explosive gas or vapour.

7.2.2.6 External Light

The ROGIDS performance shall not be affected by natural and artificial visible and non-visible light conditions.

7.2.2.7 Operation During Reduced Visibility Conditions

The ROGIDS performance shall not be affected by reduced visibility conditions resulting from operations under environmental conditions defined in Subsection 3.8.5.

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7.2.2.8 Compatibility With the Monitored Surface

The ROGIDS performance shall not be affected by the material, the surface finish and/or surface treatment of the airplane monitored surface.

7.2.2.9 Non-Frozen Contaminants on the Monitored Surface

ROGIDS performance should not be affected by non-frozen contaminants on the monitored surface. Any non-frozen contaminants identified by the manufacturer and/or end users to affect the performance of the ROGIDS shall be documented in the summary test report.

7.2.2.10 Dynamic Response

The GIDS performance shall not be affected by the dynamic operating conditions of installation (user, vehicle, and airplane movement encountered during ground operations).

7.2.2.11 Electromagnetic Interference Effects

7.2.2.12 The ROGIDS shall not be the source of harmful electromagnetic interference and shall not be adversely affected by electromagnetic interference from other equipment or systems.

7.2.2.13 Fluid Foaming Effects

The ROGIDS performance should not be affected by foaming in applied de/anti-icing fluids.

7.3 Installed Equipment Performance:

Installed ROGIDS shall comply with the requirements of Subsection 3.4 and the operator's approved deicing program.

The ROGIDS shall achieve, when installed, the performance specified in Chapter 4, taking into account the following:

- a. If the surface where an ROGIDS sensor makes its measurement is smaller than the monitored surface, the capacity of the ROGIDS to assess the condition of the monitored surface shall be demonstrated.
- b. The installation, sensor resolution and/or operation of the sensing unit(s) shall be determined, either by analysis or by experiment, so as to ensure detection of frozen contamination in compliance with the operator's deicing program and regulatory requirements.

7.4 Conditions of Test

7.4.1 Safety Precautions

Any unusual characteristics or hazards to personnel or property (e.g., laser radiation, etc.) resulting from operation of the ROGIDS shall be analyzed and documented before the test.

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, this procedure does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes, and to take the necessary precautionary measures to ensure the health and safety of all personnel involved.

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7.4.2 Power Input

The test(s) shall be conducted with the ROGIDS powered by the installed equipment electrical power generating system.

7.4.3 Associated Equipment and Systems

All other electrical or mechanical equipment likely to be operated simultaneously on ground shall be activated for the test(s).

7.4.4 Environment

During the test, the environmental conditions shall not exceed those specified by the airplane manufacturer or ground support equipment manufacturer, as applicable, and accepted by the ROGIDS manufacturer.

7.4.5 Warm-up Period:

All tests shall be conducted after a warm-up period as specified by the manufacturer.

7.5 Test Procedures for Installed Equipment Performance

7.5.1 General

These test procedures are aimed at demonstrating proper operation (qualitative) of the installed ROGIDS, since simulation of all icing conditions listed in Subsection 3.8.5 is usually not feasible, they also address additional conditions that are not covered by Chapter 6 tests.

7.5.2 Ground Test Procedure

Testing will consist of compatibility and operational tests. A simulated detector output may be used to demonstrate proper operation of the display and other parts of the system operation.

7.5.2.1 Conformity Inspection

The installed ROGIDS shall be inspected to determine conformity with acceptable workmanship and engineering practices, that proper mechanical and electrical connections have been made, and that the equipment is installed in accordance with the manufacturer's recommendations.

7.5.2.2 Maintainability

Verify access and removal of the equipment in accordance with the best maintenance practices.

Verify that it is not possible to incorrectly install or connect any Line Replaceable Unit (LRU).

7.5.2.3 System Operations

The installed system shall be operated according to the documented system operating procedures. Proper function shall be verified.

Validate that the RGIDS display correctly identifies the inspected surface.

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## 7.5.2.4 Interference Effects

- a. General: The effects of some possible interference which may affect the ROGIDS performance are not always easy to identify through dedicated tests. Therefore, when reliable tests cannot be defined to validate the effect of some possible interference, the ROGIDS behavior may need to be monitored for an appropriate period of time to demonstrate its functionality under actual operating conditions.
- b. Thermal compatibility: Validate that the thermal characteristics of the ROGIDS do not affect its ability to accurately perform its intended function.
- c. External light: Validate that the ROGIDS performance is not affected by artificial or natural external light (visible and/or non-visible).
- d. Operation under reduced visibility conditions: Validate that ROGIDS performance is not affected by reduced visibility conditions.
- e. Compatibility with the monitored surface: Validate that ROGIDS performance is not affected by the material, the surface finish and/or surface treatment of the airplane monitored surface.
- f. Non-frozen contaminants on the monitored surface: Validate that ROGIDS performance is not affected by non-frozen contaminants (e.g., grease, dirt, fuel) commonly occurring in airplane operation and maintenance. If tests show that non-frozen contaminants affect the frozen contamination detection or fluid monitoring abilities of the ROGIDS, this limitation shall be noted in the documentation supplied to the operator.
- g. Dynamic response: Validate that the ROGIDS performance is not affected by dynamic operating conditions of installation (user, vehicle, and airplane movement encountered during ground operations).
- h. Electromagnetic Interference and Electromagnetic Compatibility: Validate that the ROGIDS is not the source of harmful interference and is not adversely affected by interference from other equipment or systems.
- i. Fluid Foaming Effects: De/anti-icing fluids shall be applied according to the standard de/anti-icing methods as defined by the operator's approved program. If tests show that foaming of applied de/anti-icing fluids affects the frozen contamination detection or fluid monitoring abilities of the ROGIDS, this limitation shall be noted in the documentation supplied to the operator.

## 7.5.2.5 Power Supply

Under installed conditions, verify the proper operation of the equipment.

## 7.5.2.6 Displays and Controls Accessibility

Demonstrate that all equipment controls and displayed data are readily accessible, intuitive and easily interpreted.

## 7.5.2.7 Frozen Contamination Detection and Fluid Monitoring

The ROGIDS shall be monitored to demonstrate its functionality under actual operating conditions and tested as follows:

- a. When the airplane surfaces have not been deiced.

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Determine the presence of frozen contamination consistent with the performance criteria defined in Paragraph 4.1.1.

- b. When used for a post de/anti-icing check immediately following de/anti-icing.

Determine the presence of frozen contamination consistent with the performance criteria defined in Paragraph 4.1.1.

- c. When airplane surfaces have been de/anti-iced.

Tests shall be conducted on a stationary airplane under conditions of winter precipitation to demonstrate that the ROGIDS or an array of ROGIDS indicates the onset of an unsafe condition.

NOTE: The Operator may define additional acceptance tests prior to receipt of the ROGIDS for service use.

8. NOTES

- 8.1 The change bar ( | ) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

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APPENDIX D FROST

In a situation where an airplane has not been deiced and where ice, including frost, with a rough surface may be present, a thickness detection threshold of less than 0.5mm may be required.

Detection of frost requires a threshold consistent with a Roughness Parameter of  $R_p=0.000015$ , similar to that accepted for insect contamination ( $R_p=0.000017$ ).

The empirically derived Roughness Parameter ( $R_p$ ) has been developed to be used to relate the aerodynamic effects of distributed leading edge roughness to the geometric qualities of the roughness elements.

The Roughness Parameter,  $R_p$ , is defined as:

$$R_p = A \times (k/c) \times N \times 10 \quad (\text{Eq. 1})$$

where:

- A = Cross sectional area of an individual roughness element
- k/c = Ratio of the roughness element height to the airfoil chord
- N = Number of roughness elements per square inch (roughness distribution density)
- 10 = Factor used to correlate  $R_p$  to the equivalent factor normally used to define roughness severity in numerical predictions.

This translates into a substantial range of frost particulate heights and densities.

Based on an assumption for the geometric definition of frost particulates (spherical) the range of heights and densities of the frost that would have to be detected at an  $R_p$  of 0.000015 would include as a minimum:

$R_p$	Density (#/in**2)	Density (#/cm**2)	Height (inch)	Height (mm)
0.000015	6156	954	0.00265	0.067
	900	140	0.00503	0.128
	6.45	1	0.02609	0.663

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COMMITTEE G-12, AIRCRAFT GROUND DEICING

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APPENDIX A

TABLE A1: Test Set 1 – Detection of Clear Ice Pre-Deicing

1. Sensor at Minimum Sight Angle and Maximum Distance (Far) and Maximum Sight Angle and Minimum Distance (Near).
2. Precipitation Type: None
3. Recommended Temperature:  $\leq -5^{\circ}\text{C}$
4. Fluid Type Required: None
5. See Appendices B and C for definitions of parameters.

Test #	Test Plate	Sensor Position	Illumination
1-1	1	Far	Daylight
1-2	2	Far	Daylight
1-3	3	Far	Daylight
1-4	1	Near	Daylight
1-5	2	Near	Daylight
1-6	3	Near	Daylight
1-7	1	Far	Night-time
1-8	2	Far	Night-time
1-9	3	Far	Night-time
1-10	1	Near	Night-time
1-11	2	Near	Night-time
1-12	3	Near	Night-time
1-13	1	Far	Shadow
1-14	2	Far	Shadow
1-15	3	Far	Shadow
1-16	1	Near	Shadow
1-17	2	Near	Shadow
1-18	3	Near	Shadow

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TABLE A2: Test Set 2 – Detection of Residual Clear Ice Post Deicing

1. Sensor at Minimum Sight Angle and Maximum Distance (Far) and Maximum Sight Angle and Minimum Distance (Near).
2. Precipitation Type: None
3. Recommended Temperature:  $\leq -5^{\circ}\text{C}$
4. Illumination: Night-time
5. See Appendices B and C for definitions of parameters.

Test #	Test Plate	Fluid Type Required	Sensor Position
2-1	1	Type I (E base) over ice	Far
2-2	2	Type I (E base) over ice	Far
2-3	3	Type I (E base) over ice	Far
2-4	1	Type I (P base) over ice	Far
2-5	2	Type I (P base) over ice	Far
2-6	3	Type I (P base) over ice	Far
2-7	1	Type II (P base) over ice	Far
2-8	2	Type II (P base) over ice	Far
2-9	3	Type II (P base) over ice	Far
2-10	1	Type III (P base) over ice	Far
2-11	2	Type III (P base) over ice	Far
2-12	3	Type III (P base) over ice	Far
2-13	1	Type IV (E base) over ice	Far
2-14	2	Type IV (E base) over ice	Far
2-15	3	Type IV (E base) over ice	Far
2-16	1	Type IV (P base) over ice	Far
2-17	2	Type IV (P base) over ice	Far
2-18	3	Type IV (P base) over ice	Far
2-19	1	Type I (P base) over thick ice	Far
2-20	2	Type I (P base) over thick ice	Far
2-21	3	Type I (P base) over thick ice	Far
2-22	1	Type I (E base) over ice	Near
2-23	2	Type I (E base) over ice	Near
2-24	3	Type I (E base) over ice	Near
2-25	1	Type I (P base) over ice	Near
2-26	2	Type I (P base) over ice	Near
2-27	3	Type I (P base) over ice	Near
2-28	1	Type II (P base) over ice	Near
2-29	2	Type II (P base) over ice	Near
2-30	3	Type II (P base) over ice	Near
2-31	1	Type III (P base) over ice	Near
2-32	2	Type III (P base) over ice	Near
2-33	3	Type III (P base) over ice	Near
2-34	1	Type IV (E base) over ice	Near
2-35	2	Type IV (E base) over ice	Near
2-36	3	Type IV (E base) over ice	Near
2-37	1	Type IV (P base) over ice	Near
2-38	2	Type IV (P base) over ice	Near
2-39	3	Type IV (P base) over ice	Near
2-40	1	Type I (P base) over thick ice	Near
2-41	2	Type I (P base) over thick ice	Near
2-42	3	Type I (P base) over thick ice	Near

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TABLE A3: Test Set 3 – Detection of Residual Clear Ice Post Deicing During Precipitation

1. Sensor at Minimum Sight Angle and Maximum Distance (Far).
2. See Appendices B and C for definitions of parameters.
3. Note: In the event that the tests in this table are not performed, the tests in Appendix A, Table 2, must be repeated using both daylight and shadow illumination.

Test #	Precipitation Type	Precipitation Rate g/dm <sup>2</sup> /h	Recommended Temperature °C	Test Plate	Fluid Type Required	Illumination
3-1	Freezing Drizzle	5-10	< = -5	1	Type IV P Over Type I P Over Ice	Daylight
3-2	Freezing Drizzle	5-10	< = -5	2	Type IV P Over Type I P Over Ice	Daylight
3-3	Freezing Drizzle	5-10	< = -5	3	Type IV P Over Type I P Over Ice	Daylight
3-4	Light Fr. Rain	19-25	< = -5	1	Type IV P Over Type I P Over Ice	Daylight
3-5	Light Fr. Rain	19-25	< = -5	2	Type IV P Over Type I P Over Ice	Daylight
3-6	Light Fr. Rain	19-25	< = -5	3	Type IV P Over Type I P Over Ice	Daylight
3-7	Rain	65-75	< = +1	1	Type IV P Over Type I P Over Ice	Daylight
3-8	Rain	65-75	< = +1	2	Type IV P Over Type I P Over Ice	Daylight
3-9	Rain	65-75	< = +1	3	Type IV P Over Type I P Over Ice	Daylight
3-10	Freezing Fog	Visibility < 100m	< = -5	1	Type IV P Over Type I P Over Ice	Daylight
3-11	Freezing Fog	Visibility < 100m	< = -5	2	Type IV P Over Type I P Over Ice	Daylight
3-12	Freezing Fog	Visibility < 100m	< = -5	3	Type IV P Over Type I P Over Ice	Daylight
3-13	Snow	> 25	< = -5	1	Type IV P Over Type I P Over Ice	Daylight
3-14	Snow	> 25	< = -5	2	Type IV P Over Type I P Over Ice	Daylight
3-15	Snow	> 25	< = -5	3	Type IV P Over Type I P Over Ice	Daylight
3-16	Freezing Drizzle	5-10	< = -5	1	Type IV P Over Type I P Over Ice	Night-time
3-17	Freezing Drizzle	5-10	< = -5	2	Type IV P Over Type I P Over Ice	Night-time
3-18	Freezing Drizzle	5-10	< = -5	3	Type IV P Over Type I P Over Ice	Night-time
3-19	Light Fr. Rain	19-25	< = -5	1	Type IV P Over Type I P Over Ice	Night-time
3-20	Light Fr. Rain	19-25	< = -5	2	Type IV P Over Type I P Over Ice	Night-time
3-21	Light Fr. Rain	19-25	< = -5	3	Type IV P Over Type I P Over Ice	Night-time
3-22	Rain	65-75	< = +1	1	Type IV P Over Type I P Over Ice	Night-time
3-23	Rain	65-75	< = +1	2	Type IV P Over Type I P Over Ice	Night-time
3-24	Rain	65-75	< = +1	3	Type IV P Over Type I P Over Ice	Night-time
3-25	Freezing Fog	Visibility < 100m	< = -5	1	Type IV P Over Type I P Over Ice	Night-time
3-26	Freezing Fog	Visibility < 100m	< = -5	2	Type IV P Over Type I P Over Ice	Night-time
3-27	Freezing Fog	Visibility < 100m	< = -5	3	Type IV P Over Type I P Over Ice	Night-time
3-28	Snow	> 25	< = -5	1	Type IV P Over Type I P Over Ice	Night-time
3-29	Snow	> 25	< = -5	2	Type IV P Over Type I P Over Ice	Night-time
3-30	Snow	> 25	< = -5	3	Type IV P Over Type I P Over Ice	Night-time
3-31	Freezing Drizzle	5-10	< = -5	1	Type IV P Over Type I P Over Ice	Shadow
3-32	Freezing Drizzle	5-10	< = -5	2	Type IV P Over Type I P Over Ice	Shadow
3-33	Freezing Drizzle	5-10	< = -5	3	Type IV P Over Type I P Over Ice	Shadow
3-34	Light Fr. Rain	19-25	< = -5	1	Type IV P Over Type I P Over Ice	Shadow
3-35	Light Fr. Rain	19-25	< = -5	2	Type IV P Over Type I P Over Ice	Shadow
3-36	Light Fr. Rain	19-25	< = -5	3	Type IV P Over Type I P Over Ice	Shadow
3-37	Rain	65-75	< = +1	1	Type IV P Over Type I P Over Ice	Shadow
3-38	Rain	65-75	< = +1	2	Type IV P Over Type I P Over Ice	Shadow
3-39	Rain	65-75	< = +1	3	Type IV P Over Type I P Over Ice	Shadow
3-40	Freezing Fog	Visibility < 100m	< = -5	1	Type IV P Over Type I P Over Ice	Shadow
3-41	Freezing Fog	Visibility < 100m	< = -5	2	Type IV P Over Type I P Over Ice	Shadow
3-42	Freezing Fog	Visibility < 100m	< = -5	3	Type IV P Over Type I P Over Ice	Shadow
3-43	Snow	> 25	< = -5	1	Type IV P Over Type I P Over Ice	Shadow
3-44	Snow	> 25	< = -5	2	Type IV P Over Type I P Over Ice	Shadow

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## APPENDIX B

## B.1 SCOPE

The required test conditions to demonstrate the ability of the ROGIDS to comply with the performance specifications of Chapters 3 and 4 use the same principles as laboratory test procedures to establish endurance times for airplane deicing/anti-icing fluids (SAE Types I, II, III, and IV). These test procedures are described in SAE ARP5485 and SAE ARP5945.

## B.1.1 Safety

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, this procedure does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes, and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

## B.2 FLUID SAMPLE SELECTION PROCEDURE FOR SAE TYPE I FLUIDS

## B.2.1 Requirements

B.2.1.1 Production Batch: The sample shall be a fluid taken from a manufacturer's production batch.

B.2.1.2 Fluid Selection: Fluid selection for Type I shall include ethylene glycol or propylene glycol based fluids as listed in Appendix A, Tables 2 and 3.

B.2.1.3 Fluid Concentration: All Type I fluid tests shall be performed using a fluid with a freezing point between -28°C and -43°C.

## B.2.1.4 Manufacturer's Documentation:

- a. Fluid name, fluid type and batch number.
- b. The freezing point versus refraction at 20°C data for the fluid.

## B.2.2 Condition of the Sample to be Used for Test:

To minimize dissolving of the ice sample, it is recommended that the fluid be applied as cold as possible, but at least 3°C above the freezing point of the fluid. The sample's refractive index shall be measured and recorded.

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

## B.3.1 Requirements

## B.3.1.1 Production Batch

The sample shall be a neat fluid taken from a manufacturer's production batch.

## B.3.1.2 Viscosity

The viscosity shall be equal to or greater than the viscosity specified in the manufacturer's fluid specific Holdover Time (HOT) guidelines.

**SAE AS5681 Draft****B.3.1.3 Fluid Selection**

Fluid selection for Type II, Type III and Type IV shall include ethylene glycol or propylene glycol based fluids as listed in Appendix A, Tables 2 and 3.

**B.3.1.4 Fluid Concentration:** All tests shall be performed with neat 100% fluids.

**B.3.1.5 Fluid Manufacturer's Documentation**

- a. Fluid name, fluid type and batch number.
- b. The freezing point versus refraction at 20°C data for the fluid.

**B.3.2 Condition of the Sample to be Used for Test**

To minimize dissolving of the ice sample, it is recommended that the fluid be applied as cold as possible, but at least 3°C above the freezing point of the fluid. The sample's refractive index shall be measured and recorded.

**B.4 TEST PROCEDURE - GENERAL:****B.4.1 Purpose:**

This section establishes the minimum requirements for test equipment and test procedures used to demonstrate the ability of the ROGIDS to comply with the performance specifications of Chapters 4 and 5.

Section B.4 covers requirements that are common to many or all conditions (except where otherwise noted). Section B.5 establishes the specific requirements for each precipitation condition.

**B.4.2 ROGIDS Sensor and Plate Test Set-up:**

The size and surface finishes of the test plates shall be as described in Table B1 and illustrated in Figure B1.

Develop the ice sample on each plate over one circular area of 315 cm<sup>2</sup>. The ice sample shall be positioned so that it is equally distributed over both surface finishes of the test plate.

For the tests involving shadow illumination, the shadow shall be created to cover the top or bottom half of the ice sample, thereby creating four equal and distinct quadrants (two surface finishes, each with two illumination conditions on the sample).

Tests shall be performed with the ROGIDS placed at two positions:

- a. Far - One ROGIDS at manufacturers specified minimum operational sight angle and maximum distance.
- b. Near - One ROGIDS at manufacturers specified minimum distance and maximum operational sight angle.

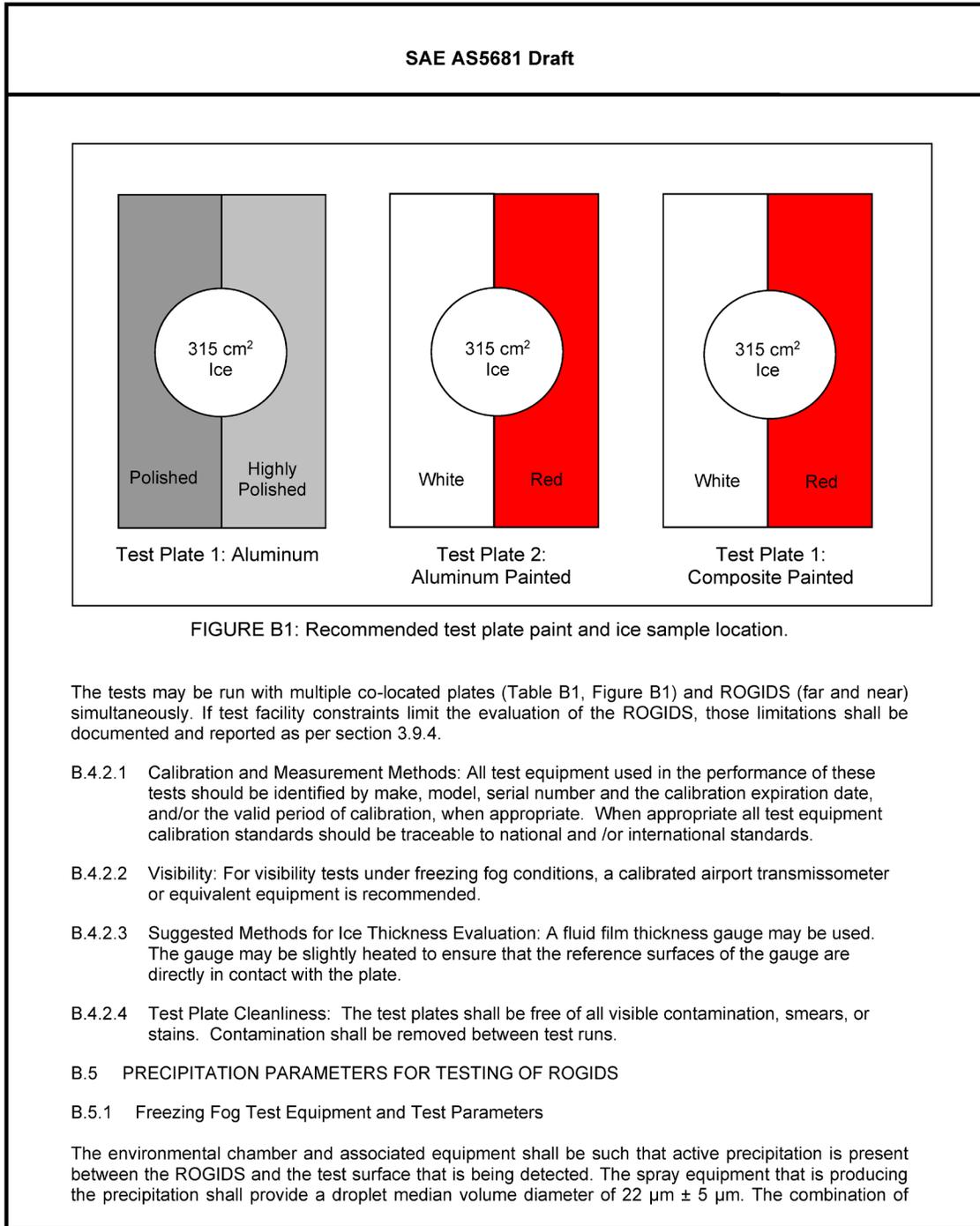
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TABLE B1 – Test Plates

<b>ALL TEST PLATES</b>	
Dimensions	500 mm long x 300 mm wide. Recommended thickness = 3 mm
<b>TEST PLATE 1</b>	
Material	Airplane type Aluminum alloy 2024
Surface finish	Half polished (150 mm wide) Average surface roughness: $0.3 \leq Ra \leq 0.5 \mu\text{m}$ Half highly polished (150 mm wide) Average surface roughness: $Ra \leq 0.2 \mu\text{m}$
<b>TEST PLATE 2</b>	
Material	Airplane type Aluminum alloy 2024
Surface finish	Half painted (150 mm wide) white polyurethane (Note 1) Half painted (150 mm wide) red polyurethane (Note 1)
<b>TEST PLATE 3</b>	
Material	Fiber Reinforced Composite
Surface finish	Half painted (150 mm wide) white polyurethane (Note 1) Half painted (150 mm wide) red polyurethane (Note 1)

NOTES:

1. Paint shall be applied to the test plates using typical aircraft painting processes. Record paint manufacturer, brand name, color reference, and application method..
2. To facilitate ice sample formation on the test plates, the area where the ice sample will be formed may be slightly roughened.



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precipitation rate and range should be adjusted to give conditions equivalent to a field visibility of 100 m or less with the ROGIDS operating at its maximum range when in service. The ambient air temperature is recommended to be less than or equal to -5°C.

**B.5.2 Freezing Drizzle Test Equipment and Test Parameters**

The environmental chamber and associated equipment shall be such that active precipitation is present between the ROGIDS and the test surface that is being detected. The spray equipment producing the precipitation shall provide a droplet median volume diameter of  $300 \mu\text{m} \pm 100 \mu\text{m}$ . The intensity should be between 5 and 10 g/dm<sup>2</sup>/h and the ambient air temperature is recommended to be less than or equal to -5°C.

**B.5.3 Light Freezing Rain Test Equipment and Test Parameters**

The environmental chamber and associated equipment shall be such that active precipitation is present between the ROGIDS and the test surface that is being detected. The spray equipment producing the precipitation shall provide a droplet median volume diameter of  $1000 \mu\text{m} \pm 100 \mu\text{m}$ . The intensity should be between 19 and 25 g/dm<sup>2</sup>/h and the ambient air temperature is recommended to be less than or equal to -5°C.

**B.5.4 Rain Test Equipment and Test Parameters**

The environmental chamber and associated equipment shall be such that active precipitation is present between the ROGIDS and the test surface that is being detected. The spray equipment producing the precipitation shall provide a droplet median volume diameter of  $1000 \mu\text{m} \pm 100 \mu\text{m}$ . The intensity should be between 65 and 75 g/dm<sup>2</sup>/h and the ambient air temperature is recommended to be less than or equal to +1°C.

**B.5.5 Snow Test Equipment and Test Parameters:**

The environmental chamber and associated equipment shall be such that active precipitation is present between the ROGIDS and the test surface that is being detected. Snow shall be produced having a density of  $\leq 0.10 \text{ g/cm}^3$ . The intensity should be greater than 25 g/dm<sup>2</sup>/h and the ambient air temperature is recommended to be less than or equal to -5°C.

At the time of the publication of this document, no known technology exists to produce sufficient quantities of artificial snow in an environmental chamber. Therefore, until such equipment becomes available, the snow test shall be performed outdoors in natural conditions.

For tests conducted in natural conditions, the only relevant environmental parameter is that the intensity of the snow shall be equal to or greater than 25 g/dm<sup>2</sup>/h.

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## APPENDIX C

## TEST PROCEDURE – AMBIENT ILLUMINATION TESTS

## C.1 Purpose:

This objective of the ambient illumination tests is to determine the ROGIDS clear ice detection performance under illumination conditions simulating daylight and night-time ambient lighting during winter operations and under the presence of shadow falling on the inspected surface.

Night-time illumination test conditions simulate the light levels during night-time or twilight deicing operations. Daylight illumination test conditions simulate the case of daylight deicing in full sunlight. Shadow test conditions simulate strong shadows on the inspected aircraft surface caused by sunlight being partially blocked by structures such as the aircraft fuselage or deicing truck.

## C.2 Lighting requirements:

The test plate illumination may be provided by natural light or, when the ROGIDS clear ice detection performance tests occur in a climatic chamber, by artificial sources located at an appropriate distance from the surface and oriented to eliminate direct (specular) reflections into the ROGIDS.

## a. Night-time illumination

The average illumination on the test plate shall be between 100-500 lux (9-46 footcandles) [1] and color temperature of approximately 2100-3200K. Natural lighting may be a combination of de-icing pad illumination, solar and diffuse skylight. (Artificial lighting used in a climatic chamber can be provided by diffused 150 watt high pressure sodium bulbs with a color temperature of 2,100 K [2].)

## b. Daylight illumination

The illuminance on the test plate shall be greater than 25,000 lux (2,300 footcandles) for natural lighting [1] and color temperature of approximately 5000-6500K. Unobscured sunlight with the sun position more than 30 degrees above the horizon is recommended.

When artificial sources are used in a climatic chamber, the illumination from the artificial sources on the target plate shall be equivalent to the amount produced by unobscured sunlight within the operating wavelength band of the ROGIDS. Specifically:

1. The illuminance on the test plate shall be greater than 25,000 lux (2,300 footcandles) for ROGIDS operating within the visible wavelength region (400-700 nm) or
2. For ROGIDS operating outside the visible region, the irradiance within the wavelength operating range of the ROGIDS shall be shown to provide the equivalent irradiance of unobscured sunlight when the sun position is more than 30 degrees above the horizon

CAUTION: High intensity lighting can cause premature melting of the ice samples.

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In ROGIDS tests where there is precipitation, the light source should illuminate the test plates through the precipitation.

- c. Shadow illumination: The solar illuminance on the test plate shall be greater than 25,000 lux (2,300 footcandles). The shadow is created by fixing flat plates with straight edges in the path of the sunlight such that the shadow covers approximately half of the ice patch without obscuring the ROGIDS line of sight.

In ROGIDS tests where there is precipitation, the light source shall illuminate the test plates through the precipitation.

**C.3 Test procedures:**

The ROGIDS detection testing in Section 6.5 shall be conducted with test plate illumination conditions listed in Appendix A, Tables 1, 2, and 3.

In the Shadow illumination test, the ROGIDS clear ice detection performance inside and outside the shadowed regions shall be recorded.

**References**

[1] Bond, D.S. and Henderson, F.P. The Conquest of Darkness, AD 346297, Defense Documentation Center, Alexandria, VA., 1963.

[2] Edmundo A. Sierra, Jr., Kimberlea Bender, Isabelle Marcil, John D'Avirro, Edward Pugacz, and Frank Eyre, "Comparison of Human Ice Detection Capabilities and Ground Ice Detection System Performance Under Post Deicing Conditions", DOT/FAA/CT- YY/##, December 2005.

**Definitions**

**ILLUMINANCE:** The amount of visible light power incident per unit area of a surface; measured in lux (lumens/meter<sup>2</sup>) or footcandles (Lumens/foot<sup>2</sup>)

**IRRADIANCE:** The amount of non-visible (e.g. infrared) light power per unit surface area; measured in Watts/meter<sup>2</sup>

**APPENDIX G**

**TRANSPORT CANADA  
HOLDOVER TIME (HOT) GUIDELINES  
WINTER 2006-2007**



**Transport Canada  
Holdover Time (HOT) Guidelines  
Winter 2006-2007**

**Original Issue, July 2006**

**Transport Canada Holdover Time Guidelines**

**Winter 2006-2007**

**CHANGE CONTROL RECORDS**

This page indicates the changes made to individual pages within the document and those changed pages have the appropriate date in the footer. Sidebars are shown to assist in identifying the changes from the previous version.

It is the responsibility of the end user to periodically check the following website for any Holdover Time Guideline updates: <http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm>.

<i>REVISION</i>	<i>DATE</i>	<i>DESCRIPTION OF CHANGES</i>	<i>AFFECTED PAGES</i>	<i>AUTHOR</i>

**Transport Canada Holdover Time Guidelines****Winter 2006-2007****SUMMARY OF CHANGES FROM PREVIOUS YEAR**

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

**General**

Ground Icing Operations and Holdover Time (HOT) Guideline information is provided in two documents. The two documents complement each other and should be used together for a more thorough understanding of the subject matter. The first document (TP 14052E) includes reference material related to Ground Icing Operations. The most recent version of TP 14052E is Edition 2, published April 2005. The second document consists of the HOT Guidelines, provided in this dedicated Transport Canada website.

**Type I Fluid**

The Type I holdover guideline values are unchanged.

**Type II Fluid**

Fluid-specific tables have been created for two new Type II fluids, Clariant Safewing MP II Flight and Kilfrost ABC-TF2. However, the Kilfrost ABC-TF2 fluid is currently in the qualification process.

The Type II generic holdover guideline values are unchanged.

**Type III Fluid**

The Type III holdover guideline values are unchanged.

**Type IV Fluid**

Fluid-specific tables have been created for three new Type IV fluids, Clariant Safewing MP IV Launch, Dow Chemical UCAR™ Endurance EG106 and Kilfrost ABC-S PLUS. However, the Kilfrost ABC-S PLUS is currently in the qualification process.

The Type IV generic holdover guideline values are unchanged.

**Note on Operations During Ice Pellet Conditions**

Transport Canada is conducting research to provide additional guidance for aircraft operations during ice pellet conditions. Because further research is necessary, no changes to the operational and HOT guidelines with respect to ice pellet conditions have been made at this time.

**Transport Canada Holdover Time Guidelines****Winter 2006-2007****CHANGES TO TP 14052 SECOND EDITION, APRIL 2005**

The following changes will be incorporated into TP 14052 at its next revision. For the time being they are recorded here in advance due to the longer life cycle time associated with the updating and publication of TP 14052 and are for immediate use.

**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  $-3^{\circ}\text{C}$  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 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) have 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.

**Transport Canada Holdover Time Guidelines****Winter 2006-2007****HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2006-2007**

Table 1	SAE Type I Fluid Holdover Guidelines
Table 2-Generic	SAE Type II Fluid Holdover Guidelines
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-II+	Kilfrost Type II Fluid Holdover Guidelines ABC-II PLUS
Table 2-K-ABC-TF2	Kilfrost Type II Fluid Holdover Guidelines ABC-TF2
Table 2-O-EM-II	Octagon Type II Fluid Holdover Guidelines E Max II
Table 2-S-E26	SPCA Type II Fluid Holdover Guidelines Ecowing 26
Table 3	SAE Type III Fluid Holdover Guidelines
Table 4-Generic	SAE Type IV Fluid Holdover Guidelines
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-2030	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2030 ECO
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-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-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 4-S-AD-480	SPCA Type IV Fluid Holdover Guidelines AD-480
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 Neat Fluids

**Transport Canada Holdover Time Guidelines**

**Winter 2006-2007**

TABLE 1

**SAE TYPE I<sup>3</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007**

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

Outside Air Temperature <sup>5</sup>		Approximate Holdover Times Under Various Weather Conditions (minutes)								
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains <sup>1</sup>			Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
				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	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	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/m<sup>2</sup> (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 criteria time is the shortest 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 2006-2007**

TABLE 2-Generic

**SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>**

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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>	
-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	CAUTION: No holdover time guidelines exist	
		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 – 0:35	0:15 – 0:45 <sup>3</sup>	0:10 – 0:25 <sup>3</sup>			
		75/25	5:00	0:20 – 0:55	0:15 – 0:25	0:15 – 0:30 <sup>3</sup>	0:10 – 0:20 <sup>3</sup>			
below -14 to -25	below 7 to -13	100/0	8:00 <sup>5</sup>	0:15 – 0:20 <sup>5</sup>	0:15 – 0:30 <sup>5</sup>					
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 criteria time is the shortest 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 2006-2007**

TABLE 2-C-2025

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	8:00	1:30 – 2:05	0:40 – 1:10	0:40 – 1:00	0:25 – 0:35	0:10 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:55 – 1:45	0:25 – 0:45	0:25 – 0:45	0:20 – 0:25	0:05 – 0:50	
		50/50	3:00	0:20 – 0:35	0:05 – 0:15	0:10 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45 – 1:50	0:35 – 1:00	0:35 – 1:05 <sup>3</sup>	0:20 – 0:35 <sup>3</sup>		
		75/25	5:00	0:40 – 1:20	0:25 – 0:45	0:30 – 0:40 <sup>3</sup>	0:15 – 0:25 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:25 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-C-Flight

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	8:00	3:30 – 4:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	5:00	2:30 – 4:00	0:40 – 1:20	1:15 – 2:00	0:30 – 0:55	0:05 – 1:20	
		50/50	3:00	0:55 – 1:45	0:10 – 0:25	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:55 – 1:45	0:40 – 1:05	0:35 – 1:30 <sup>3</sup>	0:25 – 0:45 <sup>3</sup>		
		75/25	5:00	0:40 – 1:10	0:20 – 0:40	0:25 – 1:10 <sup>3</sup>	0:30 – 0:40 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:30 – 0:50	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-K-ABC-2000

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	8:00	1:30 – 3:05	0:30 – 1:00	0:55 – 1:35	0:40 – 0:50	0:15 – 1:10	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:40 – 3:30	0:30 – 1:05	0:45 – 1:15	0:40 – 0:50	0:15 – 1:40	
		50/50	3:00	1:00 – 2:10	0:15 – 0:30	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:35 – 1:25	0:25 – 0:45	0:25 – 0:50 <sup>3</sup>	0:10 – 0:30 <sup>3</sup>		
		75/25	5:00	0:35 – 1:15	0:25 – 0:50	0:25 – 0:55 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:20 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-K-ABC-II+

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
ABC-II 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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>	
-3 and above	27 and above	100/0	8:00	1:10 – 2:25	0:25 – 0:55	0:35 – 1:10	0:30 – 0:40	0:05 – 1:00	CAUTION: No holdover time guidelines exist	
		75/25	5:00	1:10 – 2:25	0:25 – 0:50	0:30 – 1:00	0:20 – 0:40	0:05 – 0:50		
		50/50	3:00	0:15 – 0:45	0:15 – 0:35	0:05 – 0:25	0:05 – 0:15			
below -3 to -14	below 27 to 7	100/0	8:00	0:30 – 1:05	0:15 – 0:35	0:15 – 0:45 <sup>3</sup>	0:10 – 0:30 <sup>3</sup>			
		75/25	5:00	0:20 – 0:55	0:15 – 0:35	0:15 – 0:30 <sup>3</sup>	0:10 – 0:20 <sup>3</sup>			
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.							

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-K-ABC-TF2

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
ABC-TF2**

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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	8:00	1:10 – 2:25	0:20 – 0:45	0:40 – 1:20	0:30 – 0:45	0:10 – 1:10	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:20 – 2:25	0:15 – 0:30	0:45 – 1:25	0:30 – 0:45	0:10 – 1:25	
		50/50	3:00	0:45 – 1:25	0:05 – 0:15	0:20 – 0:40	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	8:00	0:50 – 1:40	0:15 – 0:35	0:35 – 1:15 <sup>3</sup>	0:30 – 0:40 <sup>3</sup>		
		75/25	5:00	0:35 – 1:25	0:15 – 0:25	0:30 – 1:30 <sup>3</sup>	0:30 – 0:40 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:30 – 1:00	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-O-EM-II

**OCTAGON TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	8:00	2:05 – 3:45	0:40 – 1:20	0:45 – 1:35	0:30 – 0:40	0:15 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:25 – 2:50	0:25 – 0:55	0:40 – 1:10	0:20 – 0:30	0:10 – 1:05	
		50/50	3:00	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	8:00	0:50 – 1:45	0:35 – 1:10	0:35 – 1:00 <sup>3</sup>	0:20 – 0:30 <sup>3</sup>		
		75/25	5:00	0:30 – 1:20	0:25 – 0:50	0:35 – 1:05 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:20 – 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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 2-S-E26

**SPCA TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>**  
**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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-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	CAUTION: No holdover time guidelines exist
		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	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	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10 <sup>3</sup>	0:15 – 0:35 <sup>3</sup>		
		75/25	5:00	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50 <sup>3</sup>	0:15 – 0:25 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00	0:25 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

**TABLE 3**

**SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007**

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

Outside Air Temperature <sup>3</sup>		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			Freezing Drizzle <sup>1</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
					Very Light	Light	Moderate				
-3 and above	27 and above	100/0	120	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	60	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	30	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/00	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 criteria time is the shortest 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 2006-2007**

TABLE 4-Generic

**SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>**

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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-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	CAUTION: No holdover time guidelines exist
		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 <sup>3</sup>	0:10 – 0:25 <sup>3</sup>		
		75/25	5:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30 <sup>3</sup>	0:10 – 0:20 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00 <sup>5</sup>	0:15 – 0:40 <sup>5</sup>	0:15 – 0:30 <sup>5</sup>				
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 criteria time is the shortest 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 2006-2007**

TABLE 4-C-2001

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>	
-3 and above	27 and above	100/0	12:00	1:20 – 3:20	1:00 – 1:55	0:55 – 1:55	0:40 – 1:00	0:15 – 2:00	CAUTION: No holdover time guidelines exist	
		75/25	5:00	1:20 – 2:00	0:35 – 1:00	0:35 – 1:10	0:25 – 0:35	0:10 – 1:25		
		50/50	3:00	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	12:00	0:45 – 1:35	0:30 – 0:50	0:55 – 1:35 <sup>3</sup>	0:30 – 0:45 <sup>3</sup>			
		75/25	5:00	0:30 – 1:00	0:20 – 0:35	0:40 – 1:10 <sup>3</sup>	0:20 – 0:30 <sup>3</sup>			
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 0:45	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.							

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-C-2012

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:40 – 1:15	0:40 – 1:10	0:25 – 0:45	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:10 – 2:05	0:25 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00	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	12:00	0:45 – 1:35	0:20 – 0:40	0:25 – 0:45 <sup>3</sup>	0:15 – 0:25 <sup>3</sup>		
		75/25	5:00	0:25 – 1:05	0:20 – 0:40	0:15 – 0:30 <sup>3</sup>	0:10 – 0:20 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-C-2030

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
SAFEWING MP IV 2030 ECO**

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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	1:55 – 3:20	0:50 – 1:30	0:55 – 2:00	0:40 – 0:50	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:15 – 2:05	0:35 – 1:05	0:40 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	3:00	0:30 – 0:45	0:15 – 0:25	0:15 – 0:25	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:50 – 2:00	0:45 – 1:25	0:30 – 1:10 <sup>3</sup>	0:20 – 0:35 <sup>3</sup>		
		75/25	5:00	0:40 – 1:30	0:35 – 1:05	0:35 – 1:20 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:25 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-C-Launch

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	4:00 – 4:00	1:00 – 1:35	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	3:40 – 4:00	0:40 – 1:20	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45	
		50/50	3:00	1:25 – 2:45	0:10 – 0:25	0:30 – 0:50	0:20 – 0:25		
below -3 to -14	below 27 to 7	100/0	12:00	1:00 – 1:55	0:40 – 1:05	0:35 – 1:40 <sup>3</sup>	0:25 – 0:45 <sup>3</sup>		
		75/25	5:00	0:40 – 1:20	0:20 – 0:40	0:25 – 1:10 <sup>3</sup>	0:25 – 0:45 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:30 – 0:50	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-D-ULTRA+

**DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	1:35 – 3:35	0:35 – 1:15	0:45 – 1:35	0:25 – 0:40	0:10 – 1:20	CAUTION: No holdover time guidelines exist
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25 – 3:00	0:25 – 0:55	0:45 – 1:25 <sup>3</sup>	0:30 – 0:45 <sup>3</sup>		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00 <sup>5</sup>	0:40 – 2:10 <sup>5</sup>	0:20 – 0:45 <sup>5</sup>				
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. <sup>5</sup> 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 These holdover times only apply to outside air temperatures to -24°C (-11°F).

