

# Aircraft Ground Icing General Research Activities During the 2007-08 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 2007-08 Winter



*Prepared by:*  
**APS Aviation Inc.**



March 2009  
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The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

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

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Prepared by: APS Aviation Inc.

Reviewed by:

Feb 27, 2026

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John D'Avirro, Eng., PBDM  
Program Manager

Date

Approved by: \* \*

Feb 27, 2026

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Jack Rigley, P. Eng.  
Vice President, Communications Engineering  
ADGA Group

Date

Un sommaire français se trouve avant la table des matières.

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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 examine the effect of heated fluids on Type II, III and IV fluid endurance times;
- To evaluate weather data from previous winters that can have an impact on the holdover time table format;
- 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, III and IV fluids;
- To develop performance specifications for an integrated weather system that measures holdover time;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests on non-aluminum plates;
- To conduct endurance time tests in frost on various test surfaces;
- To compile historical data for calculation of holdover times based on a small number of inputs; and
- To assist Department of National Defence Canada in evaluating the standards used at various Department of National Defence sites.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2007-08 are documented in six reports. The titles of the reports are as follows:

- TP 14869E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter;
- TP 14870E Winter Weather Impact on Holdover Time Table Format (1995-2008);
- TP 14871E Research for Further Development of Ice Pellet Allowance Times: Aircraft Trials to Examine Anti-Icing Fluid Flow-Off Characteristics Winter 2007-08;
- TP 14872E Aircraft Ground Icing General Research Activities During the 2007-08 Winter;
- TP 14873E Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables; and
- TP 14874E Effect of Heat on Endurance Times of Anti-Icing Fluids.

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

- *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2007-08 and Other Artificial Snow Projects;*

- *Fluid Endurance Times Using Composite Surfaces; and*
- *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions.*

In addition, the following report was written for Department of National Defence as part of this contract; this report does not have a TP number:

- Development of the Canadian Forces Approved Ground Icing Program (AGIP), Evaluation Methods for Current Performance and Recommendations for Improvement Project: Report on Site Visit to 14 Wing Greenwood.

This report, TP 14872E, has the following objective:

- To document the exploratory research and general activities carried out for the Transportation Development Centre during the winter of 2007-08.

The following activities are detailed in this report: Development of a Survey of Deicing Operations in Freezing Rain and Freezing Drizzle; Evaluation of Holdover Times below -25°C; Evaluation of Endurance Times in Rain and Snow; Endurance Times in Snow Pellets; Development of Advisory Circular for ROGIDS; Holdover Time Guidelines Website; Options for the Future of Holdover Time Testing; Evaluation of Tempered Steam Technology; and Test Procedures, Presentations and Fluid Manufacturer Reports for 2007-08.

## **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, Stephanie Bendickson, Michael Chaput, John D'Avirro, Peter Dawson, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Dany Posteraro, Marco Ruggi, Filippo Suriano, Joey Tiano, David Youssef and Victoria Zoitakis.

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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16. Abstract <b>This report documents the general activities completed by APS Aviation Inc. (APS) related to aircraft ground deicing research in the winter of 2007-08. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2007-08, which are documented in separate reports. The ten activities included in this report are described below.</b>					
<ol style="list-style-type: none"> <li>1. Survey of Deicing Operations in Freezing Rain and Freezing Drizzle: APS is conducting a survey on behalf of Transport Canada (TC) to determine whether the current operational practice of takeoff during freezing drizzle and/or freezing rain conditions needs to be limited through additional regulatory intervention.</li> <li>2. Holdover Times of Anti-Icing Fluids Below -25°C.</li> <li>3. Holdover Times in Conditions of Rain mixed with Snow.</li> <li>4. Fluid Endurance Time Testing in Snow Pellet Conditions.</li> <li>5. Advisory Circular for Approval of Ice Detection Cameras: APS is supporting the development of an Advisory Circular for 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 TC 2008-09 Holdover Time (HOT) table Guidelines.</li> <li>7. Options for the Future of Holdover Time Testing.</li> <li>8. Activities Supporting the Development of the Chinook Tempered Steam Technology.</li> <li>9. Implementation of Holdover Time Determination Systems: APS met with TC on several occasions to revise and advance the performance specification exemption document that would enable use of Holdover Time Determination Systems (HOTDS) in Canada.</li> <li>10. Test Procedures, Presentations, and Fluid Manufacturer Reports: An account of the test procedures, presentations and fluid manufacturer reports.</li> </ol>					
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15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.) Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). Ils sont disponibles au Centre de développement des transports. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. On trouvera dans la préface l'objet de ces rapports. Les travaux décrits dans le présent rapport ont été, en partie, coparrainés par la Federal Aviation Administration (FAA).						
16. Résumé Ce rapport fait état des activités générales menées par APS Aviation Inc. (APS) en matière de recherche sur le dégivrage d'aéronefs au sol au cours de l'hiver 2007-2008. Les activités dont fait état ce rapport ont été effectuées en plus des projets de recherche principale menés pendant l'hiver 2007-2008, qui sont documentés dans des rapports distincts. Les dix activités qui font l'objet du présent rapport sont énumérées ci-dessous.						
<ol style="list-style-type: none"> <li>1. Sondage sur les opérations de dégivrage dans des conditions de pluie et de bruine verglaçantes : APS a mené un sondage pour le compte de Transports Canada (TC) pour déterminer si la pratique opérationnelle actuelle de décollage dans des conditions de bruine verglaçante ou de pluie verglaçante doit être limitée par des interventions réglementaires supplémentaires.</li> <li>2. Durées d'efficacité des liquides d'antigivrage à des températures inférieures à -25 °C.</li> <li>3. Durées d'efficacité dans des conditions de pluie mêlées à de la neige.</li> <li>4. Essais sur les durées d'endurance des liquides dans des conditions de neige roulée.</li> <li>5. Circulaire consultative pour l'approbation des caméras de détection de givre : APS contribue à l'élaboration de la circulaire consultative pour 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.</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 sur les durées d'efficacité (2008-2009) officielles de TC.</li> <li>7. Options pour l'avenir des essais relatifs aux durées d'efficacité.</li> <li>8. Activités de soutien au développement de la technologie à base de vapeur tempérée de Chinook.</li> <li>9. Mise en œuvre des systèmes de détermination des durées d'efficacité : APS a rencontré TC à plusieurs reprises pour réviser et faire progresser le document d'exemption de spécification de rendement qui permettrait l'utilisation des systèmes de détermination des durées d'efficacité (HOTDS).</li> <li>10. Procédures d'essai, présentations, et rapports des fabricants de liquides : Un compte rendu des procédures d'essais des présentations, et des rapports aux fabricants de liquides pour le programme d'essais de 2007-2008 figure dans le présent rapport.</li> </ol>						
17. Mots clés <b>Dégivrage, SAE, normes, durée d'efficacité, systèmes de détermination des durées d'efficacité, D-ICE, durées d'endurance, ROGIDS</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 general activities related to aircraft ground deicing research completed by APS Aviation Inc. (APS) in the winter of 2007-08 on behalf of the Transportation Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA). The ten activities documented in this report are described below and were carried out in addition to the main research projects completed in the winter of 2007-08, which are documented in separate reports.

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

Under the auspices of the freezing rain and freezing drizzle internal Transport Canada Working Group, APS conducted a survey on behalf of TC of air operators and pilots to ascertain the current “best practices and procedures” in dealing with takeoffs in freezing rain, freezing drizzle, and ice pellets.

### **Holdover Times of Anti-Icing Fluids Below -25°C (Section 3)**

APS conducted preliminary tests to determine if there is a significant difference in the endurance times of a Type II/IV fluid at -25°C versus at the fluid’s lowest operational use temperature (LOUT).

### **Holdover Times in Conditions of Rain mixed with Snow (Section 4)**

TC and the FAA currently do not provide guidelines for operations in mixed snow and rain conditions. However, European aircraft operators have guidance material for dealing with such conditions. APS conducted tests to identify whether additional work is required in mixed conditions or if the current guidelines can be modified to include mixed rain and snow conditions.

### **Fluid Endurance Time Testing in Snow Pellet Conditions (Section 5)**

Currently, there are no Holdover Time (HOT) Guidelines for snow pellets. APS conducted tests to identify whether additional work is required in snow pellet conditions or if the current guidelines can be expanded to include snow pellets in the current snow HOT column.

### **Advisory Circular for Approval of Ice Detection Cameras (Section 6)**

The proposed SAE International (SAE) Aerospace Standard (AS) 5681 specifies the minimum performance requirements of remote on-ground ice detection systems (ROGIDS). APS has supported the development of an Advisory Circular for the application of AS 5681 by providing expert opinion and document development support.

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

APS developed and implemented a website for the official Transport Canada 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 2008 with the 2008-09 HOT Guidelines.

## **Options for the Future of Holdover Time Testing (Section 8)**

During the winter of 2007-08, Transport Canada management indicated that it was considering removing itself from annual holdover time testing and ground icing activities in the future. Although the exact extent and timeline of this change were not immediately clear, the need arose to identify future options to carry out this work. Eight possible options were identified.

## **Activities Supporting the Development of the Chinook Tempered Steam Technology (Section 9)**

APS coordinated and conducted a series of tests to evaluate the Tempered Steam Technology (TST) for aircraft deicing applications. Previous testing performed on behalf of Chinook and Transport Canada with the TST in 2006-07 clearly demonstrated the ability of the TST to defrost a wing test bed in all temperature ranges. In Winter 2007-08, APS conducted tests to evaluate the ability of the TST to deice operational aircraft. In addition, these tests examined operational issues related to the use of TST for general ground deicing applications.

## **Implementation of Holdover Time Determination Systems (Section 10)**

APS assisted in the revision of an Air Carrier Exemption and Minimum Assurance Requirements and Performance Specifications for the implementation of Holdover Time Determination Systems (HOTDS) into Canadian air operations.

## **Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 11)**

A number of test procedures, presentations, and fluid manufacturer reports were produced by APS for the 2007-08 test program. An account of these activities is included in this report.

## SOMMAIRE

Ce rapport fait état des activités générales se rapportant à la recherche sur le dégivrage d'aéronefs au sol menée par APS Aviation Inc. (APS), au cours de l'hiver 2007-2008, pour le compte du Centre de développement des transports (CDT) de Transports Canada (TC) et de la Federal Aviation Administration (FAA). Les dix 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 2007-2008, qui sont documentés dans des rapports distincts.

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

Sous les auspices du groupe de travail de TC sur la pluie verglaçante et la bruine verglaçante, APS a mené un sondage auprès des exploitants aériens et des pilotes pour connaître les « pratiques et procédures exemplaires » actuelles relatives aux décollages dans ces conditions et en présence de granules de glace.

### **Durées d'efficacité des liquides d'antigivrage à des températures inférieures à -25 °C (Section 3)**

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

### **Durées d'efficacité dans des conditions de pluie mêlées à de la neige (Section 4)**

À l'heure actuelle, TC et la FAA ne publient pas de lignes directrices encadrant les opérations dans des conditions de pluie et de neige mixtes. Cela dit, les exploitants européens d'aéronefs disposent de directives à cet effet. APS a mené une série d'essais pour déterminer si des travaux supplémentaires sont nécessaires relativement aux conditions mixtes, ou si les lignes directrices actuelles peuvent être élargies en vue d'inclure les conditions de pluie et de neige mixtes.

### **Essais sur les durées d'endurance des liquides dans des conditions de neige roulée (Section 5)**

À l'heure actuelle, il n'existe pas de lignes directrices sur les durées d'efficacité dans des conditions de neige roulée. APS a mené une série d'essais pour déterminer si des travaux supplémentaires sont nécessaires relativement à la neige roulée, ou si les lignes directrices actuelles peuvent être élargies en vue d'inclure ces conditions dans la colonne actuelle portant sur la neige.

## **Circulaire consultative pour l'approbation des caméras de détection de givre (Section 6)**

La norme aérospatiale (AS) 5681 proposée par la SAE International (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 circulaire consultative sur l'application de la norme AS 5681 en fournissant des avis d'experts et un soutien dans la mise au point de documents.

## **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. Le site Web a été mis à jour en juillet 2008 par APS, qui y a inclus les lignes directrices sur les durées d'efficacité de 2008-2009.

## **Options pour l'avenir des essais relatifs aux durées d'efficacité (Section 8)**

Au cours de l'hiver 2007-2008, la direction de TC a indiqué qu'elle envisageait de se retirer des activités annuelles d'essais sur les durées d'efficacité et le givrage au sol. La portée exacte et le calendrier précis de ce changement n'étaient pas connus à ce moment, mais il s'est avéré nécessaire de déterminer les options futures pour mener à bien ce travail. Huit approches possibles ont été cernées.

## **Activités de soutien au développement de la technologie à base de vapeur tempérée de Chinook (Section 9)**

APS a coordonné et effectué une série d'essais pour évaluer la technologie à base de vapeur tempérée (TBVT) pour le dégivrage des aéronefs. Des essais antérieurs menés pour le compte de Chinook et de TC sur la TBVT en 2006-2007 ont clairement démontré la capacité de cette technologie à dégivrer une aile de banc d'essai, et ce, dans toutes les plages de température. Au cours de l'hiver 2007-2008, APS a mené des tests pour évaluer le dégivrage des aéronefs opérationnels par TBVT. En outre, ces tests ont examiné les questions opérationnelles liées à l'utilisation de la TBVT pour les applications générales de dégivrage au sol.

## **Mise en œuvre des systèmes de détermination des durées d'efficacité (Section 10)**

APS a participé à la révision d'une exemption pour transporteurs aériens et d'exigences minimales d'assurance et de spécifications de rendement pour la mise en œuvre des systèmes de détermination des durées d'efficacité (HOTDS) dans les exploitations aériennes canadiennes.

## **Procédures d'essai, présentations, et rapports des fabricants de liquides (Section 11)**

APS a produit un certain nombre de procédures d'essais, de présentations, et de rapports aux fabricants de liquides pour le programme d'essais de 2007-2008. Le présent rapport contient une description de ces activités.

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- I Exemption from Subsection 602.11(4) of the Canadian Aviation Regulations and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 Ground Icing Operations, December 2007
- J Presentations at Various Meetings

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## **GLOSSARY**

AEA	Association of European Airlines
APS	APS Aviation Inc.
AS	Aerospace Standard
ASL	Aviation Safety Letter
CAR	Canadian Aviation Regulations
CBAA	Canadian Business Aviation Association
CBAAC	Commercial and Business Aviation Advisory Circular
CDF	CENTRAL DEICING FACILITY
CF	Canadian Forces
CHINOOK	Chinook Mobile Heating and Deicing Corporation
DIIS	D-ICE Deicing Information System
DND	Department of National Defence
EC	Environment Canada
EG	Ethylene Glycol
FAA	Federal Aviation Administration
FZDZRA	Freezing Drizzle and Freezing Rain
HOT	Holdover Time
HOTDS	Holdover Time Determination Systems
LOUT	Lowest Operational Use Temperature
MSC	Meteorological Service of Canada
NRC	National Research Council Canada

PG	Propylene Glycol
RDU	Research and Development Unit
ROGIDS	Remote On-Ground Detection Systems
SAE	SAE International
TC	Transport Canada
TCCA	Transport Canada Civil Aviation
TDC	Transportation Development Centre
TST	Tempered Steam Technology
YOW	MacDonald–Cartier International Airport
YYZ	Toronto–Pearson International Airport

## 1. INTRODUCTION

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

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

Under contract to the TDC, with financial support from the FAA, APS Aviation Inc. (APS) has undertaken research activities to further advance aircraft ground de/anti-icing technology. Each of the research activities is documented in a separate individual report. The general activities are documented in this report in separate sections (shown in parentheses):

- a) Survey of Deicing Operations in Freezing Rain and Freezing Drizzle (Section 2);
- b) Holdover Times of Anti-Icing Fluids Below -25°C (Section 3);
- c) Holdover Times in Conditions of Rain mixed with Snow (Section 4);
- d) Fluid Endurance Time Testing in Snow Pellet Conditions (Section 5);
- e) Advisory Circular for Approval of Ice Detection Cameras (Section 6);
- f) Holdover Time Guidelines Website (Section 7);
- g) Options for the Future of Holdover Time Testing (Section 8);
- h) Activities Supporting the Development of the Chinook Tempered Steam Technology (Section 9);
- i) Implementation of Holdover Time Determination Systems (Section 10); and
- j) Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 11).

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

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

### 2.1 Background

This work is being conducted under the auspices of the Takeoff in Freezing Drizzle and Freezing Rain (FZDZRA) Working Group. The objective of the Working Group is to determine whether the current operational practice of takeoff during freezing drizzle and/or freezing rain conditions needs to be limited through additional regulatory intervention.

At the first Working Group meeting, it was agreed that it would be appropriate to canvas air operators on their current “best practices and procedures” in dealing with takeoffs in FZDZRA conditions. Transport Canada (TC) requested APS Aviation Inc. (APS) conduct a survey of air operators on its behalf to obtain this information.

### 2.2 Survey Objectives

The primary objective of the survey was to obtain information on the current practices of Canadian air operators related to takeoffs in FZDZRA conditions. However, TC also used the opportunity to collect information related to takeoffs in ice pellet conditions.

The specific objectives of the survey were as follows:

- a) To get a more in-depth understanding of air operator procedures dealing with takeoff operations during conditions of freezing drizzle, freezing rain, and ice pellets;
- b) To understand what mitigating factors air operators consider in determining the acceptability of takeoffs in freezing drizzle, freezing rain, or ice pellets;
- c) To understand the current knowledge level of industry in this area;
- d) To understand the level of training provided to pilots in this area; and
- e) To understand specific operating limitations, either self-imposed or imposed by external factors.

## 2.3 Survey Participants

Three groups of potential survey participants were identified:

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

An attempt was made to contact each air operator registered in the 702 (Aerial Work Operations), 703 (Air Taxi Operations), 704 (Commuter Operations), and 705 (Airline Operations) categories. TC had a list of these operators but, due to privacy regulations, could only provide a company name and general contact phone number for each. APS personnel built a complete database for these operators. Each was contacted by phone and was requested to provide a contact name, phone number, and email address for either their chief pilot or operations manager. The final APS database included 177 air operators in the 702, 703, 704, and 705 categories.

Air operators in the 604 category (Private Operator Passenger Transportation) were contacted through the Canadian Business Aviation Association (CBAA). The CBAA sent an email to all of its members informing them of the nature and purpose of the survey and requesting their participation. The CBAA estimated the email was sent to 320 of its members.

In addition to air operators, it was also deemed appropriate to solicit input directly from flight crews (pilots), as it was felt that they would provide a different perspective from the air operators. Pilots were contacted through an article published in the October 2008 Aviation Safety Letter (ASL). The ASL is a quarterly newsletter published by Transport Canada Civil Aviation (TCCA) in both English and French and distributed to all holders of a valid Canadian pilot licence or permit. It includes articles that address aviation safety. There are approximately 15,500 IFR pilots in Canada that receive the ASL.

## 2.4 Survey Format

It was postulated that some air operators, if they could be identified, would not be comfortable divulging the detailed and somewhat sensitive information requested in the survey to TC. However, it was critical that this information come to light, and therefore it was deemed necessary for the survey to be administered so participants could respond anonymously and be assured that their responses could in no way be linked to them or their company by either TC or APS.

Use of a web-based program to administer the survey and collect the results was identified as the best way to conduct the survey anonymously. The participants were directed to a website (a different website for each version of the survey; see Subsection 2.5) and completed the survey online. They did not require a password to access the survey. Once they had completed the survey questions, they submitted their responses, which were collected and held on a secure online server. No data was collected on the person submitting the responses, on the time/date the responses were sent, or on the computer they were sent from.

## **2.5 Survey Versions**

As the operations and knowledge bases of the three participant groups differed slightly, it was necessary to tailor the survey to each group. Furthermore, as the ASL is published in both English and French, the flight crew survey also had to be published in both languages. In the end, four versions of the survey were prepared:

- 1) Air operators (702-705);
- 2) Air operators (604);
- 3) Flight crew (English); and
- 4) Flight crew (French).

Each survey was accessed through a different web address. Copies of the surveys are included in Appendix B.

Not all questions in the flight crew survey were asked of all respondents. The respondents followed one of two routes through the survey – the commercial route or the general aviation route – based on their response to the first question. The flight crew survey routing is shown in a diagram in Appendix B.

## **2.6 Survey Administration**

The air operators (702-705) survey and air operators (604) survey were administered in June 2008. Participants of the air operators (702-705) survey (those in the APS database) were invited to participate in the survey by an individual email sent by the APS project leader. Participants of the air operators (604) survey received an email from the CBAA that provided the scope and purpose of the survey and provided a link to the survey website.

The flight crew survey is being administered throughout Fall 2008. Participants were invited to participate through an article published in the October 2008 edition of the ASL.

## 2.7 Response Rates

The response rates for the completed surveys were as follows:

- 1) Air operators (702, 703, 704, 705): 48 percent (85 responses); and
- 2) Air operators (604): 21 percent (68 responses).

The response rate for the 702-705 survey was higher than the response rate for the 604 survey. This was expected for several reasons: the appropriate contact (Chief Pilot or Operations Manager) for the 702-705 air operators was addressed directly (from the APS database), and reminder emails were sent to the 702-705 air operators mid-way through the survey and the day before the survey was closed. The 604 air operators could not be similarly contacted.

The flight crew survey is currently being administered. Response rates from this survey will be documented in a future TC report.

## 2.8 Survey Results

Summaries of the air operators (702-705) and air operators (604) survey results are provided in Appendix C. These results were provided to TC in July 2008.

The flight crew survey is currently being administered. Results will be documented in a future TC report.

## **3. HOLDOVER TIMES OF ANTI-ICING FLUIDS BELOW -25°C**

### **3.1 Background**

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

### **3.2 Objective**

The objective of these tests was to determine the differences in the endurance times of Type II/IV fluid tests at -25°C in comparison to testing conducted at the fluid's LOUT. The standard endurance time testing procedure and methodology were followed. Preliminary testing was conducted with only three fluids in conjunction with standard HOT testing. The comparative endurance time testing was conducted using the same fluids and dilution at both -25°C and -28.5°C in freezing fog conditions.

### **3.3 Test Results**

Three fluids were used for the comparative endurance time testing. A duplicate of each test was conducted for a total of three comparative sets of tests. Table 3.1 summarizes the results obtained.

### **3.4 Conclusion**

The results obtained from the comparative endurance time testing indicated that the 3.5°C difference in test temperature (from -25°C to -28.5°C) did not seem to have a significant difference on the fluid endurance time. It should be noted that Brix measurements were not taken during the tests; visual fluid failure was used as the comparative measure, although the failure call was difficult. These limited results indicated that, based on the current generation of fluids (designed with a LOUT of

approximately -28.5°C), the current -25°C HOT could be expanded to apply to the fluid LOUT; however, if fluid manufacturers begin to develop fluids with lower LOUTs, further testing will be required to substantiate the new LOUT HOTs. Tests are recommended to substantiate these findings. It is suggested that progressive Brix measurements be taken during the tests, as well as final Brix measurements to validate the visual fluid failure call.

**Table 3.1: Endurance Time Tests – LOUT vs. -25°C**

Test #	Fluid Name	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Endurance Time (min)	Actual Rate of Precip. (g/dm <sup>2</sup> /h)	Ambient Temp. (°C)
LOUT1	Dow EG 106	13:27:30	14:03:00	35.5	4.5	-28.5
LOUT1A	Dow EG 106	13:34:40	14:13:00	38.3	4.2	-28.5
LOUT4	Dow EG 106	10:58:30	11:32:00	33.5	5.3	-25
LOUT4A	Dow EG 106	11:08:00	11:46:00	38.0	5.4	-25
LOUT2	Kilfrost ABC-S+	13:27:15	14:05:00	37.8	4.8	-28.5
LOUT2A	Kilfrost ABC-S+	13:34:50	14:18:00	43.2	4.5	-28.5
LOUT5	Kilfrost ABC-S+	10:56:30	11:39:00	42.5	5.2	-25
LOUT5A	Kilfrost ABC-S+	11:08:15	11:51:00	42.8	5.5	-25
LOUT3	Kilfrost P2143-2	13:25:20	13:54:00	28.7	4.7	-28.5
LOUT3A	Kilfrost P2143-2	13:25:30	13:54:30	29.0	4.8	-28.5
LOUT6	Kilfrost P2143-2	10:06:50	10:36:30	29.7	5.1	-25
LOUT6A	Kilfrost P2143-2	10:07:00	10:36:00	29.0	5.2	-25

Note: Tests were conducted at NRC Climatic Engineering Chamber on March 31, 2008. Neat fluid was applied to standard aluminum test plate surfaces in freezing fog.

## **4. HOLDOVER TIMES IN CONDITIONS OF RAIN MIXED WITH SNOW**

### **4.1 Background**

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

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

### **4.2 Objective**

The objective of this project is to investigate if endurance time testing conducted during mixed precipitation conditions (rain mixed with snow) will demonstrate signs of fluid adhesion to aluminum test surfaces with neat Type II and Type IV fluids. Comparative testing was conducted with the same fluid in mixed rain and snow conditions and light freezing rain conditions. The relevant procedure is included in Appendix D.

It should be noted that these limited preliminary tests were conducted at the request of the FAA. This limited testing was conducted in conjunction with the standard HOT testing conducted at the National Research Council Canada (NRC) in April 2008.

### 4.3 Test Results

Two neat fluids were used for the comparative endurance time testing. Testing was conducted in both simulated mixed rain and snow (conducted at +1°C) as well as simulated freezing rain (conducted at -3°C). The rain rate of precipitation was measured using the standard HOT testing protocol used for simulated freezing precipitation. The simulated snow rate of precipitation was approximated based on calibration work conducted; the dispensing apparatus showed good repeatability and could be set to achieve desired rates of precipitation. The endurance times recorded were compared. The refractive index (Brix) and level of adherence were monitored during the test to quantify the levels of fluid dilution and adherence during each test. Table 4.1 demonstrates the results obtained.

**Table 4.1: Rain and Snow vs. Light Freezing Rain Endurance Time Tests**

Test #	Fluid Name	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Endurance Time (min)	Approx. Rate of Precip. (g/dm <sup>2</sup> /h)	Ambient Temp. (°C)	Final Brix (°)	Precipitation (Type)
RS1	Dow EG 106	20:47:00	21:46:00	59.0	25	1	8.00	Rain/Snow
RS1-1	Dow EG 106	12:06:00	12:57:00	51.0	24	-3	5.50	Light Freezing Rain
RS2	Kilfrost ABC-S +	20:47:00	21:56:00	69.0	25	1	5.50	Rain/Snow
RS2-2	Kilfrost ABC-S +	12:06:40	13:08:00	61.3	24	-3	6.50	Light Freezing Rain

Notes: Tests were conducted at NRC Climatic Engineering Chamber on April 9, 2008. Neat fluid was applied to standard aluminum test plate surfaces.

### 4.4 Conclusions

For both ethylene glycol (EG) and propylene glycol (PG) fluids (EG106 and ABC-S +), the estimated endurance time in rain and snow was on average 14 percent longer compared to that of the light freezing rain only test. At the estimated time of failure for both conditions, adherence was present on the plate. The condition of the fluid during the test showed characteristics similar to light freezing rain conditions (i.e., presence of adherence and erosion of the fluid layer). Light freezing rain HOTs seem a good conservative approach for mixed rain and snow conditions and are in accordance with the AEA recommendation. It should be noted that these observations are based on only two comparative tests, and additional tests would be required to substantiate the conclusion.

## 5. FLUID ENDURANCE TIME TESTING IN SNOW PELLET CONDITIONS

### 5.1 Background

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

Although occurrences of snow pellets during aircraft operations have been reported, no Holdover Time (HOT) Guidelines currently exist for snow pellet conditions. Some aircraft operators have voiced concern regarding the lack of HOT guidance material due to the recent increased frequency of occurrence of snow pellet conditions. APS Aviation Inc. (APS) conducted some preliminary work investigating the melting time properties of simulated snow pellets versus natural snow; this work was presented at the Lisbon HOT Working Group meeting and was reported in the Transport Canada (TC) report, TP 14713E, *Aircraft Deicing Research in Natural and Simulated Ice Pellet Conditions* (1).

### 5.2 Objective

The objective of this project was to compare endurance time testing conducted during simulated snow pellet conditions and simulated snow conditions with various thickened fluids. These preliminary tests were completed at the request of the Federal Aviation Administration (FAA) and TC.

The purpose of these tests is to identify whether additional work is required in snow pellet conditions or if the current guidelines can be extended to include snow pellets in the current snow HOT column.

### 5.3 Test Results

Three neat fluids were used for the comparative endurance time testing. Testing was conducted in both simulated snow pellets and simulated snow conditions. The endurance times recorded were compared. The average refractive index (Brix) at failure (calculated by taking the average of several readings across the plate) was also recorded to quantify the levels of fluid dilution at the end of each test. Table 5.1 summarizes the results obtained.

**Table 5.1: Simulated Snow Pellets vs. Simulated Snow Endurance Time Tests**

Test #	Fluid	Precipitation Type	Rate of Precipitation (g/dm <sup>2</sup> /h)	OAT (°C)	Measured Endurance Time (min)	AVG Brix at Failure (°)
1	Type III PG	Snow Pellets	10	-10	28	19
2	Type III PG	Snow Pellets	10	-10	25	19.8
3	Type III PG	Snow	10	-10	25	17.7
4	Type IV EG	Snow Pellets	25	-7	36	13.6
5	Type IV EG	Snow	25	-7	33	13.3
6	Type IV PG	Snow Pellets	25	-7	31	20.3
7	Type IV PG	Snow	25	-7	30	20

## 5.4 Conclusions

In conclusion, fluid endurance times in simulated snow pellet conditions were similar to those of simulated snow. On average, the simulated snow pellet tests had endurance times six percent longer in comparison to those of the simulated snow tests. The average final Brix measurement indicated similar levels of fluid dilution for each of the comparative test sets.

It should be noted that data used to generate snow holdover times may already include snow pellets. Snow pellets are usually brief, and endurance time testing conducted during snow conditions may have included snow pellets that may not have been disregarded unless the condition was severe.

Falcon 20 testing showed that ice pellet contamination in anti-icing fluid is removed from the wing at rotation; therefore, snow pellets would likely also be removed. Snow pellets will generally occur during snow conditions, not during freezing rain or freezing drizzle conditions; therefore, the risk of adherence is low, if not negligible.

If research is to continue, it is recommended that the following testing be conducted:

- Wind tunnel testing to investigate flow-off of de/anti-icing fluid contaminated with snow pellets;
- Further endurance time testing with different fluids, dilutions, temperatures, and rates; and
- Intra-laboratory comparison of simulated endurance time results.

## 6. ADVISORY CIRCULAR FOR APPROVAL OF ICE DETECTION CAMERAS

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 (2)*, have demonstrated that the ability to detect ice can be somewhat difficult for both visual and tactile detection. It has been determined that, under certain circumstances, Remote On-Ground Detection Systems (ROGIDS) can be more reliable than either human visual or tactile ice detection.

From 2005 to 2007, APS Aviation Inc. (APS) worked with regulatory authorities to develop SAE International (SAE) Aerospace Standard (AS) 5681, the standard that specifies the minimum performance requirements of ROGIDS. As a ground-based system, the main objective of a 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 deicing operations to provide information about the condition of the monitored aircraft surfaces.

Since 2007, APS has assisted in the development of an Advisory Circular to be issued by regulatory agencies, the FAA and Transport Canada (TC), to provide guidance so that ROGIDS can be introduced into service. This Advisory Circular will provide the following:

- a. Guidance material and recommendations for operational approval of ROGIDS;
- b. Guidance and recommendations for certificate holders/air operators and operators of deicing facilities regarding the use of ROGIDS as a primary means for post-deicing inspection of aircraft;
- c. Guidance and recommendations for the use of ROGIDS as an advisory means to supplement visual and tactile pre-deicing checks for clear ice; and
- d. Guidance on how to incorporate the use of ROGIDS into the approved deicing programs of certificate holders or operators of deicing facilities.

### 6.1 Development of Standard

APS has been an ongoing contributor to the development of the ROGIDS Advisory Circular through continued support at all industry meetings. The following is a list of the relevant meetings:

- Meeting 1: *December 5-6, 2007, Ottawa*: Preliminary discussions to establish the plan for development of a "ROGIDS use" Advisory Circular; first draft of Advisory Circular produced;

- Meeting 2: *June 25-27, 2008, Montreal*: Development of ROGIDS Advisory Circular;
- Meeting 3: *September 16-18, 2008, Atlantic City*: Continued development and refinement of ROGIDS Advisory Circular; and
- Meeting 4: *December 2-4, 2008, Ottawa*: Final changes made to ROGIDS Advisory Circular; Advisory Circular provided to TC and the FAA.

## 6.2 Current Version of Advisory Circular

The December 2008 draft version of the ROGIDS Advisory Circular is included for reference in Appendix E.

## 7. HOLDOVER TIME GUIDELINES WEBSITE

### 7.1 Background

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

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

- a) The TC Civil Aviation Commercial and Business Aviation Advisory Circular (CBAAC) document;
- b) The TC Civil Aviation website; and
- c) The Transportation Development Centre (TDC) website.

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

Therefore, in the summer of 2003, TC asked APS Aviation Inc. (APS) to develop and implement a website for official TC HOT Guidelines to standardize the HOT information published on websites and to eliminate the safety risks associated with information discrepancies. This single source of HOT 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 2008, the 2008-09 HOT Guidelines were published on the website and replaced the 2007-08 HOT Guidelines, which were archived on the site. Appendix F contains the original issue of the 2008-09 HOT Guidelines as they appear in English on the website. As in previous years, the changes from the previous year's guidelines are summarized on page 3 of the document and explained in detail in the TC report, TP 14869E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter* (3).

The changes made for the 2008-09 HOT Guidelines include the following:

- Addition of one new Type II fluid: Kilfrost ABC-K Plus;
- A warning was added concerning possible viscosity issues with the Aviation Xi'an High-Tech KHF-II Type II fluid;
- Addition of the Type IV Dow Chemical UCAR™ Flight Guard AD-480 table; and
- A note was included in the Type II and IV HOT tables to advise that radiational cooling during active frost conditions can affect holdover times.

For the changes to be approved, APS is required to obtain approval from both TC and the TDC. The form provided in Figure 7.1 is used for this purpose.

### **7.3 Future Responsibilities**

APS has undertaken the responsibility to ensure the website is operational, in terms of Internet availability, for a period of one year. In the summer of 2009, APS intends to update the website with new data from 2008-09 testing and upload the 2009-10 HOT Guidelines.

## **Request for Change to Holdover Time Guidelines Website**

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

Description of Change: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Affected Pages: \_\_\_\_\_

Requested By: \_\_\_\_\_

Reason for Change: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Confirmed by: \_\_\_\_\_

Barry Myers  
Senior Development Officer  
Transportation Development Centre

Confirmed by: \_\_\_\_\_

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/Katrina Bell)
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. OPTIONS FOR THE FUTURE OF HOLDOVER TIME TESTING

This project was stimulated by initial discussions held among Transport Canada (TC), the Federal Aviation Administration (FAA), and APS Aviation Inc. (APS) on March 5, 2008, in Ottawa, Ontario. A meeting was arranged when TC senior management announced that the future direction of TC was to remove itself from annual holdover time (HOT) testing and ground icing activities. Although the exact extent and impact of TC's change in direction were not known, it was clear that potential options for the future of this work needed to be identified and assessed. TC requested that APS participate in this process as a third party to organize meetings, analyse the options, and prepare a report.

A document was developed from two brainstorming sessions attended by key APS personnel and from a meeting attended by APS personnel and TC on June 10, 2008. *Options for the Future of Holdover Time Testing, Draft Version 4.0* describes eight options the group identified for the future of holdover time testing and includes a flowchart outlining the roles of the various stakeholders in each option. The document was provided to TC in June 2008.

A copy of the flowchart is provided in Figure 8.1. Each of the first four column headings list a task/cost involved in HOT testing; the rows below indicate the organization responsible for each task/cost in each of the eight options. The columns include answers to the below questions.

- 1) **Who Funds Fluid Evaluation?** The organization in this column pays for the HOT testing. TC/FAA are noted as responsible in "some years" because, currently, the set fee paid by the fluid manufacturers may not cover the cost of testing in years when a minimal number of fluids are tested.
- 2) **Who Collects HOT Testing Revenues from Fluid Manufacturers (FMs)?** The organization in this column manages the HOT testing.
- 3) **Who Publishes HOT Guidelines?** The organization in this column is responsible for making the HOT Guideline information available to users, for example, by maintaining a website with the current guidelines.
- 4) **Who Funds HOT Guidelines?** The organization in this column funds the costs associated with annual changes to the guidelines, such as revising the generic tables and presenting the test data to the industry.

At the June 10 meeting, it was concluded that the next step would be to request more information from TC management. Once this information is available, the group will be able to reduce the number of possible options and develop further detailed information for the remaining options. This may require that stakeholder consultations and costing exercises be completed.

8. OPTIONS FOR THE FUTURE OF HOLDOVER TIME TESTING

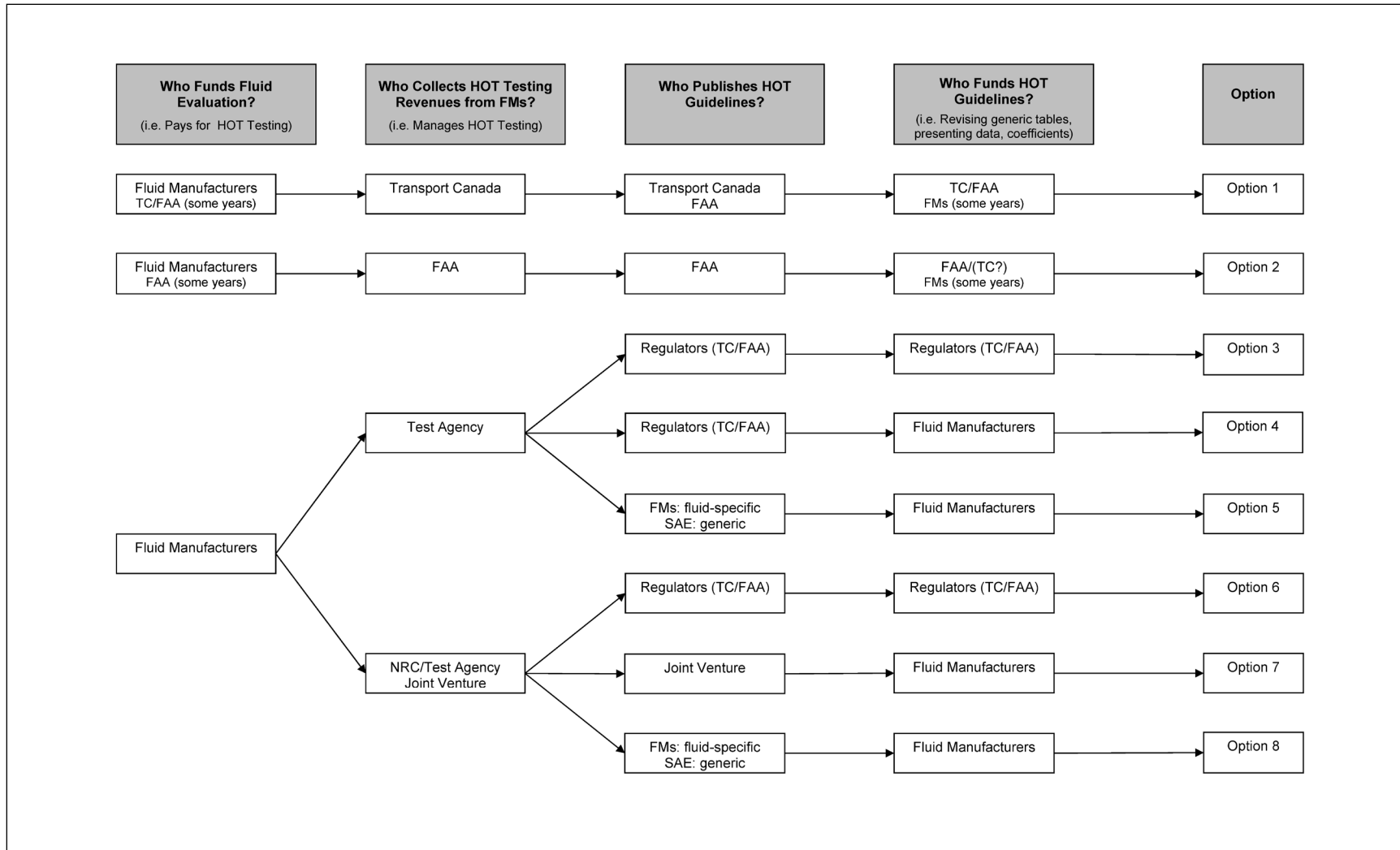


Figure 8.1: Future HOT Options Diagram

## 9. ACTIVITIES SUPPORTING THE DEVELOPMENT OF THE CHINOOK TEMPERED STEAM TECHNOLOGY

### 9.1 Introduction

Despite dramatic improvements in previous years in the quality of de/anti-icing fluids, fluid delivery, recovery equipment, industry procedures, and ground crew and flight crew training, the negative aspects of the use of glycol for aircraft ground de/anti-icing are still prominent. These negative aspects include, but are not limited to, the following:

- Environmental concerns (toxicity, biodegradability);
- Occupational hazards;
- Glycol-associated high costs; and
- Aircraft delays and airport throughput.