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-D-E106

**DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	2:05 – 3:10	0:40 – 1:20	1:10 – 2:00	0:50 – 1:15	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:50 – 3:20	0:30 – 1:05	0:55 – 1:50 <sup>3</sup>	0:45 – 1:10 <sup>3</sup>		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:30 – 1:05	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-K-ABC-S

**KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	2:35 – 4:00	1:00 – 1:40	1:20 – 1:50	1:00 – 1:25	0:20 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:35 – 0:50	0:10 – 0:50	
		50/50	3:00	0:20 – 0:35	0:05 – 0:15	0:15 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45 – 2:05	0:45 – 1:20	0:20 – 1:00 <sup>3</sup>	0:10 – 0:30 <sup>3</sup>		
		75/25	5:00	0:25 – 1:00	0:25 – 0:50	0:20 – 1:10 <sup>3</sup>	0:10 – 0:35 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-K-ABC-S PLUS

**KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	1:50 – 3:40	0:45 – 1:25	1:15 – 1:55	0:50 – 1:10	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:10 – 2:10	0:25 – 0:55	0:45 – 1:10	0:30 – 0:45	0:05 – 1:00	
		50/50	3:00	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	12:00	0:40 – 1:25	0:35 – 1:00	0:30 – 1:35 <sup>3</sup>	0:25 – 0:35 <sup>3</sup>		
		75/25	5:00	0:40 – 1:15	0:25 – 0:50	0:25 – 1:15 <sup>3</sup>	0:30 – 0:40 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-O-MF

**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	2:40 – 4:00	0:50 – 1:35	0:55 – 2:00	0:35 – 1:00	0:15 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	5:00	2:05 – 3:15	0:45 – 1:45	1:15 – 2:00	0:35 – 1:10	0:10 – 0:40	
		50/50	3:00	0:55 – 1:45	0:25 – 1:15	0:35 – 1:00	0:15 – 0:30		
below -3 to -14	below 27 to 7	100/0	12:00	0:50 – 2:30	0:25 – 0:50	0:25 – 1:10 <sup>3</sup>	0:20 – 0:40 <sup>3</sup>		
		75/25	5:00	0:30 – 1:05	0:20 – 0:50	0:20 – 1:00 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-O-MF-04

**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	2:40 – 4:00	1:25 – 2:00	2:00 – 2:00	1:10 – 1:30	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	5:00	2:05 – 3:15	1:05 – 2:00	1:50 – 2:00	1:00 – 1:20	0:20 – 2:00	
		50/50	3:00	0:55 – 1:45	0:25 – 1:15	0:35 – 1:10	0:25 – 0:35		
below -3 to -14	below 27 to 7	100/0	12:00	0:50 – 2:30	0:35 – 1:10	0:25 – 1:30 <sup>3</sup>	0:20 – 0:40 <sup>3</sup>		
		75/25	5:00	0:30 – 1:05	0:40 – 1:20	0:20 – 1:00 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:20 – 0:45	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-O-MFLO

**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-3 and above	27 and above	100/0	12:00	2:20 – 3:35	0:40 – 1:30	1:20 – 2:00	0:30 – 1:00	0:10 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:25 – 2:00	0:20 – 0:55	0:40 – 1:05	0:20 – 0:35	0:05 – 1:15	
		50/50	3:00	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	12:00	1:10 – 2:20	0:25 – 1:00	0:35 – 1:45 <sup>3</sup>	0:30 – 0:50 <sup>3</sup>		
		75/25	5:00	0:40 – 1:25	0:15 – 0:40	0:35 – 1:15 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	0:30 – 1:00	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007**

TABLE 4-S-AD-480

**SPCA TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2006-2007<sup>1</sup>  
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 <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>
-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	CAUTION: No holdover time guidelines exist
		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	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	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
		75/25	5:00	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05 <sup>3</sup>	0:15 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00	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.						

**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.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest 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 2006-2007

**TABLE 5**  
**CURRENTLY QUALIFIED FLUIDS (2006-2007)**

**NOTE:**

Concentrate fluids have also been qualified at 50/50 (glycol/water) dilution.

<b>#</b>	<b>COMPANY NAME</b>	<b>FLUID NAME</b>	<b>EXPIRY (Y-M-D)</b>
1-1	Arcton Ltd.	Arctica DG	08-04-10
1-2	Aviation Xi <sup>®</sup> an High-tech	KHF-1	07-09-22
1-3	Battelle	D <sup>3</sup> : Degradable by Design Deicer™ ADF 1006A	08-01-13
1-4	Beijing Wangye Aviation Chemical Product Co. Ltd.	KLA-1	07-09-07
1-5	Clariant GmbH	Clariant Safewing MP I 1938 TF	06-08-25*
1-6	Clariant GmbH	Clariant Safewing MP I 1938 TF Pre-Mix	07-09-14
1-7	Clariant GmbH	Clariant Safewing MP I 1938 ECO	06-08-30*
1-8	Clariant GmbH	Clariant Safewing EG I 1996	06-08-24*
1-9	Chemical Specialists and Development Inc.	Prist Wing De-Icer	08-05-17
1-10	Dow Chemical Company	Dow UCAR™ Aircraft Deicing Fluid Concentrate	06-10-26
1-11	Dow Chemical Company	Dow UCAR™ ADF XL-54	07-03-10
1-12	Dow Chemical Company	Dow UCAR™ PG Aircraft Deicing Fluid	08-02-02
1-13	Dow Chemical Company	Dow UCAR™ PG ADF Dilute 55/45	08-02-02
1-14	HOC Industries	SafeTemp I ES	07-10-27
1-15	HOC Industries	SafeTemp ES Plus	07-09-15
1-16	<i>Inland Technologies Inc.</i>	<i>Inland Duragly-P ready to use</i>	<i>05-09-11</i>
1-17	<i>Inland Technologies Inc.</i>	<i>Inland Duragly-E ready to use</i>	<i>05-10-20</i>
1-18	Kilfrost Limited	Kilfrost DF PLUS	07-08-26
1-19	Kilfrost Limited	Kilfrost DF PLUS (80)	06-07-05*
1-20	Kilfrost Limited	Kilfrost DF PLUS (88)	07-08-26
1-21	Lyondell Chemical Co.	Lyondell ARCOPlus	08-02-14
1-22	Lyondell Chemical Co.	Lyondell ARCTIC Plus™	08-04-10
1-23	Newave Aerochemical Co. Ltd.	FCY-1A	07-06-15
1-24	Octagon Process Inc.	Octagon Octaflo EF	07-05-12
1-25	Octagon Process Inc.	Octagon Octaflo EG	07-05-12
1-26	SPCA	SPCA DE-950	08-05-30
1-27	Viterbo S.A.	Jarkleer SAE Type I	07-01-20

<sup>†</sup> 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.ugac.quebec.ca/amil/>  
 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.

Fluids listed in italics have expired and will be removed from this listing four years after expiry.

\* Currently in re-qualification process.

## Transport Canada Holdover Time Guidelines

Winter 2006-2007

TABLE 5 (cont.)

## CURRENTLY QUALIFIED FLUIDS (2006-2007)

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
2-1	Clariant GmbH	Clariant Safewing MP II 1951	07-06-02
2-2	Clariant GmbH	Clariant Safewing MP II 2025 ECO	06-08-24*
2-3	Clariant GmbH	Clariant Safewing MP II Flight	08-04-27
2-4	<i>Kilfrost Limited</i>	<i>Kilfrost ABC-II PLUS</i>	<i>05-10-29</i>
2-5	Kilfrost Limited	Kilfrost ABC-3	06-08-22*
2-6	Kilfrost Limited	Kilfrost ABC-2000	06-07-05*
2-7	Kilfrost Limited	Kilfrost ABC-TF2	**
2-8	Octagon Process Inc.	Octagon E Max II	06-07-22
2-9	SPCA	SPCA Ecowing 26	07-05-24

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
3-1	Clariant GmbH	Clariant Safewing MP III 2031 ECO	07-07-12

**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.

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
4-1	Clariant GmbH	Clariant Safewing MP IV 2001	06-06-02*
4-2	Clariant GmbH	Clariant Safewing MP IV 2012 Protect	07-07-12
4-3	Clariant GmbH	Clariant Safewing MP IV 2030 ECO	06-07-27
4-4	Clariant GmbH	Clariant Safewing MP IV Launch	08-05-16
4-5	Dow Chemical Company	Dow UCAR ADF/AAF ULTRA+	06-12-20
4-6	Dow Chemical Company	UCAR AAF FlightGuard AD-480 <sup>(1)</sup>	08-05-31
4-7	Dow Chemical Company	UCAR™ Endurance EG106	08-01-25
4-8	<i>Ely Chemical Company</i>	<i>Octagon Max-Flight</i>	<i>06-07-06</i>
4-9	Kilfrost Limited	Kilfrost ABC-S	07-08-02
4-10	Kilfrost Limited	ABC-S PLUS	**
4-11	<i>Octagon Process Inc.</i>	<i>Octagon Max-Flight</i>	<i>06-07-06</i>
4-12	Octagon Process Inc.	Octagon Max-Flight 04	08-05-30
4-13	Octagon Process Inc.	Octagon MaxFlo	07-03-24
4-14	SPCA	SPCA AD-480	07-07-05

<sup>(1)</sup> This product is identical to SPCA AD-480; the SPCA AD-480 holdover time table applies.

<sup>†</sup> 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.ugac.quebec.ca/amil/>  
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.

Fluids listed in italics have expired and will be removed from this listing four years after expiry.

\* Currently in re-qualification process.

\*\* Currently in qualification process.

**Transport Canada Holdover Time Guidelines**

**Winter 2006-2007**

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) <sup>1</sup>	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing <sup>2</sup>
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C	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
Below -3°C (27°F)	(18°F) below OAT	Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	(18°F) below OAT

- 1 Fluids must only be used at temperatures above their lowest operational use temperature (LOUT).
- 2 To be applied before first step fluid freezes, typically within 3 minutes.

**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/m<sup>2</sup> (~ 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.

**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.**

**Transport Canada Holdover Time Guidelines**

**Winter 2006-2007**

**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) <sup>1</sup>	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing <sup>2</sup>
-3°C (27°F) and above	50/50 Heated <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 freezing point of the fluid is at least 7°C (13°F) below OAT and that aerodynamic acceptance criteria (LOUT) are met. Consider the use of Type I when Type II/III/IV fluid cannot be used (see Table 6).		

- 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 fluid.

**NOTES**

- For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

**CAUTIONS**

- Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.
- Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II, III or IV should 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.

**Transport Canada Holdover Time Guidelines**

**Winter 2006-2007**

**TABLE 8  
VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART<sup>1</sup>**

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 30	≤¾	>¾ 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	≤¾	>¾ to 7/8	>7/8 to 2	>2

<sup>1</sup> 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 THE TABLE**

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.

## Transport Canada Holdover Time Guidelines

Winter 2006-2007

TABLE 9  
LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING NEAT FLUIDS

	FLUID NAME	LOWEST ON-WING VISCOSITY <sup>a</sup> (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
TYPE II	Clariant Safewing MP II 2025 ECO	5,500 <sup>b</sup>	5,750 <sup>g</sup>
	Clariant Safewing MP II Flight	3,340 <sup>g</sup>	3,340 <sup>g</sup>
	Kilfrost ABC-2000	2,350 <sup>c</sup>	2,350 <sup>g</sup>
	Kilfrost ABC-II Plus	3,600 <sup>c</sup>	3,600 <sup>g</sup>
	Kilfrost ABC-TF2	3,550 <sup>c</sup>	3,460 <sup>g</sup>
	Octagon E Max II	13,520 <sup>d</sup>	13,520 <sup>g</sup>
	SPCA Ecowing 26	4,900 <sup>e</sup>	4,600 <sup>g</sup>
TYPE IV	Clariant Safewing MP IV 2001	18,000 <sup>b</sup>	18,000 <sup>c</sup>
	Clariant Safewing MP IV 2012 Protect	7,800 <sup>b</sup>	7,250 <sup>g</sup>
	Clariant Safewing MP IV 2030 ECO	10,500 <sup>b</sup>	10,500 <sup>c</sup>
	Clariant Safewing MP IV Launch	7,550 <sup>g</sup>	7,550 <sup>g</sup>
	Dow UCAR ADF/AAF ULTRA+	36,000 <sup>f</sup>	28,000 <sup>c</sup>
	Dow UCAR Endurance EG106	24,850 <sup>f</sup>	2,230 <sup>g</sup>
	Kilfrost ABC-S	17,000 <sup>c</sup>	17,000 <sup>c</sup>
	Kilfrost ABC-S PLUS	10,450 <sup>c</sup>	11,040 <sup>g</sup>
	Octagon Max-Flight	5,540 <sup>d</sup>	5,540 <sup>g</sup>
	Octagon Max-Flight 04	5,540 <sup>d</sup>	5,540 <sup>g</sup>
	Octagon MaxFlo	8,670 <sup>g</sup>	8,670 <sup>g</sup>
	SPCA AD-480	15,200 <sup>e</sup>	12,800 <sup>c</sup>

<sup>a</sup> 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.

<sup>b</sup> Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of neat fluid, at 20°C, 0.3 rpm, for 15 minutes 0 seconds.

<sup>c</sup> Brookfield Spindle LV2-disc with guard leg, 150 mL of neat fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.

<sup>d</sup> Brookfield Spindle LV1 with guard leg, 500 mL of neat fluid, at 20°C, 0.3 rpm, for 33 minutes 20 seconds.

<sup>e</sup> Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of neat fluid, at 20°C, 0.3 rpm, for 30 minutes 0 seconds.

<sup>f</sup> Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of neat fluid, at 0°C, 0.3 rpm, for 10 minutes 0 seconds.

<sup>g</sup> Brookfield Spindle LV1 with guard leg, 500 mL of neat fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.

**SIGNIFICANCE OF THIS TABLE**

The viscosity values of the fluids in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the neat 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.

Note: The fluid manufacturer should be consulted for lowest on-wing viscosity associated with dilutions.

**APPENDIX H**

**PRESENTATIONS AT VARIOUS MEETINGS**



## PRESENTATIONS AT VARIOUS MEETINGS

- 1. Standing Committee Meeting, Ottawa, Canada, September 2005**
  - a. Aircraft De/Anti-Icing Fluid Holdover Time Update for the 2005-06 Season.
  
- 2. DND Icing Operations Standing Committee, Ottawa, Canada, October 2005**
  - a. Testing of Aircraft Ground De/Anti-Icing Fluids.
  
- 3. SAE G-12 HOT Subcommittee and HOT Work Group Meetings, Montreal, Canada, November 2005**
  - a. Holdover Time Table Format Changes; and
  - b. Endurance Time Testing in Simulated Ice Pellet Conditions.
  
- 4. SAE G-12 HOT Subcommittee and HOT Work Group Meetings, Lisbon, Portugal, May 2006**
  - a. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type I (WG and HOT);
  - b. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type II (WG and HOT);
  - c. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type III (WG and HOT);
  - d. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2005-06 Winter Test Season – Type IV (WG and HOT);
  - e. Aircraft Deicing Research in Simulated Ice Pellet Conditions (WG and HOT);
  - f. Results From Testing of Fluid Freeze Point Buffer – SAE Type I Fluids in a First-Step Deicing Application (WG);
  - g. Aircraft Ground Deicing Fluid Endurance Times in Snow Pellet Conditions (WG);
  - h. Preliminary Aircraft Ground Deicing Research Using Composite Materials (WG);
  - i. Holdover Times for Heavy Snow (WG and HOT); and
  - j. Development of Holdover Time Determination Systems (WG and HOT).

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# AIRCRAFT DE/ANTI-ICING FLUID HOLDOVER TIME UPDATE FOR THE 2005-06 SEASON



**TRANSPORT CANADA  
STANDING COMMITTEE MEETING ON AIRCRAFT  
OPERATIONS UNDER ICING CONDITIONS**

**OTTAWA – SEPTEMBER 21, 2005**

**RESEARCH PERFORMED ON BEHALF OF:**

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA



 Transports  
Canada
 

 Transport  
Canada

AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE




**TRANSPORT CANADA**

**CHANGES TO FLUID  
HOLDOVER TIME  
GUIDELINE FORMAT**

**2005-06 WINTER OPERATIONS**

**CHANGES TO HOLDOVER TIME  
GUIDELINE FORMAT**

- "Above 0°C" temperature range was removed
- Incorporated within the newly modified "-3°C and above" temperature range
- Fluid viscosity information for each Type III/IV fluid-specific table was removed
  - Placed in a separate Viscosity table
  - Also includes viscosities measured using the new AIR 9968 method
- Words previously abbreviated, including outside air temperature (OAT) and volume (vol), were replaced with full spellings




**CHANGES TO HOLDOVER TIME  
GUIDELINE FORMAT**

- Title of the frost column was changed from "Frost" to "Active Frost"
- Title of the snow column was changed from "Snow" to "Snow and Snow Grains"
- "Cautions" section was changed so that each sentence forms a new bullet
- One note was modified in the generic tables and added to the fluid-specific tables to explain how holdover time values are derived




**TRANSPORT CANADA**

**CHANGES TO FLUID  
HOLDOVER TIME  
GUIDELINE VALUES**

**2005-06 WINTER OPERATIONS**

**TEST CONDITIONS**

SNOW

LIGHT FREEZING RAIN

FREEZING DRIZZLE

FREEZING FOG

RAIN ON A  
COLD-SOAKED WING






### TEST LOCATIONS



**APS TEST SITE**



**MONTREAL – TRUDEAU INTERNATIONAL AIRPORT**



### TEST LOCATIONS



**NRC CLIMATIC CHAMBER**



**OTTAWA, ONTARIO**



### FLUIDS TESTED



**TYPE I**

**NO NEW FLUIDS TESTED**




### TRANSPORT CANADA TYPE I HOT GUIDELINES 2005-06

SAE TYPE I<sup>1</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)							Ratio on Cold Soaked Wing	Other <sup>2</sup>
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains <sup>3</sup>		Freezing Drizzle	Light Freezing Rain			
			Very Light	Light	Moderate					
-3 and above	27 and above	45	11 - 17	18	11 - 18	6 - 11	4 - 6	2 - 5		
below -3 to -6	below 27 to 21	45	8 - 13	14	8 - 11	5 - 8	4 - 6			
below -6 to -12	below 21 to 14	45	6 - 10	11	6 - 10	4 - 6	4 - 7	2 - 5	CAUTION: No known time guidelines exist.	
below -12	below 14	45	7	7	4 - 7	2 - 4				

NO CHANGES

**NOTES**

- To use these times, the fluid must be heated to a minimum temperature (usually 5°C (40°F) at the nozzle and an average rate of at least 1 liter (1.0 gal) (20 lb) (100 gal) must be applied to several surfaces. Other fluid types will be shorter.
- Heavy ice, snow packs, ice pellets, sleet and heavy freezing rain and fog.
- Type I Fluid: Fluid viscosity is limited to that the freezing point of the mixture is at least 10°C (50°F) below outside air temperature.
- Use light freezing rain holdover times if positive certification of freezing drizzle is not possible.
- Consult fluid for correct operation and temperature (S.O.U.T) is required.

**CAUTIONS**

- The only acceptable decision criteria time is the shortest time within the appropriate holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high turbulence content.
- High wind velocity will also reduce holdover time.
- Multisurface times may be reduced where aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground de-icing/anti-icing do not provide in-flight icing protection.

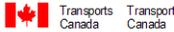
## FLUIDS TESTED



**TYPE II**

**ONE FLUID TESTED**

**FLUID WILL NOT BE COMMERCIALIZED**




## TRANSPORT CANADA TYPE II HOT GUIDELINES 2005-06

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>

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

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)									
Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration (mass %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>		
-3 and above	27 and above	1000	0:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:50	0:15 - 0:30	0:05 - 0:45			
		75:05	0:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:30	0:10 - 0:25	0:05 - 0:25			
		50:00	0:00	0:15 - 0:30	0:05 - 0:15	0:10 - 0:15	0:05 - 0:10				
below -3 to -14	below 27 to 7	1000	0:00	0:20 - 1:00	0:10 - 0:20	0:15 - 0:25*	0:10 - 0:20*			CAUTION: No holdover time guidelines exist	
		75:05	0:00	0:20 - 1:00	0:10 - 0:20*	0:15 - 0:30*	0:10 - 0:20*				
below -14 to -25	below 7 to -13	1000	0:00 <sup>3</sup>	0:15 - 0:30 <sup>4</sup>							
below -25	below -13	1000	0:00 <sup>3</sup>								

NO CHANGES

**NOTES:**

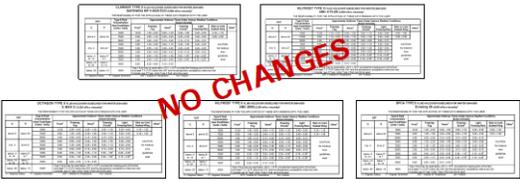
- Based on the lowest holdover times of the Type II fluids listed in Table 6-2.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and ice.
- These holdover times only apply to outside air temperatures to -25°C (-13°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS:**

- The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
- The time of production 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 TYPE II FLUID-SPECIFIC HOT GUIDELINES 2005-06

- CLARIANT SAFEWING MP II 2025 ECO
- KILFROST ABC 2000
- KILFROST ABC II PLUS
- OCTAGON E MAX II
- SPCA ECOWING 26



NO CHANGES

## FLUIDS TESTED



**TYPE III**

**ONE FLUID TESTED (DILUTIONS ONLY)**

**CLARIANT SAFEWING MPIII 2031 ECO**




## TRANSPORT CANADA TYPE III HOT GUIDELINES 2004-05

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2004-2005

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)										
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Very Light Snow	Light Snow	Moderate Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>		
-3 and above	27 and above	120	20-40	35	20-35	10-20	10-20	6-10	6-20			
		120	20-40	30	15-30	9-15	10-20	6-10				
below -3 to -10	below 27 to 14	120	20-40	30	15-30	8-15				CAUTION: No holdover time guidelines exist		
below -10	below 14	120	20-40	30	15-30	8-15						

**NOTES:**

- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and ice.
- Snow includes snow grains.
- Ensure that the lowest operational use temperature (LOUT) is respected; otherwise consider use of Type I when Type II fluid cannot be used.

**CAUTIONS:**

- The only acceptable decision criteria time is the shortest 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 do not provide in-flight icing protection.

## TRANSPORT CANADA TYPE III HOT GUIDELINES 2005-06

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006

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

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)									
Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration (mass %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>2</sup>		
-3 and above	27 and above	1000	0:00	0:30 - 1:00	0:20 - 0:45	0:30 - 0:50	0:15 - 0:30	0:05 - 0:45			
		75:05	0:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:30	0:10 - 0:25	0:05 - 0:25			
		50:00	0:00	0:15 - 0:30	0:05 - 0:15	0:10 - 0:15	0:05 - 0:10				
below -3 to -10	below 27 to 14	1000	0:00	0:20 - 1:00	0:10 - 0:20	0:15 - 0:25*	0:10 - 0:20*			CAUTION: No holdover time guidelines exist	
		75:05	0:00	0:20 - 1:00	0:10 - 0:20*	0:15 - 0:30*	0:10 - 0:20*				
below -10	below 14	1000	0:00	0:15 - 0:30 <sup>4</sup>							

NO CHANGES

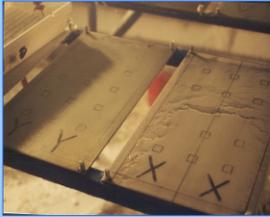
**NOTES:**

- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and ice.
- Ensure that the lowest operational use temperature (LOUT) is respected; otherwise consider use of Type I when Type II fluid cannot be used.

**CAUTIONS:**

- The only acceptable decision criteria time is the shortest 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.

## FLUIDS TESTED



**TYPE IV**

**2 FLUIDS TESTED**

**ONLY ONE WILL BE COMMERCIALIZED**

**OCTAGON MAXFLO**




### CHANGES TO TYPE IV GENERIC TABLE BASED ON MAXFLO TEST DATA

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow Show Grains	Freezing Drizzle	Light Freezing Rain	Rain on a Cold Soaked Wing	Other
-3 and above	27 and above	100/00	12:00	1:05 - 2:15	0:30 - 0:55	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50	<b>CAUTION: No Holdover Time Guidelines Exist</b>
		75/25	5:00	1:05 - 1:45	<b>0:20</b> 0:25 - 0:50	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	100/00	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45	0:10 - 0:25		
		75/25	5:00	0:25 - 0:50	<b>0:20</b> 0:25 - 0:35	0:15 - 0:30	0:10 - 0:20		
below -14 to -25	below 7 to -13	100/00	12:00	0:15 - 0:40	0:15 - 0:30				
below -25	below -13	100/00	Type IV Holdover times below -25 Celsius (10 Fahrenheit) provided the frozen point of the fluid is at least 10°C (50 Fahrenheit) below the OAT and the wind speed is less than 10 mph (16 km/h). Caution: use of Type IV below -25°C is not recommended.						

## REMOVAL OF OBSOLETE DATA

- Process for the removal of obsolete data was discussed and implemented by the SAE G-12 HOT Subcommittee at New Orleans G-12 meeting in 2001
- Fluids not commercially available for 4 years
- Not re-certified




## REMOVAL OF OBSOLETE DATA

- Data for two fluids, Hoechst 1957 and Union Carbide Ultra+ (in dilution), were removed from the Type IV data set and analysis in 2001
- In 2003 in Vancouver, data for SPCA AD-404 were removed
- In 2004 in Frankfurt, data for Clariant Safewing Four were removed
- Removal of the data resulted in increases to the Type IV generic table




## OBSOLETE DATA 2005

- One fluid met both criteria
- Clariant Safewing MP IV 1957 was tested for holdover times in 1997-98 and 1998-99
- Not available for 4 years
- Not re-certified




### INCREASES TO TYPE IV GENERIC TABLE AFTER ELIMINATION OF CLARIANT SAFEWING MP IV 1957

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow Show Grains	Freezing Drizzle	Light Freezing Rain	Rain on a Cold Soaked Wing	Other
-3 and above	27 and above	100/00	12:00	<b>1:15 - 2:30</b> 1:05 - 2:15	<b>0:25 - 1:15</b> 0:30 - 0:55	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50	<b>CAUTION: No Holdover Time Guidelines Exist</b>
		75/25	5:00	1:05 - 1:45	<b>0:20 - 0:55</b> 0:25 - 0:50	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	100/00	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45	0:10 - 0:25		
		75/25	5:00	0:25 - 0:50	<b>0:20</b> 0:20 - 0:35	0:15 - 0:30	0:10 - 0:20		
below -14 to -25	below 7 to -13	100/00	12:00	0:15 - 0:40	0:15 - 0:30				
below -25	below -13	100/00	Type IV Holdover times below -25 Celsius (10 Fahrenheit) provided the frozen point of the fluid is at least 10°C (50 Fahrenheit) below the OAT and the wind speed is less than 10 mph (16 km/h). Caution: use of Type IV below -25°C is not recommended.						

■ Increases due to removal of C1957
 ■ Reductions due to MaxFlo

## TRANSPORT CANADA TYPE IV HOT GUIDELINES 2005-06

**SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>**  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Type IV Fluid Concentration (wt% Fluid/Water)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other <sup>2</sup>
Degrees Celsius	Degrees Fahrenheit	wt%	Active Frost	Freezing Fog	Snow or Snow Drizzle	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
-3 and above	27 and above	1000	12:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50	
		75/25	6:00	1:00 - 1:45	0:20 - 0:55	0:30 - 0:50	0:15 - 0:30	0:05 - 0:35	
below -3 to -14	below 27 to 5 <sup>4</sup>	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
		1000	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:40 <sup>5</sup>	0:10 - 0:20 <sup>5</sup>		
below -14 to -25	below 7 to -23	75/25	6:00	0:20 - 0:35	0:10 - 0:20	0:15 - 0:30 <sup>5</sup>	0:10 - 0:30 <sup>5</sup>		
below -25	below -13	1000	12:00 <sup>6</sup>	0:15 - 0:40 <sup>7</sup>	0:15 - 0:30 <sup>7</sup>				

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) above the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.

**NOTES**

- Based on the lowest holdover times of the Type IV fluids listed in Table 6.
- Heavy snow, snow pellets, ice pellets, moisture and heavy freezing rain, and hail.
- These holdover times only apply to ice crystals or temperatures to -15°C (5°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Check that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptance decision criteria time is the shortest 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 VISIBILITY TABLE

## TRANSPORT CANADA VISIBILITY TABLE 2005-06

TABLE 8  
VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART<sup>1</sup>

Lighting	Temperature Range		Visibility in Snow (Statute Miles)		
	°C	°F	Heavy	Moderate	Very Light
Darkness	-1 and above	30 and above	≤1%	>2% to 4	>4
	Below -1	Below 30	≤3/4	>3/4 to 1%	>1% to 3
Daylight	-1 and above	30 and above	≤1%	>1% to 1%	>1% to 3
	Below -1	Below 30	≤3/8	>3/8 to 7/8	>7/8 to 2

1 Based on "Relationship between Visibility and Snowfall Intensity (TP 1418)E", Transportation Development Centre, Transport Canada, November 2005, and "Theoretical Considerations in the Determination of Snowfall Using Visibility" (TP 1293)E, Transportation Development Centre, Transport Canada, November 1995.

# TRANSPORT CANADA LOWEST ON-WING VISCOSITY TABLE

## LOWEST ON-WING VISCOSITY 2004-05

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2004-2005**  
~~SAFEWING MP II 2025 ECO (5,000 mPa.s viscosity)<sup>1</sup>~~

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

OAT		Type II Fluid Concentration (wt% Fluid/Water)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other <sup>2</sup>
°C	°F	wt%	Frost <sup>3</sup>	Freezing Fog	Snow <sup>4</sup>	Freezing Drizzle <sup>5</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
above 0	above 32	1000	12:00	1:30 - 2:05	0:45 - 1:20	0:40 - 1:00	0:25 - 0:35	0:10 - 1:15	
		75/25	6:00	0:55 - 1:45	0:25 - 0:45	0:25 - 0:45	0:20 - 0:25	0:05 - 0:50	
0 to -3	30 to 27	50/50	4:00	0:20 - 0:35	0:10 - 0:20	0:10 - 0:15	0:05 - 0:10		CAUTION: No holdover time guidelines exist
		1000	6:00	1:30 - 2:05	0:40 - 1:10	0:40 - 1:00	0:25 - 0:35		
below -3 to -14	below 27 to 5 <sup>4</sup>	75/25	6:00	0:55 - 1:45	0:25 - 0:45	0:25 - 0:45	0:20 - 0:25		
below -14 to -25	below 7 to -23	1000	6:00	0:25 - 0:45	0:15 - 0:30				
below -25	below -13	1000	12:00	0:45 - 1:50	0:35 - 1:00	0:35 - 1:05	0:20 - 0:35		

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 OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature wt% = Volume

## LOWEST ON-WING VISCOSITY 2005-06

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2004-2005**  
~~SAFEWING MP II 2025 ECO (5,000 mPa.s viscosity)<sup>1</sup>~~

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

OAT		Type II Fluid Concentration (wt% Fluid/Water)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other <sup>2</sup>
°C	°F	wt%	Frost <sup>3</sup>	Freezing Fog	Snow <sup>4</sup>	Freezing Drizzle <sup>5</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
above 0	above 32	1000	12:00	1:30 - 2:05	0:45 - 1:20	0:40 - 1:00	0:25 - 0:35	0:10 - 1:15	
		75/25	6:00	0:55 - 1:45	0:25 - 0:45	0:25 - 0:45	0:20 - 0:25	0:05 - 0:50	
0 to -3	30 to 27	50/50	4:00	0:20 - 0:35	0:10 - 0:20	0:10 - 0:15	0:05 - 0:10		CAUTION: No holdover time guidelines exist
		1000	6:00	1:30 - 2:05	0:40 - 1:10	0:40 - 1:00	0:25 - 0:35		
below -3 to -14	below 27 to 5 <sup>4</sup>	75/25	6:00	0:55 - 1:45	0:25 - 0:45	0:25 - 0:45	0:20 - 0:25		
below -14 to -25	below 7 to -23	1000	6:00	0:25 - 0:45	0:15 - 0:30				
below -25	below -13	1000	12:00	0:45 - 1:50	0:35 - 1:00	0:35 - 1:05	0:20 - 0:35		

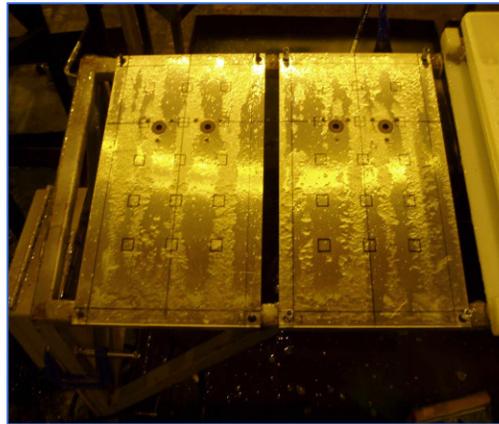
Type II fluid may be used below -25°C (13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature wt% = Volume



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# TESTING OF AIRCRAFT GROUND DE/ANTI-ICING FLUIDS



**DND ICING OPERATIONS STANDING COMMITTEE**

## MICHAEL CHAPUT

MANAGER, PROJECTS AND BUSINESS DEVELOPMENT

APS AVIATION INC.  
MONTREAL, QUEBEC, CANADA  
MCHAPUT@ADGA.CA  
WWW.APSAVIATION.CA



## APS COMPANY PROFILE



- Aviation consulting and engineering firm, founded in Montreal, Canada, in 1967
- APS has completed over 500 projects for over 100 clients worldwide



## APS COMPANY SERVICES



- Aviation Engineering Consulting Services
- Aerodrome / Airport Certification
- Product Development and Marketing Assistance for Aerospace Manufacturers
- Implementation of Global Navigation Satellite System (GNSS) and GPS Operations
- Risk Assessment and Safety Management
- Ground De/Anti-icing Research and Development

## CLEAN AIRCRAFT CONCEPT

- International aviation regulations prohibit the takeoff of aircraft when snow, ice or frost is adhering to wings, tails, control surfaces, propellers, engine intakes and other critical surfaces of the aircraft
- Even small amounts of contamination can have catastrophic results on aerodynamic performance



## DRYDEN AFTERMATH

- Since 1990, APS has conducted extensive aircraft ground de/anti-icing research and development on behalf of:



- A large portion of this work was the development of fluid holdover time tables for global use
- APS has produced over 80 technical reports on aircraft ground de/anti-icing for Transport Canada/FAA

## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

DE/ANTI-ICING FLUID CERTIFICATION

FLUID ENDURANCE TIME TESTING

HOLDOVER TIME TABLES 2005-06

## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

DE/ANTI-ICING FLUID CERTIFICATION

FLUID ENDURANCE TIME TESTING

HOLDOVER TIME TABLES 2005-06

## SAE G-12 DE-ICING COMMITTEE

- Born in the early 1990s due to increasing number of accidents related to aircraft ground de-icing
- Numerous Subcommittees within G-12:
  - HOLDOVER TIME
  - FLUIDS
  - FACILITIES
  - NEW DE-ICING TECHNOLOGIES
  - METHODS
  - ICE DETECTION
  - DE-ICING EQUIPMENT



## SAE G-12 DE-ICING COMMITTEE



## SAE G-12 DE-ICING STANDARDS

- **AMS1424:** Aircraft Deicing/Anti-Icing Fluid, SAE Type I
- **AMS1428:** Aircraft Deicing/Anti-Icing, Non-Newtonian, SAE Types II, III, and IV
- **AMS1431:** Compound, Solid Runway and Taxiway Deicing/Anti-Icing
- **AMS1435:** Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways
- **AIR9968:** Viscosity Test of Thickened Aircraft Deicing/Anti-Icing Fluids
- **ARP4737:** Aircraft Deicing/Anti-Icing Methods
- **ARP5485:** Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Types II, III and IV
- **ARP5945:** Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Type I
- **AS5900:** Standard Test Method for Aerodynamic Acceptance of SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluids
- **AS5901:** Water Spray and High Humidity Endurance Test Methods for SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluids



## SAE G-12 DE-ICING STANDARDS

- **AMS1424:** Aircraft Deicing/Anti-Icing Fluid, SAE Type I
- **AMS1428:** Aircraft Deicing/Anti-Icing, Non-Newtonian, SAE Types II, III, and IV
- **AMS1431:** Compound, Solid Runway and Taxiway Deicing/Anti-Icing
- **AMS1435:** Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways
- **AIR9968:** Viscosity Test of Thickened Aircraft Deicing/Anti-Icing Fluids
- **ARP4737:** Aircraft Deicing/Anti-Icing Methods
- **ARP5485:** Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Types II, III and IV
- **ARP5945:** Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Type I
- **AS5900:** Standard Test Method for Aerodynamic Acceptance of SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluids
- **AS5901:** Water Spray and High Humidity Endurance Test Methods for SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluids



## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

DE/ANTI-ICING FLUID CERTIFICATION

FLUID ENDURANCE TIME TESTING

HOLDOVER TIME TABLES 2005-06

## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

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FLUID ENDURANCE TIME TESTING

HOLDOVER TIME TABLES 2005-06

## DE/ANTI-ICING FLUID TYPES

→ 4 types of aircraft ground de/anti-icing fluids:

TYPE I

TYPE II

TYPE III

TYPE IV



## DE/ANTI-ICING FLUID TYPES



### Type I Fluid

- Low viscosity / non-thickened
- Primarily for de-icing
- Limited anti-icing properties = low holdover times
- Applied heated and at high pressure



## DE/ANTI-ICING FLUID TYPES



### Type II Fluid

- High viscosity / thickened
- Much longer holdover times than Type I
- Applied at ambient temperature, or heated



## DE/ANTI-ICING FLUID TYPES



### Type III Fluid

- Low viscosity / lightly thickened
- Better holdover time performance than Type I, less than Type II or IV
- Improved aerodynamic performance in comparison to highly thickened fluids. Ideal for aircraft with slower rotation speeds
- Applied heated and at high pressure



## DE/ANTI-ICING FLUID TYPES



### Type IV Fluid

- High viscosity / thickened
- Longest holdover times available
- Applied at ambient temperature, or heated



## DE/ANTI-ICING FLUID CERTIFICATION

- Every year, Transport Canada and FAA produce a list of certified aircraft de/anti-icing fluids in their guidance material

Transport Canada Holdover Time Guidelines		Winter 2005-2006	
TABLE 5 (cont.)			
CURRENTLY QUALIFIED FLUIDS (2005-2006)			
Table 5-2: Qualified Type II Anti-icing Fluids*			
#	Company Name	Fluid Name	Expiry (YY-MM-DD)
2-1	Chemart GmbH	Chemart Soltherma MP II 1991	07-06-07
2-2	Chemart GmbH	Chemart Soltherma MP II 2005 ECO	06-06-07
2-3	Kilbuck Limited	Kilbuck AIC-3 PLUS	05-10-09
2-4	Kilbuck Limited	Kilbuck AIC-3	06-08-07
2-5	Kilbuck Limited	Kilbuck AIC-2000	06-07-07
2-6	Oslogren Process Inc.	Oslogren E Max II	06-07-07
2-7	SPICA	SPICA Eternity 20	07-06-07

## DE/ANTI-ICING FLUID CERTIFICATION

- To be included in Transport Canada and FAA's list of certified fluids, each aircraft de/anti-icing fluid must undergo the following tests:

- Physical properties testing
- Anti-icing performance testing (WSET and HHET)
- Aerodynamic acceptance testing
- Fluid endurance time testing (Types II, III, IV)



## PHYSICAL PROPERTIES TESTING

## PHYSICAL PROPERTIES TESTING



- Thermal Stability
- Storage Stability
- Environmental
  - Aquatic Toxicity
  - Total Oxygen Demand
  - Biochemical Oxygen Demand
- Shear Stability



## PHYSICAL PROPERTIES TESTING



- Viscosity
- Flash Point
- pH
- Foaming Properties
- Dry-Out
- Corrosion



## PHYSICAL PROPERTIES TESTING

- **SAE AMS1424:** Aircraft Deicing/Anti-Icing Fluid, SAE Type I
- **SAE AMS1428:** Aircraft Deicing/Anti-Icing Fluid, Non-Newtonian, SAE Types II, III & IV
- Tests have historically been performed by Scientific Material International, Miami, Florida

S M I

Scientific Material International  
12219 SW 131 Avenue  
Miami, Florida

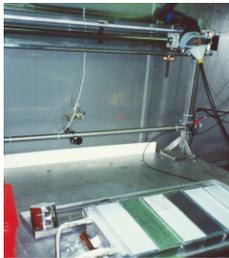
## PHYSICAL PROPERTIES TESTING

- Some physical properties tests have “test and report” requirements
- Other physical properties tests have minimum requirements that are established within AMS1424 and AMS1428
- All tests performed to provide quality assurance to the end user



## ANTI-ICING PERFORMANCE TESTING

### ANTI-ICING PERFORMANCE TESTING

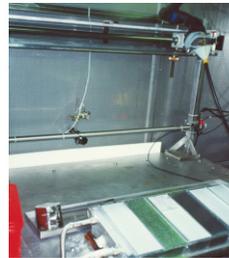


→ Water Spray Endurance Time (WSET)

- Type I 3 minutes
- Type II 30 minutes
- Type III 20 minutes
- Type IV 80 minutes



### ANTI-ICING PERFORMANCE TESTING



→ High Humidity Endurance Time (HHET)

- Type I 20 minutes
- Type II 4 hours
- Type III 2 hours
- Type IV 8 hours



### ANTI-ICING PERFORMANCE TESTING

- SAE AS5901: Water Spray and High Humidity Endurance Test Methods for SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-Icing Fluids
- Tests have historically been performed by Anti-Icing Materials International Laboratory (AMIL), University of Quebec at Chicoutimi, Chicoutimi, Canada



## AERODYNAMIC ACCEPTANCE TESTING

## AERODYNAMIC ACCEPTANCE TESTING



- Ensure acceptable aerodynamic characteristics of de/anti-icing fluids as they flow off aircraft lifting and control surfaces during ground acceleration, takeoff, and climb



## AERODYNAMIC ACCEPTANCE TESTING

- **SAE AS5900**: Standard Test Method for Aerodynamic Acceptance of SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-Icing Fluids
- Tests have historically been performed by Anti-Icing Materials International Laboratory (AMIL), University of Quebec at Chicoutimi, Chicoutimi, Canada



## WSET, HHET & AERODYNAMIC ACCEPTANCE TESTING

- All tests have minimum requirements that are established within AMS1424 and AMS1428
- All tests performed to provide quality assurance to the end user



## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

DE/ANTI-ICING FLUID CERTIFICATION

FLUID ENDURANCE TIME TESTING

HOLDOVER TIME TABLES 2005-06

## PRESENTATION TOPICS

SAE G-12 DE-ICING COMMITTEE

DE/ANTI-ICING FLUID CERTIFICATION

**FLUID ENDURANCE TIME TESTING**

HOLDOVER TIME TABLES 2005-06

## FLUID ENDURANCE TIME TESTING



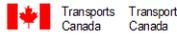
- Objective: Create fluid holdover time tables for operational use
- APS began fluid endurance time testing in 1990/91
- Over 80 fluids have been tested
- APS has conducted over 13,000 endurance time tests



## DE/ANTI-ICING FLUID HOLDOVER TIME

Time from initial application of anti-icing fluid onto an aircraft to the moment the fluid can no longer be guaranteed to provide protection at the anticipated takeoff time

(Transport Canada TP 13832)



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.	5 min.	3 min.	
- 8 and below	30 min.	15 min.	15 min.		

**1990-91**

**TYPE I**

**TYPE II**

GUIDELINE FOR HOLDOVER TIMES ACHIEVED BY ISO TYPE II FLUID MIXTURES (DEPENDENT ON WEATHER CONDITIONS)

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.	5 min.	3 min.	
- 8 and below	30 min.	15 min.	15 min.		