Under contract to the Transportation Development Centre (TDC), APS Aviation Inc. (APS) has undertaken research activities to further advance aircraft ground de/anti-icing technology.

Tempered Steam Technology (TST), developed by the Chinook Mobile Heating and Deicing Corporation (CHINOOK), is a unique innovation that aims to reduce the cost and the environmental impact of deicing aircraft. With its patented delivery system, TST will use heated steam-infused air, or tempered steam, to melt contaminants on aircraft surfaces and heated air alone to dry them in an environmentally friendly, user-friendly, and budget-friendly manner. TST does not involve the use of glycol whatsoever, and therefore it is designed for deployment at airport gate operations.

In January 2008, a discussion with the Department of National Defence (DND) and Canadian Forces (CF) was held to propose TST testing on a DND and CF operational aircraft.

The TST has proven to provide numerous benefits to operators such as DND and CF. These benefits include, but are not limited to, the following:

- General cost savings (glycol use and recovery);
- Reduction in environmental impact;
- Increased operational flexibility;
- Deicing capability for those aircraft not currently certified for glycol deicing; and
- Northern operations where conventional deicing is subject to the lowest operational use temperature (LOUT) limitations.

A sizable amount of work has been performed by APS since April 2006 to evaluate the TST for aircraft deicing applications.

## 9.2 Previous Work Funded by Transport Canada

Eight tests were completed in Smiths Falls, Ontario, during March and April 2007. The tests aimed to evaluate the effectiveness of using TST as a deicing tool in the following precipitation conditions:

- Natural frost (four tests);
- Simulated snow contamination (two tests); and
- Simulated ice contamination (two tests).

Natural frost testing demonstrated that deicing and drying of the wing surfaces can be achieved by using both tempered steam and hot air components of the TST system or by using hot air alone.

The results from tests with snow and ice contamination indicate that the TST would be effective for deicing or as a pre-deicing tool to remove large quantities of accumulated contamination prior to deicing.

For a complete review of these eight tests, refer to the Transport Canada (TC) report, TP 14780E, *Evaluation of Tempered Steam Technology (TST) for Aircraft Deicing Applications* (4).

## 9.3 Previous Chinook Work

In August 2005, APS was contracted by CHINOOK to provide consulting services for the development of business-planning documentation and for the preparation of applications for financial support and investment. This work comprised Phase I of the CHINOOK project.

A total of 43 tests were performed with the CHINOOK TST from March 2006 to April 2007 in Ottawa and Smiths Falls, Ontario. All tests were performed on a JetStar wing test bed provided by the TDC. This work comprised Phase II of the CHINOOK project (APS file CM2003.002), and it resulted in the development of a technical report for CHINOOK entitled *Evaluation of the Chinook Tempered Steam Technology for Aircraft Deicing Applications*.

In August 2007, APS conducted Phase III activities to continue the evaluation of the TST for aircraft deicing applications. This included deicing tests on an operational aircraft.

## 9.4 Overall Project Objectives for 2007-2008

In the winter of 2008, APS undertook a research and development project, in conjunction with TC, to further evaluate the use of tempered steam for aircraft deicing applications. The focus of this testing was to conduct deicing tests with the TST on operational aircraft.

APS requested the participation of DND and CF to provide two operational aircraft. Through discussion, it was proposed that the following tests be conducted:

- Frost Testing on a Bell CH-146 Griffon Helicopter (March 17-20, 2008; Petawawa); and
- Frost Testing on a Bombardier CC-144 Challenger Aircraft (March 25-28, 2008; Ottawa).

## 9.5 Methodology (Equipment, Procedures, and Personnel Requirements)

The following subsections describe the experimental methodology used to test the CHINOOK TST on operational aircraft.

### 9.5.1 General Methodologies

The CHINOOK TST is a unique innovation that employs steam-infused air to melt contaminants on aircraft surfaces and hot air to dry residual water created by the deicing process.

Currently, two delivery platforms are available for CHINOOK testing:

- Research and development unit (RDU) (Subsection 9.5.2); and
- Operational prototype (Subsection 9.5.3).

During deicing tests, only the RDU was available. At the time of testing, the operational prototype had not been introduced for testing; however, the following subsections describe both delivery platforms.

### 9.5.2 Research and Development Unit

The RDU was the first-generation truck-mounted TST system. The RDU was introduced for testing purposes in March 2007. Although not a suitable platform for operational deicing activities, the RDU allowed for improved mobility in comparison

to the proof-of-concept delivery platform that had been employed for preliminary work to assess the aircraft deicing capabilities of the TST in 2006-07. The boiler apparatus, boom assembly, and delivery head assembly were manufactured directly onto the RDU, allowing the vehicle to be entirely self-contained, without any additional infrastructure.

Due to the late arrival of the first TST operational prototype in April 2008, the RDU was employed for most testing performed in the winter of 2008.

### **9.5.3 Operational Prototype**

The second-generation truck-mounted system, also known as the operational prototype, was introduced for testing in April 2008. Built on a deicing vehicle chassis, the prototype was a major advancement in comparison to the previous RDU and offered vastly improved manoeuvrability and output capabilities.

### **9.5.4 Delivery Heads**

Tempered steam and hot air were applied to the test surface using a specially designed delivery head. The delivery head is a lightweight air blanket that is perforated to allow for an even distribution of tempered steam and hot air across the test surface. In addition to providing the tempered steam and hot air for deicing and drying, the delivery head provides the containment necessary to allow the tempered steam and hot air to work.

### **9.5.5 Description of Aircraft**

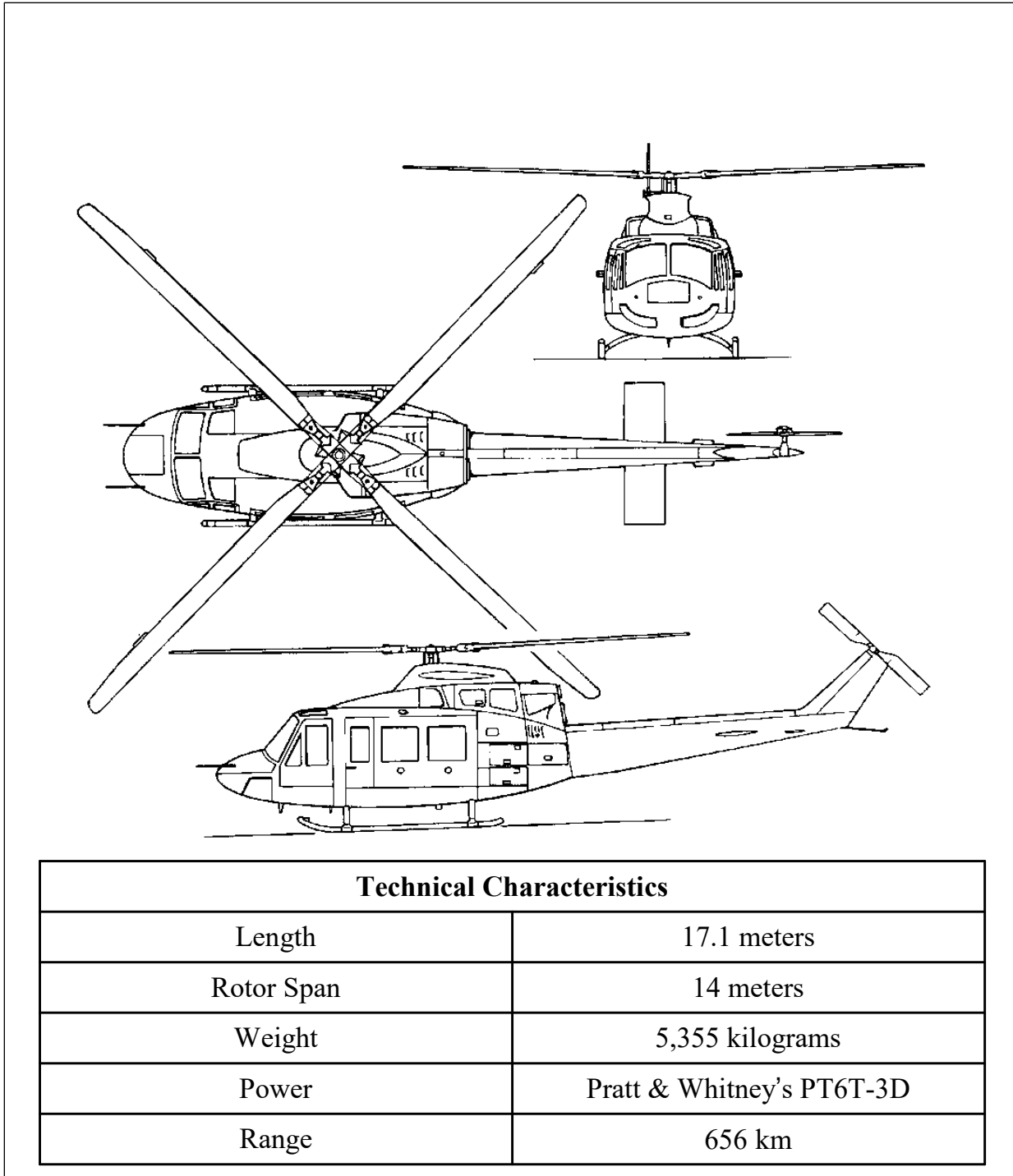
An operational Bell CH-146 Griffon Helicopter was used during frost tests conducted on March 17-20, 2008. An operational Bombardier CC-144 Challenger Aircraft was scheduled for frost testing on March 25-28, 2008.

#### *9.5.5.1 Bell CH-146 Griffon Helicopter*

The Bell CH-146 Griffon is a utility transport tactical helicopter used primarily for search and rescue missions, tactical transport, and humanitarian relief operations. Figure 9.1 shows the technical characteristics of this aircraft.

Pre-flight deicing of helicopters is critical to military readiness. As with fixed-wing aircraft, rotary aircraft are subject to contamination by frost, snow, freezing drizzle, and freezing rain. This can cause icing of rotor blades and fuselages, rendering the aircraft inoperable.

Conventional glycol-based deicing fluids can potentially damage the helicopter rotor and internal components.



**Figure 9.1: Three Views and Technical Characteristics of Bell CH-146 Griffon**

Manual deicing methodologies require a significant amount of time, which can be harmful to the mission readiness of the helicopter. Manual deicing procedures such as scraping and thermal cycling can cause significant damage to the rotors and fuselage components of the helicopter.

The rotor system is made up of a four-blade flex-beam main rotor. The majority of materials used in the construction of each blade are of a composite material. Each blade is made of unidirectional glass fibre with a  $\pm 45^\circ$  wound torque casing of glass fibre cloth. Trailing edges are also of unidirectional glass fibre with spaces between them. These spaces are filled with a Nomex honeycomb core. The entire blade is then bonded together by a glass fibre wrapping with the leading edge protected by a titanium abrasion strip.

The main rotor head is made up of steel and a light alloy.

#### 9.5.5.2 *Bombardier CC-144 Challenger Aircraft*

The CC-144 Challenger, DND and CF's twin-engine, long-range executive jet, offers rapid air transportation for Canadian and international VIPs. Figure 9.2 shows the technical characteristics of this aircraft.

### 9.5.6 Description of Test Procedures

The procedure employed during testing with the CHINOOK TST comprised the following main elements:

- Test condition:
  - Recording of environmental data (Subsection 9.5.6.1);
  - Recording of surface condition and photo documentation (Subsection 9.5.6.2);
- Test observation:
  - Application of tempered steam and hot air (Subsection 9.5.6.3); and
  - Post-deicing verification (Subsection 9.5.6.4).

A procedure was developed and is included in Appendix H.

9.5.6.1 Recording of Environmental Data

Weather information for each test was gathered from several sources:

- Aviation routine weather report (METAR) information from the [www.wunderground.com](http://www.wunderground.com) and [www.navcanada.ca](http://www.navcanada.ca) websites; and
- Environment Canada (EC) hourly updates on the [www.weather.gc.ca](http://www.weather.gc.ca) website.

EC weather data were employed as the primary weather data for all tests.

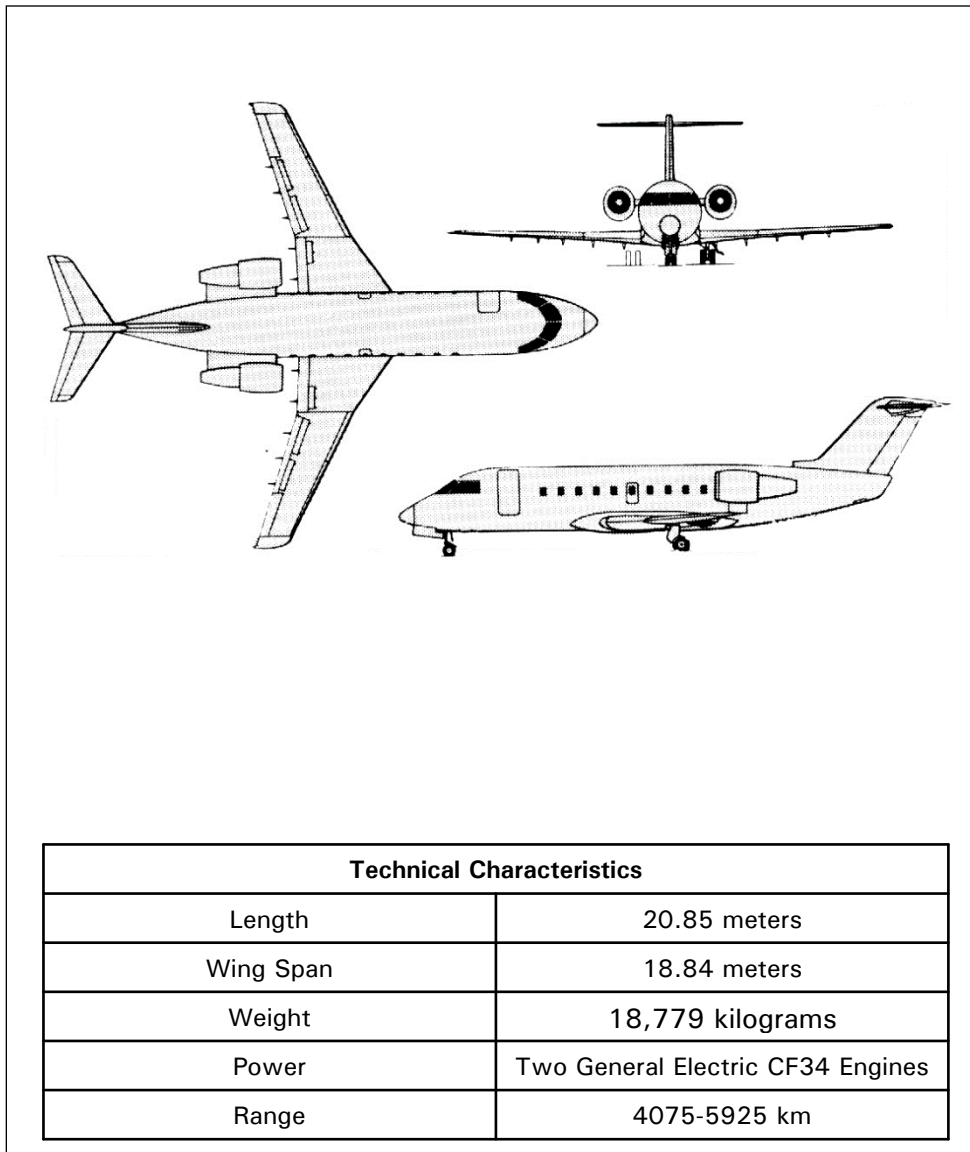


Figure 9.2: Three Views and Technical Characteristics of CC-144 Challenger

#### 9.5.6.2 Recording of Test Surface Condition and Photo Documentation

APS provided photo documentation of all tests. All photos documented in these tests are included in Appendix G.

#### 9.5.6.3 Application of Tempered Steam and Hot Air

The APS project manager was responsible for selecting the type of deicing process for each test (tempered steam, hot air, or both), as well as the exposure time for each process. The exposure time to tempered steam and hot air was determined by APS based on visual monitoring of the surface conditions during testing. When the desired condition was achieved, the end of the test was determined by APS personnel, and the TST system was manoeuvred away from the surface to allow for post-deicing inspection.

#### 9.5.6.4 Post-Deicing Verification

After the completion of the tempered steam and hot air applications, APS personnel completed a thorough examination of all surfaces, including all quiet areas. APS personnel recorded pertinent final test information on data forms, and final post-deicing photo documentation was taken.

#### 9.5.6.5 Temperature Measurement Equipment

Surface temperature profiles during testing with the TST provide valuable information and assist in explaining differences in test results. In previous testing with the TST, surface temperature profiles prior to, during, and after the application of tempered steam and hot air were gathered by thermistors that were affixed to the test surface using an adhesive tape. In discussion with DND and CF, it was decided that no actual temperature equipment would be affixed to any aircraft surfaces. Instead, a non-contact method of surface temperature collection was adopted to ensure no aircraft surface damage occurred. The following type of non-invasive temperature collection equipment was employed during testing:

- *Wahl Temperature Reader and Surface Temperature Probe:* A calibrated surface temperature device was used to manually take readings at pre-defined areas of the test surface. The Wahl Temperature Probe is a hand-held device, and therefore temperature collection was subject only to the individual reach of the individual using the device. To enable more flexibility in recording temperatures using this approach, an extension pole was manufactured by APS personnel to allow for temperature measurement beyond the reach of any individual.

### 9.5.7 Test Sites

All testing on the Bell CH-146 Helicopter was completed at CFB Petawawa, and all testing on the Bombardier CC-144 Challenger was completed at MacDonald–Cartier International Airport (YOW) in Ottawa.

### 9.5.8 Personnel

For all testing on operational aircraft, three APS personnel were employed to perform the various test-related activities. DND and CF were responsible for the positioning of the aircraft. CHINOOK personnel provided general test and equipment support.

## 9.6 Tests on Bell CH-146 Griffon

On March 18 and 19, 2008, APS attempted to coordinate a series of tests to evaluate the TST's defrosting capabilities on a Bell CH-146 Griffon.

The objectives of these tests were as follows:

- Evaluate the TST's ability to defrost rotary-wing aircraft following periods of natural frost;
- Determine the times required to defrost and dry rotary-wing aircraft in natural frost conditions;
- Examine whether or not residual water is created by the application of TST to frost-covered rotary-wing aircraft, and determine whether or not residual water propagates to and accumulates in main rotor assembly, including mast and swash plate assembly;
- Examine the temperature decay profiles of the rotor and rotor blades subjected to TST; and
- Determine procedural requirements and limitations of using TST for defrosting rotary-wing aircraft.

In addition to these, a subsequent test was performed to indicate whether it would be possible to use the TST to remove contamination that may adhere to the internal components of the rotor assembly.

In total, three tests were performed on this aircraft:

- Test #1: Preliminary Test
  - A preliminary test was conducted to identify any procedural limitations in the defrosting of blades and rotor assembly. Ideal truck positioning was also analysed.
- Test #2: Blade Temperature Profile Test
  - A second test was conducted to demonstrate the TST's ability to defrost the blades and rotor assembly of the helicopter. In addition to this, this test provided an examination of the temperature decay profile post deicing.
- Test #3: Internal Components Test
  - A third test was conducted to evaluate the use of hot air forced upward through the lower hatch of the helicopter to remove any contamination in the rotor assembly.

### 9.6.1 Test #1

Test #1 was a preliminary test to identify any procedural limitations in the defrosting of blades and rotor assembly. Optimal positioning was also defined, whereas manual rotation of the entire rotor assembly was needed.

#### 9.6.1.1 General Information

- Date: March 19, 2008
- Start Time of Process: 08:10:00
- End Time of Process: 08:30:00
- Total Exposure Time to Hot Air: 20 minutes<sup>1</sup>

A freezing rain event prior to testing left a significant amount of frozen contamination on both the rotors and blades.

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<sup>1</sup> Both tempered steam and hot air were used. However, the time of each was not recorded. This test was performed primarily as a positioning test.

#### 9.6.1.2 Meteorological Information (Petawawa)

- Time: 08:00:00
- Temperature: 0.5 °C
- Dew Point Temperature: -0.3 °C
- Relative Humidity: 94 percent
- Wind Direction/Speed: NNW, 9 km/h

#### 9.6.1.3 Surface Temperature Measurements

No surface temperature measurements were recorded in this test.