## FLUID ENDURANCE TIME TESTING

→ Endurance time testing was undertaken in 1990-91 by APS (under contract to Transport Canada) to:

- substantiate values in existing Type I and Type II holdover time tables
- evaluate the endurance time performance of new fluids



## TEST PROCEDURE DESIGN FLUID ENDURANCE TIME TESTS

- Pour de/anti-icing fluids onto standard test plates
- Plates mounted on a test stand inclined at 10°
- Expose the plates to various winter precipitation conditions
- Record the time elapsed before the plates reach the end condition



## TEST PLATE



- Aluminum panel
- 30 cm x 50 cm x 0.32 cm
- Crosshair markings on the panel to evaluate failure



## FLUID FAILURE



- Fluid failure occurs when:
  - Accumulation of snow bridging on top of the fluid or plate
  - Accumulation of ice on top of the fluid or plate, or ice suspended within the fluid
  - Contaminated fluid covers more than 1/3 of the entire plate surface



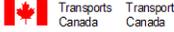
### CORRELATION OF WING AND PLATE FAILURES






### PRECIPITATION CONDITIONS

SNOW  
 LIGHT FREEZING RAIN  
 FREEZING DRIZZLE  
 FREEZING FOG  
 RAIN ON A COLD-SOAKED WING  
 FROST




### MONTREAL AIRPORT TEST SITE

Test Stand and Flat Plates



Failed Test Plate in Natural Snow Conditions



### ENDURANCE TIME TESTING

NATURAL SNOW



### NRC CLIMATIC ENGINEERING FACILITY – OTTAWA

Interior View of National Research Council Climate Engineering Facility



Exterior View of National Research Council Climate Engineering Facility

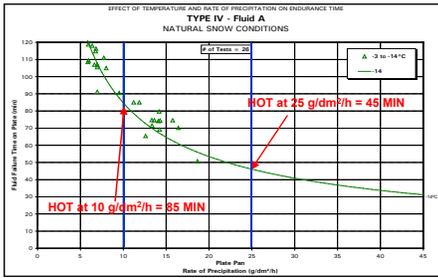


### ENDURANCE TIME TESTING

SIMULATED PRECIPITATION – FREEZING FOG

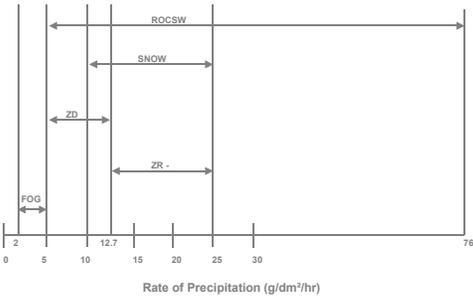


### REGRESSION ANALYSIS



**HOLDOVER TIME RANGE = 45 – 85 MINUTES**

### PRECIPITATION RATE LIMITS FOR THE EVALUATION OF FLUID HOLDOVER TIME RANGES



### TEST TEMPERATURES

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 2-Genus  
SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>  
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						Other <sup>2</sup>
		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
3 and above	1000	0:00	0:15-1:30	0:30-0:45	0:30-0:35	0:15-0:30	0:05-0:10	
27 and above	7500	0:00	0:25-1:00	0:15-0:30	0:30-0:45	0:15-0:25	0:05-0:10	
5000	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:10		
below 27	1000	0:00	0:20-1:00	0:10-0:30	0:15-0:20 <sup>4</sup>	0:15-0:20 <sup>4</sup>	0:05-0:10	CAUTION: No holdover time guidelines exist
below 10	7500	0:00	0:25-1:00	0:15-0:30	0:15-0:20 <sup>4</sup>	0:15-0:20 <sup>4</sup>	0:05-0:10	
below 0	5000	0:00 <sup>5</sup>	0:15-0:30 <sup>5</sup>	0:15-0:30 <sup>5</sup>				
below -13	1000	0:00						

<sup>1</sup>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.

Above -3°C  
↓  
-3°C  
↓  
-14°C to -25°C  
↓  
-25°C



### ENDURANCE TIME TESTING

- SAE ARP5485: Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Types II, III and IV
- SAE ARP5945: Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids, SAE Type I



### ENDURANCE TIME TESTING

- Every year, fluid manufacturers provide TC with samples of new fluids intended for commercial use;
- These fluids are tested for endurance times using SAE ARP5485 and ARP5945 procedures
- Two types of fluid holdover time tables are compiled using this test data:
  - Generic Holdover Time Tables
  - Brand-Specific Holdover Time Tables



### GENERIC HOLDOVER TIME TABLE

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 2-Genus  
SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>  
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						Other <sup>2</sup>
		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
3 and above	1000	0:00	0:15-1:30	0:25-0:45	0:30-0:35	0:15-0:30	0:05-0:10	
27 and above	7500	0:00	0:25-1:00	0:15-0:30	0:30-0:45	0:15-0:25	0:05-0:10	
5000	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:10		
below 27	1000	0:00	0:15-1:00	0:05-0:15	0:15-0:20 <sup>4</sup>	0:15-0:20 <sup>4</sup>	0:05-0:10	CAUTION: No holdover time guidelines exist
below 10	7500	0:00	0:20-1:00	0:15-0:30	0:15-0:20 <sup>4</sup>	0:15-0:20 <sup>4</sup>	0:05-0:10	
below 0	5000	0:00 <sup>5</sup>	0:15-0:30 <sup>5</sup>	0:15-0:30 <sup>5</sup>				
below -13	1000	0:00						

<sup>1</sup>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.

- Generic fluid holdover time tables are compiled using all of the test data collected for each fluid TYPE
- Generic fluid holdover time tables contain the lowest holdover time values of all the fluids tested (for any given fluid type)



### IMPORTANT TOOL IN SAFE OPERATIONS



Transport Canada Holdover Time Guidelines Winter 2005-2006

SAE TYPE I<sup>1</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>

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

Outside Air Temperature <sup>2</sup>	Snow or Snow Grains <sup>3</sup>					Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>5</sup>
	Active Frost	Freezing Fog	Very Light	Light	Moderate				
-3 and above	27 and above	45	11-17	16	11-16	8-11	9-13	4-6	2-5
below -3 to -6	below 27 to 21	45	8-13	14	8-14	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			

### PRESENTATION TOPICS

- SAE G-12 DE-ICING COMMITTEE
- DE/ANTI-ICING FLUID CERTIFICATION
- FLUID ENDURANCE TIME TESTING
- HOLDOVER TIME TABLES 2005-06

### PRESENTATION TOPICS

- SAE G-12 DE-ICING COMMITTEE
- DE/ANTI-ICING FLUID CERTIFICATION
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- HOLDOVER TIME TABLES 2005-06

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.	min.	3 min.	
- 8 and below	30 min.	15 min.	15 min.		

**1990-91**

**TYPE I**

GUIDELINE FOR HOLDOVER TIMES ACHIEVED BY ISO TYPE II FLUID MIXTURES (DEPENDENT ON WEATHER CONDITIONS)

(MIN. VALUES)

OAT [°C]	ISO TYPE II FLUID MIXTURE CONCENTRATION		WEATHER CONDITIONS				
	Active Frost	Freezing Fog	Freezing Rain	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>5</sup>	
+ 0	1000	8.00	0.25 - 1.30	0.20 - 0.45	0.30 - 0.55	0.15 - 0.30	
- 3 and above	7525	5.00	0.25 - 1.00	0.15 - 0.30	0.20 - 0.45	0.10 - 0.25	
below -3 to -6	5050	3.00	0.15 - 0.30	0.05 - 0.10	0.05 - 0.15	0.05 - 0.10	
below -6 to -10	1000	8.00	0.25 - 1.00	0.15 - 0.30	0.15 - 0.45 <sup>1</sup>	0.10 - 0.25 <sup>1</sup>	
below -10	7525	5.00	0.25 - 0.50	0.15 - 0.25	0.15 - 0.30 <sup>1</sup>	0.10 - 0.20 <sup>1</sup>	

### TC HOLDOVER TIME TABLES 2005-06

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 1

SAE TYPE I<sup>1</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>

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

Outside Air Temperature <sup>2</sup>	Snow or Snow Grains <sup>3</sup>					Freezing Drizzle <sup>4</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>5</sup>
	Active Frost	Freezing Fog	Very Light	Light	Moderate				
-3 and above	27 and above	45	11-17	16	11-16	8-11	9-13	4-6	2-5
below -3 to -6	below 27 to 21	45	8-13	14	8-14	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.

TYPE I - GENERIC HOLDOVER TIME TABLE

### TC HOLDOVER TIME TABLES 2005-06

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>

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

Outside Air Temperature <sup>2</sup>	Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions					Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>5</sup>
		Active Frost	Freezing Fog	Snow or Snow Grains <sup>3</sup>	Freezing Drizzle <sup>4</sup>	Freezing Rain			
-3 and above	1000	8.00	0.25 - 1.30	0.20 - 0.45	0.30 - 0.55	0.15 - 0.30	0.05 - 0.40		
below -3 to -6	7525	5.00	0.25 - 1.00	0.15 - 0.30	0.20 - 0.45	0.10 - 0.25	0.05 - 0.25		
below -6 to -10	5050	3.00	0.15 - 0.30	0.05 - 0.10	0.05 - 0.15	0.05 - 0.10			
below -10	1000	8.00	0.25 - 1.00	0.15 - 0.30	0.15 - 0.45 <sup>1</sup>	0.10 - 0.25 <sup>1</sup>			
below -10	7525	5.00	0.25 - 0.50	0.15 - 0.25	0.15 - 0.30 <sup>1</sup>	0.10 - 0.20 <sup>1</sup>			

CAUTION: No holdover time guidelines exist.

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.

TYPE II - GENERIC HOLDOVER TIME TABLE

## TC HALDOVER TIME TABLES 2005-06

Outside Air Temperature	Type II Fluid Concentration	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
27 and above	1000	12:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:05 - 0:35	
27 and above	75/25	5:00	1:05 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35	
below -3	1000	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:40 <sup>2</sup>	0:10 - 0:20 <sup>3</sup>		CAUTION: No holdover time guidelines exist
below -3 to -10	75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>2</sup>	0:10 - 0:20 <sup>3</sup>		
below -10	1000	12:00 <sup>4</sup>	0:15 - 0:40 <sup>2</sup>	0:15 - 0:30 <sup>2</sup>				

Outside Air Temperature	Type III Fluid Concentration	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
27 and above	1000	12:00	2:0 - 4:0	3:5 - 20:35	10 - 20	10 - 20	9 - 15	6 - 20
27 and above	75/25	6:0	1:5 - 3:0	2:5 - 15:25	8 - 15	8 - 15	8 - 15	2 - 10
below -3	1000	12:00	2:0 - 4:0	3:0 - 15:20	8 - 15	8 - 15	8 - 15	
below -3 to -10	75/25	6:0	1:5 - 3:0	2:5 - 10:25	7 - 10	9 - 12	6 - 9	
below -10	1000	12:00	2:0 - 4:0	3:0 - 15:20	8 - 15			

5 TYPE II - BRAND-SPECIFIC HALDOVER TIME TABLES

## TC HALDOVER TIME TABLES 2005-06

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 3  
SAE TYPE III FLUID HALDOVER GUIDELINES FOR WINTER 2005-2006  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature <sup>1</sup>		Type III Fluid Concentration	Active Frost	Freezing Fog	Snow or Snow Grains (minutes)			Freezing Drizzle <sup>2</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>3</sup>
Degrees Celsius	Degrees Fahrenheit	Fluid/Water (Active/Standby)			Very Light	Light	Moderate				
27 and above	27 and above	1000	12:00	2:0 - 4:0	3:5 - 20:35	10 - 20	10 - 20	10 - 20	9 - 15	6 - 20	
27 and above	27 and above	75/25	6:0	1:5 - 3:0	2:5 - 15:25	8 - 15	8 - 15	8 - 15	8 - 15	2 - 10	
below -3	below 27 to -10	1000	12:00	2:0 - 4:0	3:0 - 15:20	8 - 15	8 - 15	8 - 15	8 - 15		CAUTION: No holdover time guidelines exist
below -3 to -10	below 27 to -10	75/25	6:0	1:5 - 3:0	2:5 - 10:25	7 - 10	9 - 12	6 - 9			
below -10	below -10	1000	12:00	2:0 - 4:0	3:0 - 15:20	8 - 15					

TYPE III - GENERIC HALDOVER TIME TABLE

## TC HALDOVER TIME TABLES 2005-06

Transport Canada Holdover Time Guidelines Winter 2005-2006

TABLE 4 - Generic  
SAE TYPE IV FLUID HALDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Type IV Fluid Concentration	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>2</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>3</sup>
Degrees Celsius	Degrees Fahrenheit	Fluid/Water (Active/Standby)							
27 and above	27 and above	1000	12:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:05 - 0:35	
27 and above	27 and above	75/25	5:00	1:05 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35	
below -3	below 27 to -14	1000	12:00	0:15 - 0:25	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 -14	75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>2</sup>	0:10 - 0:20 <sup>3</sup>		
below -14	below 7 to -25	1000	12:00 <sup>4</sup>	0:15 - 0:40 <sup>2</sup>	0:15 - 0:30 <sup>2</sup>				
below -25	below -13	1000							

TYPE IV - GENERIC HALDOVER TIME TABLE

## TC HALDOVER TIME TABLES 2005-06

9 TYPE IV - BRAND-SPECIFIC HALDOVER TIME TABLES

## TRANSPORT CANADA GUIDANCE MATERIAL 2005-06

- Holdover Time Tables for 2005-06
  - <http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu>
  - [http://206.222.76.45/tables/HOT\\_Guidelines\\_2005-2006-English.pdf](http://206.222.76.45/tables/HOT_Guidelines_2005-2006-English.pdf)
- Transport Canada Guidelines for Ground Icing Operations Update TP 14052E



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# HOLDOVER TIME TABLE FORMAT CHANGES



**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
MONTREAL – NOVEMBER 3, 2005**

**PRESENTED ON BEHALF OF:**

**TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA  
SAFETY AND SECURITY**





AND

**FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE**




## BACKGROUND

→ Suggestion from groups within the industry that TC and FAA did not consult with the SAE G-12 prior to modifying the HOT table format



## BACKGROUND

→ Presentation was provided by APS to the SAE G-12 Holdover Time Workgroup in October 2004

→ Same presentation was provided to the entire SAE G-12 Holdover Time Subcommittee in October 2004



## REVISIONS TO HOT TABLE FORMAT, NOTES AND CAUTIONS FOR FUTURE YEARS

### CURRENT TC TII/IV HOLDOVER TIME TABLE

Fluid X (23,100 mPa.s viscosity)<sup>1</sup>

OAT		Weather Conditions							CAUTION
°C	°F	DRIZZLE	RAIN	ICE	SNOW	WIND	WIND	WIND	
above	above	75/25							<b>CAUTION</b> <b>No holdover time guidelines exist</b>
0	32	50/50							
		100/0							
0	32	75/25							
10	50								
-3	27	50/50							
below	below	100/0							
-3	27								
10	50	75/25							
-14	7								
below	below	100/0							
-14	7								
10	50								
-25	-13	100/0							

<sup>1</sup> OAT TII/IV holdover time is used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (12°F) below the OAT and the aerodynamic acceptance criteria are met. Complete use of OAT TII/IV below OAT TII/IV holdover time cannot be used.

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside air temperature Vol = Volume

**Notes (6) and Cautions (3)**

### CURRENT TC TII/IV HOLDOVER TIME TABLE

#### NOTES AND CAUTIONS

- **Notes:**
  1. Lowest on-wing viscosity- Brookfield Spindle LV1, 20°C, 0.3 rpm, 15 minutes
  2. During conditions that apply to aircraft protection for active frost
  3. The lowest use temperature is limited 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. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail
  6. Snow includes snow grains
- **Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.

## POTENTIAL FORMAT CHANGES

## RECOMMENDED CHANGE #1 REMOVAL OF ABOVE 0°C TEMPERATURE BAND

CURRENT TC TII/IV HOLDOVER TIME TABLE

OAT		TII/IV		Temperature Holdover Time Acceptance Factor						
°C		°F		Volume						
				FRONT	REAR/END	WING	WHEEL	TAIL	WING	OTHER*
above	above	1000								
0	32	75/25								
		50/50								
		1000								
0	32	75/25								
to	to									
-3	27	50/50								
below	below	1000								
-3	27									
to	to									
-14	7	75/25								
below	below	1000								
-14	7									
to	to									
-25	-13	1000								
below	below	1000								
-25	-13									

**CAUTION**  
No holdover time guidelines exist

\*C = Degrees Celsius \*F = Degrees Fahrenheit OAT = Outside air temperature Vol = Volume

TII/IV HOLDOVER TIME TABLE WITH TEMPERATURE BAND REMOVED

OAT		TII/IV		Temperature Holdover Time Acceptance Factor						
°C		°F		Volume						
				FRONT	REAR/END	WING	WHEEL	TAIL	WING	OTHER*
above	above	1000								
-3	27	75/25								
		50/50								
below	below	1000								
-3	27									
to	to									
-14	7	75/25								
below	below	1000								
-14	7									
to	to									
-25	-13	1000								
below	below	1000								
-25	-13									

**CAUTION**  
No Holdover time guidelines exist

\*C = Degrees Celsius \*F = Degrees Fahrenheit OAT = Outside air temperature Vol = Volume

## RECOMMENDED CHANGE #2 REMOVAL OF VISCOSITY INFORMATION

REMOVAL OF VISCOSITY INFORMATION

~~Fluid X (20-100 mPas viscosity)~~

OAT		TII/IV		Temperature Holdover Time Acceptance Factor						
°C		°F		Volume						
				FRONT	REAR/END	WING	WHEEL	TAIL	WING	OTHER*
above	above	1000								
-3	27	75/25								
		50/50								
below	below	1000								
-3	27									
to	to									
-14	7	75/25								
below	below	1000								
-14	7									
to	to									
-25	-13	1000								
below	below	1000								
-25	-13									

**CAUTION**  
No Holdover time guidelines exist

\*C = Degrees Celsius \*F = Degrees Fahrenheit OAT = Outside air temperature Vol = Volume

**CURRENT TC TII/IV HOLDOVER TIME TABLE**

**NOTES AND CAUTIONS**

- **Notes:**
  1. ~~Lowest on wing viscosity Brookfield Spindle LV1-204C-0.3 rpm-16 minutes~~
  2. ~~During conditions that apply to aircraft protection for active frost~~
  3. The lowest use temperature is limited 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. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail
  6. Snow includes snow grains
- **Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.

**RECOMMENDED CHANGE #3**

**REMOVAL OF ABBREVIATIONS**

**REMOVAL OF ABBREVIATIONS**

Outside Air Temperature		Approximate Holdover Times Anticipated Under Various Weather Conditions (Shorter values)						
Degrees Celsius	Degrees Fahrenheit	ACTIVE FROST	FROSTING FOG	SNOW	FREEZING DRIZZLE	SLUSHY RAIN	SNOW OR ICE	HAIR
Values	Values	MIN	MIN	MIN	MIN	MIN	MIN	MIN
above 1000	above 1800							
-3 to 75/25	27 to 165/150							
-3 to 50/50	27 to 122/100							
below 1000	below 1800							
-3 to 75/25	27 to 165/150							
-14 to 7	7 to 45/30							
below 1000	below 1800							
-14 to 7	7 to 45/30							
below 1000	below 1800							
-25 to -13	13 to 9/5							

SAE 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 SAE Type I when SAE Type IV fluid cannot be used.

~~-10—Degrees Celsius—°F—Degrees Fahrenheit—OAT—Outside air temperature—Vol—Volume—~~

**POTENTIAL CHANGE #4**

**CHANGES TO NOTES**

**CURRENT TC TII/IV HOLDOVER TIME TABLE**

**NOTES AND CAUTIONS**

- **Notes:**
  1. ~~Lowest on wing viscosity Brookfield Spindle LV1-204C-0.3 rpm-16 minutes~~
  2. ~~During conditions that apply to aircraft protection for active frost~~
  3. The lowest use temperature is limited 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. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail
  6. Snow includes snow grains
- **Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.

**ADDITION OF THE WORD "ACTIVE" TO THE FROST COLUMN**

Outside Air Temperature		Approximate Holdover Times Anticipated Under Various Weather Conditions (Shorter values)						
Degrees Celsius	Degrees Fahrenheit	ACTIVE FROST	FROSTING FOG	SNOW	FREEZING DRIZZLE	SLUSHY RAIN	SNOW OR ICE	HAIR
Values	Values	MIN	MIN	MIN	MIN	MIN	MIN	MIN
above 1000	above 1800							
-3 to 75/25	27 to 165/150							
-3 to 50/50	27 to 122/100							
below 1000	below 1800							
-3 to 75/25	27 to 165/150							
-14 to 7	7 to 45/30							
below 1000	below 1800							
-14 to 7	7 to 45/30							
below 1000	below 1800							
-25 to -13	13 to 9/5							

SAE 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 SAE Type I when SAE Type IV fluid cannot be used.

# POTENTIAL CHANGE #5 CHANGES TO NOTES

### CURRENT TC TII/IV HOLDOVER TIME TABLE

#### NOTES AND CAUTIONS

- **Notes:**
  1. ~~Lowest on wing viscosity Brookfield Spindle LV1, 20°C, 0.3 rpm, 15 minutes~~
  2. ~~Operating conditions then apply to aircraft protection for active frost~~
  3. The lowest use temperature is limited 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. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail
  6. ~~Snow includes snow grains~~
- **Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.

### ADDITION OF "SNOW GRAINS" TO THE SNOW COLUMN

Outside Air		Approximate Holdover Times (Integrated Table)						
		Various Weather Conditions						
		Other weather						
Temperature	Volume	ACTIVE FROST	FREEZING RAIN	SNOW	FREEZING DRIZZLE	ICE PELLETS	SNOW GRAINS	OTHER
Degrees Celsius	Fahrenheit	Volume	PROCT	TYPE	PROCT	TYPE	PROCT	TYPE
above	above	75/25						
-3	27	50/50						
below	below	100/0						
-3	27							
to	to	75/25						
-14	7							
below	below	100/0						
-14	7							
to	to	100/0						
-25	-13							
below	below	100/0						
-25	-13							

No Holdover time guidelines exist

SAE 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. Complete use of SAE Type I when SAE Type IV fluid cannot be used

# POTENTIAL CHANGE #6 CHANGES TO CAUTIONS

### CURRENT TC TII/IV HOLDOVER TIME TABLE

#### CAUTIONS

- **Current TC Type II/IV HOT Table Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.
- **Current TC Type III HOT Table Cautions:**
  1. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  2. High wind velocity or jet blast may reduce holdover time.
  3. Holdover time may also be reduced when aircraft skin temperature is lower than outside air temperature.
  4. Fluids used during ground de-icing do not provide ice protection during flight.

### CURRENT TC TII/IV HOLDOVER TIME TABLE

Fluid X (23,100 mPa.s viscosity)<sup>1)</sup>

OAT		Approximate Holdover Times (Integrated Table)						
		Various Weather Conditions						
		Other weather						
°C	°F	Volume	ACTIVE FROST	FREEZING RAIN	SNOW	FREEZING DRIZZLE	ICE PELLETS	SNOW GRAINS
Degrees Celsius	Degrees Fahrenheit	Volume	PROCT	TYPE	PROCT	TYPE	PROCT	TYPE
above	above	75/25						
0	32	50/50						
below	below	100/0						
0	32							
to	to	75/25						
-3	27	50/50						
below	below	100/0						
-3	27							
to	to	75/25						
-14	7							
below	below	100/0						
-14	7							
to	to	100/0						
-25	-13							
below	below	100/0						
-25	-13							

CAUTION No holdover time guidelines exist

SAE 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. Complete use of SAE Type I when SAE Type IV fluid cannot be used

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside air temperature Vol = Volume

Notes (6) and Cautions (3)

**CURRENT TC TII/IV HOLDOVER TIME TABLE**

**NOTES AND CAUTIONS**

- **Notes:**
  1. Lowest on-wing viscosity- Brookfield Spindle LV1, 20°C, 0.3 rpm, 15 minutes
  2. During conditions that apply to aircraft protection for active frost
  3. The lowest use temperature is limited 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. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail
  6. Snow includes snow grains
- **Cautions:**
  1. The real time of protection 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 aircraft skin temperature is lower than OAT.
  2. The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
  3. Fluids used during ground de-icing do not provide ice protection during flight.

**POTENTIAL NEW TII/IV HOLDOVER TIME TABLE**

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions							
Degrees Celsius	Degrees Fahrenheit		ACTIVE FROST	FREEZING RAIN	SNOW	SNOW GRAINS	DRIZZLE	RAIN	ICE ON WING	OTHER
		100/0								
above	above	75/25								
-3	27	50/50								No Holdover time guidelines exist
below	below	100/0								
-3	27	75/25								
-14	7									
below	below	100/0								
-14	7									
below	below	100/0								
-25	-13									
below	below	100/0	SAE 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 SAE Type I when SAE Type IV fluid cannot be used.							
-25	-13									

Notes (3) and Cautions (3 or 4)

**SAE G-12 HOLDOVER TIME MEETING**

- Transport Canada indicated at that time that they would move forward with the changes in the upcoming year
- NO NEGATIVE FEEDBACK was received by Transport Canada from those in attendance
- An informal show of hands was also performed at this meeting, and all in attendance were in favor of the proposed changes



**MINUTES OF MEETING**

Forms and Caution Notes for Future HOT Tables

Michael Dupont of APS presents recommended changes for future HOT tables using the Transport Canada tables as an example. The recommendations included:

- Removal of the above 0°C temperature band
- Removal of viscosity information
- Removal of abbreviations
- Deletion of viscometer instructions and the statement "During conditions that apply to aircraft protection for active frost", to be replaced by adding the term active to the frost column. A similar change would be incorporated into the snow column by deleting the note Snow includes snow grains and adding snow grains to the snow column
- Notes and cautions would be removed from the HOT tables and placed on a separate page. They would be replaced by numerical subscripts referencing the new page
- The note referring to LIQUID aerodynamic acceptance and buffer requirements would remain on the HOT table. For example with Type IV fluids: this note reads SAE Type IV fluid may be used below -25C (-13F) provided the freezing point of the fluid is at least 7C below OAT and the aerodynamic acceptance criteria are met. Consider the use of SAE Type I when SAE Type IV fluid cannot be used.
- Potential new TII/IV holdover time table

At the conclusion of his presentation, Dupont presented a potential new TII/IV holdover table which incorporated the items listed in these minutes under this item 15 and replaced the above 0C (32F) and the 0 to -10 (-10 to 23F) bands with an above -10 (-12F) band.



**SAE G-12 HOLDOVER TIME SUBCOMMITTEE MEETING**

**PITTSBURGH, MAY 2005**

**TC/FAA TYPE IV GENERIC HOT GUIDELINES 2005-06**

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Rain	Snow Snow Grains	Freezing Drizzle	Light Freezing Rain	Ice on a Cold Surfaces	Other	
		100/0	12:00	6:05 - 0:45	0:25 - 0:15	0:40 - 1:10	0:26 - 0:40	0:10 - 0:50		
-3 and above	27 and above	75/25	6:00	1:05 - 1:45	0:25 - 0:15	0:35 - 1:15	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	0:10 - 0:25		CAUTION-No Holdover Time Guidelines Exist	
		75/25	6:00	0:25 - 0:50	0:20 - 0:35	0:15 - 0:30	0:10 - 0:20			
below -14 to -25	below 7 to -13	100/0	12:00	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.							

Increases due to removal of C1957      Reductions due to MaxFB

### TC/FAA TYPE II GENERIC HOT GUIDELINES 2005-06

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)							Other
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow - Wet	Snow - Dry	Freezing Drizzle	Light Freezing Rain	Rain on a Cold Soaked Wing	
-3 and above	27 and above	100/00	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	CAUTION: No Holdover Time Guidelines Exist	
		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 2	100/00	8:00	0:20 - 1:05	0:15 - 0:35	0:15 - 0:45	0:10 - 0:25		CAUTION: No Holdover Time Guidelines Exist	
		75/25	5:00	0:20 - 0:55	0:15 - 0:25	0:15 - 0:30	0:10 - 0:20			
below -14 to -25	below 7 to 13	100/00	8:00	0:15 - 0:20	0:15 - 0:30				CAUTION: No Holdover Time Guidelines Exist	
below -25	below -13	100/00								

### ISSUE?

→ Removal of "Above 0°C" temperature band from the generic and brand-specific holdover time tables has caused concerns within certain organizations



### RATIONALE FOR REMOVAL OF THE "ABOVE 0°C" TEMPERATURE BAND

→ Consistency with other holdover time table formats



### FAA/TC TYPE I HOT GUIDELINES 2005-06

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)							Other
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow - Wet	Snow - Dry	Freezing Drizzle	Light Freezing Rain	Rain on a Cold Soaked Wing	
-3 and above	27 and above	100/00	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	CAUTION: No holdover time guidelines exist	
		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 2	100/00	8:00	0:20 - 1:05	0:15 - 0:35	0:15 - 0:45	0:10 - 0:25		CAUTION: No holdover time guidelines exist	
below -14 to -25	below 7 to 13	75/25	5:00	0:20 - 0:55	0:15 - 0:25	0:15 - 0:30	0:10 - 0:20			
below -25	below -13	100/00	8:00	0:15 - 0:20	0:15 - 0:30				CAUTION: No holdover time guidelines exist	
		100/00								



Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)							Other
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow - Wet	Snow - Dry	Freezing Drizzle	Light Freezing Rain	Rain on a Cold Soaked Wing	
-3 and above	27 and above	100/00	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	CAUTION: No holdover time guidelines exist	
		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 2	100/00	8:00	0:20 - 1:05	0:15 - 0:35	0:15 - 0:45	0:10 - 0:25		CAUTION: No holdover time guidelines exist	
below -14 to -25	below 7 to 13	75/25	5:00	0:20 - 0:55	0:15 - 0:25	0:15 - 0:30	0:10 - 0:20			
below -25	below -13	100/00	8:00	0:15 - 0:20	0:15 - 0:30				CAUTION: No holdover time guidelines exist	
		100/00								



### TYPE III GENERIC HOLDOVER TIME GUIDELINE VALUES 2005-06



Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (minutes)							Other	
Degrees Celsius	Degrees Fahrenheit		Frost	Freezing Fog	Very Light Snow	Light Snow	Moderate Snow	Freezing Drizzle	Light FRZ Rain		Rain on a Cold Soaked Wing
-3 and above	27 and above	100/00	120	20 - 40	35	20 - 35	10 - 20	10 - 20	8 - 10	6 - 20	CAUTION: No Holdover Time Guidelines Exist
		75/25	60	15 - 30	25	15 - 25	8 - 15	8 - 15	6 - 10	2 - 10	
		50/50	30	10 - 20	15	8 - 15	4 - 8	5 - 9	4 - 6		
below -3 to -10	below 27 to 14	100/00	120	20 - 40	30	15 - 30	9 - 15	10 - 20	8 - 10		CAUTION: No Holdover Time Guidelines Exist
		75/25	60	15 - 30	25	10 - 25	7 - 10	9 - 12	6 - 9		
below -10	below 14	100/00	120	20 - 40	30	15 - 30	8 - 15				CAUTION: No Holdover Time Guidelines Exist
		100/00									

### RATIONALE FOR REMOVAL OF THE "ABOVE 0°C" TEMPERATURE BAND

→ Consistency with other holdover time table formats  
 → Movement to laboratory snow methods



### LABORATORY SNOW METHODS

- ARP5485 is currently up for vote
- ARP5485 includes procedures for laboratory snow
- Laboratory snow tests cannot be performed above 0°C
- Above 0°C holdover times cannot be provided for any other condition



### IMPLICATIONS?

- No more testing above 0°C means that the generic tables would need to be “frozen” in this temperature range
- Possibility that a future fluid would not meet the “frozen” generic holdover time values above 0°C
- Uneven competitive situation is created where new fluids would not have values above 0°C



### RATIONALE FOR REMOVAL OF THE “ABOVE 0°C” TEMPERATURE BAND

- Consistency with other holdover time table formats
- Movement to laboratory snow methods
- Variability of outdoor test data above 0°C



### VARIABILITY?

- Tests performed during day or night
  - Solar heating
  - Radiation cooling
- High or low rates of precipitation
  - Latent heat effect on plate temperature

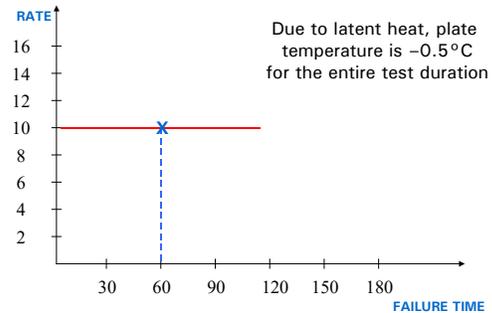


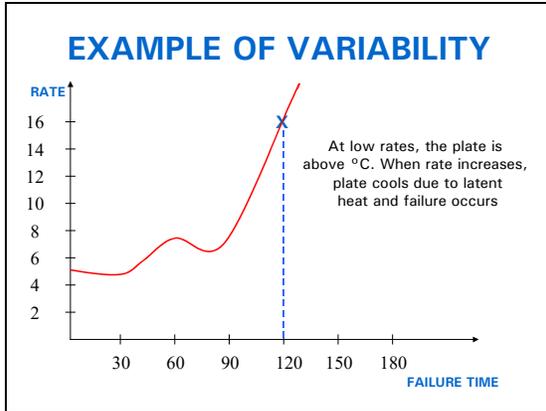
### EXAMPLE OF VARIABILITY

- 2 Tests
- Same average rate of precipitation (10 g/dm<sup>2</sup>/h)
- Same temperature (+ 1 °C)
- Same time of day (afternoon)



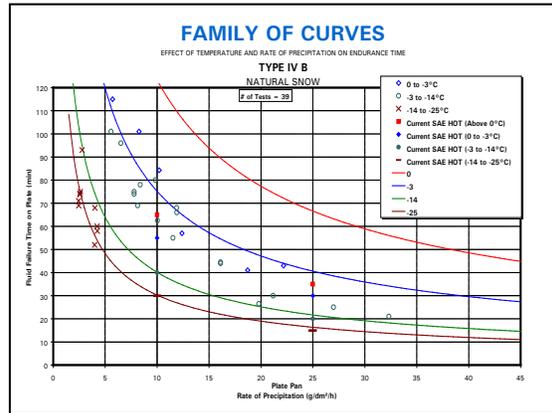
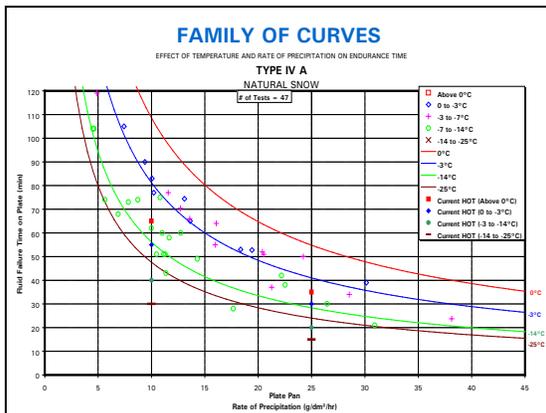
### EXAMPLE OF VARIABILITY





### EXAMPLE OF VARIABILITY

- 2 Tests
- Same average rate of precipitation (10 g/dm<sup>2</sup>/h)
- Same temperature (+ 1 °C)
- Same time of day (afternoon)
- Different Endurance times
- Different Plate Temperature Profiles



### ABOVE 0°C

- No or limited Above 0°C test data exists
- Variability of test data is concern
- Method to determine HOT's: Extrapolation

### TYPE IV NEAT SNOW (-14°C to -25°C)

## CONCLUSIONS

- Consultation with the membership of the G-12 HOT Subcommittee was performed
- Changes were made to the HOT guideline formats based on the previous discussions
- Rationale for the elimination of outdoor snow data above 0°C is extensive



**APS**  
Aviation Inc.

**ENDURANCE TIME TESTING IN  
SIMULATED ICE PELLET  
CONDITIONS**

By

**APS**  
Aviation Inc.

For

**Transportation Development Centre  
Transport Canada**

ISO 9001:2000

adga

**PRESENTATION OUTLINE**

- OBJECTIVES
- ICE PELLET PRODUCTION TIME
- ICE PELLET SIZE DISTRIBUTION
- ICE PRECIPITATION DISSOLVING IN DEICING FLUID
- RATE DISTRIBUTION ON TEST PLATE
- LOG OF TESTS
- ENDURANCE TIME TESTING ON TEST PLATE
- FAR VS. NEAR PERSPECTIVES
- RECOMMENDATIONS

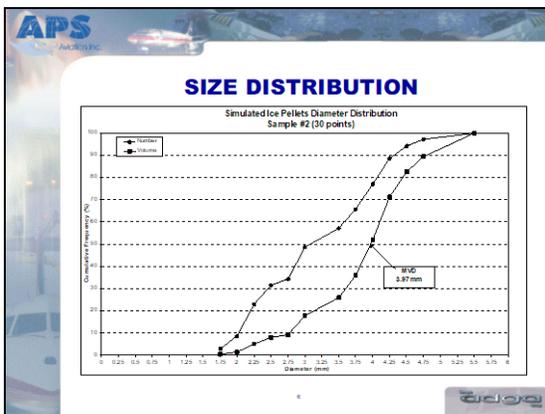
**OBJECTIVES:**

- PRIMARY OBJECTIVE: TO DOCUMENT FLUID ENDURANCE DURING ICE PELLET CONDITIONS.
- SECONDARY OBJECTIVES: PROCEDURAL FEASIBILITY FOR PRODUCING SIMULATED ICE PELLET PRECIPITATION CONDITIONS.
  - Production time
  - Size Distribution of Pellets
  - Rate Distribution
    - Test Plate
    - Airfoil

**PRODUCTION TIME:**

- 4 kilograms of simulated ice pellets per 6 hour test session.
- Two APS members were in charge of manufacturing ice pellets.
- Overnight storage of the ice pellets was feasible considering minimal temperature differentials.

**SIZE DISTRIBUTION:**



**ICE PRECIPITATION DISSOLVING IN DEICING FLUID:**

- DOCUMENT TOTAL TIME FOR ICE PRECIPITATION TO COMPLETELY DISSOLVE IN A DEICING FLUID BATH
- TESTING WAS CONDUCTED USING SIMULATED ICE PELLETS AND ICE SHAVINGS (SNOWFLAKE).

**APS**  
ACQUISITION

## Ice Pellet Dissolving in Deicing Fluid

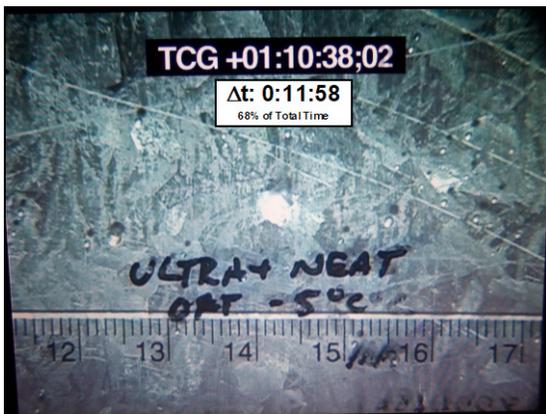
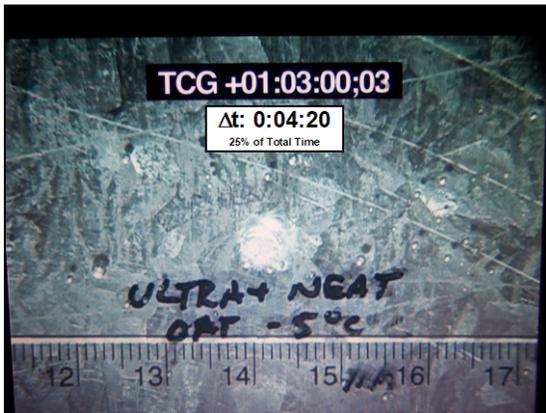
### Type IV EG Neat

Total Time to Dissolve: 17.5 minutes

Start Time: 0:58:40  
End Time: 1:16:12

Initial Brix: 41

**Edgewise**



**APS**  
ACQUISITION

## Snowflake Dissolving in Deicing Fluid

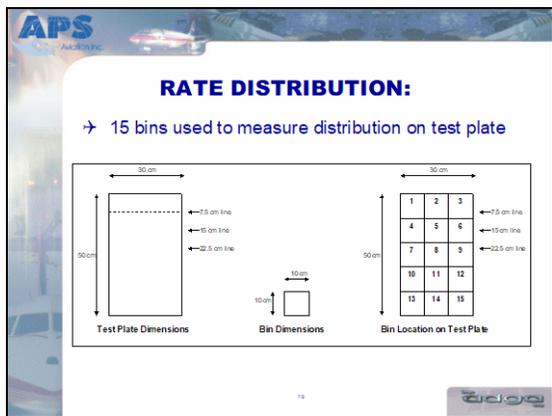
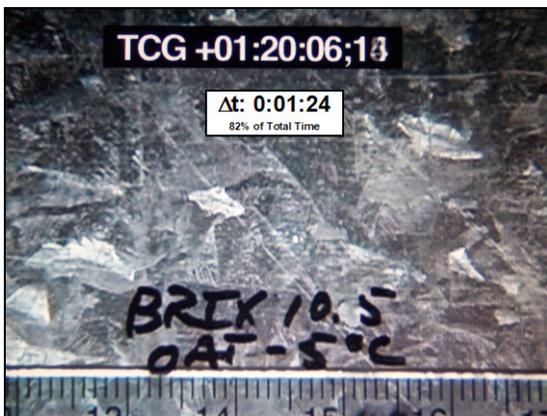
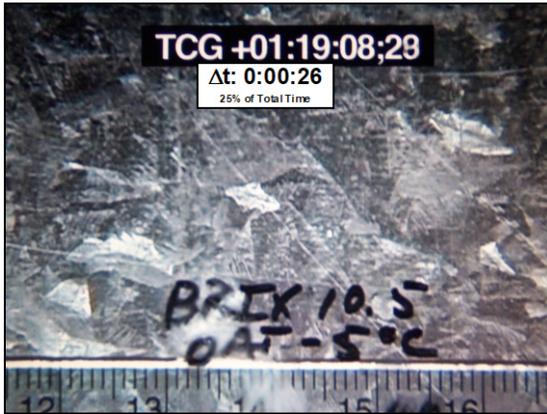
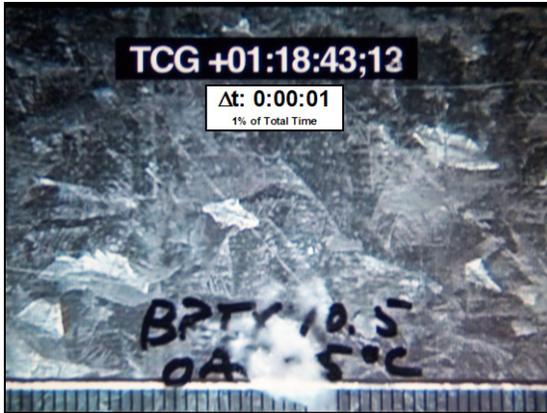
### Type I EG

Total Time to Dissolve: 1.7 min

Start Time: 1:18:42  
End Time: 1:20:24

Initial Brix: 10.5

**Edgewise**



### RATE DISTRIBUTION:

Bin #	Empty Bin (g)	Bin With Pellets (g)	Total Weight of Ice Pellets (g)	Difference in Weight from Average (g)
1	79	80.8	1.8	0.2
2	83	84.7	1.7	0.1
3	83.2	84.4	1.2	-0.4
4	79.2	80.8	1.5	-0.1
5	84.8	86.4	1.5	0.2
6	83.1	84.7	1.6	0.0
7	85.4	87.1	1.7	0.1
8	84	85.8	1.8	0.2
9	84.7	86.2	1.5	-0.1
10	87.8	89.7	1.8	0.2
11	83	84.7	1.7	0.1
12	85	86.5	1.5	-0.1
13	88.4	89.8	1.4	-0.2
14	80.6	82.5	1.9	0.3
15	85.2	86.5	1.3	-0.3

Average Weight (g)	1.6
Standard Deviation (g)	0.2

→ RESULT: DISTRIBUTION IS REASONABLE

### LOG OF TESTS:

Test #	Start Time (Local)	End Time (Local)	Test Surface	Fluid Name	Fluid Dilution	Fluid Type	Fluid Temp (°C)	OAT (°C)	Average Rate of Precip. (g/dm <sup>2</sup> /h)			
									Plate	Bin 1	Bin 2	Bin 3
1	1:55:10 PM	2:50:00 PM	Plate	Type IV PG	Neat	4	-5	-5				19.6
2	1:34:00 PM	2:13:00 PM	Plate	Type IV PG	Neat	4	-5	-5				22.5
3	2:33:00 PM	2:36:00 PM	Plate	Type IV PG	50/50	4	-5	-5				118.7
4	2:50:00 PM	2:55:00 PM	Plate	Type IV PG	50/50	4	-6	-5				62.7
5	4:04:30 PM	4:20:00 PM	Plate	Type IV PG	50/50	4	-5	-5				13.4
6	9:59:00 AM	10:48:00 AM	Plate	Type IV PG	75/25	4	-5	-5				9.4
7	1:23:00 PM	1:44:00 PM	Plate	Type IV EG	Neat	4	-5	-5				33.0
8	2:25:00 PM	2:40:00 PM	Plate	Type IV PG	50/50	4	-5	-5				15.5
9	12:31:00 PM	12:38:30 PM	Airfoil	Type IV PG	50/50	4	-5	-5	29.7	11.2	1.0	
10	4:31:00 PM	4:55:00 PM	Airfoil	Type IV PG	50/50	4	-6	-5	24.0	12.8	7.8	
11	10:00:00 AM	10:10:00 AM	Airfoil	Type I EG	10° Buffer	1	Warm	-5	25.8	15.6	6.6	

- ### LOG SUMMARY:
- 8 endurance time tests on standard aluminum test plate
    - 2 Type IV PG Neat
    - 1 Type IV PG 75/25
    - 4 Type IV PG 50/50
    - 1 Type IV EG Neat
  - 3 endurance time tests on airfoil
    - 2 Type IV PG 50/50
    - 1 Type I EG at 10° Buffer

- ### ENDURANCE TIME TESTING ON FLAT PLATE:
- DIFFICULT TO CALL FLUID FAILURE DURING ICE PELLET CONDITIONS.
  - FLUID CONDITION MAY SEEM TO VARY DEPENDING ON OBSERVER ANGLE OF INCIDENCE
  - FLUID FAILURE CHARACTERIZATION IS REQUIRED
  - SNOW HOT USED AS COMPARATIVE GUIDELINE FOR TESTING

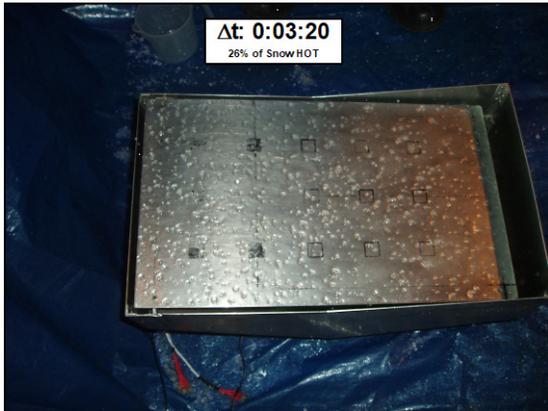
## Simulated Ice Pellets

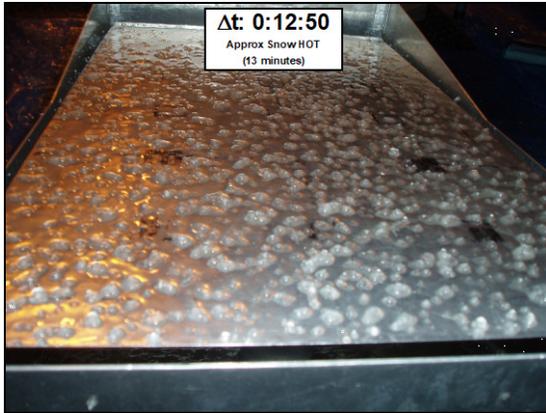
### Type IV PG 50/50

Average Rate of Precipitation: 13.4 g/dm<sup>2</sup>/h  
Snow Endurance Time: Approx 12 min

Test Surface: Plate  
Date: July 20<sup>th</sup>, 2005  
Start Time: 4:04 PM  
Initial Brx: 20  
Run #: 3







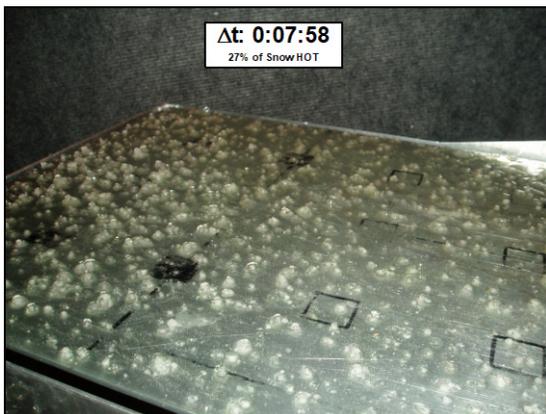
**APS**  
Advanced Performance Systems

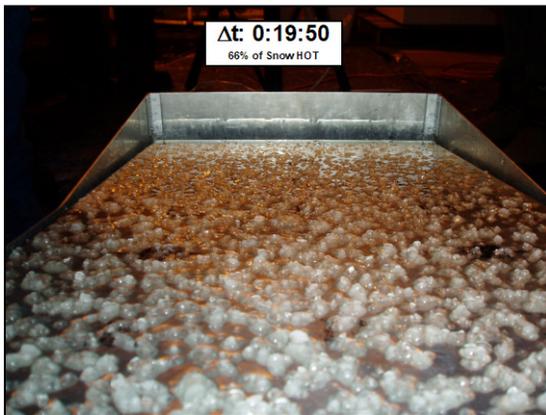
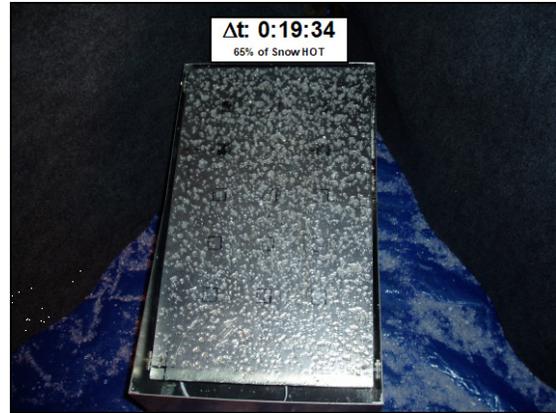
## Simulated Ice Pellets

Type IV EG Neat

Average Rate of Precipitation: 33 g/dm<sup>2</sup>/h  
Snow Endurance Time: Approx 30 min

Test Surface: Plate  
Date: August 25<sup>th</sup>, 2005  
Start Time: 1:23 PM  
Initial Brix: 41  
Run #: 1





**APS**  
AARON INC.

**NEAR VS FAR – PILOTS PERSPECTIVE:**

→ Capture simultaneous videos, from different perspectives, of an airfoil subject to ice pellets.

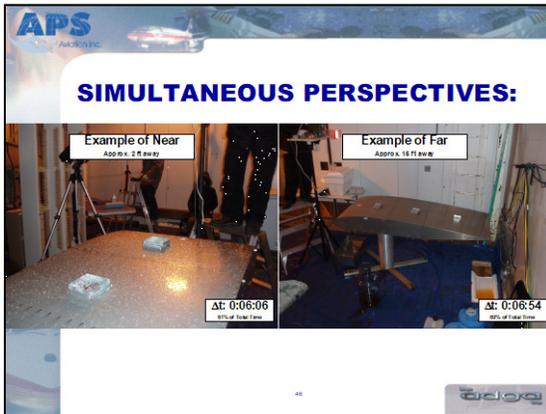
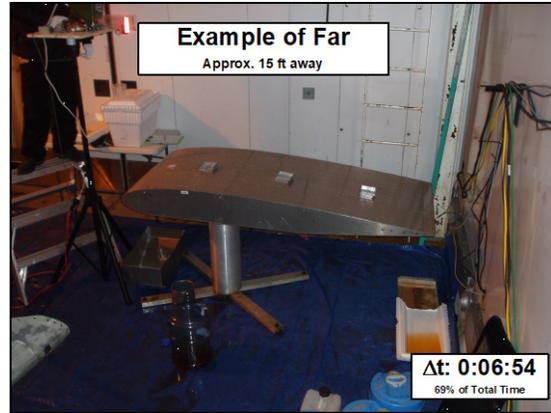
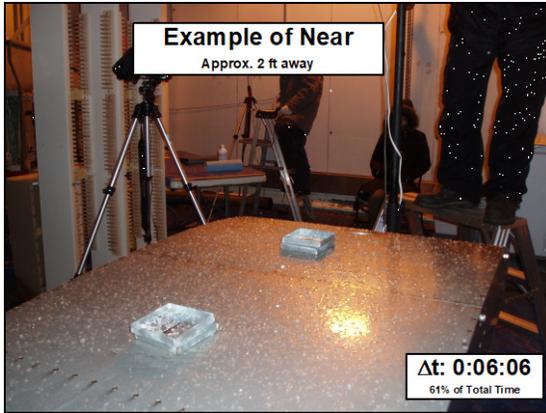
42

**APS**  
AARON INC.

**Near vs. Far  
- Pilots Perspective**

**Type I EG**  
**Test Surface: Airfoil**  
Initial Brix: 10°C Buffer

Start Time: 10:00:00  
End Time: 10:10:00

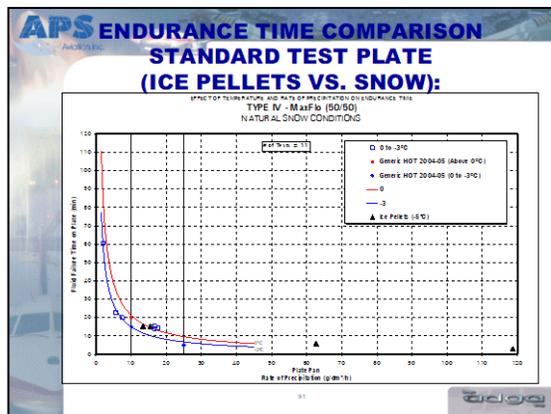


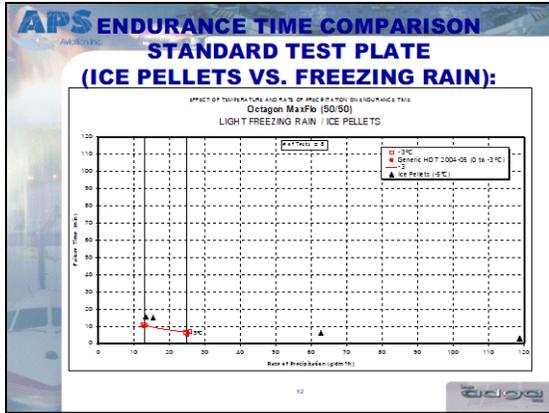
**PARTIAL LIST OF PRELIMINARY RECOMMENDATIONS:**

- Characterize fluid failure during ice pellet conditions.
- Conduct endurance time testing in natural ice pellet conditions and characterize size distribution.
- Capture simultaneous videos, from different perspectives, of an airfoil subject to ice pellets. (Use high definition video cameras)
- Other?

**PRELIMINARY CONCLUSIONS:**

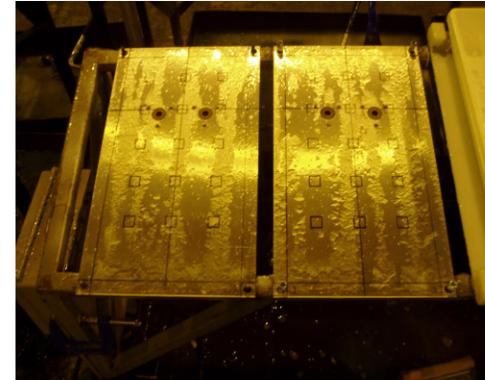
- Fluid failure characteristics in ice pellet conditions are difficult to determine and define.
- Far vs. Near: Fluid condition is harder to determine as the observer gets further away.
- Adhesion to metal surfaces was seen with warm Type I fluids.
- Ice pellets take longer to dissolve in deicing fluid as compared to snowflakes.





# AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2005-06 WINTER TEST SEASON

## TYPE I FLUID



SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2006

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA



AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE




### TYPE I FLUIDS TESTED

- ➔ One new Type I fluid, BATTELLE D3 ADF, was tested by APS for endurance times in 2005-06
- ➔ BATTELLE D3 ADF is a non-glycol based fluid formulation
- ➔ Endurance Time results of the BATTELLE fluid were compared to grandfathered Type I fluids

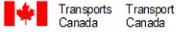


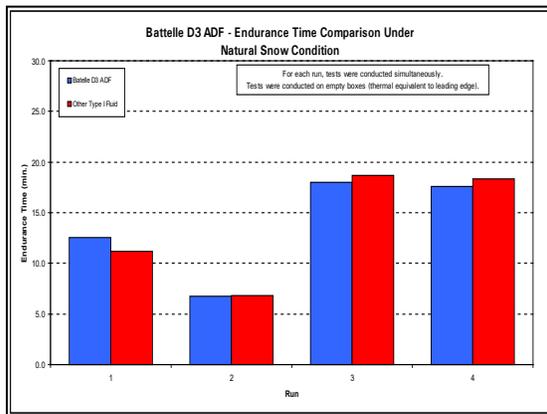
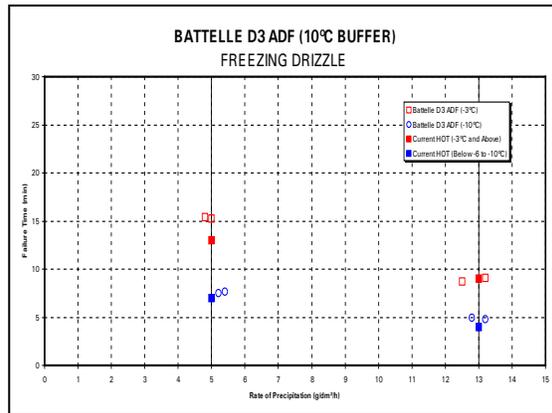


### WSET RESULTS - AMIL

**BATTELLE D3 ADF  
50/50 FLUID**

- 4 min. 25 sec.
- 4 min. 35 sec.
- 4 min. 55 sec.



### SUMMARY OF TYPE I FLUID ENDURANCE TESTING

- ➔ Endurance Time results of the BATTELLE D3 ADF compared well with grandfathered Type I fluid endurance time results
- ➔ No changes will be made to the generic Type I guidelines for 2006-07 winter operations, based on the recent testing





### FAA/TC TYPE I HOT GUIDELINES 2006-07

FAA TYPE I HOLDOVER TIME GUIDELINE

**TABLE 1. PLS Guidelines for Holdover Times for Type I Holdover Times as a Function of Weather Conditions and DWT.**  
CAUTION: THIS TABLE IS FOR INFORMATIONAL PURPOSES ONLY. CONSULTATION WITH THE USER'S OPERATIONAL PROCEDURES IS REQUIRED.

Outside Air Temperature	Degrees Fahrenheit	Active Frost	Snow/Snow Grains				Freezing Drizzle	Light Freezing Rain	Risk on Cold Soaked Wing?
			Very Light	Light**	Medium**	Heavy**			
27 and above	0-45	0-17	0-11	0-18	0-08-011	0-08-013	0-02-0-06	0-00-0-05	
Below 27 and above 10-8	0-45	0-09	0-06	0-06	0-08-0-08	0-06-0-08	0-02-0-06		
Below 10-8 and above 10-10	0-45	0-08	0-06	0-06	0-08-0-08	0-06-0-08	0-02-0-06		
Below 10-10 and above 10-14	0-45	0-08	0-06	0-06	0-08-0-08	0-06-0-08	0-02-0-06		
Below 10-14 and above 10-19	0-45	0-08	0-06	0-06	0-08-0-08	0-06-0-08	0-02-0-06		

**NO CHANGES**

THE RESPONSIBILITY FOR THE CATEGORIES OF WEATHER CONDITIONS REMAINS WITH THE USER

Outside Air Temperature <sup>a</sup>	Degrees Fahrenheit	Active Frost	Snow or Snow Grains <sup>b</sup>				Freezing Drizzle <sup>c</sup>	Light Freezing Rain	Risk on Cold Soaked Wing
			Very Light	Light	Moderate	Heavy			
27 and above	45	11-17	18	11-18	8-11	8-13	4-6	2-5	
Below 27 and above 10-8	45	8-13	14	8-14	5-8	5-9	4-6		
Below 10-8 and above 10-10	45	8-10	11	8-11	4-8	4-7	2-5		
Below 10-10 and above 10-14	45	5-9	7	4-7	2-4				

CAUTION: No holdover time guidelines exist!



### FAA/TC VISIBILITY TABLES 2006-07

**TABLE 18. SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY FOR TYPE I HOLDOVER TIME GUIDELINES**

Type of Day	Degrees Celsius	Degrees Fahrenheit	Snowfall Intensity (mm/hr)					
			0-15	5	1-10	10	15	10-15
Day	Below 10	Below 50	Light	Light	Medium	Medium	Heavy	Heavy
Day	Below 10	Below 50	Light	Light	Medium	Medium	Heavy	Heavy
Day	Below 10	Below 50	Light	Light	Medium	Medium	Heavy	Heavy
Day	Below 10	Below 50	Light	Light	Medium	Medium	Heavy	Heavy
Day	Below 10	Below 50	Light	Light	Medium	Medium	Heavy	Heavy

**TABLE 19. HOLDOVER TIMES AS A FUNCTION OF SNOWFALL INTENSITY**

Lighting	Temperature Range		Snowfall Intensity (mm/hr)			
	W	M	Light	Medium	Heavy	Very Heavy
Day	0-10	0-10	15	10	5	5
Day	0-10	0-10	15	10	5	5
Day	0-10	0-10	15	10	5	5
Day	0-10	0-10	15	10	5	5

**NO CHANGES**





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# AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2005-06 WINTER TEST SEASON

## TYPE II FLUID



SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2006

**PREPARED AND PRESENTED ON BEHALF OF:**

**TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA**



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AND

**FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE**




**TYPE II FLUIDS TESTED**

- Two new Type II fluids were tested by APS for endurance times in 2005-06
- Clariant Safewing MP II Flight
- Kilfrost P1792
- Both fluids will be commercialized



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**TYPE II FLUID PARTICULARS**

- Two batches of Kilfrost P1792 were tested
- Natural snow tests performed with the 1<sup>st</sup> batch of fluid
- After the natural snow testing was completed, a 2<sup>nd</sup> batch was sent to APS for endurance time testing
- Simulated precipitation tests, including simulated snow, were performed with both batches
- Kilfrost wishes to commercialize the 2<sup>nd</sup> batch



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**FLUID VISCOSITY**

Fluid	Viscosity - Manufacturer's Method	Viscosity - AIR Method
Clariant MP II Flight	3,340 <small>Sphere LV1, 20°C, 0.3rpm, 10minutes</small>	3,340 <small>Sphere LV1, 20°C, 0.3rpm, 10minutes</small>
Kilfrost P 1792	3,550 <small>Sphere LV2disc with guard eq. 150 mL, Fluid 20°C, 0.3rpm, 10minutes</small>	3,460 <small>Sphere LV1, 20°C, 0.3rpm, 10minutes</small>



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**WSET RESULTS - AMIL**

CLARIANT SAFEWING MP II FLIGHT NEAT FLUID	KILFROST P1792 NEAT FLUID
55 min. 40 sec.	58 min. 40 sec.
58 min. 40 sec.	56 min. 30 sec.
59 min. 00 sec.	59 min. 40 sec.



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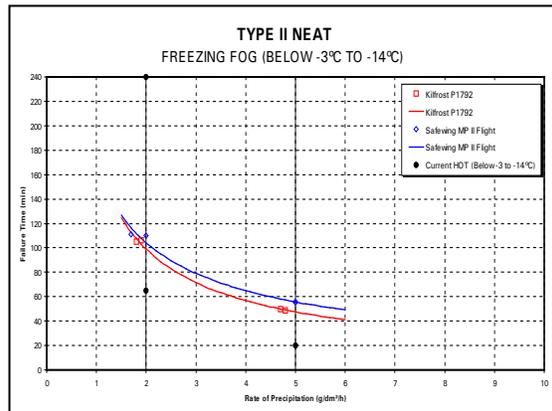
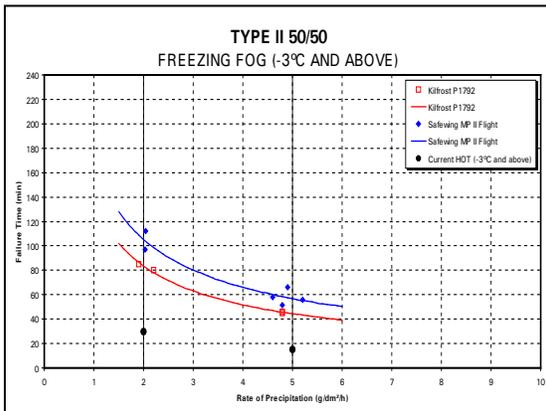
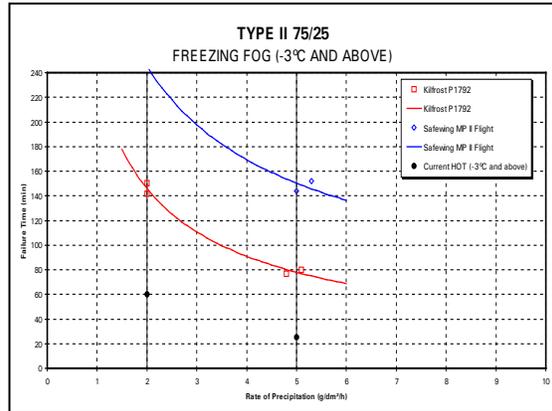
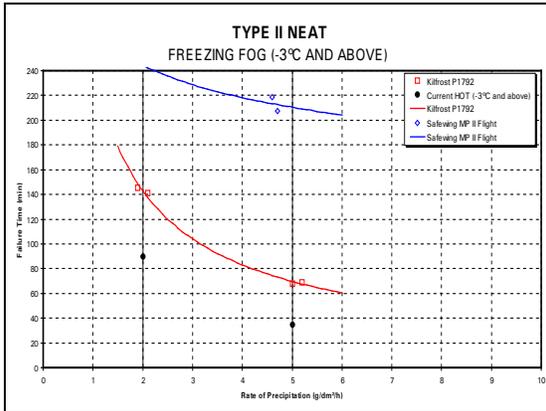

**TESTS CONDUCTED IN 2005-06**

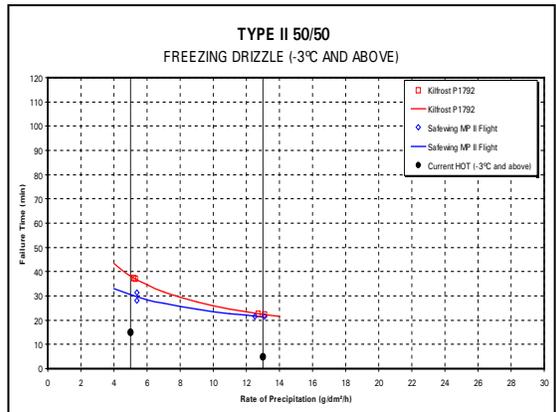
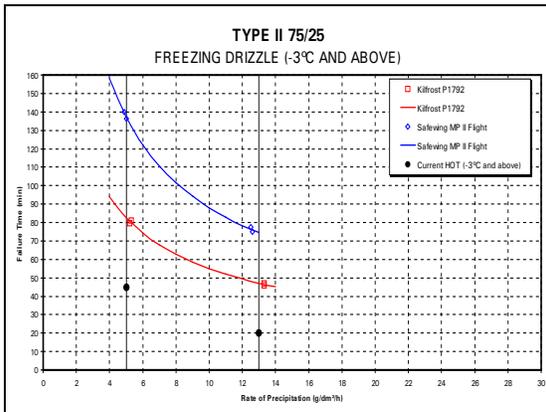
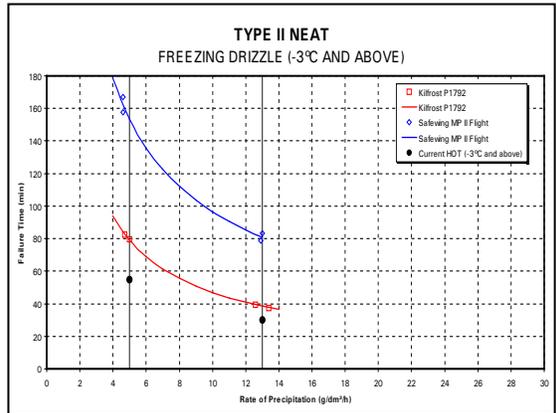
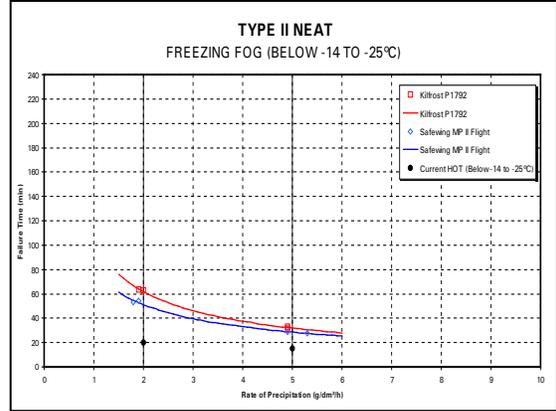
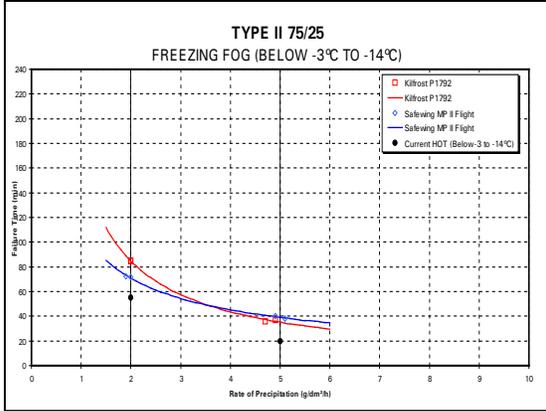
FLUID TYPE	SNOW	FREZZINGORZOLE	LEAF FREEZING SURF	FREZZINGFOG	COLDSOAK	TOTAL
Type II Neat II	18	16	16	23	8	81
Type II (75%)	18	16	16	16	8	74
Type II (50%)	8	8	8	10	0	34
<b>TOTAL</b>	<b>44</b>	<b>40</b>	<b>40</b>	<b>49</b>	<b>16</b>	<b>189</b>

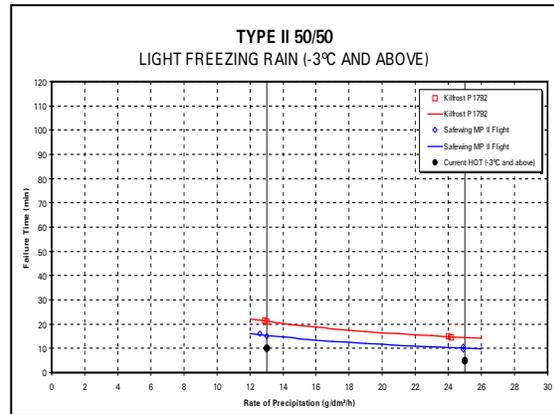
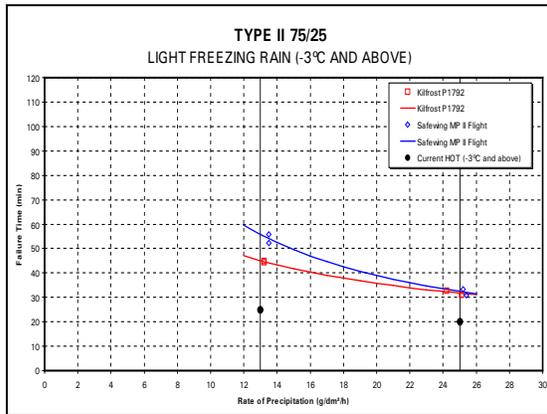
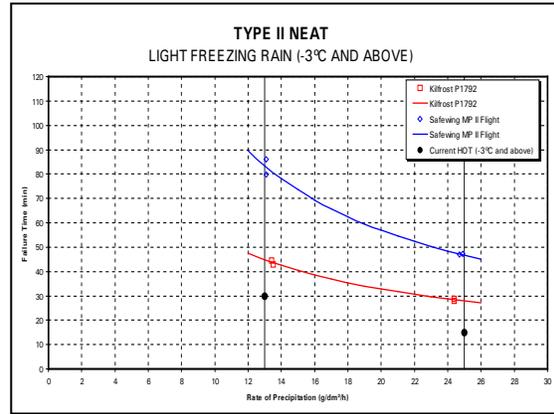
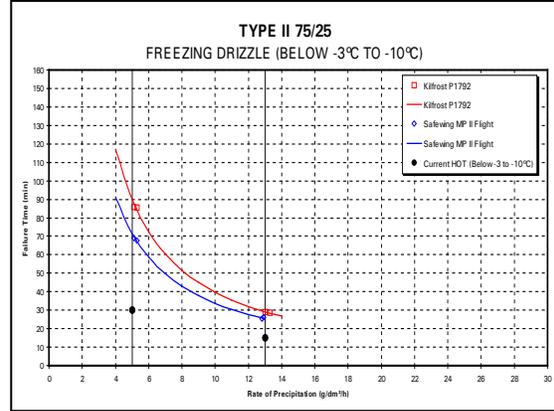
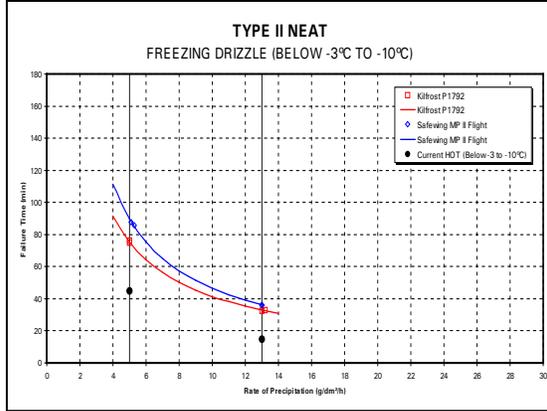


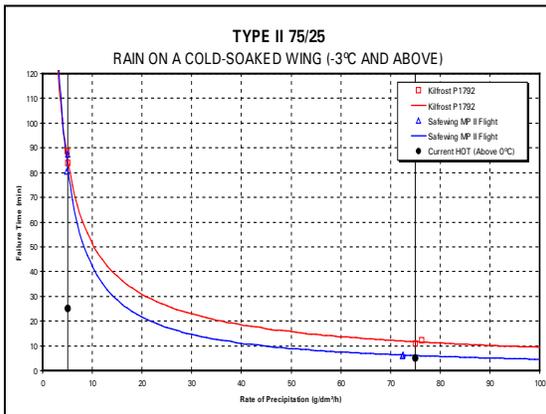
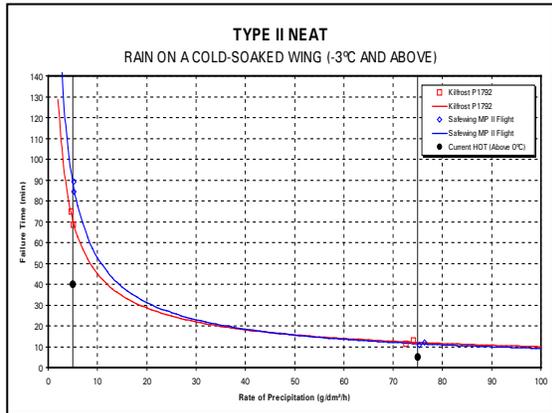
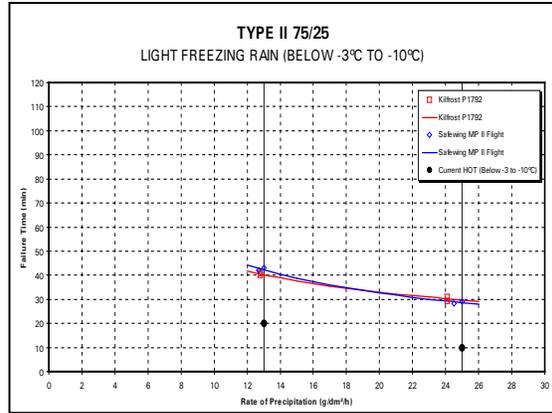
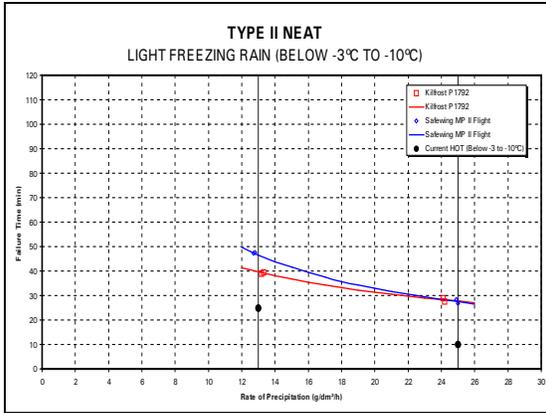
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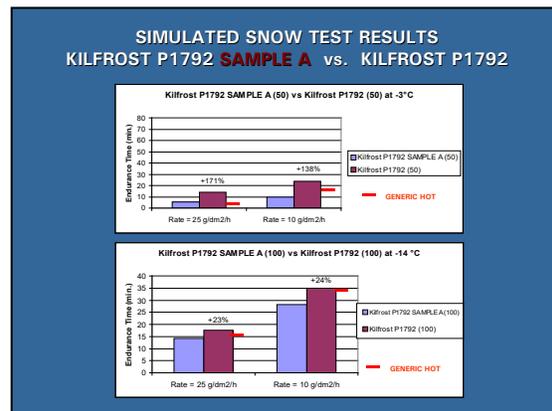
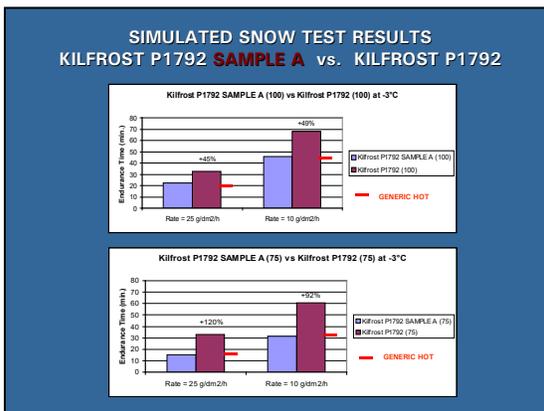
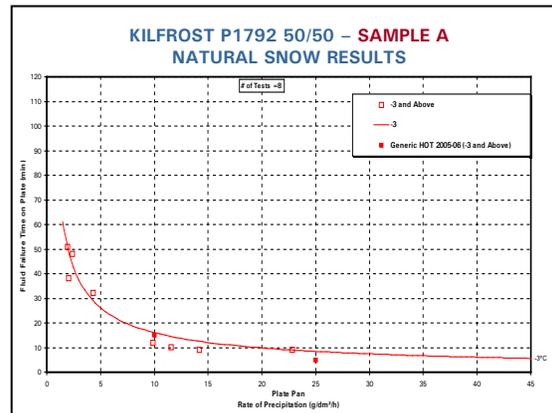
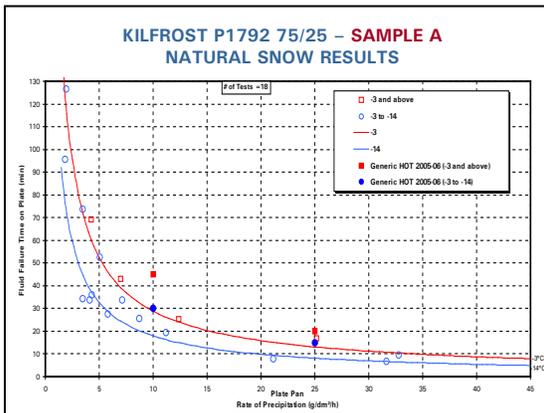
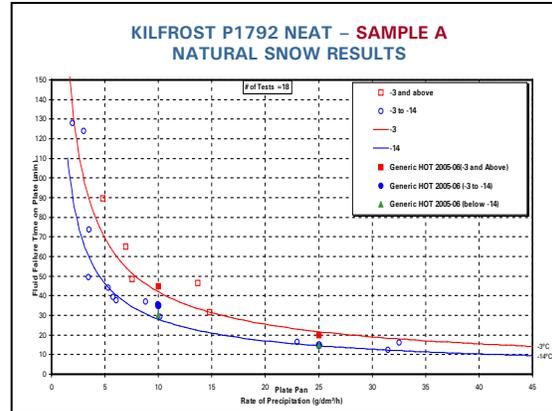




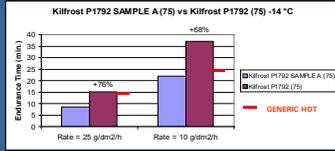
## KILFROST P1792

- ➔ Two batches of Kilfroast P1792
  - ➔ Natural snow tests performed with the 1<sup>st</sup> batch of fluid (P1792 Sample A)
  - ➔ After the natural snow testing was completed, a 2<sup>nd</sup> batch was sent to APS for endurance time testing
  - ➔ Most simulated precipitation tests, including simulated snow, were performed with both batches
  - ➔ Kilfroast wishes to commercialize the 2<sup>nd</sup> batch



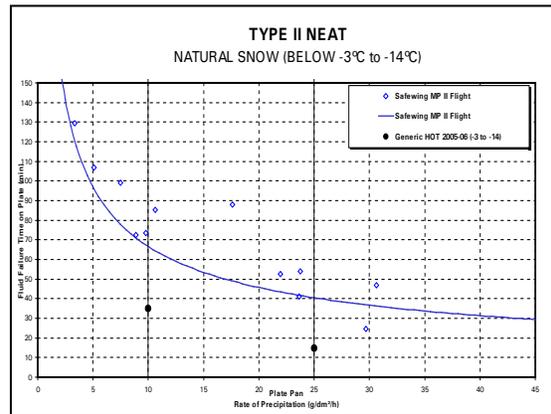
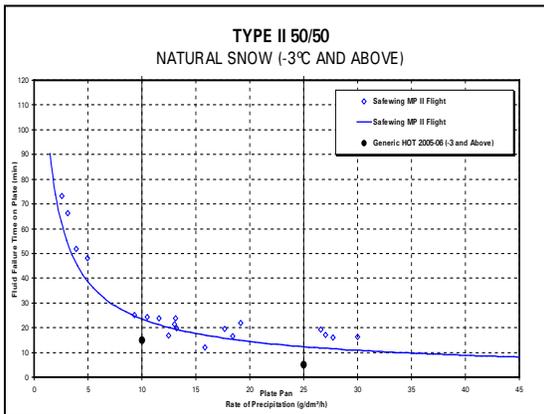
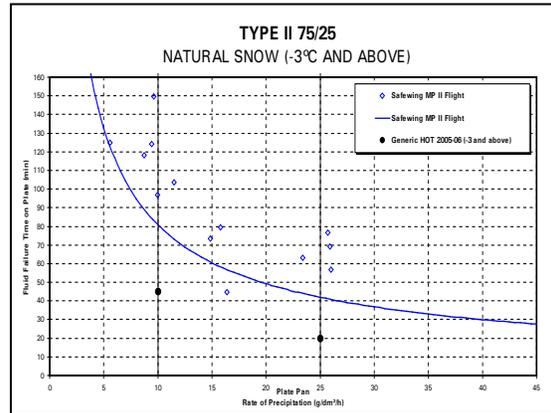
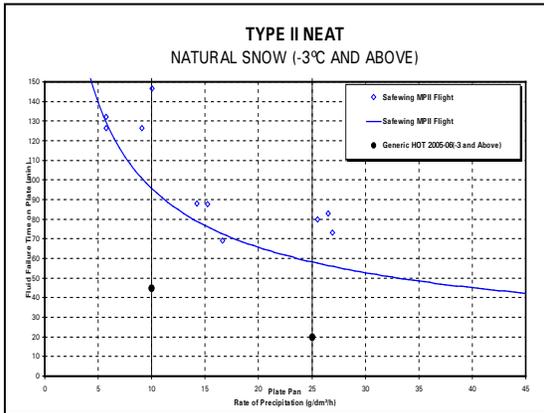
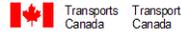
**SIMULATED SNOW TEST RESULTS  
KILFROST P1792 SAMPLE A vs. KILFROST P1792**

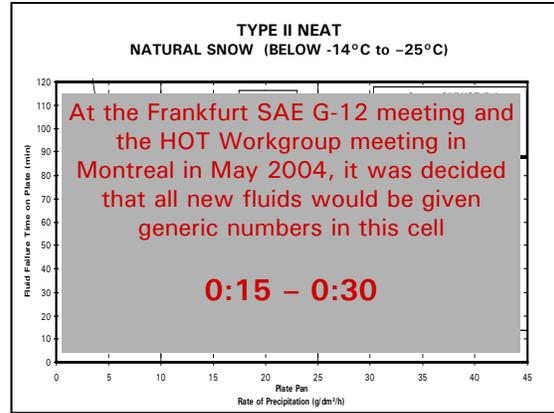
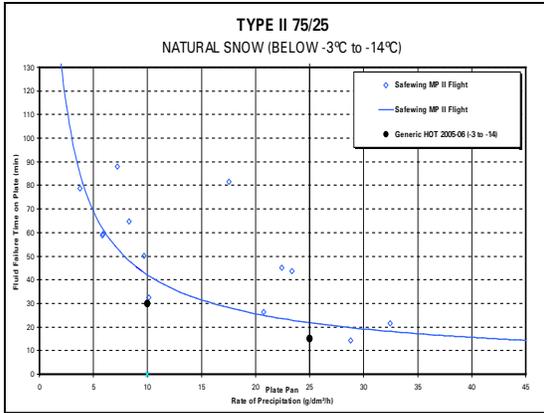


1:1 relationship between simulated and natural Snow for Kilfrost P1792 Sample A

**KILFROST P1792  
SNOW HOLDOVER TIMES**

- Natural snow data set exists for Kilfrost P1792 Sample A
- Some results were below Generic Type II values
- In all simulated snow tests with both batches, the ET performance of the 2<sup>nd</sup> batch of Kilfrost P1792 was superior to the Sample A performance
- All simulated Snow ET results with the 2<sup>nd</sup> batch were above Type II Generic values
- In 2006-07, Kilfrost will re-submit the fluid for outdoor snow tests





### SUMMARY OF TYPE II ENDURANCE TIME TESTING

- Two new Type II fluids will be produced commercially for use in 2006-07 winter operations
- No changes will be made to the generic Type II holdover time guidelines for use in 2006-07 winter operations, based on the most recent testing

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### FAA/TC TYPE II HOT GUIDELINES 2006-07

NO CHANGES

FAA TYPE II HOLDOVER TIME GUIDELINE

TABLE 2: FAA Guidelines for Holdover Times (HOT) Type II Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature.

Outside Air Temperature (Degrees Celsius)	Outside Air Temperature (Degrees Fahrenheit)	Type II Fluid Characteristics (Viscosity at Reference Temp)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Rain	Light Freezing Rain	Rate on Cold Surface (mm)	Other
-1 and above	30 and above	1000	0:00	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	None
-1 and below	30 and below	1000	0:00	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	None
-1 and below	30 and below	1000	0:00	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	None
-1 and below	30 and below	1000	0:00	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	None
-1 and below	30 and below	1000	0:00	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	None

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### TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2006-07

- CLARIANT SAFEWING MP II 2025 ECO
- CLARIANT SAFEWING MP II FLIGHT
- KILFROST ABC-2000
- KILFROST ABC-II PLUS
- KILFROST P1792
- OCTAGON E-MAX II
- SPCA ECOWING 26

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# AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2005-06 WINTER TEST SEASON

## TYPE III FLUID



SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2006

**PREPARED AND PRESENTED ON BEHALF OF:**

**TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA**


 Transports Canada / Transport Canada

AND

**FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE**




## TYPE III FLUIDS TESTED

- ➔ No new Type III products were tested by APS for endurance times in 2005-06
- ➔ No changes will be made to the generic Type III guidelines for 2006-07 winter operations


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### FAA/TC TYPE III HOT GUIDELINES 2006-07

**FAA TYPE III HOLD-OVER TIME GUIDELINE**

Table 3. FAA Guidelines for Holdover Times SAE Type III Fluid Mixtures as a Function of Weather Conditions and OAT.

**CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.**

Weather Conditions		Approximate Holdover Times Under Various Weather Conditions (Do not exceed)									
Temperature (°C)	Temperature (°F)	1000' (300')	1500' (450')	2000' (600')	2500' (750')	3000' (900')	3500' (1050')	4000' (1200')	4500' (1350')	5000' (1500')	5500' (1650')
3 and above	37 and above	1500	1200	900	600	450	300	150	100	75	50
2 and above	36 and above	1200	900	600	450	300	150	100	75	50	25
1 and above	33 and above	900	600	450	300	150	100	75	50	25	15
0 and above	32 and above	600	450	300	150	100	75	50	25	15	10
0 and below	32 and below	450	300	150	100	75	50	25	15	10	5
0 and below	32 and below	300	150	100	75	50	25	15	10	5	5
0 and below	32 and below	150	100	75	50	25	15	10	5	5	5
0 and below	32 and below	75	50	25	15	10	5	5	5	5	5
0 and below	32 and below	50	25	15	10	5	5	5	5	5	5
0 and below	32 and below	25	15	10	5	5	5	5	5	5	5
0 and below	32 and below	15	10	5	5	5	5	5	5	5	5
0 and below	32 and below	10	5	5	5	5	5	5	5	5	5
0 and below	32 and below	5	5	5	5	5	5	5	5	5	5
0 and below	32 and below	5	5	5	5	5	5	5	5	5	5

**NO CHANGES**

**SAE TYPE III HOLD-OVER TIME GUIDELINES FOR WINTER 2006-2006**

THE RESPONSIBILITY FOR APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions									
Degrees Celsius	Degrees Fahrenheit	1000' (300')	1500' (450')	2000' (600')	2500' (750')	3000' (900')	3500' (1050')	4000' (1200')	4500' (1350')	5000' (1500')	5500' (1650')
3 and above	27 and above	1500	1200	900	600	450	300	150	100	75	50
2 and above	27 and above	1200	900	600	450	300	150	100	75	50	25
1 and above	27 and above	900	600	450	300	150	100	75	50	25	15
0 and above	27 and above	600	450	300	150	100	75	50	25	15	10
0 and below	27 and below	450	300	150	100	75	50	25	15	10	5
0 and below	27 and below	300	150	100	75	50	25	15	10	5	5
0 and below	27 and below	150	100	75	50	25	15	10	5	5	5
0 and below	27 and below	100	75	50	25	15	10	5	5	5	5
0 and below	27 and below	75	50	25	15	10	5	5	5	5	5
0 and below	27 and below	50	25	15	10	5	5	5	5	5	5
0 and below	27 and below	25	15	10	5	5	5	5	5	5	5
0 and below	27 and below	15	10	5	5	5	5	5	5	5	5
0 and below	27 and below	10	5	5	5	5	5	5	5	5	5
0 and below	27 and below	5	5	5	5	5	5	5	5	5	5
0 and below	27 and below	5	5	5	5	5	5	5	5	5	5

**CAUTION: No holdover time guidelines exist!**



# AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2005-06 WINTER TEST SEASON

## TYPE IV FLUID



**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2005**

**PREPARED AND PRESENTED ON BEHALF OF:**

**TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA**



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**FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE**




**TYPE IV FLUIDS TESTED**

- Three new Type IV products were tested by APS for endurance times in 2005-06
- Clariant Safewing MP IV Launch
- Dow UCAR Endurance EG106
- Kilfrost P 1797

➤ All three fluids will be commercialized






**TYPE IV FLUID PARTICULARS**

- Dow intends to only commercialize the Neat (100/00) UCAR Endurance EG106 fluid
- Two batches of Clariant Safewing MP IV Launch were tested
  - Natural snow tests performed with the 1<sup>st</sup> batch of fluid
  - After the natural snow testing was completed, a 2<sup>nd</sup> batch was sent to APS for endurance time testing
  - Simulated precipitation tests, including simulated snow, were performed with both batches
  - Clariant wishes to commercialize the 2<sup>nd</sup> batch







**FLUID VISCOSITY**

Fluid	Viscosity - Manufacturer's Method	Viscosity - AIR Method
Clariant MP IV Launch	7,550	7,550
	Sample LV1, 20°C, 0.31pm, 10minutes	Sample LV1, 20°C, 0.31pm, 10minutes
Dow Endurance EG106	24,850	2,230
	Sample 2I, 0°C, 0.31pm, 10minutes	Sample LV1, 20°C, 0.31pm, 10minutes
Kilfrost P 1797	10,450	11,040
	Sample LV2, 0°C, with guard sp. 150 mL of fluid, 20°C, 0.31pm, 10minutes	Sample LV1, 20°C, 0.31pm, 10minutes





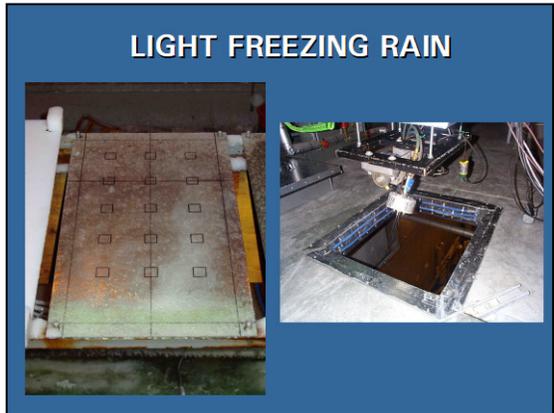
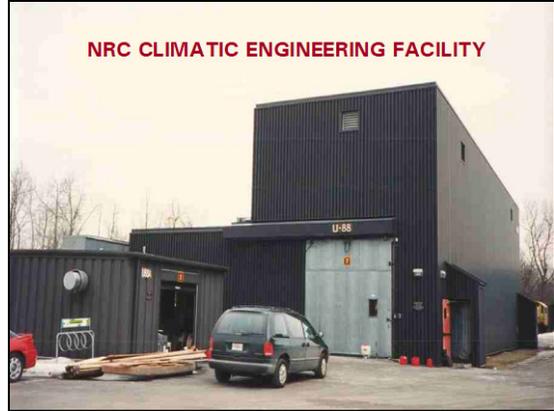

**WSET RESULTS - AMIL**

CLARIANT SAFEWING MP IV LAUNCH NEAT FLUID	DOW UCAR ENDURANCE EG106 NEAT FLUID	KILFROST P1797 NEAT FLUID
88 min.	125 min.	80 min.
86 min.	126 min.	81 min.
86 min.	124 min.	80 min.







### TESTS CONDUCTED IN 2005-06

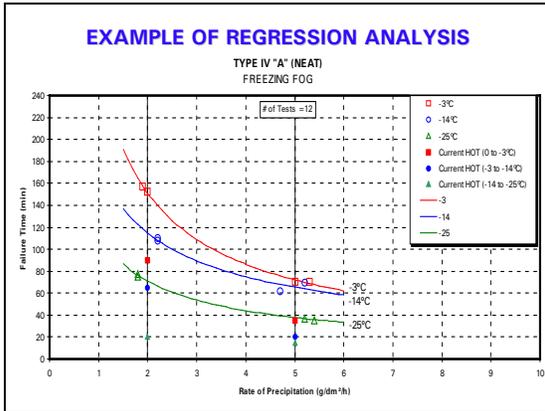
FLUID TYPE	SNOW	FREZING DRIZZLE	LIGHT FREZING RAIN	FREZING FOG	COLD SOAK	TOTAL
Type IV (Neat)	46	32	32	46	16	171
Type IV (75/25)	99	32	32	32	16	171
Type IV (80/20)	39	17	16	22	0	94
<b>TOTAL</b>	<b>143</b>	<b>81</b>	<b>80</b>	<b>100</b>	<b>32</b>	<b>436</b>

### ENDURANCE TIME DATA ANALYSIS METHODOLOGY

- Regression analysis that provides a power law relationship
- General form of the equation for light freezing rain, freezing drizzle, freezing fog, and rain on a cold-soaked wing is  $t = cR^a$
- General form of the equation for snow is  $t = cR^b(2-T)^c$

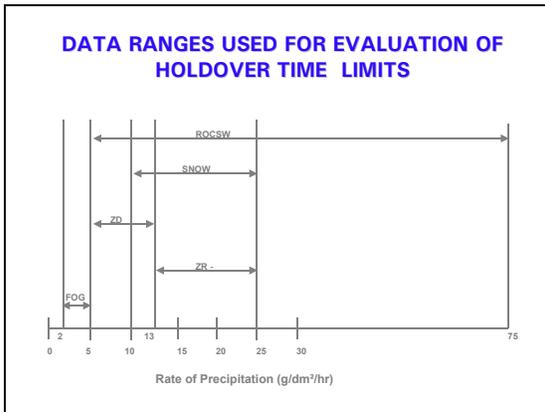
where

- t = Time,
- R = Rate of precipitation,
- T = Temperature, and
- a, b, c = The coefficients determined from the regression



### SUMMARY OF PROCEDURE USED TO DETERMINE HOLDOVER TIME LIMITS

- Curves were plotted for each fluid and each cell of the holdover time table using the **MOST RESTRICTIVE TEMPERATURE** in that cell
- Upper and lower holdover time values were determined using specific precipitation rate ranges for each condition

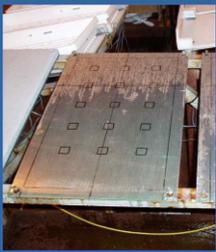


### SUMMARY OF PROCEDURE USED TO DETERMINE HOLDOVER TIME LIMITS

**Determination of Generic HOT Table Values**

- The worst performing fluid values were selected for each cell of the holdover time table
- Round numbers to the nearest whole "5" value
- For safety reasons, holdover times below 10 minutes were always rounded down

### FLUID FAILURE



Fluid failure occurs when:

- Accumulation of snow bridging on top of the fluid or plate
- Accumulation of ice on top of the fluid or plate, or ice suspended within the fluid



Transports Canada / Transport Canada



### PLATE END CONDITION

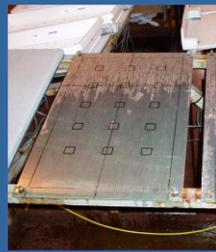


Plate end condition is achieved when fluid failures occur:

- At any 5 of the crosshair markings on the panel; or
- On more than 30% of the entire plate surface



Transports Canada / Transport Canada





### OVERVIEW OF FREEZING FOG TESTS

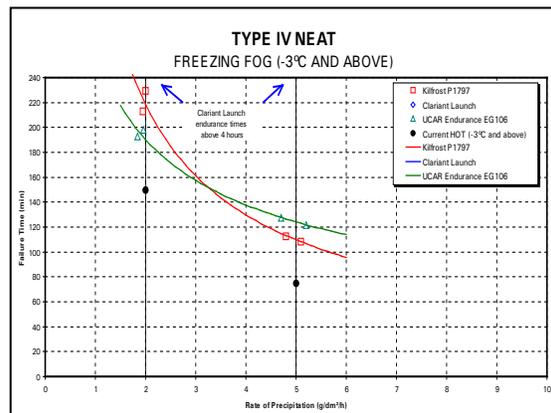
- Tests conducted at the NRC CEF in Ottawa
- Tests conducted at 2 and 5 g/dm<sup>2</sup>/h
- Test temperatures: -3, -14, and -25°C

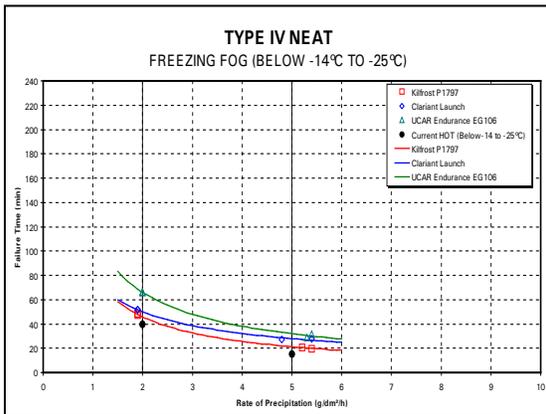
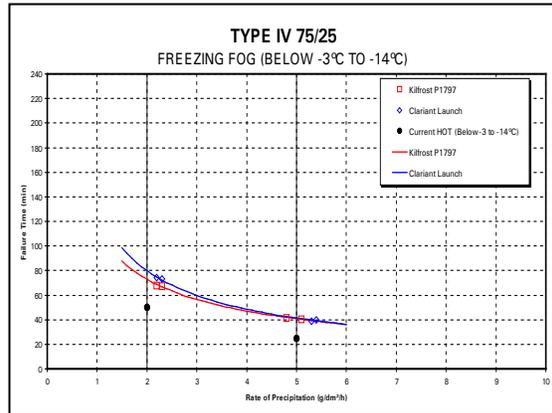
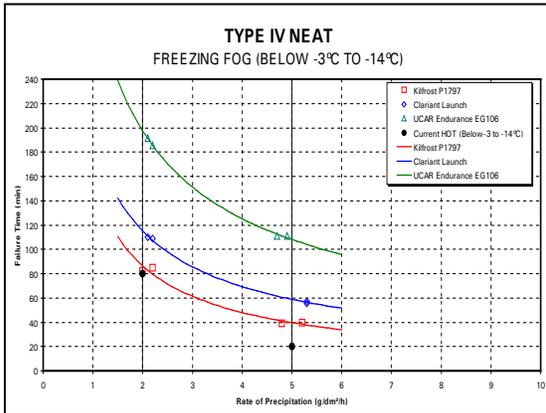
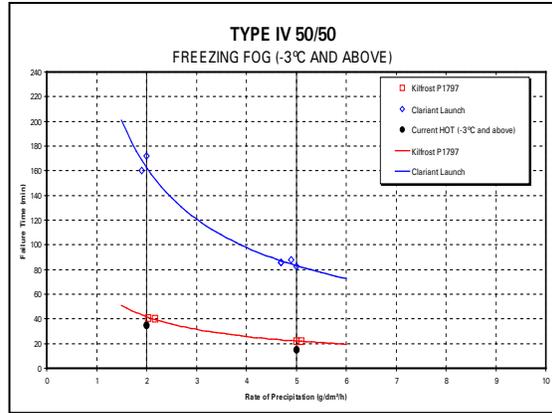
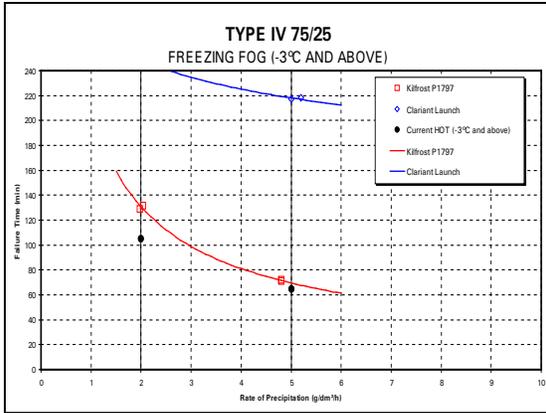




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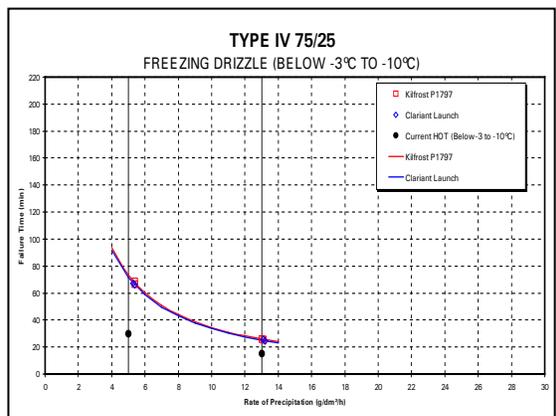
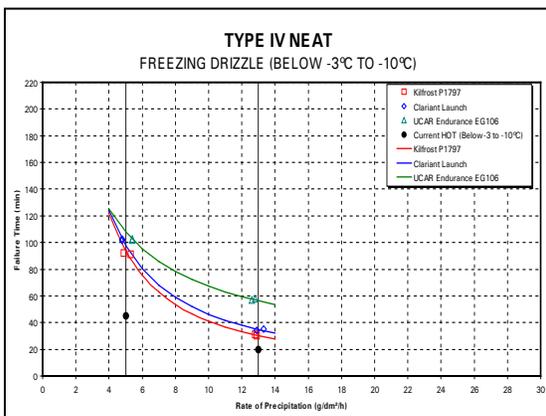
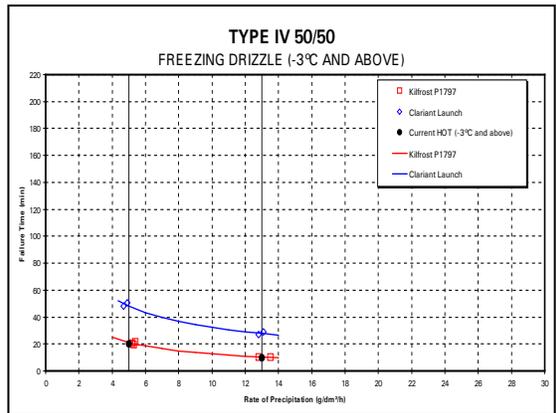
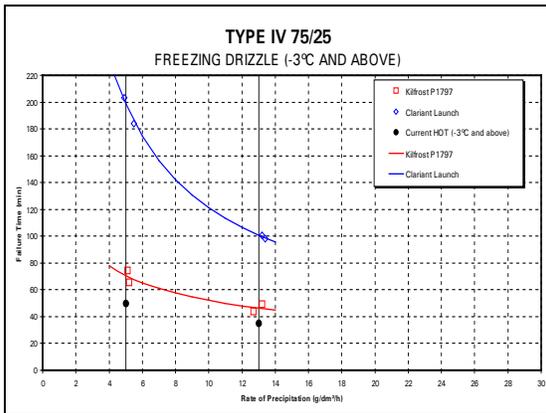
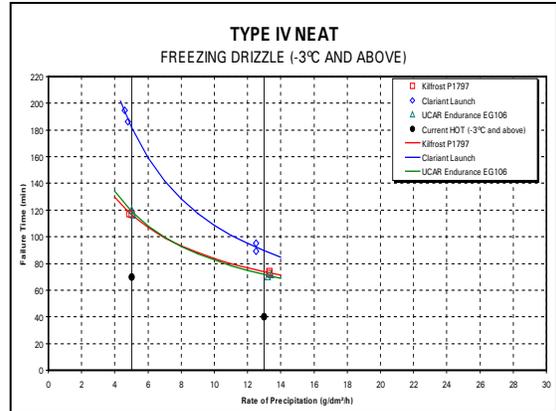


### OVERVIEW OF FREEZING DRIZZLE TESTS

- Tests conducted at the NRC CEF in Ottawa
- Tests conducted at 5 and 13 g/dm<sup>2</sup>/h
- Test temperatures: -3 and -10°C







### OVERVIEW OF LIGHT FREEZING RAIN TESTS

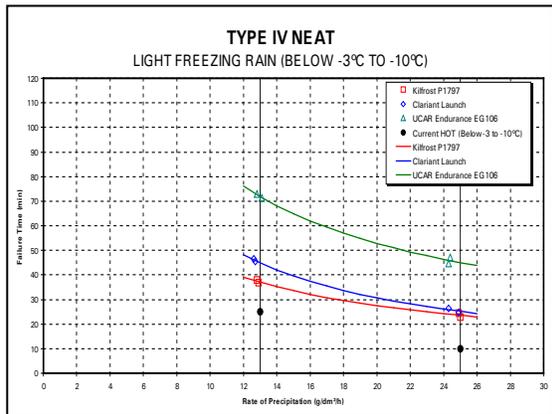
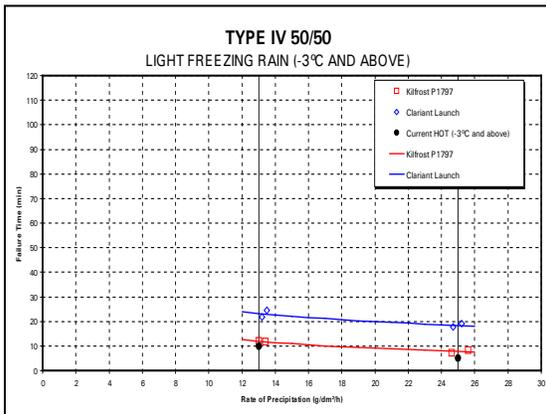
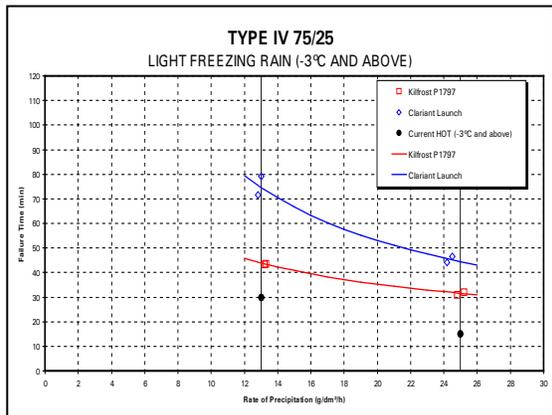
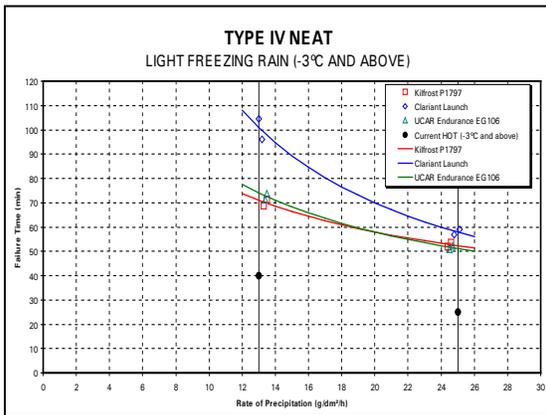
- ✦ Tests conducted at the NRC CEF in Ottawa
- ✦ Tests conducted at 13 and 25 g/dm<sup>2</sup>/h
- ✦ Test temperatures: -3 and -10°C

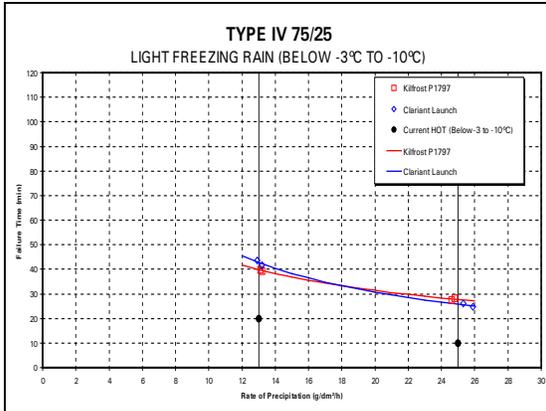



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### OVERVIEW OF RAIN ON A COLD-SOAKED WING TESTS

**TEST SITE**

- Laboratory tests conducted at the National Research Council's Climatic Engineering Facility in Ottawa.

**TEST CONDITIONS**

- Drizzle and moderate rain were simulated:
  - Drizzle (low end) rate: 5 g/dm²/hr
  - Moderate rain (high end) rate: 75 g/dm²/hr

Logos: Transport Canada, National Research Council Canada

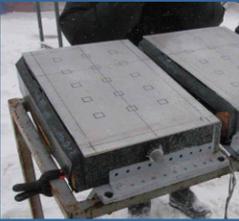
### OVERVIEW OF RAIN ON A COLD-SOAKED WING TESTS



- Boxes were filled with 65/35 glycol/water mixture which was cooled
- An insulating jacket was attached on all sides except the top
- Box depth was 7.5 cm
- The top surface was a standard flat plate

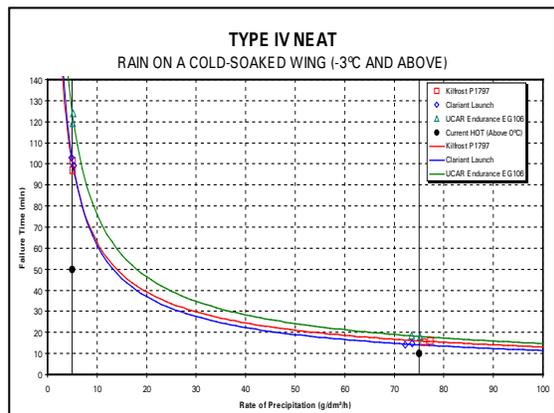
Logos: Transport Canada, National Research Council Canada

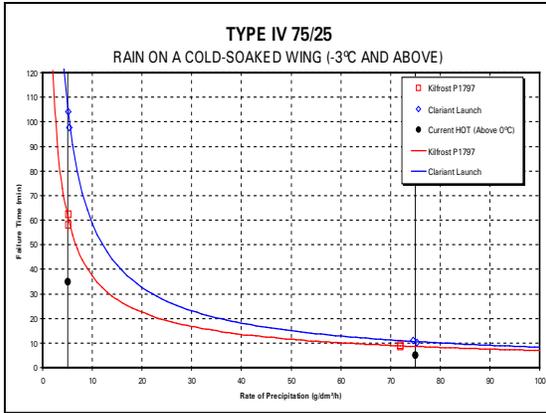
### OVERVIEW OF RAIN ON A COLD-SOAKED WING TESTS



- Plate surface temperatures were recorded using thermocouples embedded in the box
- Tests were started when the skin temperature was -10°C
- Ambient air temperature was 1°C

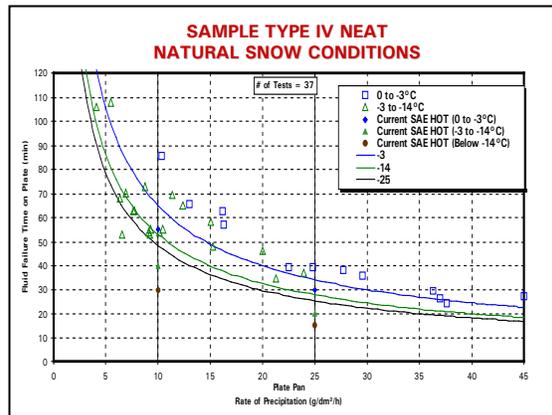
Logos: Transport Canada, National Research Council Canada





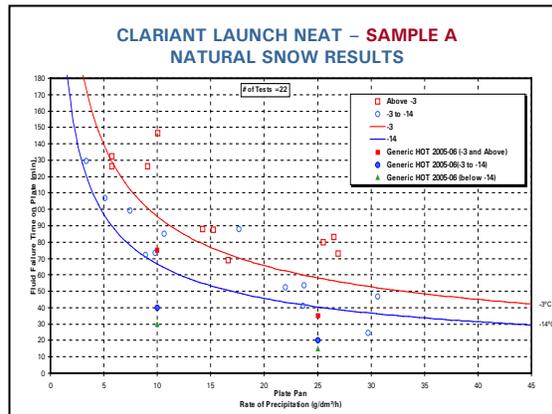
### OVERVIEW OF NATURAL SNOW TESTS

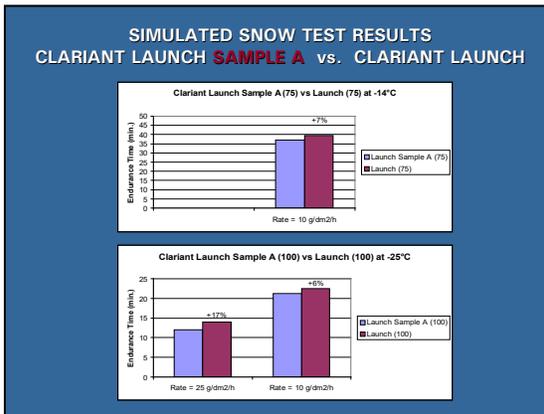
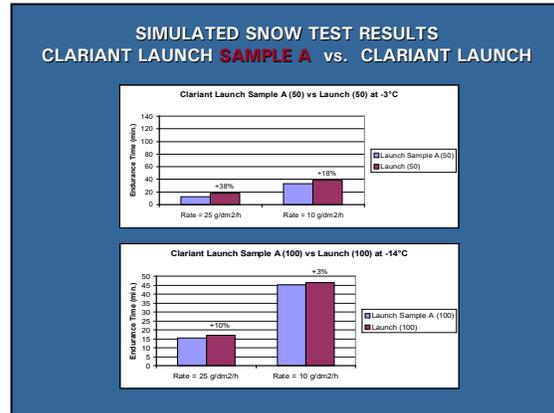
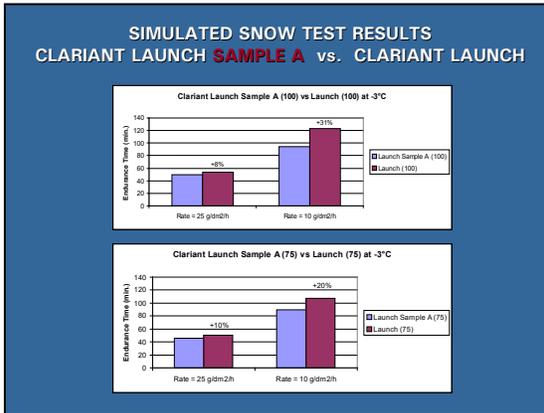
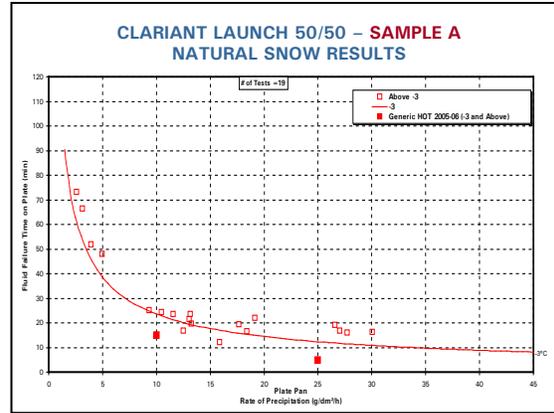
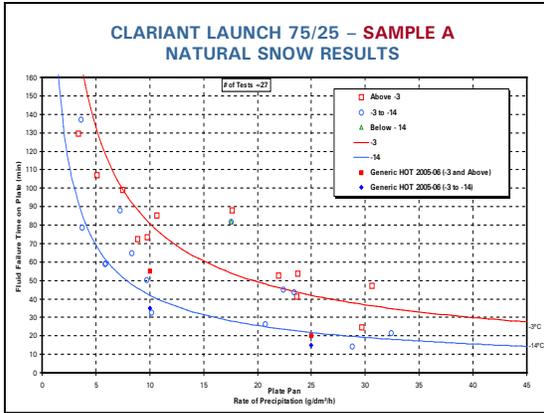
- Tests conducted at the APS test site at YUL
- No control over rate, temperature, wind
- Entire snow data set is considered when analyzing the performance of any fluid
- Snow holdover time range is determined at 10 and 25 g/dm²/h



### CLARIANT SAFEWING MP IV LAUNCH

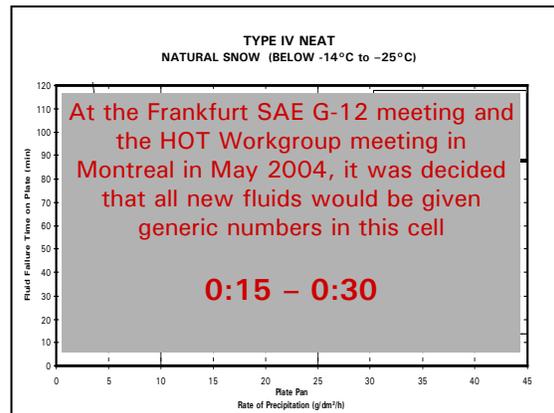
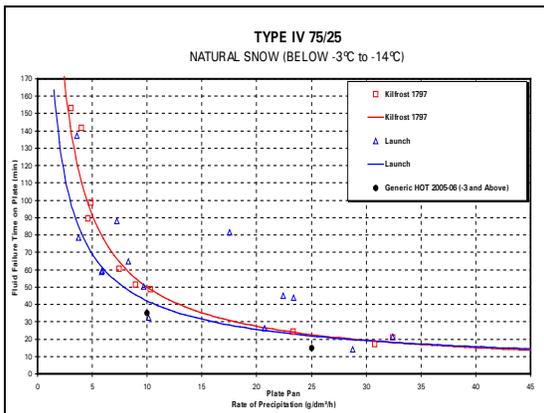
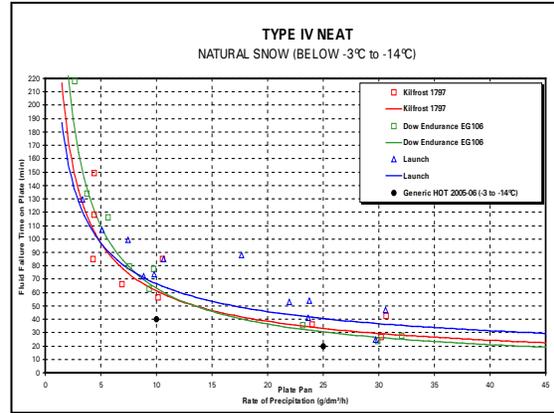
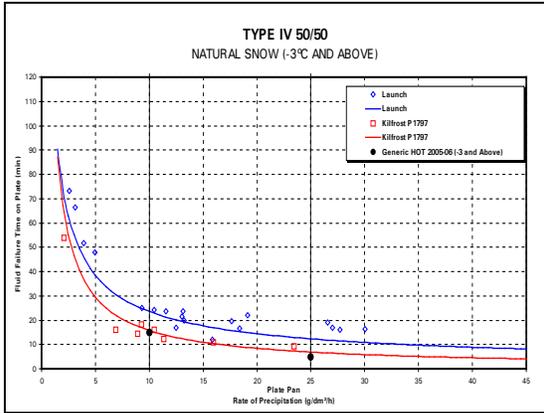
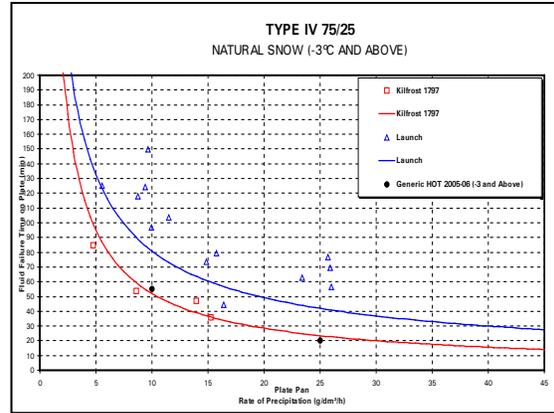
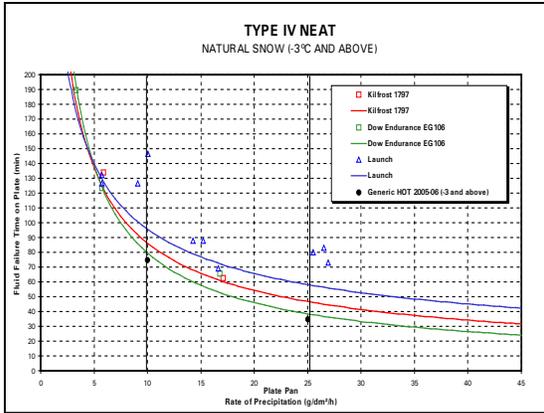
- Two batches of Clariant Safewing MP IV Launch were tested
- Natural snow tests performed with the 1<sup>st</sup> batch of fluid (Launch Sample A)
- After the natural snow testing was completed, a 2<sup>nd</sup> batch was sent to APS for endurance time testing
- Simulated precipitation tests, including simulated snow, were performed with both batches
- Clariant wishes to commercialize the 2<sup>nd</sup> batch





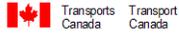
### CLARIANT SAFEWING MP IV LAUNCH SNOW HOLDOVER TIMES

- Natural snow data set exists for Launch Sample A only
- In all simulated snow tests with both batches, the ET performance of the 2<sup>nd</sup> batch of Launch was superior to the Sample A performance
- For 2006-07, snow values in the fluid-specific tables for Clariant Safewing MP IV Launch will be those of Sample A
- In 2006-07, Clariant will re-submit the fluid for outdoor snow tests



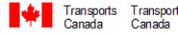
## SUMMARY OF TYPE IV ENDURANCE TIME TESTING

- Three new Type IV fluids will be produced commercially for use in 2006-07 winter operations
- No changes will be made to the generic Type IV holdover time guidelines for use in 2006-07 winter operations, based on the most recent testing




## REMOVAL OF OBSOLETE DATA

- Process for the removal of obsolete data was discussed and implemented by the SAE G-12 HOT Subcommittee at New Orleans G-12 meeting in 2001 (Resolution #1)
- In 2001, data for two fluids, Hoechst 1957 and Union Carbide Ultra + (in dilution), were removed from the Type IV data set and analysis
- In 2003 in Vancouver, data for SPCA AD-404 were removed
- In 2004 in Frankfurt, data for Clariant Safewing Four were removed
- In 2005 in Pittsburgh, data for Clariant MPIV Safewing 1957 were removed
- Removal of the data resulted in increases to the Type IV generic table




## REMOVAL OF OBSOLETE DATA

- Conditions for removal:
  - Not available for 4 years
  - Not re-certified
- No fluids meet the conditions of Resolution #1 in 2006




## FAA/TC TYPE IV HOT GUIDELINES 2006-07

**NO CHANGES**

**FAA TYPE IV HOLDOVER TIME GUIDELINE**  
TABLE 4 - FAA Guidelines for Holdover Times for Type IV Fluid Mixtures as a Function of Weather Conditions and Wind

Outside Air Temperature (Degrees Celsius)	Type IV Fluid Category	Approximate Holdover Times Under Various Weather Conditions (Hours:Minutes)
-2 and above	27 and above	12:00 - 12:00
	12 and below	1:00 - 1:00
-2 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00
-10 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00
-18 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00

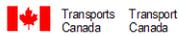
**SAE TYPE IV FLUID HOLDOVER TIMES (RESOLUTION #1) REMAINS WITH THE USER**

Outside Air Temperature (Degrees Celsius)	Type IV Fluid Category	Approximate Holdover Times Under Various Weather Conditions (Hours:Minutes)
-2 and above	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00
-2 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00
-10 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00
-18 and below	27 and above	1:00 - 1:00
	12 and below	1:00 - 1:00




## TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2006-07

- 1) CLARIANT SAFEWING MP IV 2001
- 2) CLARIANT SAFEWING MP IV PROTECT 2012
- 3) CLARIANT SAFEWING MP IV 2030 ECO
- 4) CLARIANT SAFEWING MP IV LAUNCH
- 5) DOW UCAR ULTRA +
- 6) DOW UCAR ENDURANCE EG106
- 7) KILFROST ABC-S
- 8) KILFROST P1797
- 9) OCTAGON MAX-FLIGHT
- 10) OCTAGON MAX-FLIGHT '04
- 11) OCTAGON MAXFLO
- 12) SPCA AD-480






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**APS**  
Aviation Inc.