#### 9.6.1.4 Test Observations

Test #1 was a preliminary test to identify any procedural limitations in the defrosting of this helicopter. Optimal positioning for subsequent tests was identified. It became apparent that apron space around the helicopter was limited; therefore, manual rotation of the blades became the most efficient way to perform testing. Moving the truck about the helicopter was identified as a procedural deficiency in defrosting.

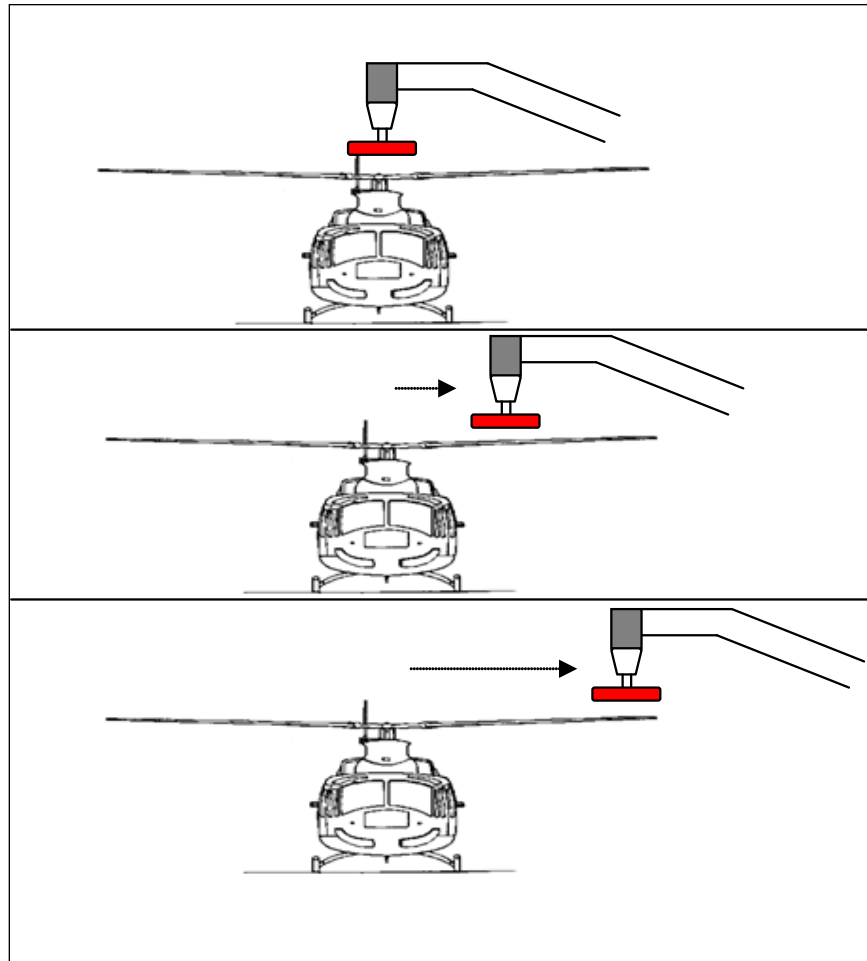
The RDU was employed for Test #1, and it was positioned to the port side of the helicopter. For a starting position, the delivery head was positioned directly over the rotor head, and it was slowly moved outward over each blade. This is depicted in Figure 9.3. Upon completion of a particular blade, the entire rotor was rotated clockwise, leaving the RDU in a static position.

The RDU was equipped with the same delivery head used for aircraft wing surfaces. Due to the much smaller area of the helicopter blade, much of the output of the tempered steam system was wasted. It became evident that a smaller delivery head design would be needed for any future helicopter testing.

As mentioned previously, a freezing rain event had occurred in the early hours before the test. A significant amount of frozen contamination had adhered to both the rotors and blades at the time of deicing. A post-deicing verification found that most of this contamination had been removed.

This test was concluded with some procedural considerations that included, but are not limited to, the following:

- Aircraft positioning is very important to determine the optimal way to deice a rotary-wing aircraft;
- Manual rotation of the blades proved to be an efficient method in deicing helicopter blades, meaning the deicing vehicle should remain static;
- A smaller delivery head should be employed in helicopter deicing.



**Figure 9.3: Depiction of Delivery Head Movement over Blade**

### 9.6.2 Test #2

The objective of Test #2 was to demonstrate the TST's ability to defrost the blades and rotor assembly of the helicopter. In addition to this, this test provided an examination of the temperature decay profile post deicing.

### 9.6.2.1 General Information

- Date: March 19, 2008
- Start Time of Process: 20:50:00
- Start Time of Tempered Steam Application: 20:50:00
- End Time of Tempered Steam Application: 21:05:45
- Start Time of Hot Air: N/A
- End Time of Hot Air: N/A
- Total Exposure Time to Tempered Steam: 15 minutes, 45 seconds
- Total Exposure Time to Hot Air: N/A

### 9.6.2.2 Meteorological Information (Petawawa)

- Time: 20:00:00
- Temperature: 1.4 °C
- Dew Point Temperature: 0.5 °C
- Relative Humidity: 94 percent
- Wind Direction/Speed: NNW, 13 km/h

### 9.6.2.3 Surface Temperature Measurements

The surface temperature profiles recorded for measurement locations on one individual blade are shown in Figure 9.4. At 0 minutes, the delivery head was placed over Position 5 at the tip of the blade and moved towards the rotor assembly.

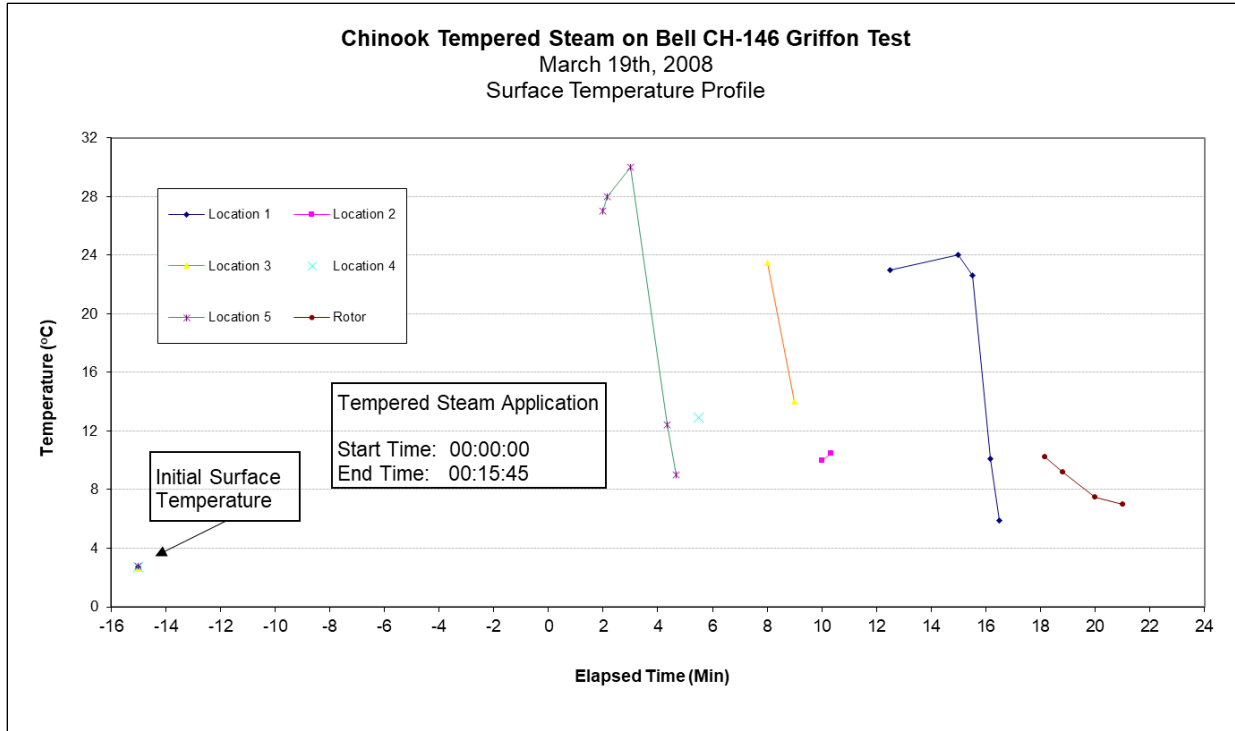


Figure 9.4: Surface Temperature Plot for Test #2

One individual blade was selected to analyse the temperature profile. This blade was divided into six locations for temperature measurement. This included five locations along the actual blade, with the rotor identified as the sixth location. The blade grip portion of the rotor was the actual surface to be examined during temperature measurements. Figure 9.5 depicts the locations used for temperature measurement.

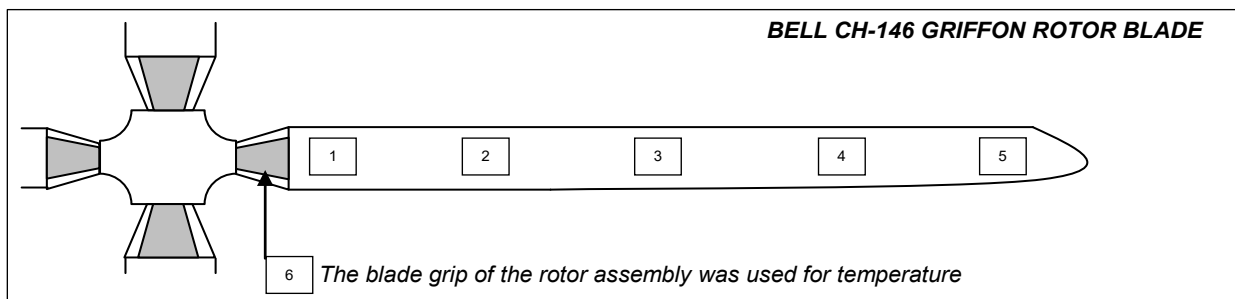


Figure 9.5: Location Setup for Temperature Measurement

9.6.2.4 Test Observations

Test #2 was an examination of the temperature profile of the chosen blade. The RDU was employed for Test #2, and it was positioned to the port side of the helicopter.

This test was run entirely with the tempered steam portion of the system. Hot air was not employed. As can be seen in Figure 9.4, temperatures reached a peak value of between 20°C and 30°C.

As mentioned in the aircraft description (Subsection 9.5.5.1), the blade is made of a composite material. This material by nature has a very low thermal mass. It is for this reason that rapid temperature decay was observed.

### 9.6.3 Test #3

Test #3 evaluated the use of hot air forced upward through the lower hatch of an aircraft to remove any contamination in the rotor assembly.

#### 9.6.3.1 General Information

- Date: March 19, 2008
- Start Time of Process: 21:54:00
- Start Time of Tempered Steam: N/A
- End Time of Tempered Steam: N/A
- Start Time of Hot Air: 21:54:00
- End Time of Hot Air: 22:07:00
- Total Exposure Time to Tempered Steam: N/A
- Total Exposure Time to Hot Air: 13 minutes, 0 seconds

#### 9.6.3.2 Meteorological Information (Petawawa)

- Time: 22:00:00
- Temperature: 1.7°C
- Dew Point Temperature: 0.4°C
- Relative Humidity: 86 percent
- Wind Direction/Speed: NNW, 11 km/h

#### 9.6.3.3 Surface Temperature Measurements

The main internal components of the rotor assembly are depicted in Figure 9.6. The surface temperature measurements of the internal components are shown in Figure 9.7.

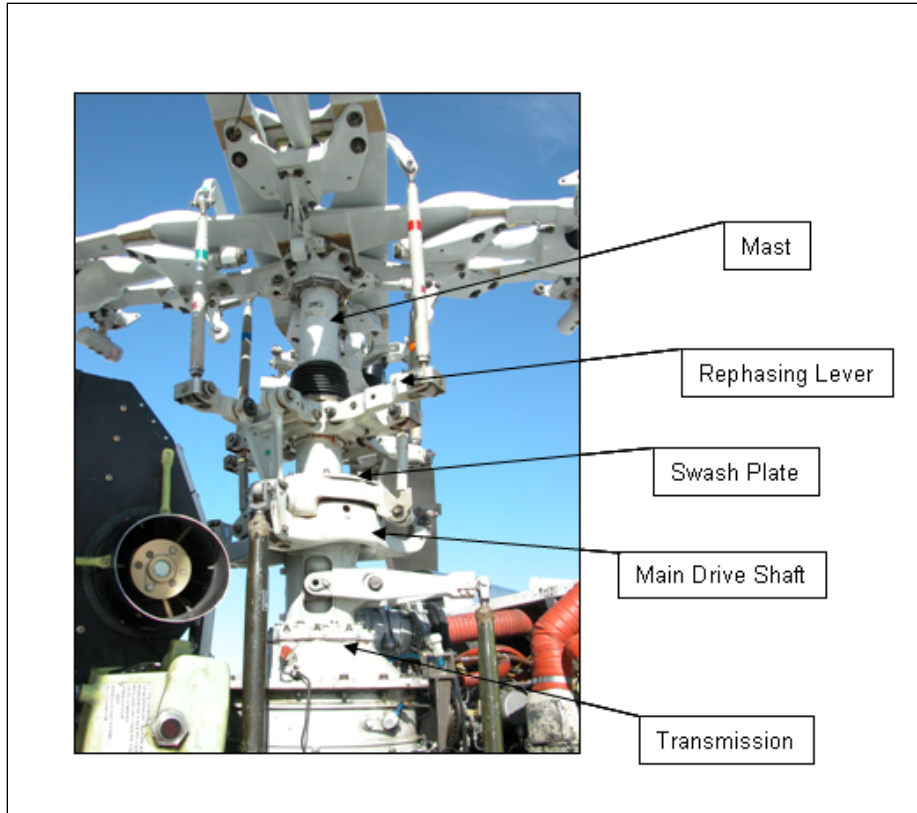


Figure 9.6: Internal Components of Rotor Assembly

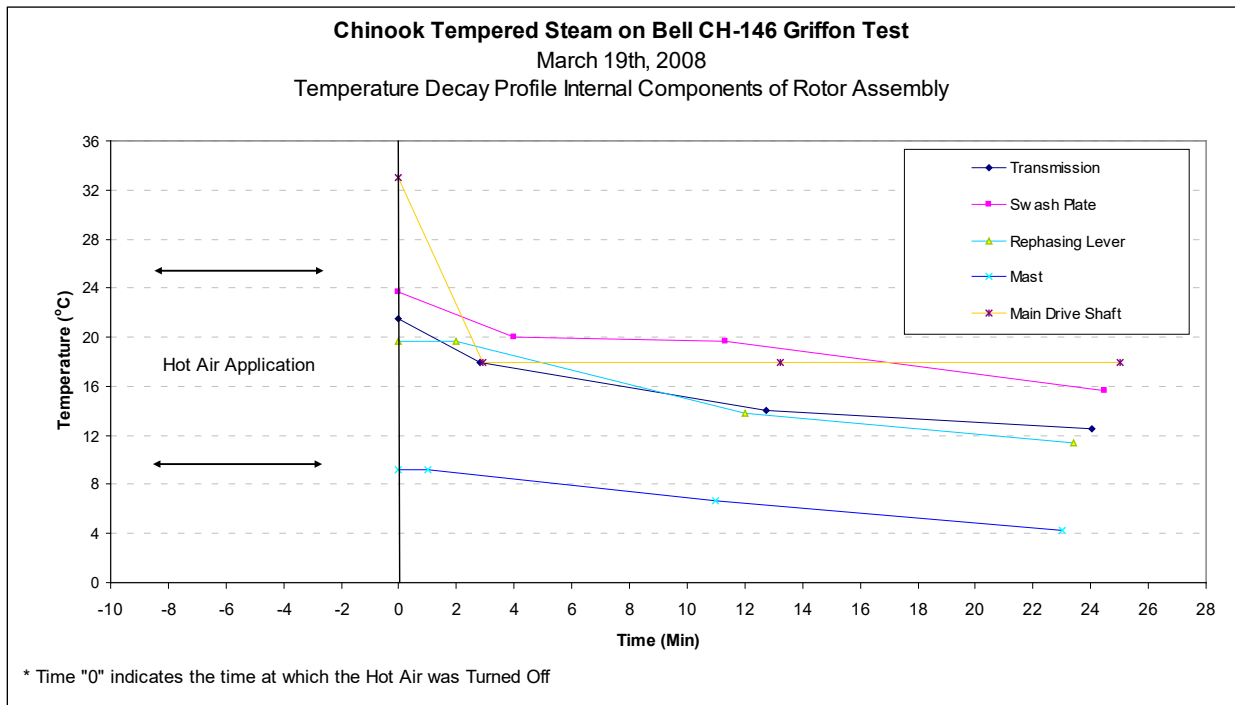


Figure 9.7: Temperature Decay of Internal Components

#### 9.6.3.4 Test Observations

Test #3 provided an examination of the TST's ability to remove any contamination that may accrue on the internal components of the rotor assembly.

For this test, the delivery head of the TST was removed, and the remaining duct portion was fitted to the hatch under the aircraft. Hot air was applied. This allowed for a constant stream of hot air to move vertically through the internal portion of the rotor cavity.

The main objective was to identify how warm the internal components would get and whether this would be sufficient in removing contamination. Hot air was applied for a 13-minute period. At the end of the period, designated internal components were measured at pre-defined intervals. It was concluded that the temperature inside the rotor cavity was well within the range to melt contamination. Figure 9.7 demonstrated that some components reached a high of 33°C. Material type and location of each component had a significant effect on its temperature retention.

### 9.7 Tests on Bombardier CC-144 Challenger Aircraft

Testing on the CC-144 Challenger Aircraft was scheduled for the period March 25-28, 2008. APS coordinated a series of tests to evaluate the TST defrosting capabilities on this aircraft.

Unfortunately, due to mechanical issues with the TST system, these tests had to be postponed. This testing will be proposed for the 2008-09 winter season.

The objective of these tests was as follows:

- Test the TST system on a smaller jet aircraft;
- Determine time required to defrost an aircraft of this size;
- Examine whether or not residual water is created by the application of TST to frost-covered aircraft, and determine whether or not residual water propagates to and accumulates in control surfaces of the aircraft;
- Examine temperature decay profiles; and
- Determine procedural requirements and limitations of using TST for defrosting.

APS proposed to conduct tests during 2-3 overnight periods. In preparation for this testing, APS developed a procedure (Appendix H) and provided planning and logistical support.

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## 10. IMPLEMENTATION OF HOLDOVER TIME DETERMINATION SYSTEMS

### 10.1 Background

Holdover Time Determination Systems (HOTDS) are designed for implementation at airports and to record measurements of the weather conditions at pre-determined intervals. The systems would compute the precipitation rate for any given weather condition, thus enabling the determination of a “single-value” fluid Holdover Time (HOT) for any combination of condition, fluid, and temperature. The information could then be relayed electronically to pilots in the flight deck.

In Winter 2005-06, APS Aviation Inc. (APS) was contracted by the Transportation Development Centre (TDC) to examine implementation issues with HOTDS.

In February 2006, a D-ICE Deicing Information System (DIIS) was installed at the central deicing facility (CDF) at Toronto–Pearson International Airport (YYZ). The system was equipped with radio modems to communicate the electronic system output information from the unit to a computer installed in the CDF Icehouse. The computer was configured to allow WestJet to employ information from the DIIS as an “advisory” tool in winter operations planning. WestJet amended its program to allow for use of the DIIS information, and Transport Canada (TC) approved this amendment.

Consultations were performed with TC, Environment Canada (EC) and NAV CANADA to examine issues of system “certification.” Discussions indicated that the system outputs consist of an operational tool and could be introduced under an Exemption to Canadian Aviation Regulations (CAR). At a meeting in February 2006, it was agreed that a performance-based specification would be developed to permit HOTDS to be operated under an exemption to CAR Standard 622.11.

As part of a previous contract with the TDC, APS prepared and submitted the following draft documents to TC:

1. Draft Exemption document from Sections 3.0, 6.0, 6.2, and 6.3 of Canadian Aviation Regulations Standard 622.11;
2. Draft Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems; and
3. Draft Assessment Paper Regarding Exemption from Canadian Aviation Regulations Standard 622.11, Sections 3.0, 6.0, 6.2, and 6.3.

It was recommended that TC initiate the process for implementation of the Exemption to CAR Standard 622.11 to enable operational use of HOTDS. APS submitted an interim report to TC, outlining the development and implementation of a performance specification and Exemption to CAR Standard 622.11.

## 10.2 Project Objectives

Appendix A contains the Statement of Work. It states that the HOTDS's ability to compute "single-value" fluid HOTS should be evaluated. It also states that consultations and proposed strategies concerning the system's implementation issues and obstacles should be conducted. Based on these consultations, an update to the exemption document shall be developed.