# **AIRCRAFT DEICING RESEARCH IN SIMULATED ICE PELLET CONDITIONS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

*For*

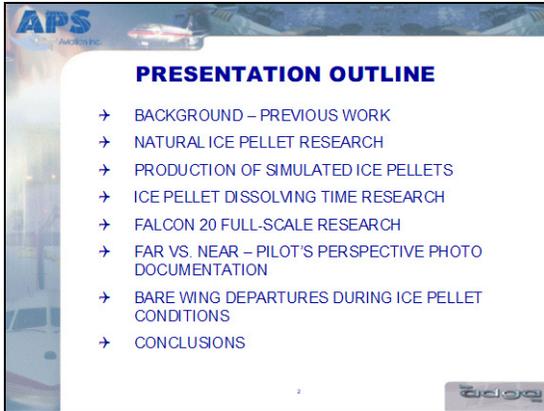
**Transportation Development Centre  
Transport Canada**

**and the**

**Federal Aviation Administration**

ISO 9001:2000

bdpa

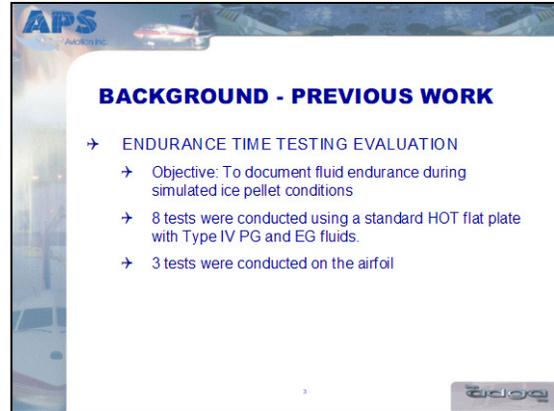


**APS**  
Aerodynamic Systems

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLET RESEARCH
- PRODUCTION OF SIMULATED ICE PELLETS
- ICE PELLET DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
- CONCLUSIONS

2

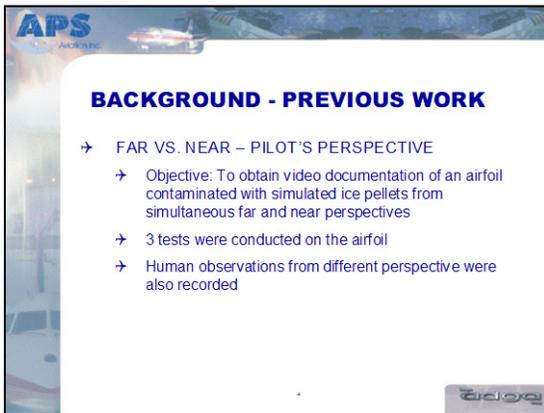


**APS**  
Aerodynamic Systems

**BACKGROUND - PREVIOUS WORK**

- ENDURANCE TIME TESTING EVALUATION
  - Objective: To document fluid endurance during simulated ice pellet conditions
  - 8 tests were conducted using a standard HOT flat plate with Type IV PG and EG fluids.
  - 3 tests were conducted on the airfoil

3

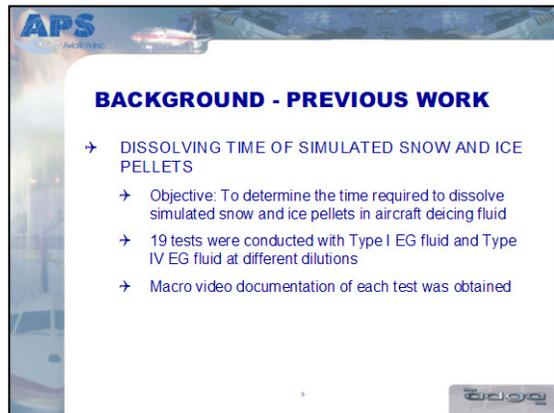


**APS**  
Aerodynamic Systems

**BACKGROUND - PREVIOUS WORK**

- FAR VS. NEAR – PILOT'S PERSPECTIVE
  - Objective: To obtain video documentation of an airfoil contaminated with simulated ice pellets from simultaneous far and near perspectives
  - 3 tests were conducted on the airfoil
  - Human observations from different perspective were also recorded

4

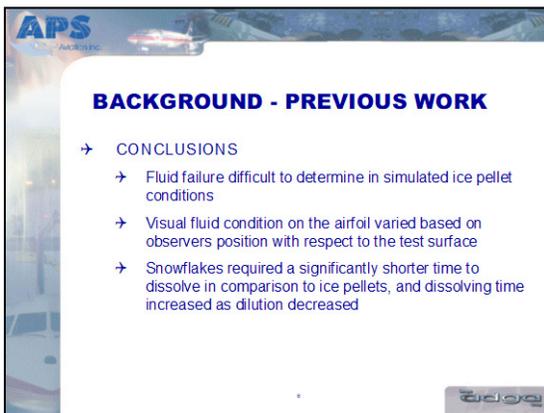


**APS**  
Aerodynamic Systems

**BACKGROUND - PREVIOUS WORK**

- DISSOLVING TIME OF SIMULATED SNOW AND ICE PELLETS
  - Objective: To determine the time required to dissolve simulated snow and ice pellets in aircraft deicing fluid
  - 19 tests were conducted with Type I EG fluid and Type IV EG fluid at different dilutions
  - Macro video documentation of each test was obtained

5

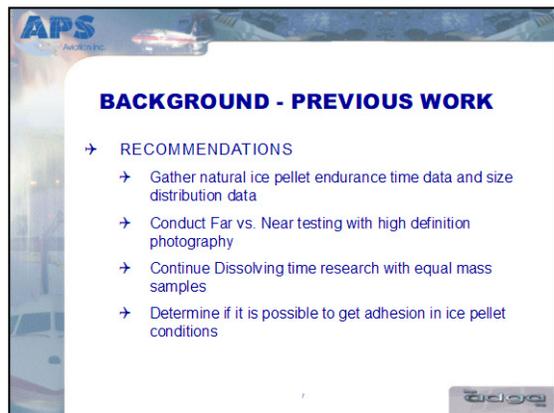


**APS**  
Aerodynamic Systems

**BACKGROUND - PREVIOUS WORK**

- CONCLUSIONS
  - Fluid failure difficult to determine in simulated ice pellet conditions
  - Visual fluid condition on the airfoil varied based on observers position with respect to the test surface
  - Snowflakes required a significantly shorter time to dissolve in comparison to ice pellets, and dissolving time increased as dilution decreased

6



**APS**  
Aerodynamic Systems

**BACKGROUND - PREVIOUS WORK**

- RECOMMENDATIONS
  - Gather natural ice pellet endurance time data and size distribution data
  - Conduct Far vs. Near testing with high definition photography
  - Continue Dissolving time research with equal mass samples
  - Determine if it is possible to get adhesion in ice pellet conditions

7

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- **NATURAL ICE PELLET RESEARCH**
- PRODUCTION OF SIMULATED ICE PELLETS
- ICE PELLET DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
- CONCLUSIONS

**NATURAL ICE PELLET RESEARCH**

- DEFINITION OF ICE PELLETS:
  - Precipitation of transparent or translucent pellets of ice, which are spherical or irregular, and which have a diameter of 5mm or less. The pellets of ice usually bounce when hitting hard ground.
- ICE PELLET INTENSITY DEFINITION:
  - Light – 0 to 25 g/dm<sup>2</sup>/hr
  - Moderate – 25 to 75 g/dm<sup>2</sup>/hr
  - Heavy – greater than 75 g/dm<sup>2</sup>/hr

**NATURAL ICE PELLET RESEARCH**

- BLACK FELT PHOTOGRAPHY OF NATURAL ICE PELLET SAMPLES
  - Natural ice pellet samples were collected using trays lined with black felt
  - Macro photography of the samples were taken to obtain a size distribution
  - Rate of precipitation was measured during several events

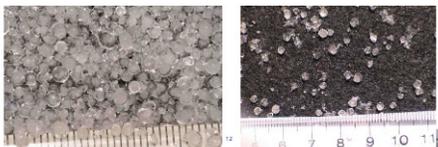
**NATURAL ICE PELLET RESEARCH**

→ LOG OF BLACK FELT PHOTOGRAPHY TESTS

Test Event	Date	Start Time	End Time	Photos (#)	Film Clips (#)	Approx. Rate (g/dm <sup>2</sup> /h)	Interim Rate (g/dm <sup>2</sup> /h)	Size	Location
1	15 Nov-05	12:05:00	12:12:00	11	N/A	N/A	N/A	1-2 mm	YUL (Near Concordia)
2	23 Dec-05	1:50:00	1:51:00	4	N/A	N/A	N/A	2 mm	YUL Test Site
3	25 Dec-05	21:00:00	21:15:00	40	N/A	N/A	N/A	1-3 mm	YUL (Marcola House)
4	29 Dec-05	20:41:00	22:11:00	138	18	7	3, 2, 2, 11	1-2.5 mm	YUL Test Site
5	29 Dec-05	20:41:00	22:11:00	59	N/A	7	3, 2, 2, 11	1-2.5 mm	YUL Test Site
5	Jan 4 2004	23:40:00	23:43:00	6	N/A	N/A	N/A	N/A	N/A
6	14 Jan-06	3:11:00	3:23:00	16	3	N/A	N/A	1-4 mm	YUL (Marcola House)
7	17 Jan-06	20:33:00	22:00:00	79	N/A	30.5	6.5, 15, 16, 23, 17, 32, 31, 30, 29, 33, 36, 38, 39	1-4 mm	YUL Test Site
7	17 Jan-06	20:28:00	0:15:00	92	5	29.5	6.5, 15, 16, 23, 17, 32, 31, 30, 29, 33, 36, 38, 39	1-4 mm	YUL Test Site
7	17 Jan-06	---	---	7	N/A	N/A	N/A	1-4 mm	YUL Test Site
8	21 Jan-06	11:34:00	11:52:00	26	5	28.7	33, 38, 36, 21, 16, 9	1-5 mm	YUL Test Site
8	21 Jan-06	11:35:00	12:01:00	43	1	20.9	33, 38, 36, 21, 16, 9, 10	1-5 mm	YUL Test Site
9	30 Jan-06	13:20	13:45:00	15	N/A	N/A	N/A	1-2 mm	YUL Test Site
10	30 Jan-06	8:00	8:15:00	22	N/A	N/A	N/A	1-3 mm	JD Home
10	30 Jan-06	13:12:00	13:38:00	35	N/A	N/A	N/A	1-2 mm	Downsview Office
11	4 Feb-06	9:47:00	9:52:00	16	N/A	N/A	N/A	1-2 mm	YUL (Marcola House)
12	18 Feb-06	21:35:00	22:45:00	101	N/A	25.6	6, 21, 38, 32, 9	1-3 mm	YUL Test Site
13	9 Mar-06	10:20:00	10:36:00	13	N/A	N/A	N/A	2-3 mm	YOW NRC (Falcon 20 test site)

**NATURAL ICE PELLET RESEARCH**

- SIZE DISTRIBUTION AND RATE OF PRECIPITATION
  - Diameter of natural ice pellets measured up to 5 mm
  - Rate of precipitation ranged from 2-58 g/dm<sup>2</sup>/hr
  - Larger ice pellets generally occurred when the rate of precipitation was highest
  - Aggregates (adhered clusters of ice pellets) commonly found amongst samples, mostly in warmer conditions



**NATURAL ICE PELLET RESEARCH**

- OCCURRENCE OF MIXED PRECIPITATION
  - Ice pellets are generally a transitional condition
  - Ice pellets often occur during the transition from liquid to solid precipitation, or vice versa
  - As a result, ice pellets are often combined with freezing rain creating a risk of adhesion

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### NATURAL ICE PELLET RESEARCH

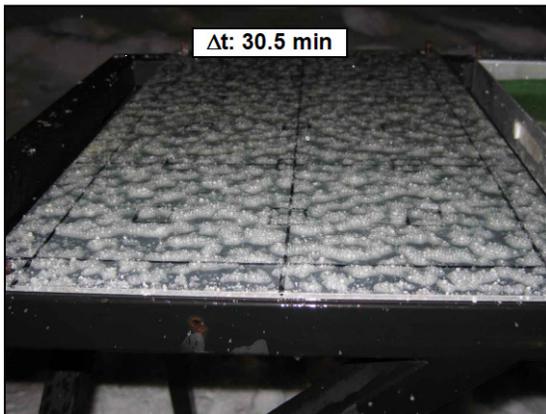
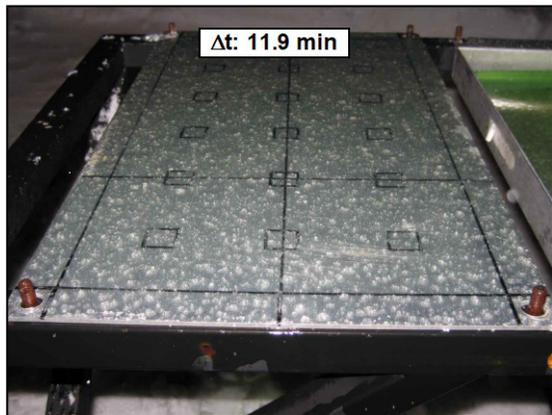
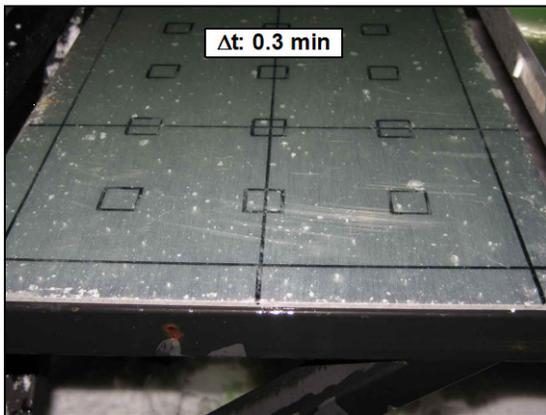
- ENDURANCE TIME TESTING
  - 5 tests were conducted during 3 events
  - Testing was conducted outdoors at the APS Test Site during natural ice pellet conditions
  - Fluid failure difficult to determine and define
  - Fluid condition appears to be visually different based on angle of incidence

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ANALYTIC

### ENDURANCE TIME TESTING IN NATURAL ICE PELLET CONDITIONS

**Type IV PG 50/50**  
**Average Rate of Precipitation: 18 g/dm<sup>2</sup>/hr**  
**Total Time: 30.5 min.**

Test Surface: Plate  
 Date: Feb 16, 2006  
 Start Time: 21:39:22



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### NATURAL ICE PELLET RESEARCH

- CONCLUSIONS
  - Diameter of natural ice pellets generally from 1-3 mm
  - During severe ice pellet events, diameter of natural ice pellets measured up to 5 mm
  - Ice pellets conditions are generally transitional and can include freezing rain
  - Fluid failure difficult to determine in natural ice pellet conditions (much like in simulated ice pellets)

**NATURAL ICE PELLET RESEARCH**

- MCGILL UNIVERSITY ICE PELLET RESEARCH
  - A researcher from McGill University collected and observed natural ice pellets at the APS test site located in YUL
  - The research was conducted to observe and photograph ice pellets in order to better understand the size distribution

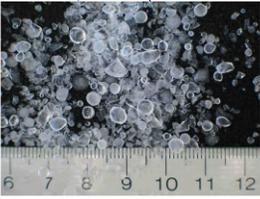
**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLET RESEARCH
- **PRODUCTION OF SIMULATED ICE PELLETS**
- ICE PELLET DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
- CONCLUSIONS

**PRODUCTION OF SIMULATED ICE PELLETS**

**PREVIOUS METHOD**

- Spray water on water phobic surface to create beads which freeze and later can be scraped and collected
- Size and shape representative of natural ice pellets
- Tedious work, and slow production



**PRODUCTION OF SIMULATED ICE PELLETS**

**CURRENT METHOD**

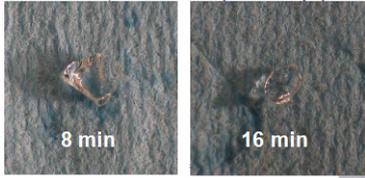
- Crush hard ice and recuperate desired size of pellet
- Size and shape representative of natural ice pellets
- Less tedious, and good production



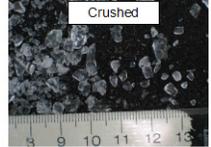
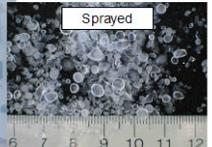
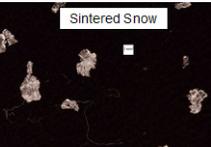
**PRODUCTION OF SIMULATED ICE PELLETS**

**CRUSHED ICE SIZE AND SHAPE REDUCTION**

- 5 mm crushed ice pellet is submerged in Type IV PG 75/25 fluid
- After 8 min, the edges of the crushed ice pellet begin rounding off
- After 16 min, the crushed ice pellet is fairly spherical



**COMPARISON OF SIMULATED AND NATURAL ICE PELLETS**

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### PRODUCTION OF SIMULATED ICE PELLETS

- Falcon 20 testing and Ice Pellet Adhesion testing required significantly large amounts of simulated ice pellets
- Crushed Ice Pellet manufacturing method was chosen based on the quantity requirements

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### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLET RESEARCH
- PRODUCTION OF SIMULATED ICE PELLETS
- **ICE PELLET DISSOLVING TIME RESEARCH**
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
- CONCLUSIONS

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### ICE PELLET DISSOLVING TIME RESEARCH

- METHODOLOGY
  - Comparative study of time required to dissolve equal masses of simulated ice pellets, natural ice pellets, simulated snow, and natural snow
  - 1 dm<sup>2</sup> pan filled with 2 mm of aircraft de/anti-icing fluid
  - Ice pellet or snow is placed in the pan and the time required to dissolve is recorded

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### CRUSHED ICE PELLET DISSOLVING TIME TEST

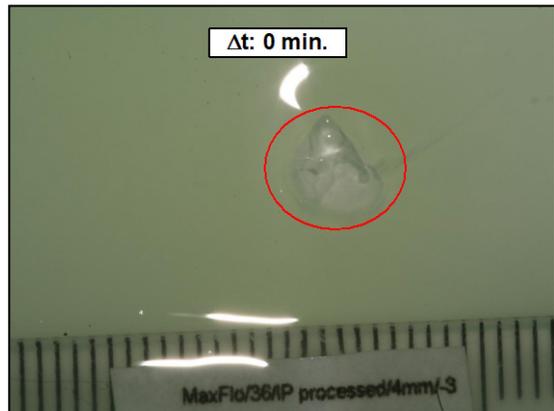
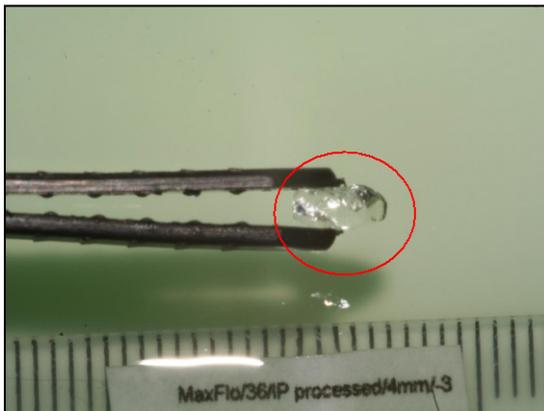
**Type IV PG Neat**

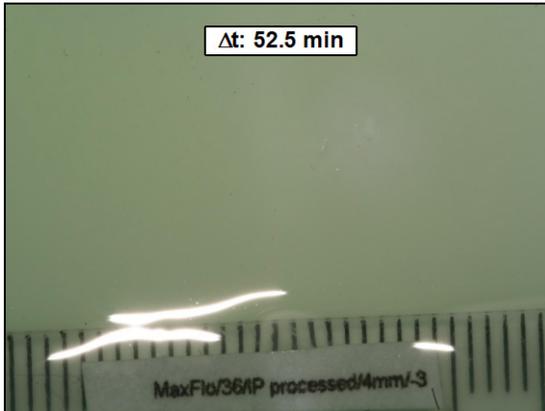
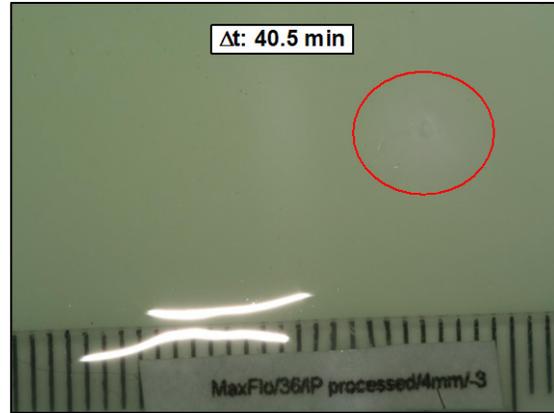
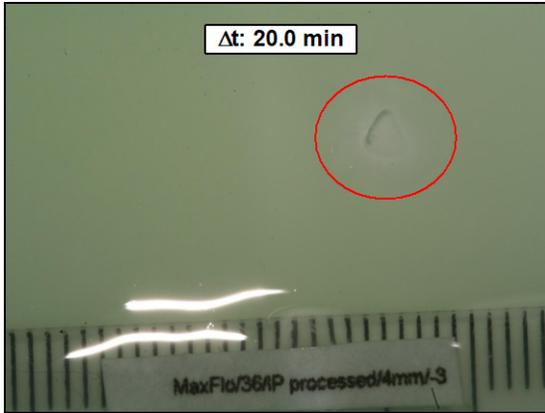
**Total Time to Dissolve: 52.5 minutes**

Start Time: 10:47:54  
End Time: 11:40:26

Initial Brix: 36  
Initial Mass: 30 mg

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**NATURAL ICE PELLET  
DISSOLVING TIME TEST**

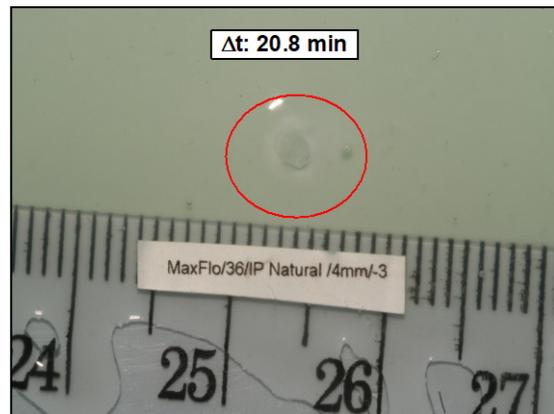
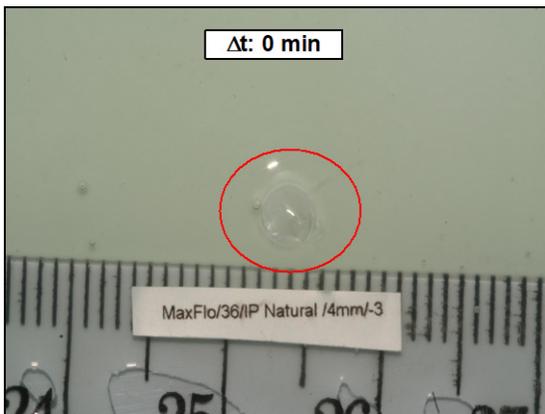
Type IV PG Neat

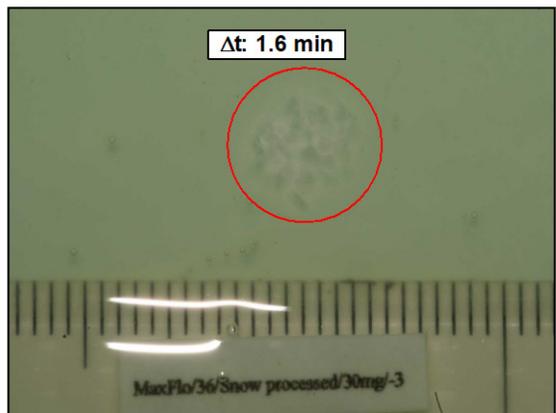
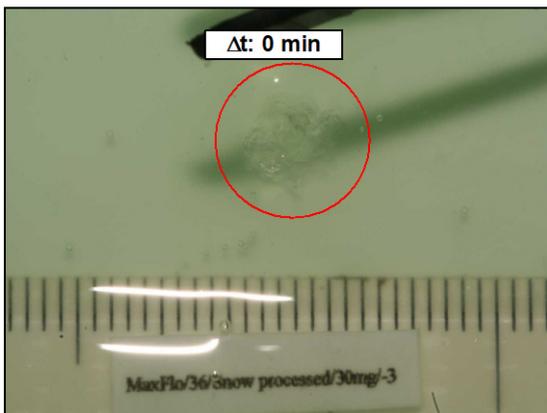
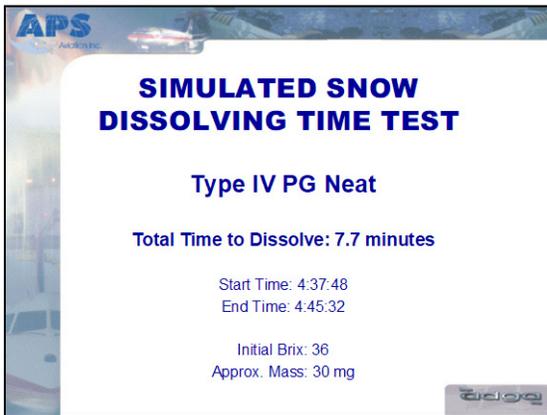
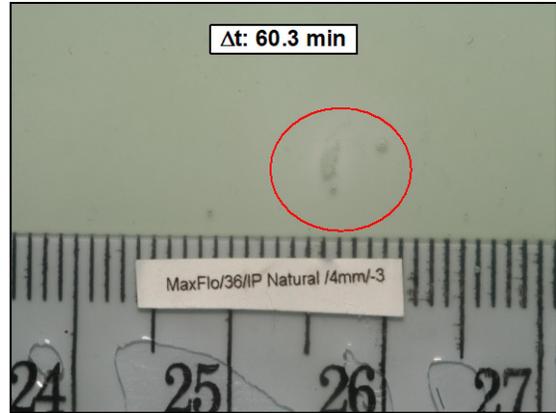
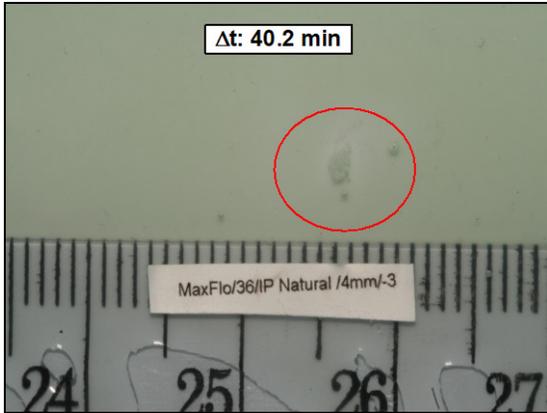
Total Time to Dissolve: 60.3 minutes

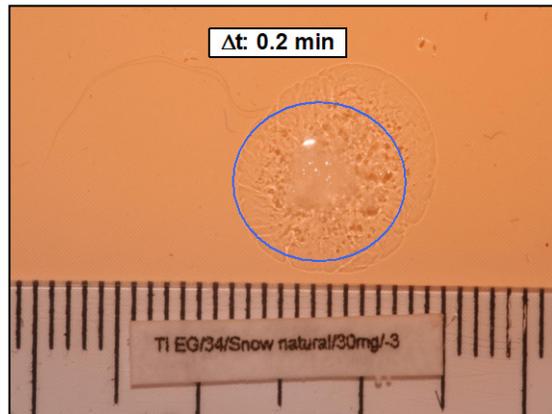
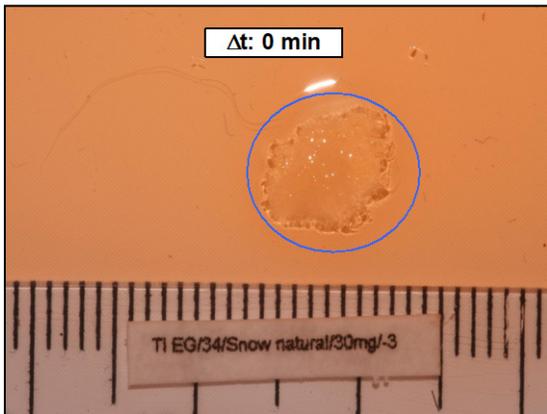
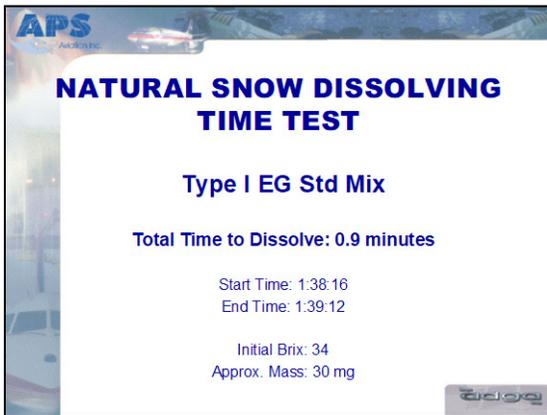
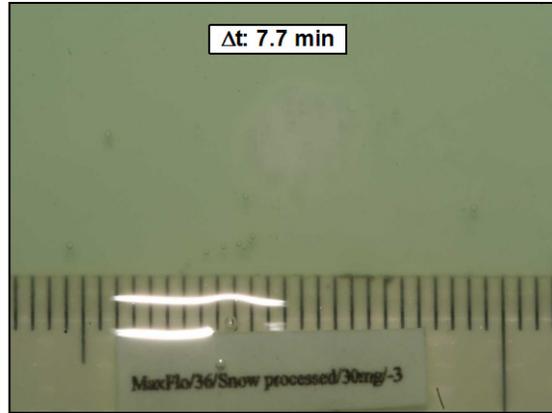
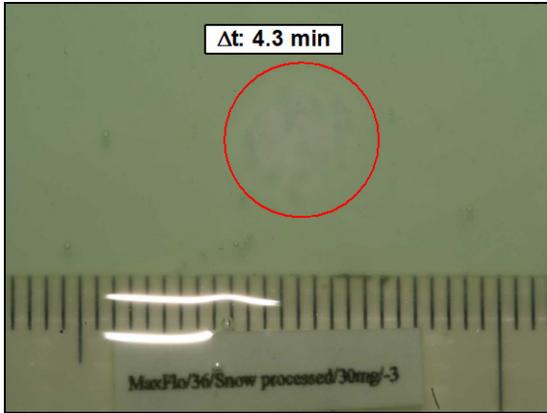
Start Time: 2:32:08  
End Time: 3:32:24

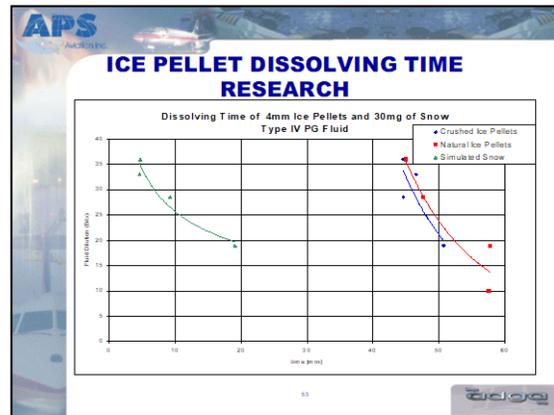
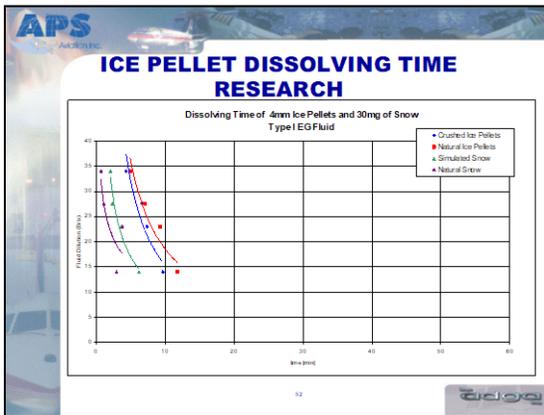
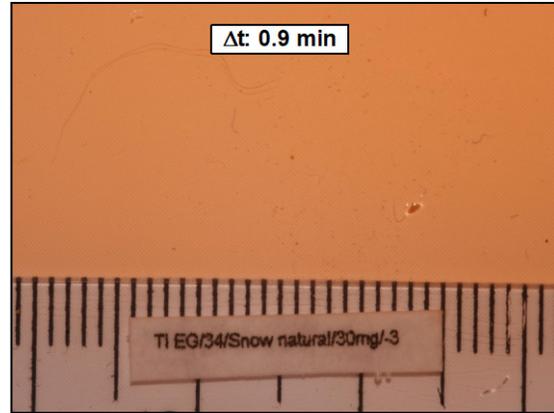
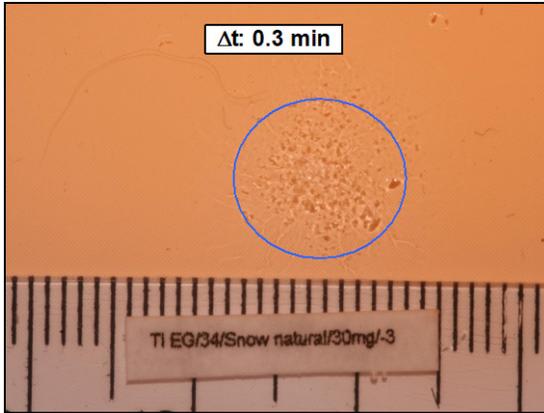
Initial Brix: 36  
Approx. Mass: 30 mg

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- ICE PELLET DISSOLVING TIME RESEARCH**
- CONCLUSIONS
  - Dissolving Time of Crushed Ice Pellets is comparable to Natural Ice pellets
  - Ice Pellets vs. Snow:
    - Snow requires less time to dissolve
    - Simulated snow comparable to natural snow

- PRESENTATION OUTLINE**
- BACKGROUND – PREVIOUS WORK
  - NATURAL ICE PELLET RESEARCH
  - PRODUCTION OF SIMULATED ICE PELLETS
  - ICE PELLET DISSOLVING TIME RESEARCH
  - **FALCON 20 FULL-SCALE RESEARCH**
  - FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
  - BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
  - CONCLUSIONS

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### FALCON 20 FULL-SCALE RESEARCH

- OBJECTIVE: To determine the level of contamination of anti-icing fluid caused by ice pellets at which the airflow at takeoff fails to remove the resultant contamination.
- METHODOLOGY:
  - Calculate quantity of ice pellets based on 20 minutes at desired precipitation rate and test surface area (approx 3m<sup>2</sup>)
  - Anti-icing fluid applied approx. 30 minutes prior to brake release
  - Ice pellets applied over a short period of time approx. 5 minutes before brake release
  - Aircraft taken to rotation speed and then underwent inspection

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### FALCON 20 FULL-SCALE RESEARCH

- SETUP



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### FALCON 20 FULL-SCALE RESEARCH

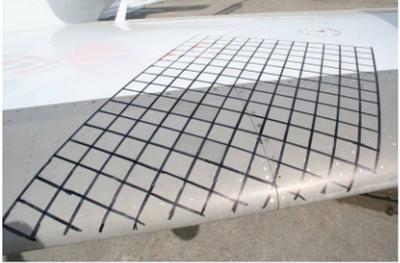
- SETUP



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### FALCON 20 FULL-SCALE RESEARCH

- SETUP



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### FALCON 20 FULL-SCALE RESEARCH

- SETUP



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### FALCON 20 FULL-SCALE RESEARCH

- Testing was conducted on 4 days from March 9<sup>th</sup> 2006 to March 17 2006
- 9 test runs were attempted, 8 test runs were completed
- High speed photography of each test run was taken
- Type IV EG and PG Neat fluid was used for testing
- OAT ranged from -5°C to -10°C
- Wing skin temperature ranged from -3°C to -10°C
- Simulated rate of precipitation ranged from 25 g/dm<sup>2</sup>/h to 167 g/dm<sup>2</sup>/h



**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLET RESEARCH
- PRODUCTION OF SIMULATED ICE PELLETS
- ICE PELLET DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- **FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION**
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS
- CONCLUSIONS

**FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION**

- OBJECTIVE: To document simultaneous perspectives representing close in and cockpit views of an airfoil subjected to ice pellet precipitation conditions
- Perspective Representations (of leading edge in reference to the cockpit):
  - A320
  - Falcon 20
  - Walk around observer

**FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION**

- METHODOLOGY
  - Quantity of ice pellets calculated based on 20 minutes at desired precipitation rate and test surface area
  - Ice pellets applied over a short period of time 5 minutes following fluid application
  - Aircraft perspective representations based on:
    - Distance from cockpit to leading edge
    - Height from cockpit to leading edge
    - Angle of leading edge with respect to cockpit

**FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION**

Test #	Aircraft	Fluid	Fluid Quantity	Pellet Size	Ice Pellet Quantity	Ice Pellet Condition
F/N-1	A320/Falcon 20	Type IV - PG	5L	3mm	0.85 lbg	Light
F/N-2	A320/Falcon 20	Type IV - PG	5L	3mm	0.85 lbg	Light/Moderate
F/N-3	A320/Falcon 20	Type IV - PG	5L	3mm	2.5 lbg	Moderate/Heavy
F/N-4	A320/Falcon 20	Type IV - PG	5L	3mm	0.45 lbg	Light (w/ tracer pellets)
F/N-5	A320/Falcon 20	Type IV - PG	5L	3mm	0.85 lbg	Light/Moderate (w/ tracer pellets)
F/N-6	A320/Falcon 20	Type IV - PG	5L	3mm	2.5 lbg	Moderate/Heavy (w/ tracer pellets)
F/N-7	A320/Falcon 20	Type IV - PG	5L	3mm	0.45 lbg	Light
F/N-8	A320/Falcon 20	Type IV - PG	5L	3mm	0.85 lbg	Light/Moderate
F/N-9	A320/Falcon 20	Type IV - PG	5L	3mm	2.5 lbg	Moderate/Heavy
F/N-10	A320/Falcon 20	Type IV - PG	5L	3mm	0.45 lbg	Light (w/ tracer pellets)
F/N-11	A320/Falcon 20	Type IV - PG	5L	3mm	0.85 lbg	Light/Moderate (w/ tracer pellets)
F/N-12	A320/Falcon 20	Type IV - PG	5L	3mm	2.5 lbg	Moderate/Heavy (w/ tracer pellets)
F/N-13	A320/Falcon 20	Type II - PG	5L	3mm	0.45 lbg	Light
F/N-14	A320/Falcon 20	Type II - PG	5L	3mm	0.85 lbg	Light/Moderate
F/N-15	A320/Falcon 20	Type II - PG	5L	3mm	2.5 lbg	Moderate/Heavy
F/N-16	A320/Falcon 20	Type II - PG	5L	3mm	0.45 lbg	Light (w/ tracer pellets)
F/N-17	A320/Falcon 20	Type II - PG	5L	3mm	0.85 lbg	Light/Moderate (w/ tracer pellets)
F/N-18	A320/Falcon 20	Type II - PG	5L	3mm	2.5 lbg	Moderate/Heavy (w/ tracer pellets)
F/N-19	A320/Falcon 20	Type I - EG	5L	3mm	0.45 lbg	Light
F/N-20	A320/Falcon 20	Type I - EG	5L	3mm	0.85 lbg	Light/Moderate
F/N-21	A320/Falcon 20	Type I - EG	5L	3mm	2.5 lbg	Moderate/Heavy
F/N-22	A320/Falcon 20	Type I - EG	5L	3mm	0.45 lbg	Light (w/ tracer pellets)
F/N-23	A320/Falcon 20	Type I - EG	5L	3mm	0.85 lbg	Light/Moderate (w/ tracer pellets)
F/N-24	A320/Falcon 20	Type I - EG	5L	3mm	2.5 lbg	Moderate/Heavy (w/ tracer pellets)

**FAR VS. NEAR – PILOT'S PERSPECTIVE**

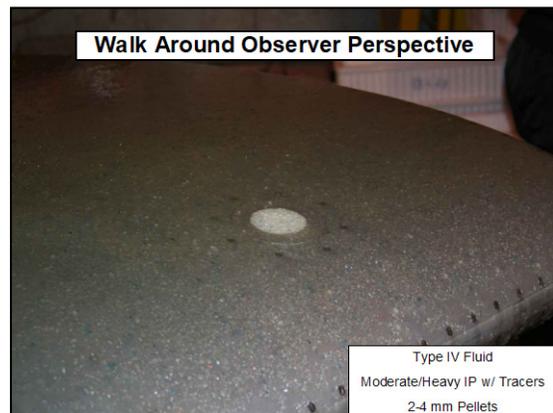
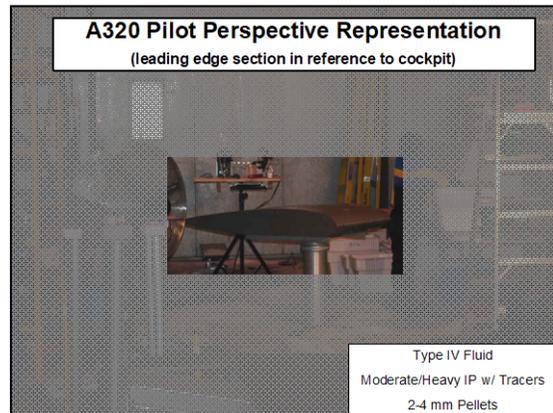
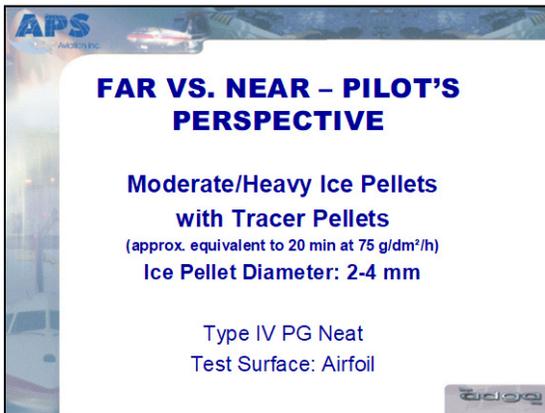
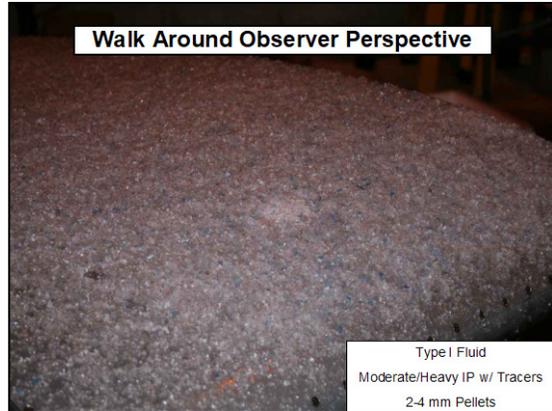
**Moderate/Heavy Ice Pellets with Tracer Pellets**  
 (approx. equivalent to 20 min at 75 g/dm<sup>2</sup>/h)  
 Ice Pellet Diameter: 2-4 mm

Type I PG Std Mix  
 Test Surface: Airfoil

**A320 Pilot Perspective Representation**  
 (leading edge section in reference to cockpit)



Type I Fluid  
 Moderate/Heavy IP w/ Tracers  
 2-4 mm Pellets



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**FULL-SCALE FALCON 20  
FAR VS. NEAR – PILOT'S  
PERSPECTIVE**

Moderate/Heavy Ice Pellets  
Ice Pellet Diameter: 3.4-4.8 mm

Type IV PG Neat  
Test Surface: Falcon 20



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**FAR VS. NEAR – PILOT'S PERSPECTIVE  
PHOTO DOCUMENTATION**

- CONCLUSIONS
  - Translucent ice pellets are difficult to see from far, even with tracer pellets
  - When bridging ice pellets are visible from far, fluid condition is severe

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**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLETT RESEARCH
- PRODUCTION OF SIMULATED ICE PELLETS
- ICE PELLETT DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- **BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS**
- CONCLUSIONS

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## BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS

- Ice pellets are a transitional condition and are often followed by, or preceded by, freezing rain or drizzle which may result in adherence to a bare surface
- Adherence created may be rough and "pimply"

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## BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS

### Natural Mixed Precipitation Ice Pellets and Freezing Rain

Test Surface: Falcon 20 Aircraft

Falcon 20 Test #2

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## BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS



Bare surface glazed with ice

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## BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS



"Pimply" surface caused by adhered ice pellets during mixed precipitation

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## BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS

→ CONCLUSIONS:

- Ice pellet conditions mixed with freezing rain or drizzle may be conducive to a rough "pimply" adhesion of the precipitate to the surface
- Use of Type IV fluid is needed to prevent adhesion

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## PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- NATURAL ICE PELLETT RESEARCH
- PRODUCTION OF SIMULATED ICE PELLETT
- ICE PELLETT DISSOLVING TIME RESEARCH
- FALCON 20 FULL-SCALE RESEARCH
- FAR VS. NEAR – PILOT'S PERSPECTIVE PHOTO DOCUMENTATION
- BARE WING DEPARTURES DURING ICE PELLETT CONDITIONS
- **CONCLUSIONS**

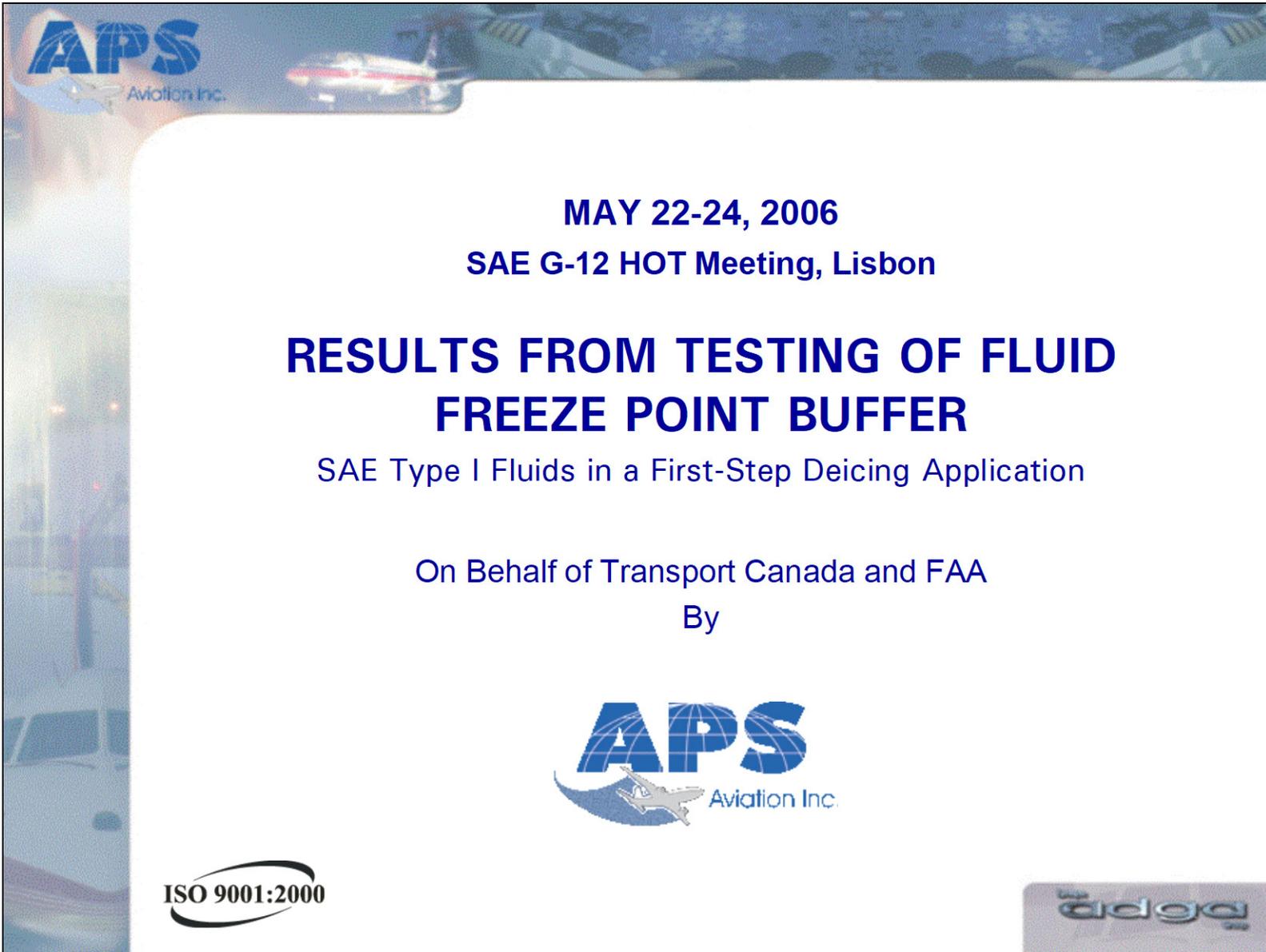
**APS**  
Aerodynamic Systems

## CONCLUSIONS

- FALCON 20 FULL-SCALE RESEARCH:
  - Resultant contamination was completely removed from the leading edge before rotation speed
  - Ice pellet clustering was not observed
- FAR VS. NEAR – PILOT'S PERSPECTIVE:
  - Fluid condition difficult is to determine from far (even with tracer pellets) due to transparency of ice pellets
- BARE WING DEPARTURES DURING ICE PELLET CONDITIONS:
  - Ice pellet conditions mixed with freezing rain or drizzle may be conducive to a rough adhesion of the precipitate to the surface

22

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**MAY 22-24, 2006**  
**SAE G-12 HOT Meeting, Lisbon**

**RESULTS FROM TESTING OF FLUID  
FREEZE POINT BUFFER**  
SAE Type I Fluids in a First-Step Deicing Application

On Behalf of Transport Canada and FAA  
By



ISO 9001:2000



### BACKGROUND

- This review was prompted by a reported case of ice on a wing following takeoff after the aircraft had been deiced and anti-iced.
- The operator questioned whether the fluid FP buffer for first-step Type I fluid applications is adequate, especially at low OAT. That buffer is currently set at -3°C, meaning the fluid freeze point may be 3°C above ambient temperature.

### DEFINITION OF BUFFER

When the Buffer is +ve, it implies that the fluid FP is such that it provides protection against freezing to the stated value.

Examples:

- If OAT = -3°C, buffer = -3°C, can use H<sub>2</sub>O
- If OAT = -5°C, buffer = +10°C, can use fluid with FP below -15°C
- If OAT = -7°C, buffer = -0°C, can use fluid with FP below -7°C

### BACKGROUND/OBJECTIVE

- The matter was discussed at several SAE G-12 meetings. Some members recommended changing the buffer so that the FP matched OAT, or even to a FP at 10°C below OAT with a view to extending the time available for application of the anti-icing overspray, before the first-step fluid freezes.
- To assess the effectiveness of changing the first-step fluid FP buffer, tests were conducted during the 2005-06 winter season.