## 10.3 Project Activities

The version of the Draft Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems document that was included in an interim report, which was considered to be preliminary in nature, and further refinements would be required prior to publication.

A HOTDS's ability to compute "single-value" fluid HOTS is greatly dependent on the system's ability to compute an accurate precipitation rate. To this end, data collected from the APS evaluation of the DIIS at Montreal-Trudeau International Airport (YUL) were employed to provide support for the refinements to the document Draft Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems. This issue will be addressed in Subsection 10.4.2.

APS met with TC officials on several occasions in Ottawa to discuss issues related to the document Draft Exemption and Draft Minimum Assurance Requirements and Performance Specifications. During these meetings, pertinent details to be included within the amended documentation were discussed and decided upon, and issues related to HOTDS implementation issues and obstacles were addressed. Final versions of these documents were submitted to TC for legal review and oversight in February 2007.

In March 2007, the Exemption from Subsection 602.11(4) of the Canadian Aviation Regulations and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 Ground Icing Operations was signed by the TC Director of Standards. This exemption allowed WestJet to employ the HOTDS outputs for use in winter planning and operations. APS submitted a TC report, TP 14781E, *Aircraft Ground Icing General Research Activities During the 2006-07 Winter* (5), which contained details related to the development of the amended Minimum Assurance Requirements and Performance Specifications for HOTDS.

The original release of the HOTDS Exemption was March 30, 2007, and was due to expire in April 2009. After the original release of the Exemption, WestJet and D-ICE undertook activities to demonstrate the compliance of the DIIS with requirements and conditions contained in the Exemption. As a result of these activities and inputs from APS, a number of corrections (some editorial, some technical in nature) were required to the Exemption. A revision of the Exemption from Subsection 602.11(4) of the Canadian Aviation Regulations and Sections 1.0, 3.0, 6.0, 6.2, 6.3, and 7.1.1.1 of Standard 622.11 Ground Icing Operations was issued on December 21, 2007. This report only contains information related to the development of the revised documentation that was signed by TC in December 2007. This document has been provided in Appendix I.

## 10.4 Revision of the HOTDS Documentation

A revision of exemption from Subsection 602.11(4) of the Canadian Aviation Regulations and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 Ground Icing Operations was issued in December 2007 to reflect the modifications to the following sections:

- Conditions;
- Precipitation Rate; and
- Holdover Time Determinations.

### 10.4.1 Conditions

In Condition 9, “cautions” was added to the list of items that must be adhered to unless superseded by this exemption. An example was added: a note on lowest operational use temperature (LOUT), which is found in HOT Guidelines. The change is defined as follows:

9. Except where superseded in this exemption, all notes, cautions, conditions, lists of qualified fluids and application procedures contained in the Holdover Time Guidelines, published by Transport Canada, on an annual basis shall continue to apply (for example, respecting the de/anti-icing fluid Lowest Operational Use Temperature (LOUT)).

### 10.4.2 Precipitation Rate

Subsection 5.1.7 of Appendix C has been modified to exclude freezing fog from rate pan measurements. In Subsection 5.1.8, tolerances were modified based on statistical assessment of realistically achievable tolerances given current technologies. The paragraph from Subsection 5.1.10 was split up to clarify intent. The changes are defined as follows:

5.1.7 Precipitation rate measurements shall be analyzed in reference to simultaneously recorded glycol pan measurements for all precipitation types, excluding freezing fog.

5.1.8 The Holdover Time Determination System precipitation rate measurements shall conform to the glycol pan measurements (ref.: SAE ARP 5485), within the following tolerances:

- a) From 0 to 10 g/dm<sup>2</sup>/h: +/- 3.0 g/dm<sup>2</sup>/h
- b) Above 10 g/dm<sup>2</sup>/h to 25 g/dm<sup>2</sup>/h: +/- 6.0 g/dm<sup>2</sup>/h
- c) Above 25 g/dm<sup>2</sup>/h: +/- 14.0 g/dm<sup>2</sup>/h

5.1.10 The precipitation rate input for the purpose of computing fluid holdover time (Subsections 5.1.12 to 5.1.18) shall be:

- a) the precipitation rate determined by the HOTDS; plus
- b) the tolerance (within a 95% confidence level) that has been demonstrated for each precipitation type and range in 5.1.8, specific to that HOTDS.

### 10.4.3 Holdover Time Determinations

Numerous changes were made to the HOTDS section. The changes were made to the following subsections:

- Subsection 5.1.12: Changes were made to clarify that the TDC does not generate regression curves or coefficients; rather, these are obtained or published by TC;
- Subsection 5.1.14: A new paragraph was added to ensure that when the manufacturer implements the regression equation, it is correctly coded and implemented. The thought is that the manufacturer will run through a set of known inputs and outputs and compare these with their system outputs;

- Subsection 5.1.15: A new paragraph was added because it is understood that current freezing precipitation detectors have a difficult time differentiating between freezing drizzle or freezing rain, and this approach provides a conservative solution to that problem. Furthermore, it minimizes extrapolation errors;
- Subsection 5.1.16: A new paragraph was added because there is no test data available from HOT evaluation testing above 25 g/dm<sup>2</sup>/h and it was not felt appropriate to extrapolate into a region where there is no data to support the extrapolation;
- Subsection 5.1.17: A new paragraph was added because there is insignificant test data available from HOT evaluation testing above 50 g/dm<sup>2</sup>/h and it was not felt appropriate to extrapolate into a region where there is insufficient data to support the extrapolation;
- Subsection 5.1.18: A new paragraph was added because there is no test data available from HOT evaluation testing above 75 g/dm<sup>2</sup>/h and it was not felt appropriate to extrapolate into a region where there is no data to support the extrapolation; and
- Subsection 5.1.20: A new paragraph was added to ensure that all notes, conditions, and cautions applicable to the annually published HOT Guidelines shall be respected, in the computation of HOTs using a HOTDS.

The changes are defined as follows:

5.1.12 The HOTDS shall incorporate the most current regression curves and associated coefficients. These regression curves and associated coefficients are:

5.1.12.1 those obtained from or published by TC, or

5.1.12.2 those where traceability and validity has been demonstrated to be equivalent to those in 5.1.12.1.

5.1.14 Holdover Time Determinations from the system, shall be verified, for each fluid, against known fluid dilution, precipitation type, rate and temperature inputs to ensure that regression curves and associated coefficients have been correctly implemented within the system.

As a minimum this verification will include:

- 5.1.14.1 normal range test cases; and
- 5.1.14.2 test cases outside the normal range to verify robustness.

5.1.15 Holdover Time Determinations for Freezing Drizzle or Freezing Rain conditions shall be based on computing the associated Holdover Time for each one of those precipitation conditions and using the resulting lowest value.

5.1.16 Holdover Time Determinations shall be inhibited in Freezing Precipitation (Freezing Fog, Freezing Drizzle or Freezing Rain) conditions exceeding of  $25 \text{ g/dm}^2/\text{h}$ .

5.1.17 Holdover Time Determinations shall be inhibited in Snow conditions exceeding  $50 \text{ g/dm}^2/\text{h}$ .

5.1.18 Holdover Time Determinations shall be inhibited in Rain on Cold-Soaked Wing conditions exceeding  $75 \text{ g/dm}^2/\text{h}$ .

5.1.20 Where applicable, the notes, conditions, cautions incorporated into the annually published holdover time guidelines shall be respected in computation outputs by the HOTDS.

## 11. 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 2007-08.

### 11.1 Procedures

Several procedures were developed to guide and support the research team in the methodology for conducting tests. Table 11.1 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.

### 11.2 Presentations

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

In 2007-08, the following meetings were held:

- a) SAE 2007 Aircraft & Engine Icing International Conference, Seville, Spain, September 24, 2007;
- b) Standing Committee Meeting, Winnipeg, Manitoba, October 10, 2007;
- c) SAE G-12 HOT Subcommittee and HOT Work Group Meetings, Montreal, Canada, November 2007;
- d) SAE G-12 HOT Subcommittee, Warsaw, Poland, May 2008; and
- e) SAE G-12 HOT Subcommittee and HOT Work Group Meetings, Montreal, Canada, November 2008.

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

### **11.2.1 SAE 2007 Aircraft & Engine Icing International Conference, Seville, Spain, September 24, 2007**

Two presentations were prepared for the SAE 2007 Aircraft & Engine Icing International Conference, Seville, Spain, held on September 24, 2007:

- 1) Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
- 2) Implementation of Holdover Time Determination Systems.

### **11.2.2 Standing Committee Meeting, Winnipeg, Manitoba, October 10, 2007**

Two presentations were prepared for the Transport Canada Standing Committee for Operations under Icing Conditions meeting in Winnipeg, Manitoba, held on October 10, 2007:

- 1) Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
- 2) De/Anti-Icing Fluid Holdover Time Update, 2007/08 Winter Operations.

### **11.2.3 SAE G-12 HOT Subcommittee Meeting, Montreal, Canada, November 14, 2007**

Three presentations were prepared for the SAE G-12 HOT Subcommittee meeting in Montreal on November 14, 2007:

- 1) Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions;
- 2) Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
- 3) Implementation of Holdover Time Determination Systems into Canadian Air Operations, Update for 2007-08 Operations.

#### **11.2.4 SAE G-12 HOT Subcommittee Meeting, Warsaw, Poland, May 14, 2008**

Seven presentations were prepared for the SAE G-12 HOT Subcommittee meeting in Warsaw on May 14, 2008:

- 1) Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2007-08 Winter Test Season;
- 2) Aircraft Ground De/Anti-Icing Research Using Composite Materials;
- 3) Substantiation of Aircraft Ground De/Anti-Icing Holdover Times in Frost Conditions;
- 4) Answers to AEA De/Anti-Icing Working Group Questions (prepared but not presented);
- 5) Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets;
- 6) Aircraft Ground De/Anti-Icing Fluid Endurance Times in Snow Pellet Conditions; and
- 7) Implementation of Holdover Time Determination Systems.

#### **11.2.5 SAE G-12 HOT Subcommittee Meeting, Montreal, Canada, November 14, 2008**

Six presentations were prepared for the SAE G-12 HOT Subcommittee meeting in Montreal on November 14, 2008:

- 1) Proposed Changes to Frost HOT Guidelines;
- 2) Examination of Effect of Heat on Endurance Times of Anti-Icing Fluids;
- 3) Holdover Times Below -25°C for Anti-Icing Fluids;
- 4) Holdover Times in Conditions of Rain mixed with Snow;
- 5) Preparation of Holdover Time Guidelines Regression Coefficient Data; and
- 6) Holdover Time Guidelines Update Fall 2008.

### **11.3 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 (HOT) use in the industry, while the remaining data is maintained by the fluid manufacturers for research purposes.

During the 2007-08 winter, 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 fluids:

- a) ABAX F292 (Type IV);
- b) Clariant Safewing MP II Flight Hard Water Dilutions (Type II);
- c) Clariant Safewing MP III (Type III);
- d) Dow Research Fluids (three fluids);
- e) Kilfrost ABC-K Plus (Type II);
- f) Kilfrost P2143-2 (Type II); and
- g) Aviation Xi'an KHF-II (Type II).

The reports for the fluids that were qualified in the winter of 2007-08 have also been included as appendices in TP 14869E (3).

**Table 11.1: List of Procedures for Winter 2007-08**

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
7.2.2	5.1	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Simulated Freezing Precipitation Flat Plate Testing	15-Jan-04	1.0	HOT
7.2.2	5.2	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing	23-Dec-04	1.0	HOT
7.2.2	5.3	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Endurance Time Test Requirements for Simulated Snow Flat Plate Testing	21-Jan-08	1.1	SIMULATED SNOW
7.2.2	5.4	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Overall Program of Tests at NRC, March-April 2008	31-Mar-08	1.0	HOT, EFFECT OF HEAT
7.2.2	5.5	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval	14-Dec-07	1.0	HOT
7.2.2	5.6	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Adhesion of Aircraft De/Anti-Icing Fluids on Aluminum Surfaces During Mixed Precipitation Conditions Snow and Rain	31-Mar-08	1.0	GENERAL & EXPL.
7.2.2	5.7	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Overall Program of Tests at NRC, July 2008	03-Jul-08	1.0	HOT
7.2.3	6.1	Variance and New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker	Development of Type I Protocol for Indoor Snow (ARP 5945)	21-Jan-08	1.0	SIMULATED SNOW
7.2.4	6.2	Variance and New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker	Variance and New De/Anti-Icing Fluids Endurance Time Testing with Snowmaker	15-Jan-08	1.0	SIMULATED SNOW

**Table 11.1: List of Procedures for Winter 2007-08 (cont'd)**

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
7.2.4	7.1	Evaluation of Endurance Times in Heavy Snow	Determination of Test Plate Temperature in Heavy Snow	20-Dec-06	1.0	SIMULATED SNOW
7.2.4	7.2	Evaluation of Endurance Times in Heavy Snow	Fluid Testing with Heavy Snow from Snow Machine in Comparison with Natural Snow	21-Jan-08	1.0	SIMULATED SNOW
7.2.4	7.3	Evaluation of Endurance Times in Heavy Snow	Operational Data Collection During Heavy Snow Precipitation Conditions	19-Dec-06	1.0	SIMULATED SNOW
7.2.5	8.1	Endurance Time Testing in Frost – Type I/II/III/IV Fluid	Endurance Time Testing in Frost	13-Nov-03	1.0	FROST
7.2.5	8.2	Endurance Time Testing in Frost – Type I/II/III/IV Fluid	Photographic Documentation of Frost Formations	17-Feb-05	2.0	FROST
7.2.6	9.1	Endurance Time Testing on Non-Aluminum Plates	Type I Endurance Time Testing on Non-Aluminum Leading Edge Thermal Equivalent Boxes - Natural Snow	17-Nov-06	1.0	COMPOSITE
7.2.7	10.1	Effect of Heat on Neat/Diluted Type II/III/IV Endurance Times	Experimental Program: Effect of Heat on Endurance Times of Anti-Icing Fluids	04-Nov-05	1.0	EFFECT OF HEAT
7.3.3	13.1	Flow of Contaminated Fluid from Aircraft Wings During Takeoff	Falcon 20 Trials to Examine Fluid Removed from Low Rotation Aircraft During Takeoff in Simulated Conditions with Ice Pellets, Snow and/or Freezing Rain	22-Feb-08	2.0	ICE PELLET
7.6.1	19.1	Evaluation of Tempered Steam Deicing	Evaluation of Tempered Steam Deicing for Deicing Operational Aircraft CH-146 Griffon, CC-144 Challenger	31-Mar-08	1.0	GENERAL & EXPL.

## REFERENCES

1. Ruggi, M., *Aircraft Deicing Research in Natural and Simulated Ice Pellet Conditions*, APS Aviation Inc., Transportation Development Centre, Montreal, January 2007, TP 14713E, 104.
2. 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>
3. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2008, TP 14869E, 78.
4. Chaput, M., Posteraro, D., Youssef, D., *Evaluation of Tempered Steam Technology (TST) for Aircraft Deicing Applications*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2007, TP 14780E, XX (to be published).
5. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2006-07 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, January 2008, TP 14781E, 30.

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**APPENDIX A**

**TRANSPORTATION DEVELOPMENT CENTRE  
WORK STATEMENT EXCERPT  
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2007-08**



**TRANSPORTATION DEVELOPMENT CENTRE  
WORK STATEMENT EXCERPT  
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2007-08**

**7.1 Winter Research**

**7.1.2 Holdover Time Determination System Exemption and Evaluation of  
“Holdover Time”**

- a) DIIS Implementation Issues and Obstacles:
  - i) Conduct consultations with Canadian air carriers, airport authorities, and deicing service providers to examine and identify potential system implementation obstacles and issues;
  - ii) Propose strategies to resolve any concerns that arise from this activity;
  - iii) Revise performance standard exemption as required; and
  - iv) Report the findings.
- b) De/Anti-Icing Fluid Holdover Time Table Implications:
  - i) Evaluate the DIIS’ ability to compute “single-value” fluid holdover times based on recorded DIIS measurements of precipitation rate, precipitation type and temperature;
  - ii) Examine the implications on air carrier operations, and therefore on air carrier deicing programs, of moving to “single-value” or extended fluid holdover times based on DIIS measurements;
  - iii) Examine the implications on regulatory guidance material and policies of moving to “single-value” or extended fluid holdover times based on DIIS measurements; and
  - iv) Report the findings.
- c) Evaluation of “Holdover Time” Resulting from Implementation of HOT Determination Systems:
  - i) Review current methodology used by pilots to determine holdover times; and
  - ii) Develop methodology to determine most appropriate way to communicate check times to pilots from data generated by a Holdover time determination system.

### **7.1.3 Survey of Deicing Operations in Freezing Rain and Freezing Drizzle**

- a) Develop a user-friendly questionnaire from the draft document provided by Transport Canada;
- b) Distribute the questionnaire using an anonymous web-based platform to conduct the survey;
- c) Collect the results;
- d) Follow up with non-responders to ensure the best possible response rate;
- e) Compile questionnaire results into a database; and
- f) Provide a summary of the results.

## **7.2 Fluid Performance Research**

### **7.2.3 Variance and New De/Anti-icing Fluids Endurance Time Testing with Snowmaker**

- e) Evaluation of Endurance Times for Snow Pellets, Preliminary Investigation:
  - i) Carry out comparative tests with two fluids (EG106 and ABC-S PLUS) between snow pellets and snow; and
  - ii) Conduct these tests at one intensity and one temperature.

### **7.2.8 Exploratory Research and Standards**

- a) Provide support to modifying and updating ARP 5485;
- b) Further develop, advance and ballot, as required, SAE Aerospace Recommended Practice ARP 5945 for Type I fluids;
- c) Develop and acquire LOU data (aerodynamic acceptance) for the currently qualified fluids for the high and low speed ramps at the maximum dilution. Provide this information to the FAA and TC for their consideration for inclusion in the HOT guidelines;
- d) Support the development of the inclusion of results from compatibility and environmental tests of AMS 1424 and 1428 in the TC/FAA list of approved fluids;
- e) Support activities of SAE G-12 Field Viscosity Workgroup;
- f) Support activities of SAE G-12 Dry-Out Workgroup; and

- g) 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:
- Review of the usage of infrared heat with Type I and Type II/IV fluids;
  - Dispersion of fluids on airport surfaces;
  - Hot water deicing;
  - Infrared system development for northern climates; and
  - Ice phobic materials (effect on Type IV's).

## 7.5 Sensors Research

### 7.5.1 Support for Development of Advisory Circular for ROGIDS

- a) Participate in several joint internal meetings held by the FAA and Transport Canada to develop Advisory Circulars for potential ROGIDS use.

## 7.6 Environment Research

### 7.6.1 Evaluation of Tempered Steam Deicing

- i. **Tempered Steam Testing *with DND Fixed and Rotary Wing Aircraft***
- a) Evaluate existing deicing technology available for aircraft critical surface;
  - b) Monitor testing activities conducted using the TST for aircraft critical surfaces tests;
  - c) Evaluate applicability of technology to current deicing operations; and
  - d) Report on the findings and present, as required, the results at the industry meetings.

## **7.7 Research Information Dissemination**

### **7.7.1 Provision of Support Services and other Activities**

- a) Provide support services to assist TDC with testing, refining data and reporting;
- b) Present findings and prepare reports on each activity described herein; and
- c) Consider the following program elements in the event that several of the other program elements do not materialize and therefore funds become available.

### **7.7.2 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 2008 for use in winter of 2008-09; and possibly any other updates.

### **7.7.5 Update: Regression Coefficients Used to Develop Holdover Times**

- a) Further review contents of interim report;
- b) Conduct additional verification and validation analysis;
- c) Update report with any additional data collected in 07/08; and
- d) Prepare final report.

### **7.7.6 Feasibility: Implementation of Centre of Excellence for Deicing Research**

- a) Develop possible settings for creating centre of excellence for deicing research;
- b) Analyze the feasibility of these settings;
- c) Establish and attend meetings with industry key players and discuss these scenarios; and
- d) Apply ideas and the results of these discussions.

**APPENDIX B**

**FREEZING RAIN AND FREEZING DRIZZLE SURVEYS**



**AIR OPERATOR SURVEY (604)**



# Air Operator Survey on Take-offs in Freezing Rain and Freezing Drizzle

Administered by APS Aviation Inc. on behalf of Transport Canada

Transport Canada has initiated a Working Group to better understand the current operational practice of take-off during freezing drizzle and/or freezing rain conditions. This survey forms part of an assessment of the current situation and is being conducted in an effort to determine whether safety can be improved in this area.

Your participation in this survey, as an air operator, will assist Transport Canada in determining whether additional guidance material, further interpretation of regulations and standards and/or additional regulations and standards are required in the area of take-off in these conditions. Transport Canada is also taking this opportunity to collect information related to take-off during conditions of ice pellets.

A similar survey is being distributed to pilots to better understand their perspective and concerns in this area.

**NOTICE OF CONFIDENTIALITY:** *This survey is being administered by an independent third party on behalf of Transport Canada. Your responses are anonymous and can not be linked to you in any way.*

**SURVEY INSTRUCTIONS:** Please answer the questions that follow by clicking on the circle/box next to the appropriate response(s). Once you have answered all questions on a page, click on the "next" arrow to go to the following page. You can go back to a previous question at any time by clicking the "back" arrow. It will take approximately 7 to 9 minutes to complete the survey.

To start the survey click on the "next" arrow below.

*Note: Some browsers may time out if the survey is left idle for more than 10 minutes. If this happens, press the refresh button on your browser to resume.*

**1. Does your company conduct operations in icing conditions?**

- Yes
- No

**2. What type(s) of operation does your company conduct?**

- 604 Private Operator Transportation
- Other (specify below)

**3. Does your company have an Approved Ground Icing Program?**

- Yes
- No

**CAR 605.30 states the following:** *No person shall conduct a take-off or continue a flight in an aircraft where icing conditions are reported to exist or are forecast to be encountered along the route of flight unless:*

*(a) the pilot-in-command determines that the aircraft is adequately equipped to operate in icing conditions in accordance with the standards of airworthiness under which the type certificate for that aircraft was issued; or*

*(b) current weather reports or pilot reports indicate that icing conditions no longer exist*

**4. Does your company believe that, with respect to CAR 605.30, the standards of airworthiness applicable to the aircraft types operated allow for take-off in the following conditions:**

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**5. Are you aware that current aircraft type certification requirements do not consider take-off operations in freezing drizzle and freezing rain conditions?**

- Yes
- No

**6. Does your company differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, +FZRA or PL?**

- Yes
- No

**7. Does your company permit/allow take-offs in the following conditions?**

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

You will now be routed to the appropriate questions based on your previous responses.

**8. Does your company place any special restrictions on take-offs in the following conditions:**

	Yes	No	Not Applicable
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**9. During active ground icing events, which include active frost, freezing fog, snow, freezing drizzle, freezing rain, ice pellets, etc., what percentage of your company's take-offs occur in the following conditions?**

	0%	>0 to 2%	>2 to 4%	>4%	Statistics Not Recorded
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light Freezing Rain (-FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate Freezing Rain (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy Freezing Rain (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice Pellets (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**11. Have you observed situations where your company has halted operations while other companies have not?**

- Yes
- No

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

- Different Aircraft Types
- Different Company Policies
- Unaware of Risks
- Other (specify below)
- Don't Know

**13. Is your company familiar with the following guidance material related to the subject matter of this survey:**

	Yes	No
TP 14052 (Guidelines for Aircraft Ground - Icing Operations)	<input type="radio"/>	<input type="radio"/>
HOT Guidelines	<input type="radio"/>	<input type="radio"/>
CBAAC 130	<input type="radio"/>	<input type="radio"/>
Airworthiness Notice D008 edition 1	<input type="radio"/>	<input type="radio"/>

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

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

**15. Does your company recommend any of the following special procedures after de/anti-icing and before take-off during the conditions specified below?** (check any/all that apply)

	Additional visual inspection prior to taxi	Additional tactile inspection prior to taxi	Additional visual inspection prior to take-off	Additional tactile inspection prior to take-off	No Special Procedures Recommended	Takeoff not Authorized in this Condition
Freezing Drizzle (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light Freezing Rain (-FZRZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate Freezing Rain (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy Freezing Rain (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice Pellets (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

- Safety Management Review
- Risk Assessment
- Other (specify below)
- None

**17. Do the manufacturers of the aircraft types operated by your company provide specific limitations or restrictions with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**18. Do the manufacturers of the aircraft types operated by your company provide specific guidance with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (IP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**20.** Do your pilots have access to a flight planning department?

- Yes
- No

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

- Yes
- No

Comments:

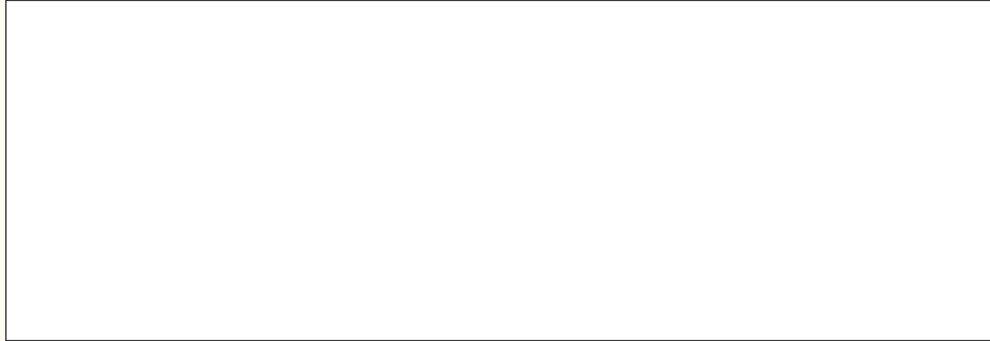
**22.** Do your pilots have an operations manager or chief pilot available immediately for guidance when operating in freezing drizzle, freezing rain and ice pellet conditions?

- Yes
- No

Comments:

**23.** Please list the principle aircraft types operated by your company. *(This question is optional. Answers will be used for classification purposes only.)*

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



Thank you for participating in this survey. Your confidential responses will assist Transport Canada in determining appropriate guidance material in this area.

To [submit your survey](#) please click on the "submit" arrow below. When your survey has been successfully received, you will be directed to the Transport Canada website.

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**AIR OPERATOR SURVEY (702-705)**



## Air Operator Survey on Take-offs in Freezing Rain and Freezing Drizzle

Administered by APS Aviation Inc. on behalf of Transport Canada

Transport Canada has initiated a Working Group to better understand the current operational practice of take-off during freezing drizzle and/or freezing rain conditions. This survey forms part of an assessment of the current situation and is being conducted in an effort to determine whether safety can be improved in this area.

Your participation in this survey, as an air operator, will assist Transport Canada in determining whether additional guidance material, further interpretation of regulations and standards and/or additional regulations and standards are required in the area of take-off in these conditions. Transport Canada is also taking this opportunity to collect information related to take-off during conditions of ice pellets.

A similar survey is being distributed to pilots to better understand their perspective and concerns in this area.

**NOTICE OF CONFIDENTIALITY:** *This survey is being administered by an independent third party on behalf of Transport Canada. Your responses are anonymous and can not be linked to you in any way.*

**SURVEY INSTRUCTIONS:** Please answer the questions that follow by clicking on the circle/box next to the appropriate response(s). Once you have answered all questions on a page, click on the "next" arrow to go to the following page. You can go back to a previous question at any time by clicking the "back" arrow. It will take approximately 7 to 9 minutes to complete the survey.

To start the survey click on the "next" arrow below.

*Note: Some browsers may time out if the survey is left idle for more than 10 minutes. If this happens, press the refresh button on your browser to resume.*

**1. Does your company conduct operations in icing conditions?**

- Yes
- No

**2. What type(s) of operation does your company conduct? (check all that apply)**

- 702 Aerial Work
- 703 Air Taxi Operations
- 704 Commuter Operations
- 705 Airline Operations
- 604 Private Operator Transportation

**3. Does your company have an Approved Ground Icing Program?**

- Yes
- No

**CAR 605.30 states the following:** *No person shall conduct a take-off or continue a flight in an aircraft where icing conditions are reported to exist or are forecast to be encountered along the route of flight unless:*

- (a) the pilot-in-command determines that the aircraft is adequately equipped to operate in icing conditions in accordance with the standards of airworthiness under which the type certificate for that aircraft was issued; or*
- (b) current weather reports or pilot reports indicate that icing conditions no longer exist*

**4. Does your company believe that, with respect to CAR 605.30, the standards of airworthiness applicable to the aircraft types operated allow for take-off in the following conditions:**

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**5. Are you aware that current aircraft type certification requirements do not consider take-off operations in freezing drizzle and freezing rain conditions?**

- Yes
- No

**6. Does your company differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, +FZRA or PL?**

- Yes
- No

**7. Does your company permit/allow take-offs in the following conditions?**

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

You will now be routed to the appropriate questions based on your previous responses.

**8. Does your company place any special restrictions on take-offs in the following conditions:**

	Yes	No	Not Applicable
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**9. During active ground icing events, which include active frost, freezing fog, snow, freezing drizzle, freezing rain, ice pellets, etc., what percentage of your company's take-offs occur in the following conditions?**

	0%	>0 to 2%	>2 to 4%	>4%	Statistics Not Recorded
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light Freezing Rain (-FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate Freezing Rain (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy Freezing Rain (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice Pellets (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**11. Have you observed situations where your company has halted operations while other companies have not?**

Yes  
 No

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

- Different Aircraft Types
- Different Company Policies
- Unaware of Risks
- Other (please specify below)
- Don't Know

**13. Is your company familiar with the following guidance material related to the subject matter of this survey:**

	Yes	No
TP 14052 (Guidelines for Aircraft Ground - Icing Operations)	<input type="radio"/>	<input type="radio"/>
HOT Guidelines	<input type="radio"/>	<input type="radio"/>
CBAAC 130	<input type="radio"/>	<input type="radio"/>
Airworthiness Notice D008 edition 1	<input type="radio"/>	<input type="radio"/>

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

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

**15. Does your company recommend any of the following special procedures after de/anti-icing and before take-off during the conditions specified below?** (check any/all that apply)

	Additional visual inspection prior to taxi	Additional tactile inspection prior to taxi	Additional visual inspection prior to take-off	Additional tactile inspection prior to take-off	No Special Procedures Recommended	Takeoff not Authorized in this Condition
Freezing Drizzle (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light Freezing Rain (-FZRZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate Freezing Rain (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy Freezing Rain (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice Pellets (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

- Safety Management Review
- Risk Assessment
- Other (please specify below)
- None

**17. Do the manufacturers of the aircraft types operated by your company provide specific limitations or restrictions with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**18. Do the manufacturers of the aircraft types operated by your company provide specific guidance with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (IP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**20.** Do your pilots have access to a flight planning department?

- Yes
- No

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

- Yes
- No

Comments:

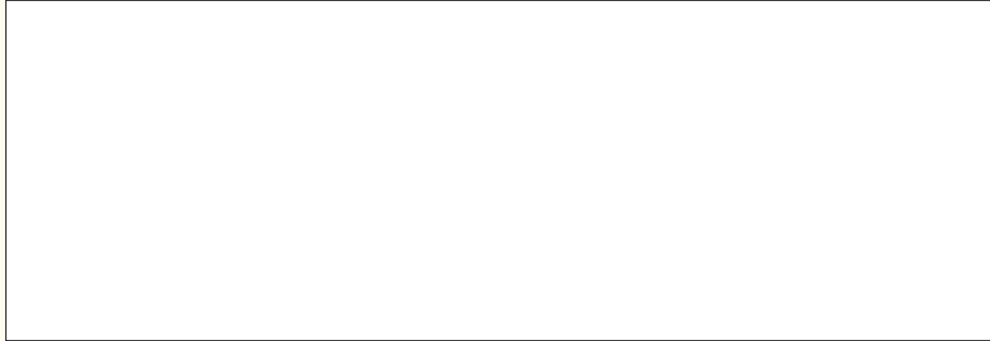
**22.** Do your pilots have an operations manager or chief pilot available immediately for guidance when operating in freezing drizzle, freezing rain and ice pellet conditions?

- Yes
- No

Comments:

**23.** Please list the principle aircraft types operated by your company. *(This question is optional. Answers will be used for classification purposes only.)*

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



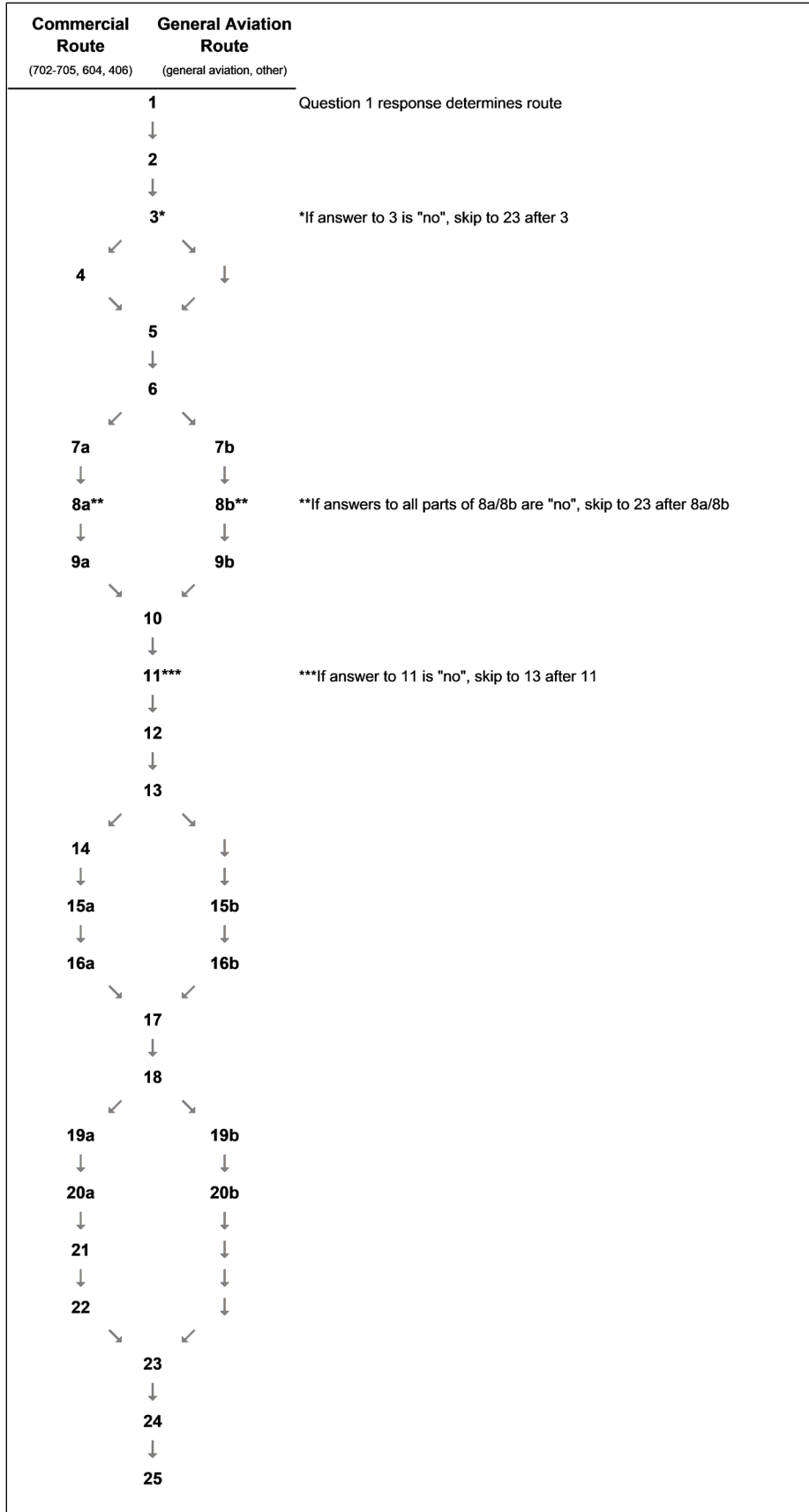
Thank you for participating in this survey. Your confidential responses will assist Transport Canada in determining appropriate guidance material in this area.

To [submit your survey](#) please click on the "submit" arrow below. When your survey has been successfully received, you will be directed to the Transport Canada website.

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## **FLIGHT CREW SURVEY ROUTING**





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**FLIGHT CREW SURVEY (ENGLISH)**



# Flight Crew Survey on Take-offs in Freezing Rain and Freezing Drizzle

Administered by APS Aviation Inc. on behalf of Transport Canada

Transport Canada has initiated a Working Group to better understand the current operational practice of take-off during freezing drizzle and/or freezing rain conditions. This survey forms part of an assessment of the current situation and is being conducted in an effort to determine whether safety can be improved in this area.

Your participation in this survey, as a pilot, will assist Transport Canada in determining whether additional guidance material, further interpretation of regulations and standards and/or additional regulations and standards are required in the area of take-off in these conditions. Transport Canada is also taking this opportunity to collect information related to take-off during conditions of ice pellets.

A similar survey has been distributed to air operators to better understand their perspective and concerns in this area.

**NOTICE OF CONFIDENTIALITY:** *This survey is being administered by an independent third party on behalf of Transport Canada. Your responses are anonymous and can not be linked to you in any way.*

**SURVEY INSTRUCTIONS:** Please answer the questions that follow by clicking on the circle/box next to the appropriate response(s). Once you have answered all questions on a page, click on the "next" arrow to go to the following page. You can go back to a previous question at any time by clicking the "back" arrow. It will take approximately 10 minutes to complete the survey.

To start the survey click on the "next" arrow below.

*Note: Some browsers may time out if the survey is left idle for more than 10 minutes. If this happens, press the refresh button on your browser to resume.*

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

- |   |  |
|---|--|
| <input type="radio"/> 604 Private Operator Transportation | <input type="radio"/> 705 Airline Operations   |
| <input type="radio"/> 702 Aerial Work                     | <input type="radio"/> 406 Flight Training Unit |
| <input type="radio"/> 703 Air Taxi Operations             | <input type="radio"/> General Aviation         |
| <input type="radio"/> 704 Commuter Operations             | <input type="radio"/> Other (specify below)    |

**2. Are you IFR rated?**

- Yes  
 No

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

- Yes
- No

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

- Yes
- No
- Don't know

5. CAR 605.30 states the following:

*No person shall conduct a take-off or continue a flight in an aircraft where icing conditions are reported to exist or are forecast to be encountered along the route of flight unless:*

*(a) the pilot-in-command determines that the aircraft is adequately equipped to operate in icing conditions in accordance with the standards of airworthiness under which the type certificate for that aircraft was issued; or*

*(b) current weather reports or pilot reports indicate that icing conditions no longer exist.*

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

	Yes	No	Don't know
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

- Yes
- No

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

- Yes
- No

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

- Yes
- No

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

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

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

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Not applicable
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Not applicable
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light Freezing Rain (-FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate Freezing Rain (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy Freezing Rain (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice Pellets (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

- Yes
- No

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

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

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

	Yes	No
TP 14052 - Guidelines for Aircraft Ground - Icing Operations <a href="http://www.tc.gc.ca/CivilAviation/commerce/Holdovertime/TP14052/menu.htm">www.tc.gc.ca/CivilAviation/commerce/Holdovertime/TP14052/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
TP 10643 - When in Doubt... <a href="http://www.tc.gc.ca/CivilAviation/general/exams/guides/TP10643/menu.htm">www.tc.gc.ca/CivilAviation/general/exams/guides/TP10643/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
Holdover Time Guidelines <a href="http://www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm">www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
Commercial & Business Aviation Advisory Circular (CBAAC) 130 <a href="http://www.tc.gc.ca/CivilAviation/commerce/circulars/AC0130r.htm">www.tc.gc.ca/CivilAviation/commerce/circulars/AC0130r.htm</a>	<input type="radio"/>	<input type="radio"/>
Airworthiness Notice D008 Edition 1 <a href="http://www.tc.gc.ca/CivilAviation/maintenance/AARPC/ans/D008.htm">www.tc.gc.ca/CivilAviation/maintenance/AARPC/ans/D008.htm</a>	<input type="radio"/>	<input type="radio"/>
NASA Ground and Airborne Icing Resources <a href="http://aircrafticing.grc.nasa.gov/courses.html">aircrafticing.grc.nasa.gov/courses.html</a>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>

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

	Freezing Drizzle (FZDZ)	Light Freezing Rain (-FZRZ)	Moderate Freezing Rain (FZRA)	Heavy Freezing Rain (+FZRA)	Ice Pellets (PL)
Additional visual inspection prior to taxi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional tactile inspection prior to taxi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional visual inspection prior to take-off	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional tactile inspection prior to take-off	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Take-off not authorized in this condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

	Freezing Drizzle (FZDZ)	Light Freezing Rain (-FZRZ)	Moderate Freezing Rain (FZRA)	Heavy Freezing Rain (+FZRA)	Ice Pellets (PL)
Additional visual inspection prior to taxi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional tactile inspection prior to taxi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional visual inspection prior to take-off	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additional tactile inspection prior to take-off	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do not take-off in this condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

- Safety Management Review
- Risk Assessment
- Other (specify below)
- Don't know

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

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

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

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Some do, Some do not
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Don't remember
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

	Yes	No	Don't remember
Freezing Drizzle (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Light Freezing Rain (-FZRZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moderate Freezing Rain (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heavy Freezing Rain (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice Pellets (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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

Yes  
 No

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

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

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

- Yes
- No

Comments:

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

- Yes
- No

Comments:

23. What type of aircraft do you principally operate?

Category

--Click Here-- ▼

Fixed Wing

Rotary Wing

Both

Class

--Click Here-- ▼

Single Engine

Multi Engine

Both

Power Plant  
Type

--Click Here-- ▼

Reciprocating/Piston

Turbine/Turbo-prop

Both

24. Please list the aircraft types you operate:

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

*Thank you for participating in this survey. Your responses will assist Transport Canada in determining appropriate guidance material in this area. To [submit your survey](#), click on the "submit" arrow below. When your survey has been successfully received, you will be redirected to the Transport Canada Transportation Development Centre website.*

**For further information on this topic, please refer to the following published guidance materials:**

TP 14052 (Guidelines for Aircraft Ground - Icing Operations): [www.tc.gc.ca/CivilAviation/commerce/Holdovertime/TP14052/menu.htm](http://www.tc.gc.ca/CivilAviation/commerce/Holdovertime/TP14052/menu.htm)

TP 10643 (When In Doubt...): [www.tc.gc.ca/CivilAviation/general/exams/guides/TP10643/menu.htm](http://www.tc.gc.ca/CivilAviation/general/exams/guides/TP10643/menu.htm)

Holdover Time Guidelines: [www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm](http://www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm)

CBAAC 130: [www.tc.gc.ca/CivilAviation/commerce/circulars/AC0130r.htm](http://www.tc.gc.ca/CivilAviation/commerce/circulars/AC0130r.htm)

Airworthiness Notice D008 Edition 1: [www.tc.gc.ca/CivilAviation/maintenance/AARPC/ans/D008.htm](http://www.tc.gc.ca/CivilAviation/maintenance/AARPC/ans/D008.htm)

NASA Ground and Airborne Icing Resources: [aircrafticing.grc.nasa.gov/courses.html](http://aircrafticing.grc.nasa.gov/courses.html)

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**FLIGHT CREW SURVEY (FRENCH)**



# Sondage auprès des équipages de conduite sur les décollages dans des conditions de pluie verglaçante ou de bruine verglaçante

Administré par APS Aviation Inc. pour Transports Canada

Transports Canada a mis sur pied un groupe de travail afin de mieux comprendre les pratiques opérationnelles actuelles en ce qui concerne le décollage dans des conditions de bruine verglaçante et (ou) de pluie verglaçante. Le présent sondage fait partie d'une évaluation de la situation actuelle et est effectué dans le but d'établir si la sécurité peut être améliorée dans ce domaine.