### PARAMETERS THAT INFLUENCE TIME TO FREEZE

The different parameters that influence the time to freeze include:

- Fluid strength
  - Initial;
  - Enrichment of fluid on the surface; and
  - Rapid dilution in precipitation.
- Precipitation Type and Intensity
- Ambient temperature (OAT)
- Temperature of protected surface, influenced by
  - Initial fluid temperature and wing temperature;
  - Fluid quantity; and
  - Wind.

### CURRENT APPLICATION TABLES (TC)

### CURRENT SAE TYPE I DEICING FLUID APPLICATION PROCEDURES (TC)

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing
-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 2°C (3°F) above OAT	

1. To be applied before first step fluid freezes, typically within 3 minutes.

Potential Change

### CURRENT SAE TYPE II, Type III and TYPE IV ANTI-ICING FLUID APPLICATION PROCEDURES (TC)

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)	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing <sup>1</sup>
-3°C (27°F) and above	50/50 Heater <sup>2</sup> /Type III/IV	Heated water or a heated mix of Type I, II, III or IV with water	50/50 Type III/IV
-14°C (7°F) and above	75/25 Heater <sup>2</sup> /Type III/IV	Heated suitable mix of Type I, Type III/IV and water with HP not more than 3°C (5°F) above ambient OAT <sup>2</sup>	75/25 Type III/IV
-20°C (-13°F) and above	100/0 Heater <sup>2</sup> /Type III/IV	Heated suitable mix of Type I, Type III/IV and water with HP not more than 3°C (5°F) above ambient OAT <sup>2</sup>	100/0 Type III/IV
Below -25°C (-13°F)	Type III/IV fluid may be used below -20°C (-4°F) and that the freezing point of the fluid is at least 7°C (5°F) below OAT and the dynamic acceptance criteria are met. Consider the use of Type I or Type III/IV fluid carriers (see Table 6).		

1 To be applied before first step (anti-icing) against ice or snow.  
2 Clear or coat may be achieved with untreated fuel.

Potential Change

### TEST OBJECTIVES

- The objective was to conduct testing with fluid mixed to the current -3°C buffer and compare these results with fluids mixed to a 0°C and +10°C buffer.
- The industry can use these test results to base their decision on whether to change the -3°C buffer.

### TEST PROCEDURE

- Tests were conducted outdoors at the APS test site at Dorval and indoors at the NRC cold chamber
- For testing outdoors and in laboratory conditions the test protocol for SAE Type I fluid ET tests was used, recording time to first freezing.
- Type I fluids mixed to freeze point buffers of -3°C, 0°C and +10°C were tested.

### APS TEST SITE



### INSIDE VIEW OF LARGE END OF NRC



### TEST PROCEDURE

The procedure used for these tests was similar to that used for endurance time testing (SAE ARP 5945).

- Fluids used were Type I PG and Type I EG.
- Fluids were mixed to buffers of -3C, 0C and +10C.
- For outdoor tests, test surface used was the Leading Edge Thermal Equivalent Box, and for indoor tests, test surface used was the standard flat plate.
- To get a comparison, fluids were applied simultaneously on the surfaces.
- The time to first freeze was measured (this is beyond the 2.5 cm border around the plate).

### METHOD TO MEASURE RI & APPLYING FLUID




### FLUID APPLICATION PROCEDURE

OUTDOOR TESTS CONDUCTED SIMULTANEOUSLY

<p><b>Current Method</b> (-3°C Buffer)</p> <p>Box 1</p> <ul style="list-style-type: none"> <li>Box empty @ DAT</li> <li>0.5 L of fluid</li> <li>Applied at 60 °C</li> <li>Paused with the 12 hole spreader</li> </ul>	<p><b>Potential Change</b> (0°C Buffer)</p> <p>Box 2</p> <ul style="list-style-type: none"> <li>Box empty @ DAT</li> <li>0.5 L of fluid</li> <li>Applied at 60 °C</li> <li>Paused with the 12 hole spreader</li> </ul>	<p><b>Potential Change</b> (+ 10°C Buffer)</p> <p>Box 3</p> <ul style="list-style-type: none"> <li>Box empty @ DAT</li> <li>0.5 L of fluid</li> <li>Applied at 60 °C</li> <li>Paused with the 12 hole spreader</li> </ul>	<p>Rate Pan</p>
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### APS TEST SITE – TEST STAND USED FOR OUTDOOR TYPE I ENDURANCE TIME TESTS

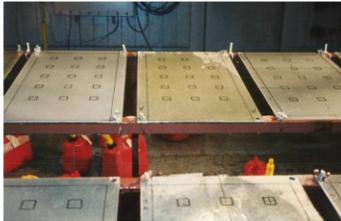


### FLUID APPLICATION PROCEDURE

INDOOR TESTS

<p><b>Current Method</b> (-3°C Buffer)</p> <p>Plate 1</p> <ul style="list-style-type: none"> <li>Plate @ DAT</li> <li>1 L of fluid</li> <li>Applied at 20 °C</li> </ul>	<p><b>Potential Change</b> (0°C Buffer)</p> <p>Plate 2</p> <ul style="list-style-type: none"> <li>Plate @ DAT</li> <li>1 L of fluid</li> <li>Applied at 20 °C</li> </ul>	<p><b>Potential Change</b> (+ 10°C Buffer)</p> <p>Plate 3</p> <ul style="list-style-type: none"> <li>Plate @ DAT</li> <li>1 L of fluid</li> <li>Applied at 20 °C</li> </ul>
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### PLATES USED FOR INDOOR TESTS



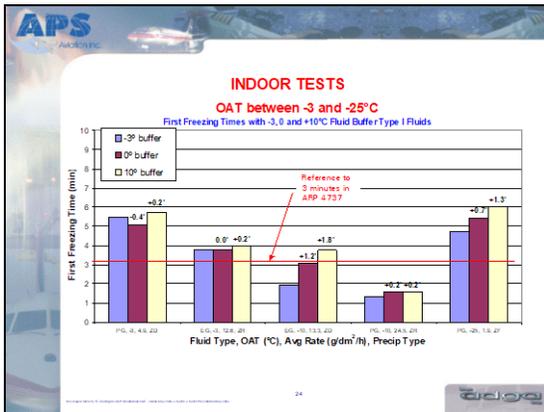
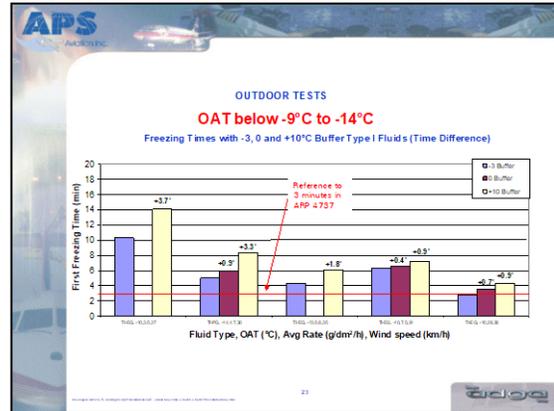
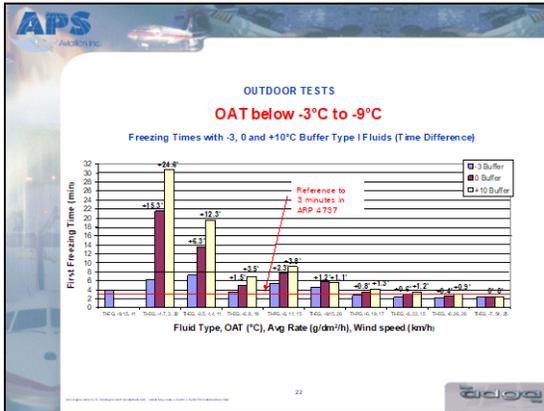
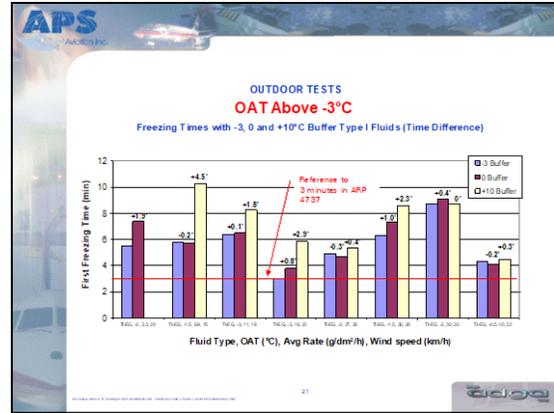
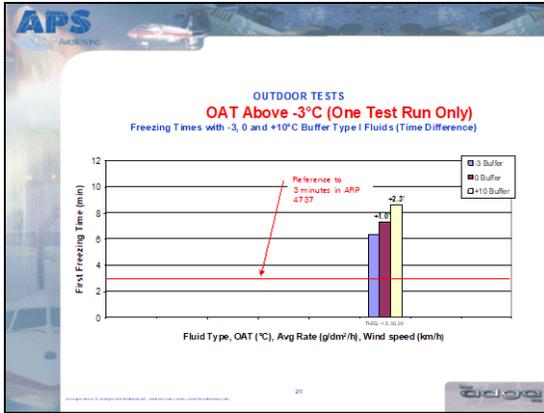
### SUMMARY OF OUTDOOR TESTS CONDUCTED

Temperature (°C )	Number of Simultaneous Test Runs
Above -3	8
Between -3 to -9	10
Between -9 to -14	5

- EG and PG Fluids
- Mostly natural snow

### SUMMARY OF INDOOR TESTS CONDUCTED

- 5 Runs
- EG and PG fluids used
- Freezing drizzle, freezing rain and freezing fog conditions
- 3°C, -10°C and -25°C



**COMPARISON OF FIRST FREEZING TIMES (min) WITH -3, 0 and +10°C BUFFER**

Temperature (°C)	Rate = 4 g/dm³			Rate = 10 g/dm³			Rate = 25 g/dm³		
	-3 Buffer	0 Buffer	+10 Buffer	-3 Buffer	0 Buffer	+10 Buffer	-3 Buffer	0 Buffer	+10 Buffer
-3	7	9	15	5	6	9	4	4	5
-14	4	6	8	3	4	4	2	3	3
-25	4	5	6	3	3	3	2	2	2

Note: Based on regression analysis of all data

### CONCLUSION

- The limited tests seem to support the premise that an increased buffer gives longer protection in conditions when its not needed, but little increase in protection when it is needed.

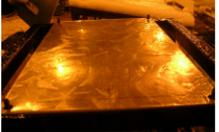
### SPECIAL HORIZONTAL PLATE TEST

- Objective: To see what happens when a Type I fluid with a negative buffer freezes and Type IV is applied
- Procedure
  - Test Conditions: -3°C, simulated freezing drizzle, 13 g/dm<sup>2</sup>/h
  - Plate leveled to horizontal (0°) to minimize fluid run off
  - Hard water applied to plate and allowed to freeze
  - Type IV fluid applied gently (using a spreader)

**PLATE LEVELED TO 0°**



**FORMATION OF ICE**



**ICE DISSOLVED IN TYPE IV FLUID**



### SPECIAL HORIZONTAL PLATE TEST

- Observations:
  - Application of Type IV dissolved the ice
  - No ice was embedded in the fluid
  - Diluted Type I fluid which was frozen (thin ice) to the surface will likely be dissolved by the application of Type IV

### OPTIONS FOR CHANGE

- Option 1: No Change (Keep -3°C Buffer)
- Option 2: Change to 0°C Buffer
- Option 3: Change to +10°C Buffer

**Option 1: NO CHANGE**

**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)	One-Step Procedure		Two-Step Procedure	
	Deicing/Anticing	Deicing/Anticing	First Step: Deicing	Second Step: Anticing
-3°C (27°F) and above	Washed mix of fluid and water with a freezing point of at least 10°C (50°F) below OAT	Washed mix of fluid and water	Washed mix of fluid and water	Washed mix of fluid and water with a freezing point of at least 10°C (50°F) below OAT
Below -3°C (27°F)	None	None	Washed mix of fluid and water with a freezing point of at least 10°C (50°F) below OAT	Washed mix of fluid and water with a freezing point of at least 10°C (50°F) below OAT

**SAE TYPE II, Type III and TYPE IV ANTIMING 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)	One-Step Procedure		Two-Step Procedure	
	Deicing/Anticing	Deicing/Anticing	First Step: Deicing	Second Step: Anticing
-12°C (10°F) and above	50/50	50/50	Washed water or a washed mix of Type II, III or IV with water	50/50 Type II/III/IV
-14°C (7°F) and above	75/25	75/25	Washed water or a washed mix of Type II, III or IV with water	75/25 Type II/III/IV
-20°C (-4°F) and above	100/0	100/0	Washed water or a washed mix of Type II, III or IV with water	100/0 Type II/III/IV
Below -20°C (-4°F)	Type II/III/IV	Type II/III/IV	Washed water or a washed mix of Type II, III or IV with water	Type II/III/IV

1. Chemicals used for critical tests, regardless of application.  
2. Chemicals may be used with confidence.



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# **AIRCRAFT GROUND DEICING FLUID ENDURANCE TIMES IN SNOW PELLET CONDITIONS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

For

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**

ISO 9001:2000

adga

### PRESENTATION OUTLINE

- BACKGROUND
- PHOTOS OF NATURAL SNOW PELLETS
- DISSOLVING TIME OF NATURAL SNOW AND PROCESSED SNOW
- DISSOLVING TIME COMPARISON SNOW AND ICE PELLETS
- CONCLUSIONS
- RECOMMENDATIONS

### BACKGROUND

- SNOW PELLETS DEFINITION:
  - Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm. Grains are brittle, easily crushed; they bounce and break on hard ground.
- Currently, no HOT Guidelines exist for snow pellets

**Transport Canada Holdover Time Guidelines Winter 2005-2006**

TABLE 4-Generic  
SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006<sup>1</sup>

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 (Percent Solution %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Heavy Rain or Sleet	Other
-3 and above	27 and above	1000	12:00	1:15 - 2:30	0:50 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50	
		75/25	5:00	1:05 - 1:40	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:10	
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10	0:05 - 0:10	
below -3 to -14	below 27 to 7	1000	2:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 <sup>2</sup>	0:10 - 0:25 <sup>2</sup>		CAUTION: No holdover time guidelines exist
		75/25	2:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>2</sup>	0:10 - 0:20 <sup>2</sup>		
		50/50	12:00 <sup>3</sup>	0:15 - 0:40 <sup>2</sup>	0:15 - 0:30 <sup>2</sup>				
below -14 to -25	below 7 to -13	1000	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 2°C (33°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.						
below -25	below -13	1000	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 2°C (33°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**

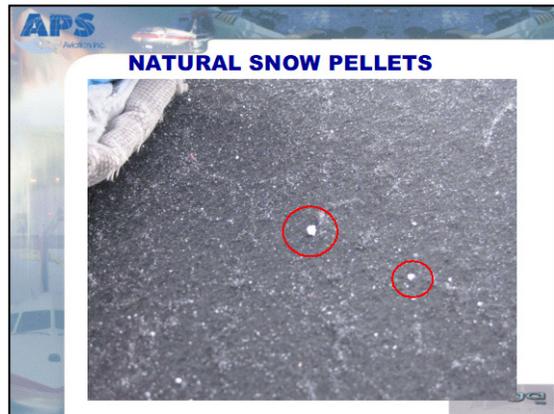
- Based on the listed holdover times of the Type IV fluids listed in Table 9.
- Heavy snow pellets, moderate and heavy freezing rain, and hail.
- These holdover times apply to outside air temperatures to -30°C (-14°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Ensure that the lowest operational use temperature (LOUT) is respected.

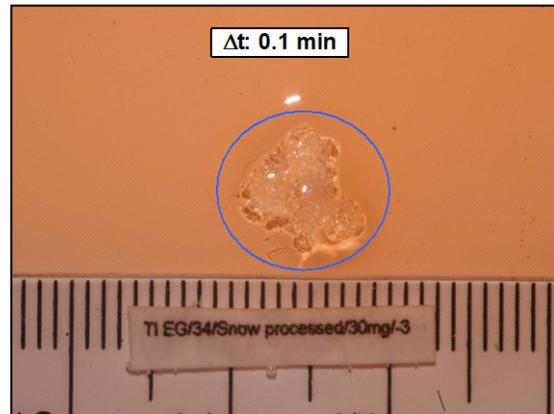
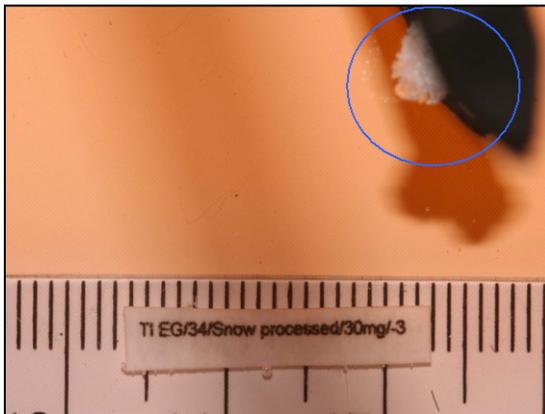
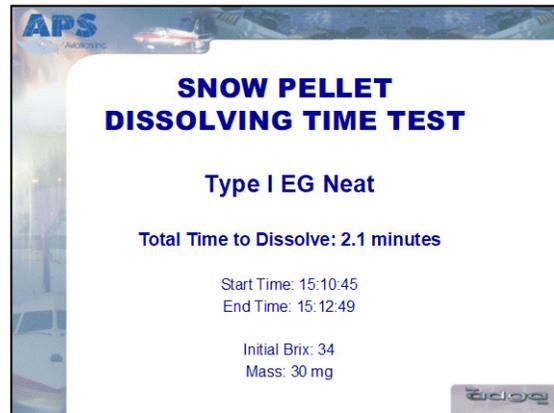
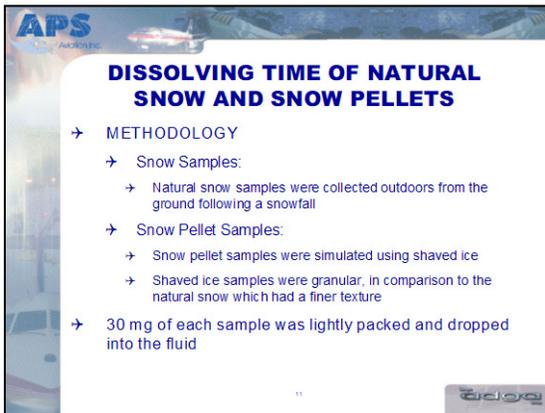
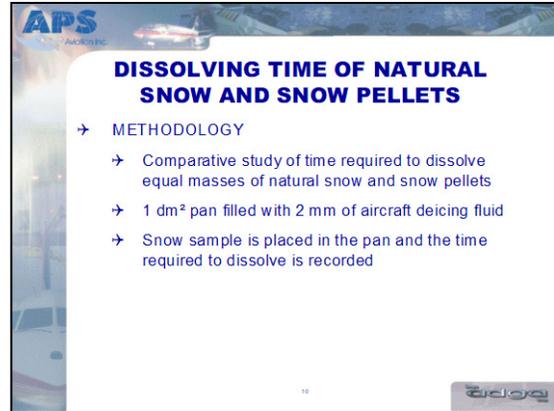
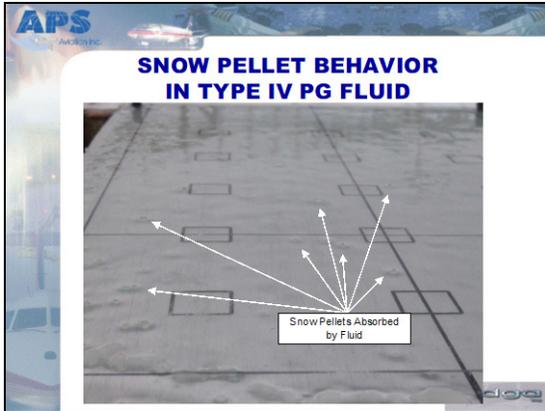
**CAUTIONS**

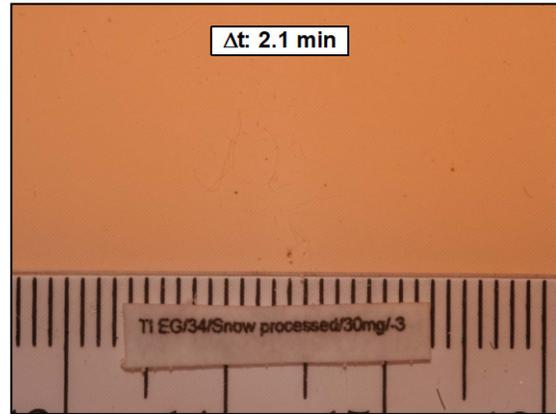
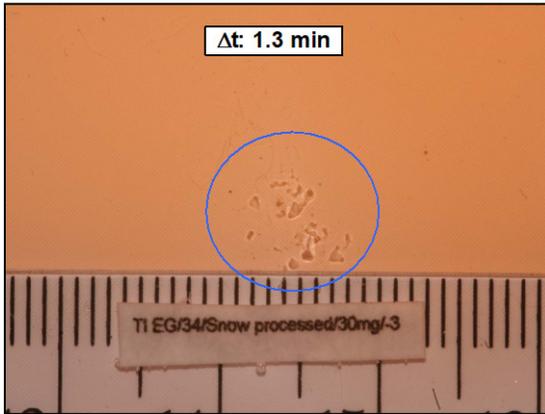
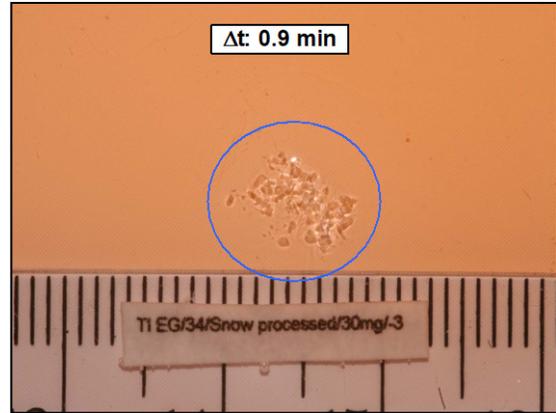
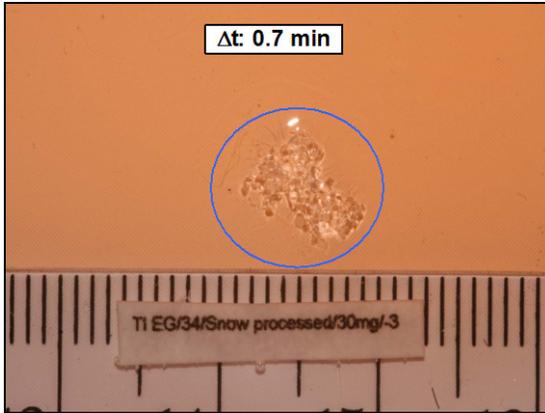
- The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- 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.

### NATURAL SNOW PELLETS

- Natural snow pellets were observed during endurance time testing at the APS test site on February 16, 2006 and March 3, 2006
- Snow pellets lasted for a brief period of 10-15 minutes
- Snow pellet diameter approximately 2-4 mm
- OAT was -10°C during the snow pellet event







**APS**

**NATURAL SNOW DISSOLVING TIME TEST**

Type I EG Neat

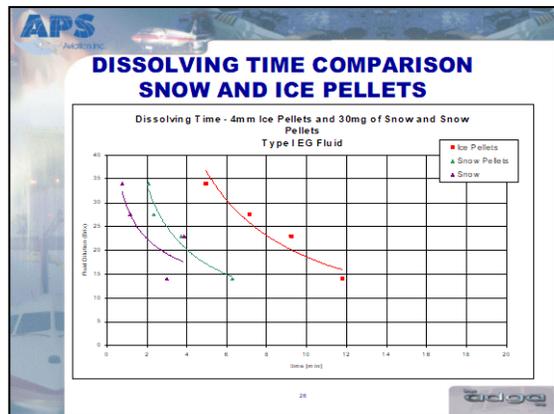
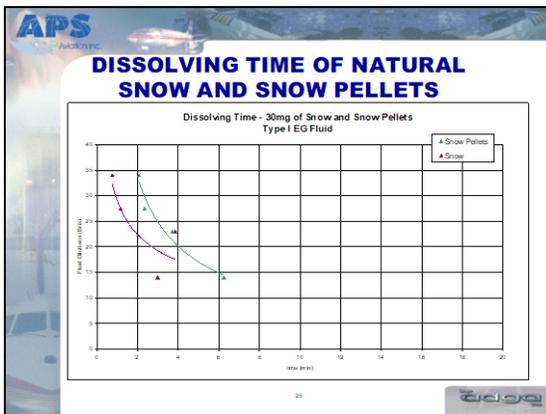
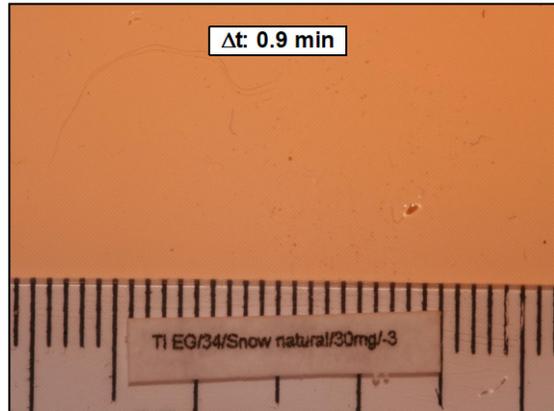
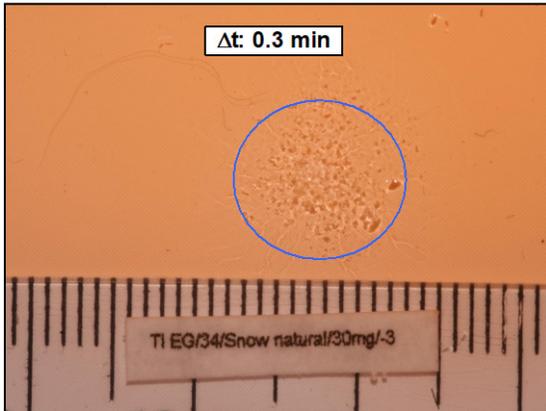
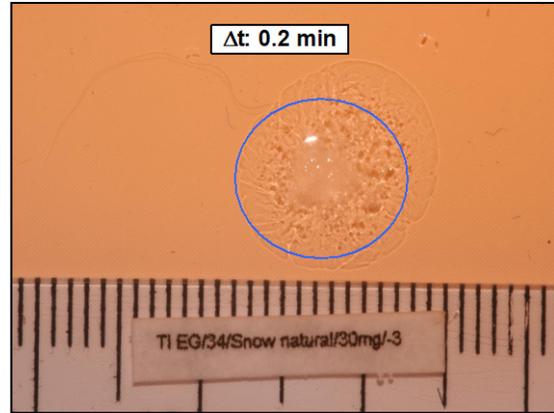
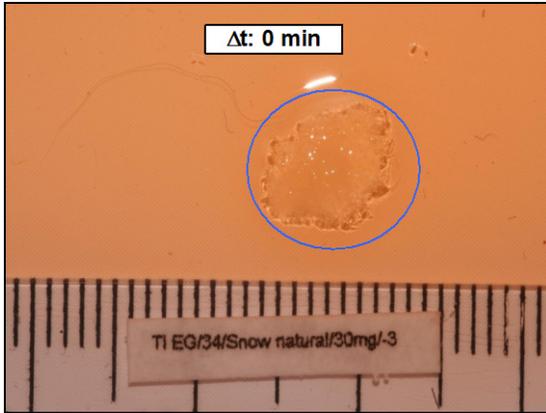
Total Time to Dissolve: 0.7 minutes

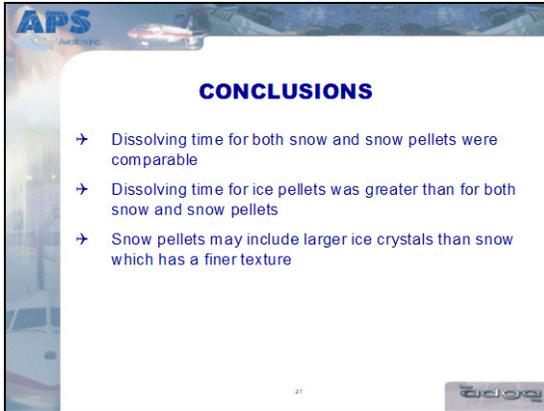
Start Time: 13:38:10  
End Time: 13:38:55

Initial Brix: 34  
Mass: 30 mg

The screenshot shows a software interface with a white background and blue text. The APS logo is in the top left corner. The text is centered and provides details about the snow dissolving test.





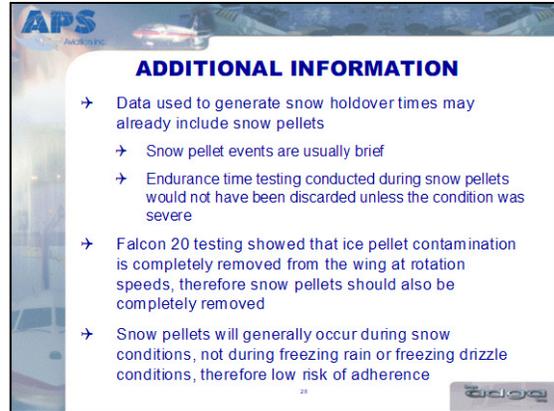


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### CONCLUSIONS

- Dissolving time for both snow and snow pellets were comparable
- Dissolving time for ice pellets was greater than for both snow and snow pellets
- Snow pellets may include larger ice crystals than snow which has a finer texture

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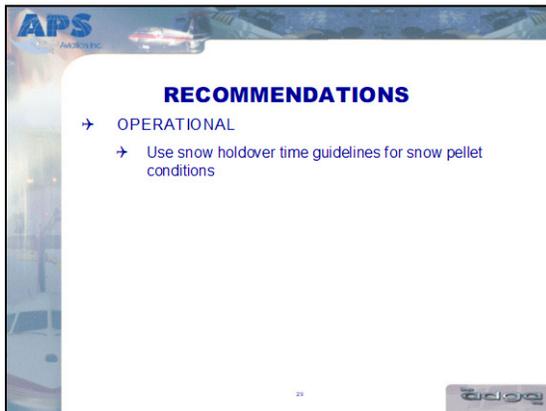


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### ADDITIONAL INFORMATION

- Data used to generate snow holdover times may already include snow pellets
- Snow pellet events are usually brief
- Endurance time testing conducted during snow pellets would not have been discarded unless the condition was severe
- Falcon 20 testing showed that ice pellet contamination is completely removed from the wing at rotation speeds, therefore snow pellets should also be completely removed
- Snow pellets will generally occur during snow conditions, not during freezing rain or freezing drizzle conditions, therefore low risk of adherence

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### RECOMMENDATIONS

- OPERATIONAL
  - Use snow holdover time guidelines for snow pellet conditions

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Aviation Inc.

# **PRELIMINARY AIRCRAFT GROUND DEICING RESEARCH USING COMPOSITE MATERIALS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

For

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**

ISO 9001:2000

**Transportation Development Centre**

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR ENDURANCE TIME TESTING
- INDOOR ENDURANCE TIME TESTING
- NATURAL FROST ENDURANCE TIME TESTING
- CONCLUSIONS
- RECOMMENDATIONS

**BACKGROUND – PREVIOUS WORK**

- COMPARATIVE ENDURANCE TIME TESTING
  - OBJECTIVE: investigate the impact of non-aluminum test plate material on fluid endurance time
  - 21 comparative tests were conducted in natural snow conditions
  - 6 comparative tests were conducted in simulated freezing precipitation conditions
  - 6 comparative tests were conducted in natural frost conditions

**BACKGROUND – PREVIOUS WORK**

- MATERIALS USED
  - Cross weave carbon fiber test plate
  - Baseline standard aluminum test plate
  - Test plates were not painted for testing



**BACKGROUND – PREVIOUS WORK**

- METHODOLOGY
  - Comparative endurance time testing with Type I fluids applied at 20°C
  - Comparative endurance time testing with Type II/III/IV fluids at ambient temperature

**BACKGROUND – PREVIOUS WORK**

- CONCLUSIONS
  - Natural Snow – Composite plate endurance time 10% longer than aluminum plate
  - Freezing Precipitation – Composite plate endurance time 4% longer than aluminum plate
  - Frost - Composite plate endurance time 19% shorter than aluminum plate (using only Type I)
  - Radiation effects on different colored surfaces may have created discrepancies in the results obtained

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- **COMPOSITE MATERIALS TESTED**
- OUTDOOR ENDURANCE TIME TESTING
- INDOOR ENDURANCE TIME TESTING
- NATURAL FROST ENDURANCE TIME TESTING
- CONCLUSIONS
- RECOMMENDATIONS

**APS**  
AIRCRAFT

**COMPOSITE MATERIALS TESTED**

- CROSS WEAVE CARBON FIBER
  - 1/8" thick panel (will be referred to as Carbon 05)
- UNIDIRECTIONAL WEAVE CARBON FIBER
  - 1/8" thick panel (will be referred to as Carbon 06 Thin)
  - 7/32" thick panel (will be referred to as Carbon 06 Thick)
- GLARE (Hybrid material using alternating layers of aluminum and glass fiber)
  - 5/32" thick panel (will be referred to as GLARE)

**APS**  
AIRCRAFT

**COMPOSITE MATERIALS TESTED**

- UNIDIRECTIONAL WEAVE CARBON FIBER



"Carbon 06 Thin" and  
"Carbon 06 Thick"

**APS**  
AIRCRAFT

**COMPOSITE MATERIALS TESTED**

- CROSS WEAVE CARBON FIBER



"Carbon 05"

**APS**  
AIRCRAFT

**COMPOSITE MATERIALS TESTED**

- GLARE



"GLARE"

**APS**  
AIRCRAFT

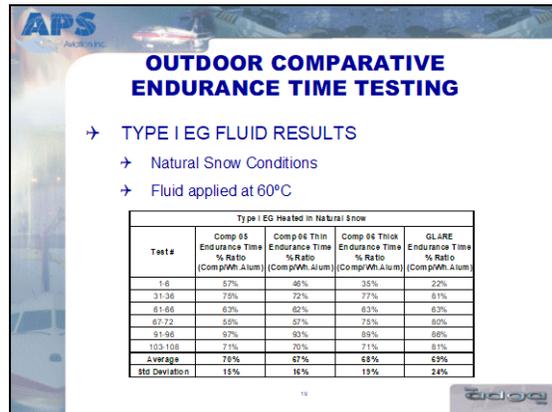
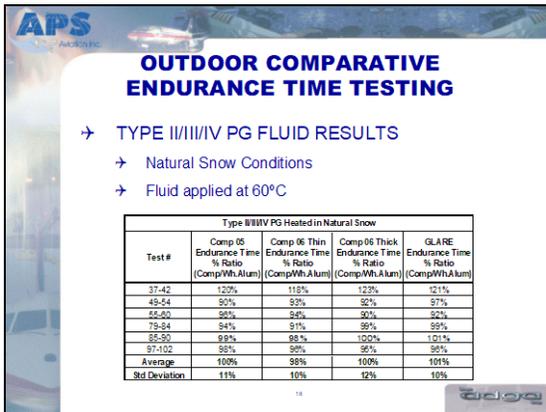
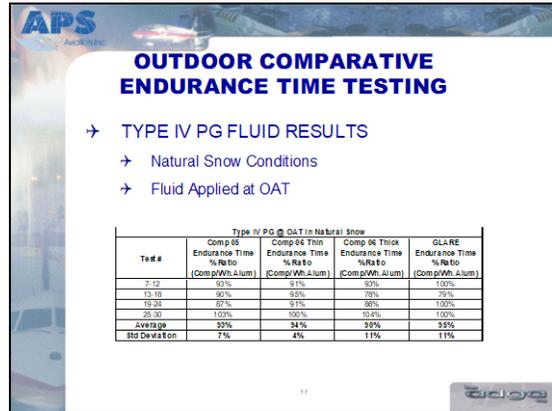
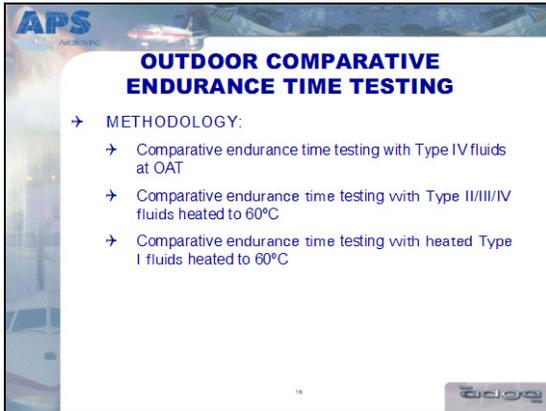
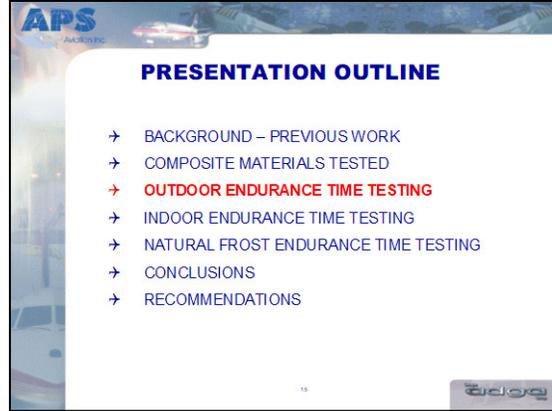
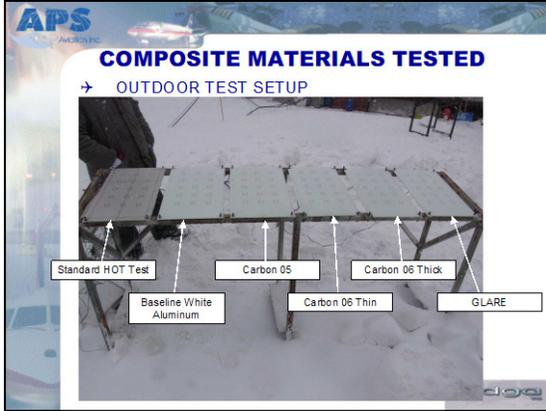
**COMPOSITE MATERIALS TESTED**

- Material samples were provided by
  - Aviation Equipment Inc.
  - Toray Composites (America) Inc.

**APS**  
AIRCRAFT

**COMPOSITE MATERIALS TESTED**

- TEST SETUP
  - All composite test plates, and the baseline aluminum test plate, were painted white with aircraft grade paint
  - White paint allowed for equal radiation effects on all surfaces
  - Standard HOT test plate (or box for Type I) was not painted. Test was conducted in conjunction for reference purposes



### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR ENDURANCE TIME TESTING
- **INDOOR ENDURANCE TIME TESTING**
- NATURAL FROST ENDURANCE TIME TESTING
- CONCLUSIONS
- RECOMMENDATIONS

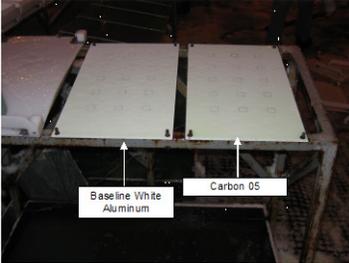
### INDOOR COMPARATIVE ENDURANCE TIME TESTING

→ METHODOLOGY:

- Similar results amongst all composite materials were obtained in outdoor testing
- Indoor comparative endurance time testing conducted with
  - Cross weave carbon fiber test plate
  - White painted aluminum test plate
  - Standard HOT test plate (in conjunction with HOT testing)
- Comparative endurance time testing with Type II/III/IV fluids heated to 60°C
- Comparative endurance time testing with Type I fluids applied at 20°C

### INDOOR COMPARATIVE ENDURANCE TIME TESTING

→ INDOOR TEST SETUP



### INDOOR COMPARATIVE ENDURANCE TIME TESTING

→ TYPE II/III/IV PG FLUID RESULTS

- Simulated Freezing Precipitation
- Fluid applied at 60°C

Type II/III/IV PG Heated in Freezing Precipitation	
Test #	Comp 05 Endurance Time % Ratio (Comp/White Alum)
C1-C2	103%
C5-C6	113%
C9-C10	97%
C13-C14	79%
C17-C18	81%
C21-C22	105%
C25-C26	73%
C29-C30	112%
C31-C32	112%
C33-C34	92%
C37-C38	88%
Average	96%
Std Deviation	14%

### INDOOR COMPARATIVE ENDURANCE TIME TESTING

→ TYPE I EG FLUID RESULTS

- Simulated Freezing Precipitation
- Fluid applied at 20°C

Type I EG Heated in Freezing Precipitation	
Test #	Comp 05 Endurance Time % Ratio (Comp/White Alum)
C3-C4	79%
C7-C8	69%
C11-C12	94%
C15-C16	72%
C19-C20	49%
C23-C24	83%
C27-C28	58%
C35-C36	68%
Average	71%
Std Deviation	15%

### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR ENDURANCE TIME TESTING
- INDOOR ENDURANCE TIME TESTING
- **NATURAL FROST ENDURANCE TIME TESTING**
- CONCLUSIONS
- RECOMMENDATIONS

**APS**  
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## NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

- METHODOLOGY:
  - Comparative endurance time testing with Type I fluids applied at 60°C

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**APS**  
AIRCRAFT

## NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

Test #	Type I EG Heated			
	Comp 05 Endurance Time % Ratio (Comp/Wh.Alum)	Comp 06 Thin Endurance Time % Ratio (Comp/Wh.Alum)	Comp 06 Thick Endurance Time % Ratio (Comp/Wh.Alum)	GLARE Endurance Time % Ratio (Comp/Wh.Alum)
P1-F5	70%	66%	73%	83%
F6-F10	67%	70%	59%	75%
F11-F15	88%	82%	71%	86%
Average	75%	73%	69%	81%
Std Deviation	12%	8%	10%	6%

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**APS**  
AIRCRAFT

## PRELIMINARY OBSERVATIONS

- Equivalent fluid endurance time when using Type II/III/IV fluids heated and at OAT on composite materials
- Type I fluid endurance time results on composite surfaces were variable and potentially lower in comparison to aluminum surfaces
- Similar fluid endurance time trends amongst the different composite materials tested

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## PRELIMINARY OBSERVATIONS

- An in-depth analysis of the data set will be conducted
- Results will be published in a report

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# HOLDOVER TIMES FOR HEAVY SNOW



**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2006**

**PREPARED AND PRESENTED ON BEHALF OF:**

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA



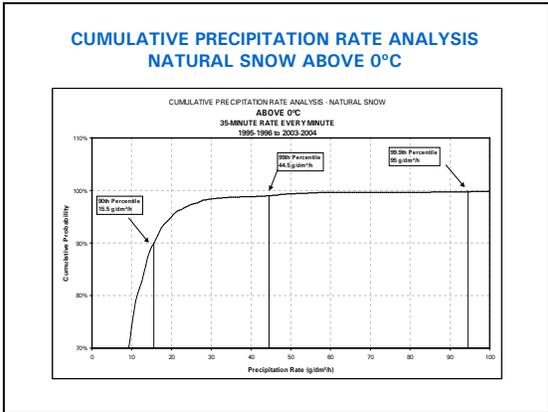
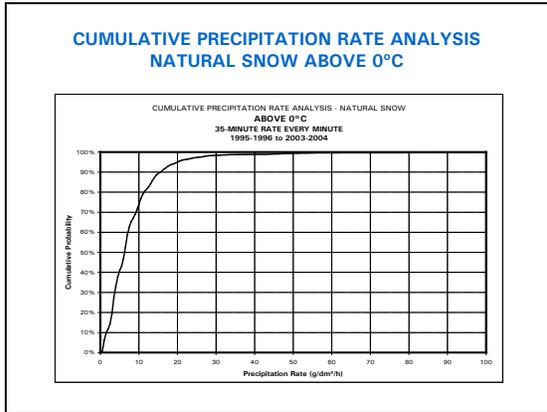
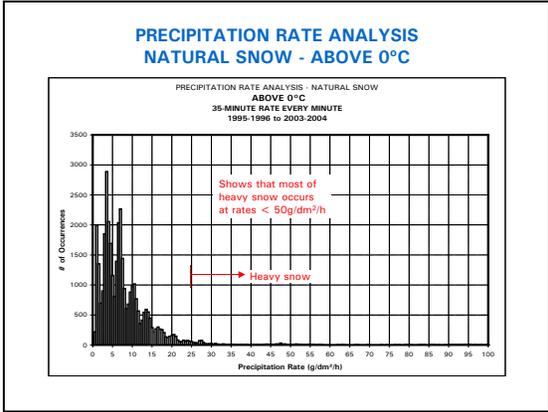
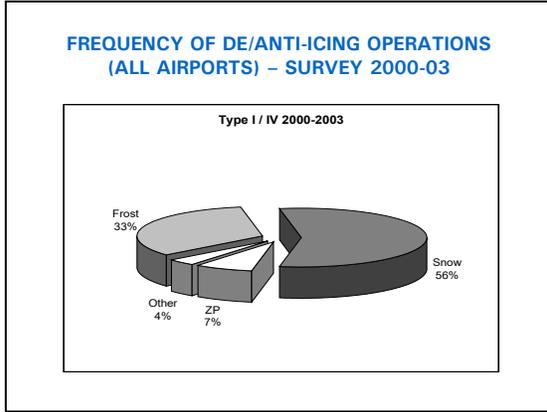
Transports Canada / Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE




# OCCURRENCE OF HEAVY SNOW CONDITIONS



**PROBABILITY OF SNOW BY HOLDOVER TIME TABLE  
TEMPERATURE RANGE – TYPE II and TYPE IV FLUIDS**

Temperature (°C)	Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	Total
above 0	5.8%	2.3%	3.2%	0.3%	11.7%
0 to -3	14.3%	5.6%	6.7%	0.9%	27.5%
below -3 to -14	29.9%	11.0%	13.1%	1.8%	55.6%
below -14 to -25	3.2%	0.9%	1.0%	0.1%	5.2%
below -25	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Total</b>	<b>53.2%</b>	<b>19.9%</b>	<b>24.0%</b>	<b>3.0%</b>	<b>100.0%</b>

< 4      4 to 10      10 to 25      > 25      g/dm<sup>2</sup>/h

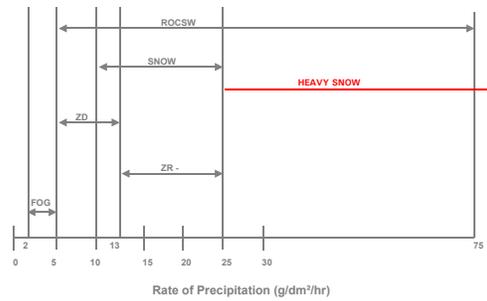
**HOLDOVER TIMES FOR  
HEAVY SNOW?**

**HOLDOVER TIME TABLES**

- Holdover times are derived from tests performed at specific rates of precipitation for each meteorological condition
- Liquid Water Equivalent
- Holdover times are a range of times and not a single value
- Values obtained from tests performed at low end and high end of the rate spectrum for each condition

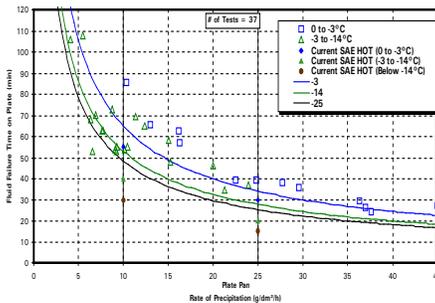


**PRECIPITATION RATE LIMITS FOR THE  
EVALUATION OF FLUID HOLDOVER TIMES**

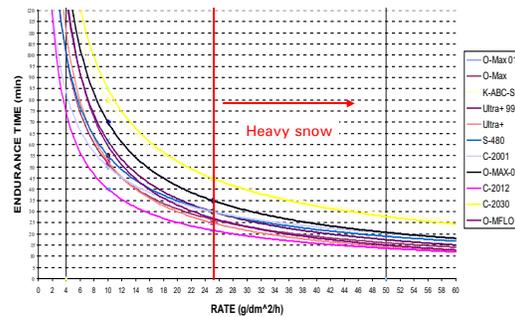


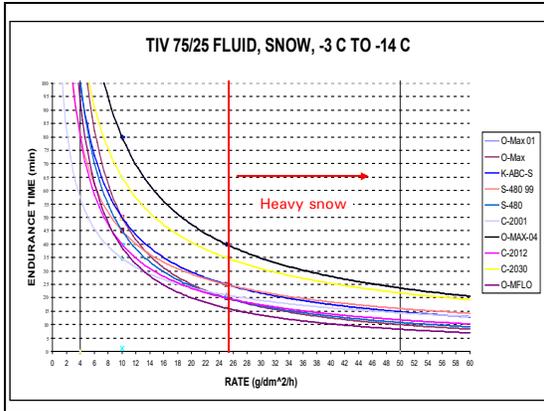
**METHOD OF DATA ANALYSIS**

Regression analysis that provides a power law relationship is used for each fluid and each dilution for each weather condition



**TIV NEAT FLUID, SNOW, -3 C TO -14 C**





### HOLDOVER TIMES FOR HEAVY SNOW?

- High number in the holdover time range for heavy snow would be that of the lower number in the moderate snow holdover time range (25 g/dm<sup>2</sup>/h)
- Need to define an upper precipitation rate limit to obtain the lowest number in the holdover time range for heavy snow

## GUIDANCE MATERIAL FOR FLIGHT CREWS

### CURRENT SITUATION

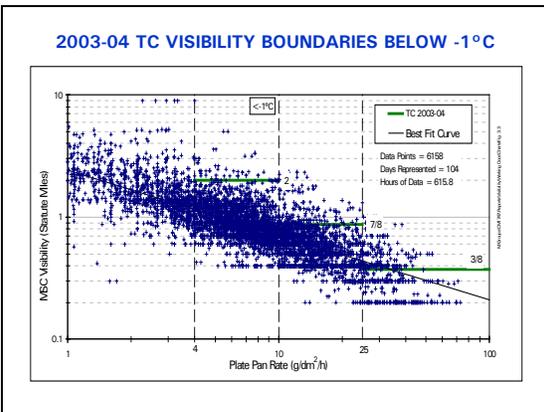
- Pilots use visual cues to assess intensity of snowfall
- TC / FAA provide carriers with visibility tables for the use of horizontal visibility to categorize the snowfall intensity
- Most meteorologists would agree that this method is not always accurate

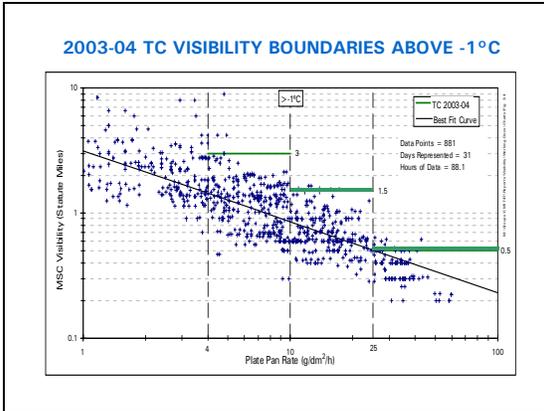


### TC VISIBILITY TABLE

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 30	≤3/8	>3/8 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


 Transports Canada    Transport Canada





**PRECIPITATION RATE**

VERSUS

**VISIBILITY**

**ACTUAL REPORTED EVENT - YUL**

**16 DECEMBER 2005 1137Z**

Reported Temperature, Precipitation: -8.0°C, Snow  
Snow intensity based on reported METAR visibility (1/2): Moderate

APS Calculated rate of precipitation: 74.3 g/dm<sup>2</sup>/h  
Snow intensity based on rate: Heavy

HOLDOVER TIME BASED ON VISIBILITY (MODERATE)

Type IV: 25 to 55  
Type I: 4 to 6

ACTUAL HOLDOVER TIME BASED ON RATE

Type IV: +/- 10  
Type I: +/- 2



**AREA OF CONCERN**

- At the high rates of precipitation experienced in heavy snow conditions, any deviation from an accurate assessment of the snow intensity could have detrimental effects
- True significance of Heavy Snow Rates:
  - 25 g/dm<sup>2</sup>/h is equivalent to 2.5 mm of water or 2.5 cm of snow per hour
  - 50 g/dm<sup>2</sup>/h is equivalent to 5 mm of water or 5 cm of snow per hour
  - 75 g/dm<sup>2</sup>/h is equivalent to 7.5 mm of water or 7.5 cm of snow per hour

**DATA COLLECTION  
TO EXAMINE  
FLIGHT CREW DECISIONS  
IN WINTER OPERATING  
CONDITIONS**

**OPERATIONAL DATA COLLECTION**

- Objective: To gather operational information to evaluate actual flight crew de/anti-icing fluid decisions in comparison to optimal decisions based on scientific measurements
  - November 2004 to April 2005
  - November 2005 to April 2006
- Data for 1459 departures at YUL were collected

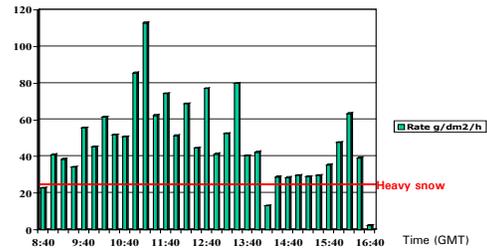


DECEMBER 16, 2005

- Heavy snow conditions prevailed at YUL for nearly 8 consecutive hours
- 0855Z to 1640Z
- Rates between 29 g/dm<sup>2</sup>/h and 113 g/dm<sup>2</sup>/h
- Data for 33 departures at YUL were collected



DECEMBER 16, 2005



EXAMPLE – EXCEEDED HOLDOVER TIME

16 DECEMBER 2005

Narrowbody  
 METAR Temperature, Precipitation: -6.0°C, +Snow  
 METAR Visibility: 1/8 SM  
 Calculated rate of precipitation: 50.2 g/dm<sup>2</sup>/h  
 Fluid treatment: Type IV  
 Current holdover time table range (MS): 25 to 55 minutes  
 Aircraft holdover time: 45 minutes

HOLDOVER TIME BASED ON RATE

Type IV: 15 minutes



EXAMPLE – EXCEEDED HOLDOVER TIME

16 DECEMBER 2005

Narrowbody  
 METAR Temperature, Precipitation: -7.0°C, Snow BLSN  
 METAR Visibility: 1/2 SM  
 Calculated rate of precipitation: 77.1 g/dm<sup>2</sup>/h  
 Fluid treatment: Type IV  
 Current holdover time table range (MS): 25 to 55 minutes  
 Aircraft holdover time: 20 minutes

HOLDOVER TIME BASED ON RATE

Type IV: 10 minutes



UNDERSTANDING THE PROBLEM

Calculated rate of precipitation: 77.1 g/dm<sup>2</sup>/h

Aircraft holdover time: 20 minutes

HOLDOVER TIME BASED ON RATE: 10 minutes

Typical Stabilized Type IV Fluid Film Thickness: 1 to 2 mm

Snowfall during holdover time of aircraft: 2.57 mm LWC



CONCLUSIONS

- Holdover times could be produced for heavy snow
- Due to the high precipitation rates, short holdover times and variability, it is inadvisable that holdover times be provided for heavy snow until liquid water equivalent is operationally available
- If liquid water equivalent is operationally available, longer and more precise holdover times could be achieved in many winter operating conditions





# SNOW TABLES

## TYPE IV

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Percent Volume %)	Holdover Times for Snow Conditions Based on TC Visibility Chart (hours:minutes)				Very Heavy Snow
Degrees Celsius	Degrees Fahrenheit		Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	
Above 0°C	Above 32	1000	2:00	1:25 - 2:00	0:40 - 1:25	0:25 - 0:40	CAUTION: No holdover time exist
		75/25	1:55	1:05 - 1:55	0:30 - 1:05	0:20 - 0:30	
		50/50	0:35	0:20 - 0:35	0:05 - 0:20	0:05 - 0:05	
below 0 to -3	below 32 to 27	1000	2:00	1:15 - 2:00	0:35 - 1:15	0:20 - 0:35	
		75/25	1:35	0:55 - 1:35	0:20 - 0:55	0:10 - 0:20	
below -3 to -14	below 27 to 7	50/50	0:35	0:15 - 0:35	0:05 - 0:15	0:00 - 0:05	
		1000	1:15	0:40 - 1:15	0:20 - 0:40	0:15 - 0:20	
below -14 to -25	below 7 to -13	75/25	0:55	0:35 - 0:55	0:15 - 0:35	0:05 - 0:15	
		1000	1:00	0:30 - 1:00	0:15 - 0:30	0:05 - 0:15	
below -25	below -13	1000	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.				

## TYPE II

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Percent Volume %)	Holdover Times for Snow Conditions Based on TC Visibility Chart (hours:minutes)				Very Heavy Snow
Degrees Celsius	Degrees Fahrenheit		Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	
Above 0°C	Above 32	1000	1:45	1:05 - 1:45	0:35 - 1:05	0:20 - 0:35	CAUTION: No holdover time exist
		75/25	1:25	0:45 - 1:25	0:25 - 0:45	0:15 - 0:25	
		50/50	0:35	0:20 - 0:35	0:10 - 0:20	0:05 - 0:10	
below 0 to -3	below 32 to 27	1000	1:35	0:55 - 1:35	0:25 - 0:55	0:15 - 0:25	
		75/25	1:20	0:45 - 1:20	0:25 - 0:45	0:15 - 0:25	
below -3 to -14	below 27 to 7	50/50	0:30	0:15 - 0:30	0:10 - 0:15	0:05 - 0:10	
		1000	1:25	0:35 - 1:25	0:15 - 0:35	0:05 - 0:15	
below -14 to -25	below 7 to -13	75/25	1:05	0:35 - 1:05	0:15 - 0:35	0:10 - 0:15	
		1000	1:00	0:30 - 1:00	0:15 - 0:30	0:05 - 0:15	
below -25	below -13	1000	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.				

## TYPE III

Outside Air Temperature		Type III Fluid Concentration Neat Fluid/Water (Percent Volume %)	Holdover Times for Snow Conditions Based on TC Visibility Chart (hours:minutes)				Very Heavy Snow
Degrees Celsius	Degrees Fahrenheit		Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	
Above 0°C	Above 32	100/0	4:0	2:0-4:0	1:0-2:0	7:10	CAUTION: No holdover time exist
		75/25	3:0	2:0-3:0	1:0-2:0	6:10	
		50/50	2:0	1:0-2:0	5:10	3:6	
below 0 to -3	below 32 to 27	1000	3:5	2:0-3:5	1:0-2:0	6:10	
		75/25	2:5	1:5-2:5	8:15	5:8	
below -3 to -10	below 27 to 14	50/50	1:5	8:15	4:8	3:4	
		1000	3:0	1:5-3:0	9:15	5:9	
below -10 to -14	below 14	75/25	2:5	1:0-2:5	7:10	4:7	
		1000	3:0	1:5-3:0	8:15	4:8	

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# DEVELOPMENT OF HOLDOVER TIME DETERMINATION SYSTEMS



**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISBON - MAY 22, 2006**

**MICHAEL CHAPUT**  
**MANAGER, PROJECTS AND BUSINESS DEVELOPMENT**

**APS AVIATION INC.**  
**MONTREAL, QUEBEC, CANADA**  
**MCHAPUT@ADGA.CA**  
**WWW.APSAVIATION.CA**



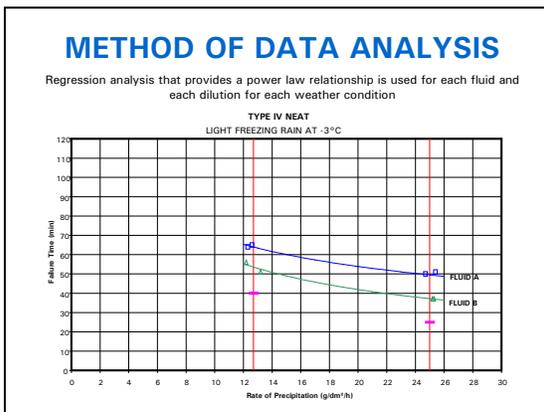
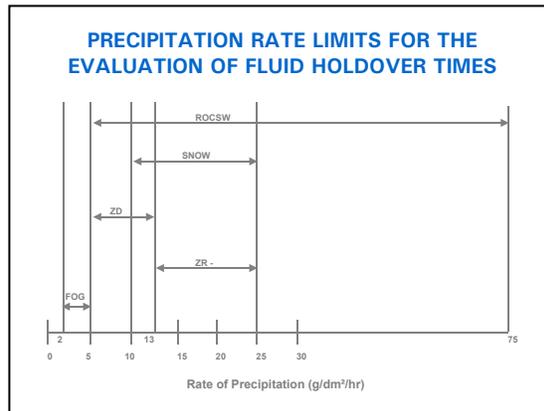
## HOLDOVER TIME TABLES

- The holdover time information provided to the industry for aircraft de/anti-icing fluids has been an important tool for safe winter operations
- Quality of the information contained within the various holdover time tables has improved dramatically
- Despite the improvement in the holdover time information, the pilot's ability to use the information has **NOT** improved



## HOLDOVER TIME TABLES

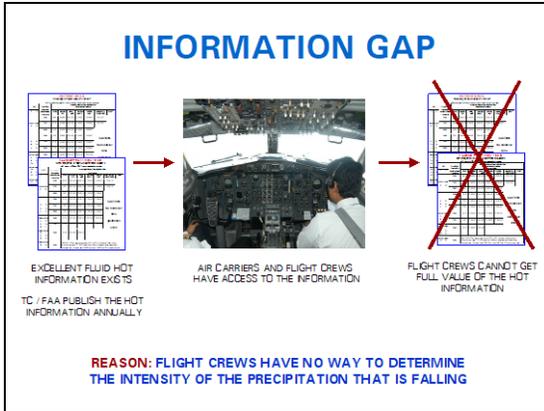
- Holdover times are derived from tests performed at specific rates of precipitation for each meteorological condition
  - Liquid Water Content
- Holdover times are a range of times and not a single value
  - Values obtained from tests performed at low end and high end of the rate spectrum for each condition

## CURRENT SITUATION

- The industry has long sought tools to assist flight crews in making holdover time decisions
- Currently, the pilot must rely solely on experience and training to:
  - Interpret the meaning of the holdover time range for each condition;
  - Determine an appropriate holdover time based solely on the reported weather conditions and/or visual observations





## HOLDOVER TIME, PRECIPITATION RATE AND VISIBILITY

### FLUID HOLDOVER TIME

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2000-2001  
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						
		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Sleet or Cold Soaked Wing	
3 and above	27 and above	1000	1200	110-230	0.50-1.00	0.40-1.00	0.25-0.40	0.10-0.50
		7500	0.50	1.00-1.40	0.20-0.50	0.20-0.30	0.10-0.20	0.05-0.10
		5000	3.00	0.10-0.30	0.00-0.10	0.10-0.20	0.00-0.10	
below -3	below 27	1000	1200	0.20-1.20	0.20-0.40	0.20-0.40	0.10-0.20	CAUTION: no holdover time guidelines exist
below -4	below 27	7500	0.50	0.20-0.50	0.10-0.20	0.10-0.20	0.10-0.20	
below -14	below 7	1000	1200	0.10-0.40 <sup>2</sup>	0.10-0.20 <sup>2</sup>			
below -25	below -13	1000						

Type IV fluid may be used below: 21°C (70°F) provided the freezing point of the fluid is at least 1°C (33°F) below the outside temperature and the aerodynamic acceptance criteria are met. Consult user of Type IV fluid for full correct use.

→ The holdover time for any aircraft de/anti-icing fluid is a function of:

- Rate of precipitation (in g/dm<sup>2</sup>/h)
- Type of precipitation
- Ambient temperature

### CURRENT SITUATION

- Pilots use visual cues to assess intensity of snowfall
- TC / FAA provide carriers with visibility tables for the use of horizontal visibility to categorize the snowfall intensity
- Most meteorologists would agree that this method is not always accurate

### TC VISIBILITY TABLE

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	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

### ACTUAL REPORTED EVENT - YUL

**4 JANUARY 2006 1306Z**

Reported Temperature, Precipitation: -9°C, Snow Grains  
Snow intensity based on reported METAR visibility (3/4): **Moderate**

APS Calculated rate of precipitation: 2.9 g/dm<sup>2</sup>/h  
Snow intensity based on rate: **Very light**

HOLDOVER TIME BASED ON VISIBILITY (MODERATE)

Type IV: 25 to 55 min.  
Type I: 4 to 6 min.

ACTUAL HOLDOVER TIME BASED ON RATE

Type IV: +/- **90 min.**  
Type I: +/- **14 min.**

### ACTUAL REPORTED EVENT - YUL

**16 DECEMBER 2005 1137Z**

Reported Temperature, Precipitation: -8.0°C, Snow  
Snow intensity based on reported METAR visibility (1/2): **Moderate**

APS calculated rate of precipitation: 74.3 g/dm<sup>2</sup>/h  
Snow intensity based on rate: **Heavy**

HOLDOVER TIME BASED ON VISIBILITY (MODERATE)

Type IV: 25 to 55 min.  
Type I: 4 to 6 min.

ACTUAL HOLDOVER TIME BASED ON RATE

Type IV: +/- **10 min.**  
Type I: +/- **2 min.**



### PRECIPITATION RATE VERSUS VISIBILITY

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Daylight	-1 and above	30 and above	<1%	>1% to 1%	>1% to 3	>3
	Below -1	Below 30	<3/8	>3/8 to 7/8	>7/8 to 2	>2

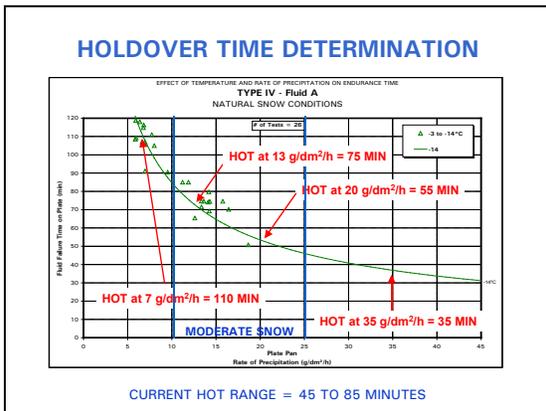
**RATE OF PRECIPITATION IS A MUCH MORE ACCURATE METHOD FOR DETERMINING FLUID HOLDOVER TIMES**



## HOLDOVER TIME DETERMINATION SYSTEM

### HOLDOVER TIME DETERMINATION SYSTEM

- Information system designed for airport use
- System would consist of numerous sensors enabling the determination of:
  - Rate of precipitation
  - Type of precipitation
  - Ambient temperature
- System outputs could be used to generate a "single-value" holdover time for each departing aircraft

## DATA COLLECTION TO EXAMINE FLIGHT CREW DECISIONS IN WINTER OPERATING CONDITIONS

### OPERATIONAL DATA COLLECTION

- Objective: To gather operational information to evaluate actual flight crew de/anti-icing fluid decisions in comparison to optimal decisions based on scientific measurements
  - November 2004 to April 2005
  - November 2005 to April 2006
- Data collection activities were performed in all winter operating conditions with active precipitation
- Data for 1459 departures at YUL were collected



### OPERATIONAL DATA COLLECTION

For each departure, the following data were collected:

- Airline
- Flight number
- Aircraft type
- Fluids requested
- Start of holdover time
- Departure time
- METAR reported weather
- Rate of precipitation during the taxi phase
- Observed weather



### OPERATIONAL DATA COLLECTION



- Pertinent information was obtained from voice transmissions
- Rate pans were placed outside during the taxi phase of the aircraft
- APS observers recorded precipitation type and ambient temperature



### FLIGHT CREW DECISIONS

- Crew de/anti-icing fluid decisions for each departure were classified into one of the four following groups:
  - **Good fluid decision:** Most appropriate fluid was selected by the flight crew for the conditions under which the departure took place
  - **Type IV fluid was unnecessary:** (In cases where Type IV was applied), departures for which the regression-generated holdover time for Type I would have been sufficient
  - **Holdover time exceeded:** Regression-generated holdover time of the fluid selected was inferior to the "holdover" time of the aircraft
  - **Aircraft did not deice:** Aircraft did not deice in active precipitation conditions



### EXAMPLE – GOOD FLUID DECISION

**9 DECEMBER 2005**

Narrowbody  
 Temperature, Precipitation: -5.0°C, Snow  
 Calculated rate of precipitation: 12.7 g/dm<sup>2</sup>/h  
 Fluid Treatment: Type IV  
 Aircraft holdover time: 22 minutes

HOLDOVER TIME BASED ON RATE

Type IV: +/- 50 minutes  
 Type I: 8 minutes



### EXAMPLE – TYPE IV FLUID WAS UNNECESSARY

**22 DECEMBER 2004**

Regional Jet  
 Temperature, Precipitation: -2.0°C, Snow  
 Calculated rate of precipitation: 1.9 g/dm<sup>2</sup>/h  
 Fluid Treatment: Type IV  
 Aircraft holdover time: 12 minutes

HOLDOVER TIME BASED ON RATE

Type IV: > 75 minutes  
 Type I: 30 minutes



**EXAMPLE – EXCEEDED HOLDOVER TIME**

**9 JANUARY 2006**

Turboprop  
 Temperature, Precipitation: -5.0°C, Snow  
 Calculated rate of precipitation: 12.2 g/dm<sup>2</sup>/h  
 Fluid treatment: Type I  
 Aircraft holdover time: 14 minutes

HOLDOVER TIME BASED ON RATE

Type I: 8 minutes



**EXAMPLE – DID NOT DEICE**

**10 FEBRUARY 2005**

Turboprop  
 Temperature, Precipitation: -6.0°C, Light Snow  
 Calculated rate of precipitation: 6.1 g/dm<sup>2</sup>/h  
 Aircraft taxied from gate to runway without deicing

HOLDOVER TIME BASED ON RATE

Type IV: > 55 minutes  
 Type I: 12 minutes



**OPERATIONAL DATA COLLECTION**  
 2004-06

1459 Total Data Points (Departures)  
 1287 Data Points Analyzed

Good fluid decision: **61%**

Type IV fluid was unnecessary: **27%**

Aircraft did not deice: **8%**

Took off with Exceeded Holdover Times: **4%**



**FLIGHT CREW DECISIONS**

SAME MORNING, SAME AIRLINE, 3 CONSECUTIVE DEPARTURES  
 3 AIRCRAFT, 3 DIFFERENT TREATMENTS

Widebody ATIS: 2 SM, -SN, -5 Rate of precipitation: 2.2 g/dm <sup>2</sup> /h Fluid Treatment: Type IV Aircraft holdover time: 15.5 minutes <b>TYPE IV NOT REQUIRED</b>	Widebody ATIS: ¼ SM, -SN, -6 Rate of precipitation: 18 g/dm <sup>2</sup> /h Fluid Treatment: Type I Aircraft holdover time: 21 minutes <b>EXCEEDED HOLDOVER TIME</b>
Widebody ATIS: 2 SM, -SN, -5 Rate of precipitation: 2.2 g/dm <sup>2</sup> /h Fluid Treatment: None Aircraft holdover time: N/A <b>DID NOT DEICE</b>	

**FLIGHT CREW DECISIONS**

SAME DAY, SAME AIRLINE, WITHIN 20-MINUTE WINDOW  
 4 AIRCRAFT, 3 TREATMENTS

Narrowbody ATIS: ¼ SM, -SN, -13 Rate of precipitation: 19.6 g/dm <sup>2</sup> /h Fluid Treatment: Type IV Aircraft holdover time: 13 minutes <b>GOOD FLUID SELECTION</b>	Narrowbody ATIS: 1½ SM, -SN IP, -13 Rate of precipitation: 14.1 g/dm <sup>2</sup> /h Fluid Treatment: Type IV Aircraft holdover time: 17.5 minutes <b>GOOD FLUID SELECTION</b>
Regional Jet ATIS: ¼ SM, -SN, -13 Rate of precipitation: 18.9 g/dm <sup>2</sup> /h Fluid Treatment: None Aircraft holdover time: N/A <b>DID NOT DEICE</b>	Narrowbody ATIS: 1½ SM, -SN IP, -13 Rate of precipitation: 13.8 g/dm <sup>2</sup> /h Fluid Treatment: Type I Aircraft holdover time: 11.5 minutes <b>EXCEEDED HOLDOVER TIME</b>

**DAN-ICE INFORMATION SYSTEM**

### DAN-ICE INFORMATION SYSTEM

→ System consists of numerous sensors enabling the determination of:

- Rate of precipitation
- Type of precipitation
- Ambient temperature
- **HOLDOVER TIME**



### DAN-ICE INSTALLATION AT YUL, MONTREAL



### PRECIPITATION RATE UNIT



- Titanium turbine and snow collector mounted on weighing platform
- Known surface area enables computation of precipitation intensity in  $g/dm^2/hr$  for any precipitation type



### TECHNICAL EVALUATION

- In August 2003, APS was contracted by Dan-Ice to conduct an independent technical evaluation of the Dan-Ice System
- Evaluate the system's ability to:
  - Compute a precipitation rate
  - Determine the prevailing meteorological conditions
  - Determine a holdover time based on the prevailing conditions and computed rate



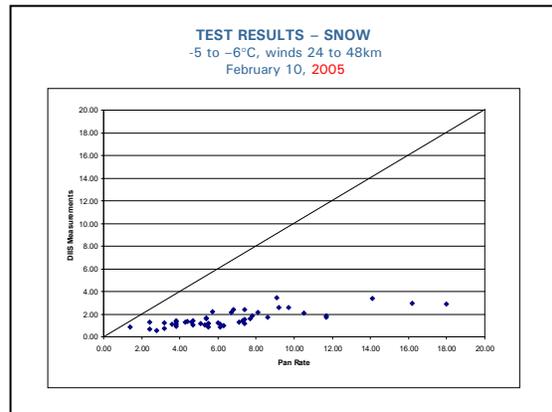
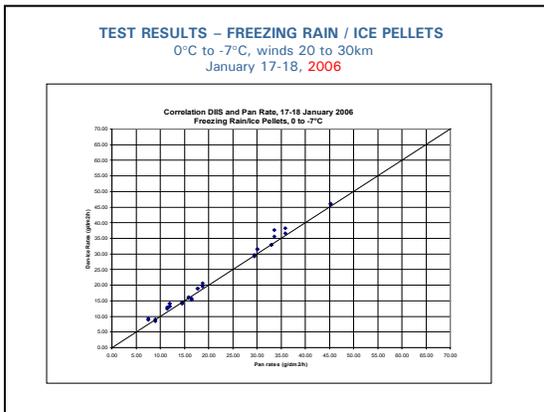
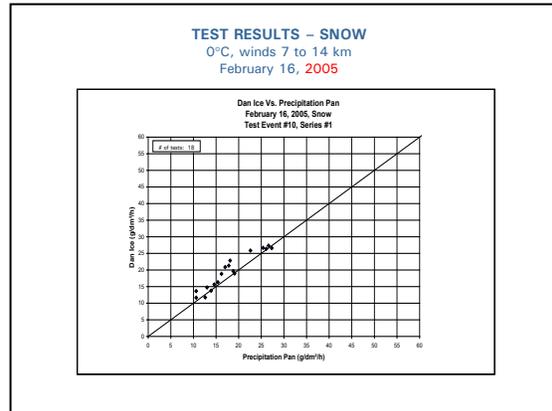
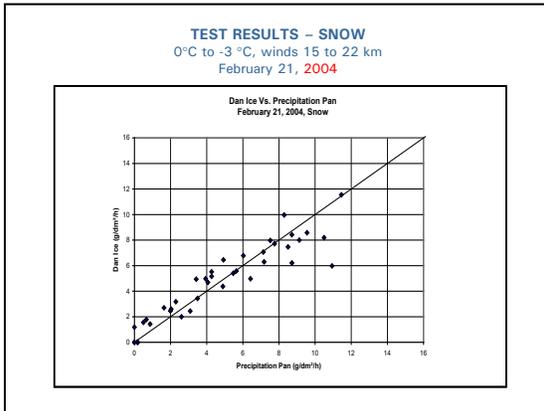
### TECHNICAL EVALUATION

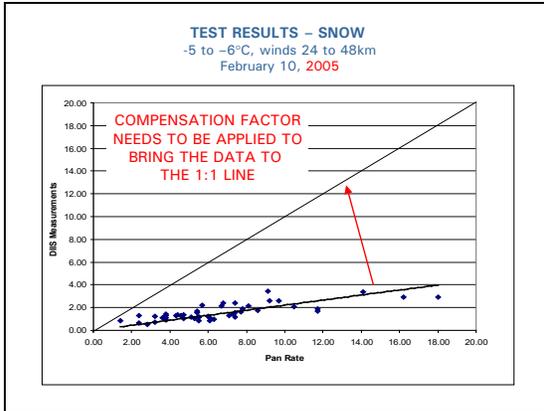
- APS compared Dan-Ice System outputs (rate, precipitation classification, temperature) with:
  - Manual data collections (using historical holdover time precipitation rate methodology)
  - Environment Canada / NavCanada weather outputs



### TWO DAN-ICE UNITS INSTALLED AT YUL

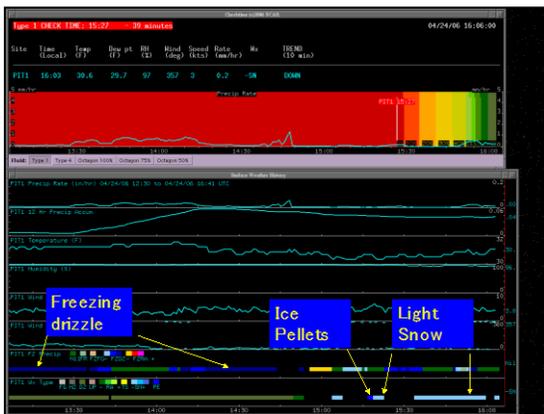
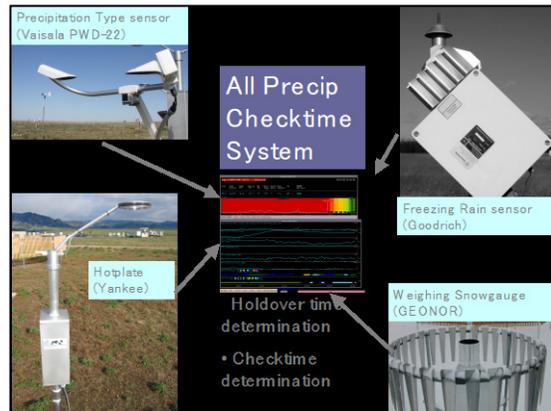






- ### TEST RESULTS SUMMARY
- Analysis of the rate outputs of the Dan-Ice system is very positive: rates measured in snow, freezing rain, freezing drizzle, snow pellets, ice pellets compare to those measured using historical methodology
  - High wind speeds result in decreased catch capability in snow conditions; compensation factor will be used to calibrate the snow data in this case
  - Ultrasonic anemometer was incorporated into the Dan-Ice system hardware in 2005-06 to measure wind speeds and trigger the use of the compensation factor in high winds
  - Ability of the Dan-Ice system to measure accurate temperature and detect and identify precipitation type was also very favorable

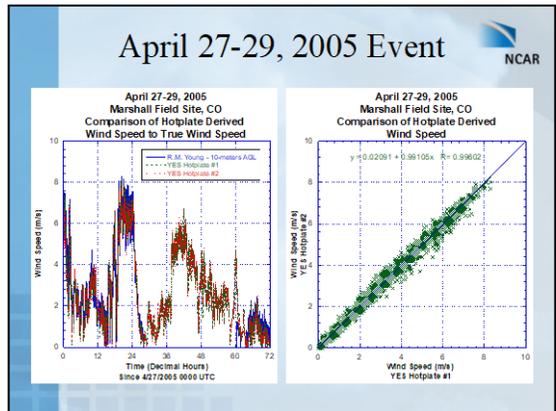
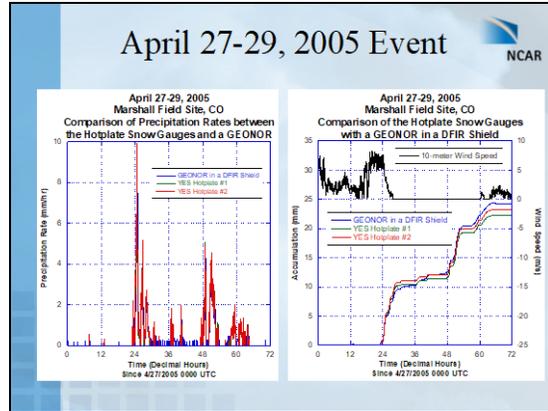
## CHECKTIME SYSTEM



- ### Benefits of Checktime System
1. Allowed United deicing staff to quickly determine when to transition from a one step deicing procedure (Type I only) to a two step procedure (Type I followed by Type IV) based on increasing snowfall rates and consequently decreasing hold times.
  2. Allowed United deicing staff to monitor the hold time status of all deiced aircraft prior to takeoff.
  3. Improved ability to determine precipitation rate at night.
  4. Ability to monitor the local weather conditions close to the deicing pad, which can in many cases be significantly different than the ASOS station weather reported on METARs, ATIS, and FAA Control tower.

### Comparison of Hotplate to Truth Measurement

- The Hotplate is compared to a GEONOR in a DFIR Shield.
- 1-minute Rates, Wind Speeds, and Accumulations are compared.

### Summary on Hotplate

- Hotplate has been commercialized (manufacturer is Yankee Environmental) and is available for airport and airline use.
- The hotplate can be used for the Check Time Product, or the full Weather Support to Deicing Decision Making (WSDDM) system.
- APS Aviation has recently published a report documenting its superior performance for estimating snowfall rates for use with holdover tables over the current visibility table during winter precipitation conditions.

### INTEGRATION OF HOLDOVER TIME DETERMINATION SYSTEMS INTO AIRPORT OPERATIONS

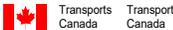


APS Aviation Inc.  
ISO 9001:2000

SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
LISSON - MAY 22, 2006

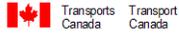
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA



### ACKNOWLEDGEMENTS

- Greater Toronto Airports Authority (GTAA)
- Penauille Servisair (YYZ CDF)
- WestJet
- Aeromag 2000



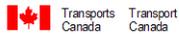
### POTENTIAL IMPACTS OF HOLDOVER TIME DETERMINATION SYSTEM IMPLEMENTATION

- Increased operational safety
- Economic savings due to reduced glycol use
- Better management of time and airport throughput
- Reduction of environmental impacts



### EXAMINATION OF IMPLEMENTATION ISSUES WITH HOLDOVER TIME DETERMINATION SYSTEMS

- During the winter of 2005-06, APS performed the following tasks on behalf of TDC:
  - Provision for support for the installation of a Holdover Time Determination System at Toronto-Pearson International Airport (YYZ); and
  - Development of Performance Specification Documentation for Holdover Time Determination Systems



### INSTALLATION OF A HOLDOVER TIME DETERMINATION SYSTEM AT TORONTO-PEARSON INTERNATIONAL AIRPORT (YYZ)

### DISMANTLING AND TRANSPORTATION OF DAN-ICE SYSTEM TO YYZ



### SITE SELECTION AT YYZ



### ELECTRICAL INSTALLATION AT YYZ



Transport Canada Transport Canada



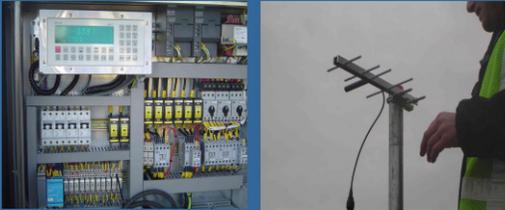
### PHYSICAL INSTALLATION OF DAN-ICE SYSTEM AT YYZ



Transport Canada Transport Canada



### WIRELESS DATA COMMUNICATION INSTALLATION



Transport Canada Transport Canada



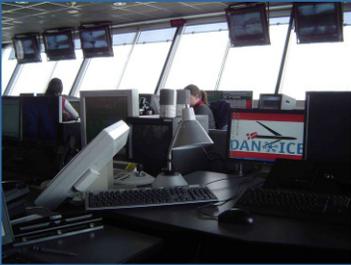
### LINE OF SIGHT TO AND FROM THE SYSTEM



Transport Canada Transport Canada



### COMPUTER INSTALLATION IN THE CDF ICEHOUSE



Transport Canada Transport Canada

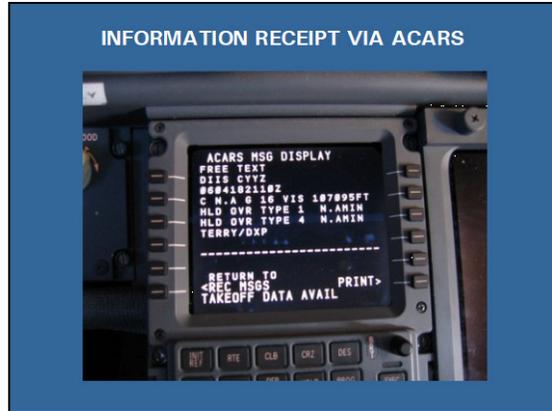
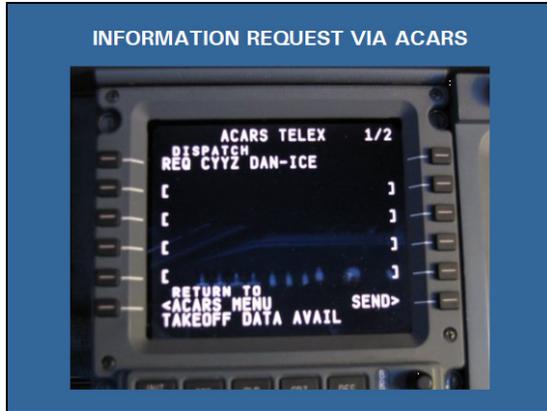


### DESIGN AND IMPLEMENTATION OF ELECTRONIC COMMUNICATION PATHWAY FOR SYSTEM INFORMATION



Transport Canada Transport Canada





### OPERATIONAL DATA COLLECTED

- ➔ Little or no winter precipitation occurred in late March and April 2006 at YYZ
- ➔ Due to the late date of completion of the project, no operational data during actual deicing conditions were collected with the system at YYZ
- ➔ The Dan-Ice system at YUL was subsequently configured to communicate information to WestJet




### LESSONS LEARNED

- ➔ Procedural portion of the installation highlighted the inputs required from all stakeholders, many of which were specific to this particular airport site
- ➔ Invaluable experience for installation of systems at other airport sites




### DEVELOPMENT OF PERFORMANCE SPECIFICATION DOCUMENTATION FOR HOLDOVER TIME DETERMINATION SYSTEMS

### ISSUE OF CERTIFICATION

- ➔ Air carriers and airports, when approached about using a Holdover Time Determination System, invariably ask if the system is "certified"
- ➔ The issue of "certification" was discussed in great detail with Transport Canada, Environment Canada (meteorological authority) and NavCanada (commercial provider of air navigation services in Canada)
- ➔ EC has no clear mandate to "certify" meteorological instruments for commercialization, and consequently no rigorous process for "certification" exists




### AWOS IMPLEMENTATION IN CANADA

- Transport Canada has developed AWOS performance specifications as part of an Exemption to Canadian Aviation Regulations (CAR) 804.01(c)
- NavCanada will collect AWOS and human observations and these data will be analyzed to demonstrate that the new AWOS meets the established TC performance specifications
- NavCanada does not intend to have its new AWOS “certified”, but rather will declare its compliance with the performance specification




### EXEMPTION APPROACH FOR HOLDOVER TIME DETERMINATION SYSTEMS?

- Holdover Time Determination System output is an operational aviation product for use under ground icing operations and falls under the appropriate CAR
- The most expeditious means of realizing the benefits of such systems was to develop a performance specification as a means of granting an Exemption from the CAR for operational use of such a system
- As part of its contract with TC, APS produced:
  - Draft Performance Specification document for Holdover Time Determination Systems
  - Draft Exemption document from CAR 622.11, Sections 3.0, 6.0, 6.2 and 6.3




### LOOKING AHEAD

- Performance specification documentation produced for the meteorological inputs; specifications must also be considered for:
  - Computation of holdover time information
  - Considerations for the delivery of service
- Examine implications on air carrier operations and air carrier deicing programs of moving to “single-value” or extended fluid holdover times based on Holdover Time Determination System measurements
- Examine the implications on regulatory guidance material and policies of moving to “single-value” or extended fluid holdover times based on Holdover Time Determination System measurements