À titre de pilote, votre participation à ce sondage aidera Transports Canada à établir si du matériel d'orientation additionnel, une interprétation plus détaillée de la réglementation et des normes et (ou) si des règlement et normes additionnels sont nécessaires en ce qui concerne le décollage dans ces conditions. Transports Canada profite également de l'occasion pour recueillir des renseignements reliés au décollage dans des conditions de granules de glace.

Un sondage équivalent a été distribué aux exploitants aériens afin de mieux comprendre leur point de vue et leurs inquiétudes dans ce domaine.

**AVIS DE CONFIDENTIALITÉ:** *Ce sondage est administré par un tiers indépendant pour le compte de Transports Canada. Vos réponses restent anonymes et ne peuvent pas vous être reliées de quelque façon que ce soit.*

**INSTRUCTIONS POUR LE SONDAGE:** Veuillez répondre aux questions suivantes en cliquant sur le cercle ou la case à côté de la ou des réponses appropriées. Une fois que vous aurez répondu à toutes les questions sur une page donnée, cliquez sur la flèche "suivant" pour vous rendre à la page suivante. Vous pouvez retourner à une question précédente en tout temps en cliquant sur la flèche "précédent". Il vous faudra environ 10 minutes pour remplir le sondage.

Pour commencer le sondage, cliquez sur la flèche "suivant" ci-dessous.

*Note: Certains logiciels de navigation pourraient s'arrêter si le sondage est inactif plus de 10 minutes. Dans ce cas, appuyez sur le bouton de rafraîchissement de votre logiciel de navigation pour reprendre.*

## 1. Dans quel type d'opération êtes-vous principalement engagé?

- |   |   |
|---|---|
| <input type="radio"/> 604 Transport de passager par un exploitant privé | <input type="radio"/> 705 Exploitation d'une entreprise de transport aérien |
| <input type="radio"/> 702 Opérations de travail aérien                  | <input type="radio"/> 406 Unités de formation au pilotage                   |
| <input type="radio"/> 703 Exploitation d'un taxi aérien                 | <input type="radio"/> Aviation Générale                                     |
| <input type="radio"/> 704 Exploitation d'un service aérien de navette   | <input type="radio"/> Autre (veuillez préciser ci-dessous)                  |

## 2. Êtes-vous qualifié IFR?

- Oui  
 Non

**3. Avez-vous déjà opéré dans des conditions de givrage en vol?**

- Oui
- Non

**4. La société qui vous emploie a-t-elle un programme approuvé de dégivrage au sol?**

- Oui
- Non
- Ne sais pas

**5. Le RAC 605.30 déclare ce qui suit:**

*Il est interdit d'effectuer le décollage d'un aéronef ou de continuer un vol lorsque des conditions de givrage ont été signalées ou sont prévues se présenter sur le trajet du vol, à moins que, selon le cas :*

*a) le commandant de bord n'établit que l'aéronef est muni de l'équipement adéquat pour être utilisé dans ces conditions, conformément aux normes de navigabilité selon lesquelles un certificat de type a été délivré à l'égard de l'aéronef;*

*b) les derniers bulletins météorologiques ou les rapports de pilote n'indiquent que les conditions de givrage prévues n'existent plus.*

**En ce qui concerne le RAC 605.30, croyez-vous que les normes de navigabilité applicables aux types d'aéronefs que vous exploitez permettent le décollage dans les conditions suivantes?**

	Oui	Non	Ne sais pas
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**6. Croyez-vous que les exigences actuelles de certification par type d'aéronef prennent en considération les opérations de décollage dans des conditions de bruine verglaçante et de pluie verglaçante?**

- Oui
- Non

**7.a La société qui vous emploie établit-elle une distinction entre les divers types et intensités de précipitations verglaçantes comme la FZDZ, la -FZRA, la FZRA, la +FZRA ou le PL?**

- Oui
- Non

**7.b Comme pilote, établissez-vous une distinction entre les divers types et intensités de précipitations verglaçantes comme la FZDZ, la -FZRA, la FZRA, la +FZRA ou le PL?**

- Oui
- Non

**8.a La société qui vous emploie permet-elle ou tolère-t-elle les décollages dans les conditions suivantes?**

	Oui	Non
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>

**8.b Comme pilote, faites-vous des décollages dans les conditions suivantes?**

	Oui	Non
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>

**9.a La société qui vous emploie établit-elle des restrictions spéciales applicables aux décollages dans les conditions suivantes?**

	Oui	Non	Non applicable
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**9.b Comme pilote, établissez-vous des restrictions spéciales applicables aux décollages dans les conditions suivantes?**

	Oui	Non	Non applicable
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. Dans les conditions suivantes, qu'est-ce qui limite habituellement votre capacité de décollage et de départ? (cochez la ou les conditions qui s'appliquent)

	Condition de circulation au sol ou sur l'aire de trafic	Condition de la piste	Limites du manuel de vol	Fermeture de l'aéroport	Disponibilité de dégivrage ou d'antigivrage d'aéronefs	Non applicable
Bruine verglaçante (FZDZ)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pluie verglaçante faible (-FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pluie verglaçante modérée (FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Forte pluie verglaçante (+FZRA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Granules de glace (PL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. Avez-vous connu des situations où vous avez dû arrêter les opérations alors que d'autres ne le faisaient pas?

- Oui  
 Non

12. Lors des situations décrites à la question précédente, pourquoi croyez-vous que les autres ont poursuivi les opérations? (cochez la ou les raisons qui s'appliquent)

- Types d'aéronefs différents  
 Différentes politiques d'entreprise  
 Pas conscients des risques  
 Autre (veuillez préciser ci-dessous)  
 Ne sais pas

13. Êtes-vous au courant du matériel d'orientation suivant relié à l'objet du présent sondage? Les liens pour chaque publication sont inclus.

	Oui	Non
TP 14052 - Lignes directrices pour les aéronefs - lors de givrage au sol <a href="http://www.tc.gc.ca/AviationCivile/commerce/DelaisEfficacite/TP14052/menu.htm">www.tc.gc.ca/AviationCivile/commerce/DelaisEfficacite/TP14052/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
TP 10643 - Dans le doute... <a href="http://www.tc.gc.ca/aviationcivile/generale/examens/guides/tp10643/menu.htm">www.tc.gc.ca/aviationcivile/generale/examens/guides/tp10643/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
Tableaux des durées d'efficacité <a href="http://www.tc.gc.ca/AviationCivile/commerce/DelaisEfficacite/menu.htm">www.tc.gc.ca/AviationCivile/commerce/DelaisEfficacite/menu.htm</a>	<input type="radio"/>	<input type="radio"/>
Circulaire d'information de l'Aviation commerciale et d'affaires (CIACA) n° 130 <a href="http://www.tc.gc.ca/AviationCivile/commerce/circulaires/CI0130r.htm">www.tc.gc.ca/AviationCivile/commerce/circulaires/CI0130r.htm</a>	<input type="radio"/>	<input type="radio"/>
Avis de navigabilité - D008, Édition 1 <a href="http://www.tc.gc.ca/AviationCivile/maintenance/aarpc/ans/D008.htm">www.tc.gc.ca/AviationCivile/maintenance/aarpc/ans/D008.htm</a>	<input type="radio"/>	<input type="radio"/>
NASA Ground and Airborne Icing Resources <a href="http://aircrafticing.grc.nasa.gov/courses.html">aircrafticing.grc.nasa.gov/courses.html</a>	<input type="radio"/>	<input type="radio"/>

**14. Le manuel d'exploitation de votre société contient-il des renseignements spécifiques et des directives aux pilotes lorsqu'ils doivent décider de décoller dans les conditions suivantes:**

	Oui	Non
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>

**15.a La société qui vous emploie recommande-t-elle l'une ou l'autre des procédures spéciales suivantes après le dégivrage ou l'antigivrage et avant le décollage durant les conditions énoncées ci-dessous? (cochez la ou les conditions qui s'appliquent ou n'inscrivez rien si aucune ne s'applique)**

	Bruine verglaçante (FZDZ)	Pluie verglaçante faible (-FZRA)	Pluie verglaçante modérée (FZRA)	Forte pluie verglaçante (+FZRA)	Granules de glace (PL)
Inspection visuelle additionnelle avant de circuler au sol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection tactile additionnelle avant de circuler au sol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection visuelle additionnelle avant de décoller	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection tactile additionnelle avant de décoller	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Le décollage dans ces conditions n'est pas autorisé	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**15.b Comme pilote, vous conformez-vous à l'une ou l'autre des procédures spéciales suivantes après le dégivrage ou l'antigivrage et avant le décollage durant les conditions énoncées ci-dessous? (cochez la ou les conditions qui s'appliquent ou n'inscrivez rien si aucune ne s'applique)**

	Bruine verglaçante (FZDZ)	Pluie verglaçante faible (-FZRA)	Pluie verglaçante modérée (FZRA)	Forte pluie verglaçante (+FZRA)	Granules de glace (PL)
Inspection visuelle additionnelle avant de circuler au sol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection tactile additionnelle avant de circuler au sol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection visuelle additionnelle avant de décoller	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inspection tactile additionnelle avant de décoller	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ne pas décoller dans ces conditions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**16.a La société qui vous emploie utilise-t-elle l'un ou l'autre des processus suivants pour évaluer la sécurité du décollage dans des conditions de bruine verglaçante, de pluie verglaçante ou de granules de glace?**  
(cochez tous les points qui s'appliquent)

- Examen de la gestion de la sécurité
- Évaluation des risques
- Autre (veuillez préciser ci-dessous)
- Ne sais pas

**16.b Parmi les actions suivantes, lesquelles prenez-vous en considération lorsque vous évaluez la sécurité d'un décollage dans des conditions de bruine verglaçante, de pluie verglaçante ou de granules de glace?**  
(Cochez toutes les actions qui s'appliquent)

- Validité de la certification pour le vol d'un aéronef dans des conditions givrantes connues
- Limites ou restrictions imposées par le manuel de vol
- Reporter le décollage
- Gravité et étendue horizontale et verticale des conditions de givrage
- Condition des surfaces critiques de l'aéronef avant le décollage
- Performances et contrôle de décollage liés à un indice de freinage réduit
- Conséquences de défaillances possibles, telles qu'une panne de moteur critique durant la phase de décollage
- Possibilité de retourner atterrir
- Autre (veuillez préciser ci-dessous)

**17. Les fabricants des types d'aéronefs que vous exploitez prescrivent-ils des limites ou restrictions spécifiques en ce qui concerne le décollage dans les conditions suivantes:**

	Oui	Non	Certains le font, d'autres pas
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**18. Les manufacturiers des types d'aéronefs que vous exploitez offrent-ils de l'orientation spécifique en ce qui concerne le décollage dans les conditions suivantes:**

	Oui	Non	Certains le font, d'autres pas
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**19.a Votre formation comprend-elle des renseignements sur la conduite de décollages dans les conditions suivantes?**

	Oui	Non	Ne m'en souviens pas
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**19.b Votre formation de pilote comprenait-elle des renseignements sur la conduite de décollages dans les conditions suivantes?**

	Oui	Non	Ne m'en souviens pas
Bruine verglaçante (FZDZ)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante faible (-FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pluie verglaçante modérée (FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Forte pluie verglaçante (+FZRA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Granules de glace (PL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**20.a Avez-vous accès à un service de plan de vol?**

- Oui
- Non

**20.b Parmi les services suivants, lesquels utilisez-vous pour la préparation des vols? (cochez tous les services qui s'appliquent)**

- Service de plans de vol
- Service de répartition
- NAV CANADA
- Vous-même
- Autre (veuillez préciser ci-dessous)

21. La société qui vous emploie utilise-t-elle un processus de mentorat ou d'autres moyens pour les pilotes plus expérimentés d'enseigner aux pilotes débutants à prendre des décisions opérationnelles sécuritaires lorsqu'ils opèrent dans des conditions de bruine verglaçante, de pluie verglaçante ou de granules de glace?

- Oui  
 Non

Commentaires:

22. Avez-vous un accès direct à un gestionnaire des opérations ou à un chef pilote pour de l'encadrement lorsque vous opérez dans des conditions de bruine verglaçante, de pluie verglaçante et de granules de glace?

- Oui  
 Non

Commentaires:

23. Quel type d'aéronef exploitez-vous principalement?

Catégorie --Sélectionnez-- ▼  
Voilure fixe  
 Voilure tournante  
 Les deux

Classe --Sélectionnez-- ▼  
Monomoteur  
 Multimoteur  
 Les deux

Type de groupe motopropulseur --Sélectionnez-- ▼  
Moteur à piston  
 Moteur à turbine ou turbopropulseur  
 Les deux

24. Veuillez dresser la liste des types d'aéronefs que vous exploitez:

25. **COMMENTAIRES DE NATURE GÉNÉRALE :** Veuillez soumettre tout commentaire qui, à votre avis, est susceptible d'améliorer la sécurité dans ce domaine. D'un autre côté, vous pouvez soumettre tous renseignements additionnels sur les opérations dans ces conditions qui n'ont pas été abordés dans les questions du présent sondage, ou développer davantage vos réponses.

*Merci d'avoir participé à ce sondage. Vos réponses aideront Transports Canada Development à identifier le matériel d'orientation approprié à ce domaine. Pour [soumettre votre sondage](#), cliquer sur la flèche "soumettre" ci-dessous. Une fois votre sondage est reçu, on vous dirigera vers le site Web du Centre de développement des transports de Transports Canada.*

**Pour de plus amples renseignements sur le sujet, veuillez consulter le matériel de référence suivant:**

TP 14052 - Lignes directrices pour les aéronefs - lors de givrage au sol [www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/TP14052/menu.htm](http://www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/TP14052/menu.htm)

TP 10643 - Dans le doute... [www.tc.gc.ca/aviationcivile/generale/examens/guides/tp10643/menu.htm](http://www.tc.gc.ca/aviationcivile/generale/examens/guides/tp10643/menu.htm)

Tableaux des durées d'efficacité [www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/menu.htm](http://www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/menu.htm)

CIACA n° 130 [www.tc.gc.ca/AviationCivile/commerce/circulaires/CI0130r.htm](http://www.tc.gc.ca/AviationCivile/commerce/circulaires/CI0130r.htm)

Avis de navigabilité - D008, Édition 1 [www.tc.gc.ca/AviationCivile/maintenance/aarpc/ans/D008.htm](http://www.tc.gc.ca/AviationCivile/maintenance/aarpc/ans/D008.htm)

NASA Ground and Airborne Icing Resources: [aircrafticing.grc.nasa.gov/courses.html](http://aircrafticing.grc.nasa.gov/courses.html)

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## **APPENDIX C**

### **SUMMARY OF FREEZING RAIN AND DRIZZLE SURVEY RESULTS**



**Freezing Rain Freezing Drizzle Survey Results: 702-705 Air Operators**



**FREEZING DRIZZLE – FREEZING RAIN SURVEY (702-705 OPERATORS)  
Summary of Results**

July 15, 2008

**1. Does your company conduct operations in icing conditions?**

Yes	80%
No	20%

**2. What type(s) of operation does your company conduct? (check all that apply)**

702 Aerial Work	22%
703 Air Taxi Operations	71%
704 Commuter Operations	46%
705 Airline Operations	26%
604 Private Operator Transportation	10%

**3. Does your company have an Approved Ground Icing Program?**

Yes	94%
No	6%

**4. Does your company believe that, with respect to CAR 605.30, the standards of airworthiness applicable to the aircraft types operated allow for take-off in the following conditions:**

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	51%	47%	1%
Light Freezing Rain (-FZRA)	35%	65%	-
Moderate Freezing Rain (FZRA)	12%	87%	1%
Heavy Freezing Rain (+ FZRA)	6%	91%	2%
Ice Pellets (PL)	44%	50%	5%

**5. Are you aware that current aircraft type certification requirements do not consider take-off operations in freezing drizzle and freezing rain conditions?**

Yes	69%
No	31%

**6. Does your company differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, + FZRA or PL?**

Yes	74%
No	26%

**7. Does your company permit/allow take-offs in the following conditions?**

	Yes	No	No Reply
Freezing Drizzle (FZDZ)	28%	71%	2%
Light Freezing Rain (-FZRA)	47%	51%	1%
Moderate Freezing Rain (FZRA)	31%	69%	-
Heavy Freezing Rain (+ FZRA)	10%	87%	3%
Ice Pellets (PL)	3%	94%	3%

**8. Does your company place any special restrictions on take-offs in the following conditions:**

	Yes	No	N/A
Freezing Drizzle (FZDZ)	64%	32%	5%
Light Freezing Rain (-FZRA)	52%	30%	18%
Moderate Freezing Rain (FZRA)	52%	20%	27%
Heavy Freezing Rain (+ FZRA)	52%	18%	30%
Ice Pellets (PL)	50%	36%	14%

**9. During active ground icing events, which include active frost, freezing fog, snow, freezing drizzle, freezing rain, ice pellets, etc., what percentage of your company's take-offs occur in the following conditions?**

	0%	>0 to 2%	>2 to 4%	>4%	Statistics Not Recorded
Freezing Drizzle (FZDZ)	11%	48%	-	-	41%
Light Freezing Rain (-FZRA)	34%	30%	2%	-	34%
Moderate Freezing Rain (FZRA)	61%	5%	-	-	34%
Heavy Freezing Rain (+ FZRA)	64%	2%	-	-	34%
Ice Pellets (PL)	23%	32%	-	2%	43%

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

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle (FZDZ)	43%	61%	45%	23%	64%	11%
Light Freezing Rain (-FZRA)	34%	52%	43%	16%	45%	23%
Moderate Freezing Rain (FZRA)	34%	39%	43%	14%	32%	38%
Heavy Freezing Rain (+ FZRA)	32%	36%	41%	18%	30%	41%
Ice Pellets (PL)	39%	43%	36%	30%	55%	28%

**11. Have you observed situations where your company has halted operations while other companies have not?**

Yes	82%
No	18%

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

Different Aircraft Types	44%
Different Company Policies	61%
Unaware of Risks	33%
Other (specify below)	19%
Don't Know	22%

Other responses include:

- Availability of anti-icing fluids;
- Perhaps lack of direction from OPs or get home itis;
- Disregard of departure with lifting surfaces contaminated by ice, frost or snow. Get homeitis syndrome;
- Use of type 4 fluid. Our aircraft only certified for type 1;
- Disregard of the danger;
- The job needs to get done regardless of limitations or regulations as observed on many regular weather limiting day; and
- Able to use type 4 fluids.

**13. Is your company familiar with the following guidance material related to the subject matter of this survey:**

	Yes	No	No reply
TP 14052	98%	2%	-
HOT Guidelines	95%	5%	-
CBAAC 130	75%	23%	2%
Airworthiness Notice D008 edition 1	41%	57%	2%

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

	Yes	No	No reply
Freezing Drizzle (FZDZ)	59%	41%	-
Light Freezing Rain (-FZRA)	59%	39%	2%
Moderate Freezing Rain (FZRA)	57%	41%	2%
Heavy Freezing Rain (+ FZRA)	52%	45%	2%
Ice Pellets (PL)	52%	48%	-

**15. Does your company recommend any of the following special procedures after de/anti-icing and before take-off during the conditions specified below? (check any/all that apply)**

	Additional visual inspection prior to taxi	Additional tactile inspection prior to taxi	Additional visual inspection prior to take-off	Additional tactile inspection prior to take-off	No Special Procedures Recommended	Takeoff not Authorized in this Condition
Freezing Drizzle (FZDZ)	48%	39%	59%	18%	9%	20%
Light Freezing Rain (-FZRA)	30%	25%	41%	18%	9%	45%
Moderate Freezing Rain	18%	16%	25%	9%	2%	70%
Heavy Freezing Rain (+ FZRA)	14%	11%	16%	7%	2%	80%
Ice Pellets (PL)	48%	36%	61%	23%	7%	20%

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

Safety Management Review	48%
Risk Assessment	52%
Other (specify below)	9%
None	27%

Other responses include:

- Experience, knowledge and judgment of the crew;
- Annual safety discussion on icing in fall prior to icing season. informal safety meeting;
- We use current HOT guidelines for fzdz and -fzdz. as that is all that is listed on the charts, there for a Risk Assessment, Safety Man. Review is not required nor will I do one!!;
- assessment of temperatures on ground and air, as well as aircraft equipment availability and serviceability; and
- Takeoff in freezing rain and ice pellets is not permitted under the CARs.

**17. Do the manufacturers of the aircraft types operated by your company provide specific limitations or restrictions with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not	No reply
Freezing Drizzle (FZDZ)	18%	52%	30%	-
Light Freezing Rain (-FZRA)	30%	48%	23%	-
Moderate Freezing Rain (FZRA)	39%	43%	18%	-
Heavy Freezing Rain (+ FZRA)	41%	41%	18%	-
Ice Pellets (PL)	14%	61%	23%	2%

**18. Do the manufacturers of the aircraft types operated by your company provide specific guidance with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not	No reply
Freezing Drizzle (FZDZ)	20%	50%	30%	-
Light Freezing Rain (-FZRA)	25%	48%	27%	-
Moderate Freezing Rain (FZRA)	25%	50%	25%	-
Heavy Freezing Rain (+ FZRA)	20%	52%	27%	-
Ice Pellets (PL)	14%	57%	30%	-

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

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	86%	11%	2%
Light Freezing Rain (-FZRA)	80%	18%	2%
Moderate Freezing Rain (FZRA)	75%	20%	4%
Heavy Freezing Rain (+ FZRA)	68%	27%	4%
Ice Pellets (PL)	80%	16%	5%

**20. Do your pilots have access to a flight planning department?**

Yes	86%
No	14%

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

Yes	98%
No	2%

Comments include:

- Initial class room training and Line indoctrination; and
- Extra assistance is available through dispatch, and the flight operations department including type chief pilots.

**22. Do your pilots have an operations manager or chief pilot available immediately for guidance when operating in freezing drizzle, freezing rain and ice pellet conditions?**

Yes	98%
No	2%

Comments include:

- Dispatch chief Pilot Ops Manger; and
- They are not released on line until there knowledge level has been assessed and policy is "When in doubt don't go."

**23. Please list the principle aircraft types operated by your company.**

Forty-seven responses to this question were received; each one is listed individually below.

- *LR35 LR45 C750.*
- *Dash 8s and light turbo props.*
- *PA31 Cessna 206.*
- *PA-31, Cessna 208B, BN2A, BE58, Cessna 206.*
- *DHC-8/100.*
- *Beechcraft King Air 90/100/200/1900 Dhc8.*
- *Sa227 AC/CC/DC.*
- *PA-31-350.*
- *P 180 SF34.*
- *Dash 8 100 and 300.*
- *C172, C206, C185, C207, C208B, PC6T, BN2A, B99, B20, DHC6.*
- *Cessna 404,208B, Dash 7 Casa 212.*
- *BE20,B200, pa31,C185,C210,C206.*
- *PA-31.*
- *B737.*
- *PA31, BE10, BE02.*
- *AC95, CL21, CV580, DHS2 and B-55.*
- *DH8,SF340,DH6,BE200,SW4& S550.*
- *FA-10FA-20.*
- *c310, c402, c404.*
- *B1900, SH36, SF34.*
- *pa31.*
- *LR35, LR45, C750.*
- *PA-31,BE-A100,C310R.*
- *PA31-350 PIPER CHIEFTAIN B200 KING AIR B200 C-208B CESSNA GRAND CARAVAN.*
- *Learjet 31, citation cj3, bell 407.*
- *PAYE AND BAE31.*

- *H25B.*
- *AJ25, CL60, BE3B, C208.*
- *HS 25.*
- *C750.*
- *c-404, c-402, c-310.*
- *BE 20.*
- *C185 floats only, C206, C207, C208, BE99, BE20, BAe31.*
- *B727-200, ATR-42, C208.*
- *BE10 , Pa31.*
- *King Air, Mitsubishi Mu-2, Cessna 208.*
- *727, 737 L382, AT42 HS74.*
- *PA31-350, BE10.*
- *LEAR.*
- *Hawkers, Falcons, Jetstreams.*
- *PC-12, C208, DH-3T.*
- *Beechcraft, Cessna.*
- *BE20 PA31 C185 C206 C210.*
- *BE10 BE20 BE02 G159.*
- *Piper Navajo, Piper Cheyenne.*
- *King Air 90.*

## 24. GENERAL COMMENTS

Eighteen responses to this question were received; each one is listed individually here:

- The question regarding special inspections for ice pellets should be modified. Ice pellet allowance times do not incorporate a visual inspection during taxi, but is nonetheless a special procedure;
- In general I feel that all flight crews are educated and aware of the effects of icing. The issue of pilots feeling they must attempt flight or must complete a flight to both please an employer or flight department along with the type of pay scale ( small base plus mileage) has an affect. More mentoring when able, the reinforcement that you do not have to go at any cost is essential in

pilots making the correct decision. Education of customers is also a key issue as there is a lot of pressure put on the young flight crews today by customer demands;

- Present Rules, Regs, training etc. ensure that the critical surfaces are free from contamination prior to take off. Our company trains crews accordingly, deice the aircraft when required and ensure aircraft performance, and safety are not compromised. Freezing drizzle, rain, etc as your survey addresses may or may not be adhering to those surfaces and as such may not even fall under the "deicing - anti icing" regs, training etc;
- More prescriptive guidance from the Manufacturers;
- presently we have an unwritten policy that restricts operation in freezing precip. However it is Captain's discretion as to whether the flight goes, considering holdover times intensity of precipitation etc. When freezing precip is being reported at a station dispatch either diverts flights to other airports or waits until precip is no longer reported;
- We operate aircraft under 702, generally Day/VFR but ferry/position aircraft IFR. We do not adhere to a specific schedule or on demand type of service and brief all flight crew during company indoctrination that they are not to depart in any icing conditions nor proceed through areas of known icing with modified aircraft;
- the decision to take off in FZDR is taken on a individual case by case basis. Improving or worsening weather is a factor as well as in cloud icing, the amount of moisture in the airmass, approach facilities available, if there is a lengthy ground hold, if the destination airport that has FZDR is a through airport or the actual destination;
- Airports that have air carriers providing scheduled services should provide or assist in the deicing equipment. Many small airports offer no assistance and thus the operator must provide the equipment. It is expensive and is often duplicated in these places by several operators, none of which can afford good equipment. One good unit could provide for efficient, effective and ultimately safer service and the costs could be shared;
- We avoid all icing conditions with our Caravans;
- propeller driven aircraft without hot edge deicing should not be allowed to take off in any freezing rain or drizzle conditions;
- I used to operate ATR42 aircraft that were grounded by TC for no apparent reasons other than following the USA commercial battle with Airbus industry. Up to this day it is the only aircraft that has been tested in the freezing rain/drizzle conditions to extreme limits. I flew the in the ice storm of 1998 all week with no operational problems encountered in all the fleet of ATRs (which had its airworthiness certificate revoked by TC a few years

earlier for fear of icing problems with this aircraft...ha ha). There were all kinds of aircraft flying throughout that week in Montreal and common sense and experience resulted in no incidents to my knowledge. If this survey is to set the bases of new ruling by TC, I hope they will get out of their towers in Ottawa and stop dreaming for themselves. You can regulate just so much. No matter how thick the book is you cannot stop the morons from doing their thing;

- As an introduction to the HOT tables I would suggest a note on the certification requirements of aircraft with regard to FZ precipitation (FZDZ, FZRA, etc);
- Procedures and policies with regards to freezing rain and freezing drizzle should be included in operations manuals to provide a safer environments where company's may not have experienced staff to mentor younger inexperienced pilots;
- Icing is avoided when ever possible by diverting, duration ( staying out of a layer until necessary) or delay. We do not dispatch into known icing that is unavoidable or a known duration to threaten flight safety;
- Only recently there has been material released on the acceptable use of Type IV fluid in ice pellets. this is still used with extreme caution;
- Transport's Info is very good I would not change it. Pilot's are the ones thier able to decide if it is safe to go or not. Let's have a little faith and let them do their job;
- Caution must be taken whenever operating in icing conditions. Please don't come up with any more restrictive regulations. We don't need any more. Thank You; and
- Freezing precipitation is of great concern to our operations. It is considered unsafe to operate in such conditions. Therefore it is not permitted to takeoff, fly through or land in condition were freezing precipitation is reported.

**Freezing Rain Freezing Drizzle Survey Results: 604 Air Operators**



**FREEZING DRIZZLE – FREEZING RAIN SURVEY (604 OPERATORS)  
Summary of Results**

July 15, 2008

**1. Does your company conduct operations in icing conditions?**

Yes	94%
No	6%

**2. What type(s) of operation does your company conduct?**

604	94%
Other	12%

Other responses include:

- 703 (4%)
- 704 (8%)
- 705 (1%)
- 702 (1%)

**3. Does your company have an Approved Ground Icing Program?**

Yes	76%
No	22%
(no reply)	2%

**4. Does your company believe that, with respect to CAR 605.30, the standards of airworthiness applicable to the aircraft types operated allow for take-off in the following conditions:**

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	47%	51%	2%
Light Freezing Rain (-FZRA)	43%	55%	2%
Moderate Freezing Rain (FZRA)	8%	82%	10%
Heavy Freezing Rain (+FZRA)	4%	88%	8%
Ice Pellets (PL)	49%	51%	-

5. Are you aware that current aircraft type certification requirements do not consider take-off operations in freezing drizzle and freezing rain conditions?

Yes	75%
No	25%

6. Does your company differentiate between various types and intensities of freezing precipitation such as FZDZ, -FZRA, FRZA, + FZRA or PL?

Yes	57%
No	43%

7. Does your company permit/allow take-offs in the following conditions?

	Yes	No
Freezing Drizzle (FZDZ)	49%	51%
Light Freezing Rain (-FZRA)	39%	61%
Moderate Freezing Rain (FZRA)	8%	92%
Heavy Freezing Rain (+ FZRA)	6%	94%
Ice Pellets (PL)	47%	53%

8. Does your company place any special restrictions on take-offs in the following conditions:

	Yes	No	N/A
Freezing Drizzle (FZDZ)	49%	27%	24%
Light Freezing Rain (-FZRA)	57%	31%	11%
Moderate Freezing Rain (FZRA)	57%	29%	14%
Heavy Freezing Rain (+ FZRA)	46%	14%	40%
Ice Pellets (PL)	49%	14%	37%

9. During active ground icing events, which include active frost, freezing fog, snow, freezing drizzle, freezing rain, ice pellets, etc., what percentage of your company's take-offs occur in the following conditions?

	0%	>0 to 2%	> 2 to 4%	>4%	Statistics Not Recorded
Freezing Drizzle (FZDZ)	26%	43%	-	-	32%
Light Freezing Rain (-FZRA)	29%	40%	-	-	32%
Moderate Freezing Rain (FZRA)	69%	-	-	-	32%
Heavy Freezing Rain (+ FZRA)	69%	-	-	-	32%
Ice Pellets (PL)	34%	31%	-	-	34%

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

	Taxiway ramp condition	Runway condition	AFM limitations	Airport closed	Availability of aircraft de/anti-icing	Not applicable
Freezing Drizzle (FZDZ)	31%	43%	47%	15%	46%	30%
Light Freezing Rain (-FZRA)	34%	51%	63%	14%	63%	11%
Moderate Freezing Rain (FZRA)	40%	57%	63%	14%	60%	11%
Heavy Freezing Rain (+ FZRA)	23%	29%	37%	14%	29%	49%
Ice Pellets (PL)	23%	29%	37%	17%	29%	49%

**11. Have you observed situations where your company has halted operations while other companies have not?**

Yes	86%
No	14%

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

Different Aircraft Types	37%
Different Company Policies	40%
Unaware of Risks	40%
Other (specify below)	10%
Don't Know	30%

Other responses include:

- Operational decisions by other companies were likely influenced by their safety culture-which influences what is acceptable and also the operational priorities of the company;
- Companies may be bound by service schedules, we are not, and have the option to wait out the weather if necessary;
- Some operators feel that a departure is possible with appropriate de-icing/anti-icing completed prior to flight. The flight crews remain unaware of the risks and AFM restrictions; and
- It would be speculative of me to assume why others continue to operate in conditions that I deem unsafe to continue operations in.

13. Is your company familiar with the following guidance material related to the subject matter of this survey:

	Yes	No	No reply
TP 14052	97%	3%	-
HOT Guidelines	86%	11%	3%
CBAAC 130	69%	29%	3%
Airworthiness Notice D008 edition 1	51%	46%	3%

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

	Yes	No
Freezing Drizzle (FZDZ)	60%	40%
Light Freezing Rain (-FZRA)	57%	43%
Moderate Freezing Rain (FZRA)	51%	49%
Heavy Freezing Rain (+ FZRA)	51%	49%
Ice Pellets (PL)	40%	60%

15. Does your company recommend any of the following special procedures after de/anti-icing and before take-off during the conditions specified below? (check any/all that apply)

	Additional visual inspection prior to taxi	Additional tactile inspection prior to taxi	Additional visual inspection prior to take-off	Additional tactile inspection prior to take-off	No Special Procedures Recommended	Takeoff not Authorized in this Condition
Freezing Drizzle (FZDZ)	40%	29%	51%	23%	11%	26%
Light Freezing Rain (-FZRA)	40%	31%	46%	20%	11%	31%
Moderate Freezing Rain	11%	6%	17%	6%	9%	66%
Heavy Freezing Rain	9%	6%	14%	6%	9%	69%
Ice Pellets (PL)	29%	26%	51%	20%	17%	23%

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

Safety Management Review	54%
Risk Assessment	69%
Other (specify below)	6%
None	23%

Other responses include:

- *Not allowed; and*
- *Pilot discretion.*

**17. Do the manufacturers of the aircraft types operated by your company provide specific limitations or restrictions with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not	No reply
Freezing Drizzle (FZDZ)	43%	43%	11%	3%
Light Freezing Rain (-FZRA)	40%	46%	11%	3%
Moderate Freezing Rain (FZRA)	37%	46%	11%	6%
Heavy Freezing Rain (+ FZRA)	40%	43%	14%	3%
Ice Pellets (PL)	31%	51%	17%	-

**18. Do the manufacturers of the aircraft types operated by your company provide specific guidance with respect to take-off in the following conditions:**

	Yes	No	Some do, Some do not	No reply
Freezing Drizzle (FZDZ)	43%	46%	6%	6%
Light Freezing Rain (-FZRA)	40%	49%	6%	6%
Moderate Freezing Rain (FZRA)	40%	46%	9%	6%
Heavy Freezing Rain (+ FZRA)	43%	40%	9%	9%
Ice Pellets (PL)	34%	51%	9%	6%

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

	Yes	No	Don't Know
Freezing Drizzle (FZDZ)	59%	32%	9%
Light Freezing Rain (-FZRA)	66%	29%	6%
Moderate Freezing Rain (FZRA)	66%	26%	9%
Heavy Freezing Rain (+ FZRA)	54%	37%	9%
Ice Pellets (PL)	54%	37%	9%

**20. Do your pilots have access to a flight planning department?**

Yes	69%
No	29%

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

Yes	74%
No	26%

Comments include:

- NOT; and
- Some of the questions are ambiguous and therefore I have grouped the icing conditions into one group for supplying answers for the questions.

**22. Do your pilots have an operations manager or chief pilot available immediately for guidance when operating in freezing drizzle, freezing rain and ice pellet conditions?**

Yes	94%
No	6%

Comments include:

- Not allowed; and
- You can always try to call the chief on his cell. He is cool with that. It is a cell and you can not always reach him.

**23. Please list the principle aircraft types operated by your company.**

Forty-four responses to this question were received; each one is listed individually here:

- Beech 200/Beech 100/C-208.
- Heavy business jet – new.
- C25B.
- Cessna 425.
- twin bizjet.
- King Air 90.
- falcon 900.
- BD100.
- Cessna 550 Cessna 560.
- king air f90,beech baron 58.
- B200 B300.
- Pilatus PC-12, Piaggio P-180, Beech King-Air 300, Cessna 208, Dehavilland DHC 6.
- Pilatus PC12.
- H25B.
- BE20 C340 C441.
- Beech 350.
- GALX HS-799 & 800 C-560.
- CL604 + LR45.
- C-425.
- LIGHT JET, MEDIUM JET, TURBOPROP.
- CJ.
- c525.
- twin turbo-prop twin turbo-jet.
- PA-31T.
- HS25/800.
- PA46T.
- Dornier 328tp.

- Beechcraft Kingair.
- King Air 350, DHC-6.
- King Air 350, Twin Otter.
- turbo jet.
- b1900 b200 c550.
- Learjet 35.
- Cessna 441 - Conquest 2.
- Dornier 328, Embracer 175.
- DORNIER 328 TURBOPROP.
- C550.
- PA46T.
- HS 125 / 700.
- King Air 350---King Air 200.
- CL60.
- Piaggio Avanti II (P180).
- MU-2B-60.
- Global Express BD700.

## 24. GENERAL COMMENTS

Twelve responses to this question were received; each one is listed individually here:

- Precise guidance / instruction for operations in the atmospheric conditions described in this survey need to be developed by the Regulators, OEM's and Operators. Specifically Operators should at least include specific references for this survey topic in their SMS, COM and Pilot Training Syllabus. OEM Aircraft Flight Manuals vary greatly in amount of information provided on this topic;
- Light freezing precip is a nebulous term, however there are cases where it is of sufficiently light intensity that crew are comfortable with type 4 anti icing with visual/tactile follow up and rapid departure. Our crew are knowledgeable, and trained in this regard;
- I believe the regulations are now specific enough and the training required is adequate. Transport does not need to add more requirements. The

simplification of the CARS was supposed to help but as per usual all it did was make it more difficult to get an answer or ruling on almost anything from transport. The interpretation area is huge and muddled. Junior pilots are already shaking their heads when confronted with questions pertaining to CARS. Icing conditions are pretty much cut and dried in our company. I don't believe we need transport meddling anymore;

- Use of common sense , flight planning, and each pilot experience as limitation beside aircraft limitations;
- Transport Canada should take the initiative to be present for attempted departures in conditions that are prohibited by the manufacturer or limitations in de-icing / anti-icing capability;
- I believe there is industry wide misunderstanding of the regs and certification standards in regards to operations in freezing precip, and this could be cleared up by spelling out in plain language in publications and operation manuals where it is easy to see, not an easy to miss side note that can be misconstrued. Experienced pilots know the risk of freezing precip and hand it down to lesser experienced crews. With the lower experience crews now flying this may not be happening as much;
- Possibly enhance pilot training in Surface Contamination training to include more on the departure and arrival segments;
- I am an operations manager for a small 2 aircraft 604 / 704 operation. I have a couple comments to make. For starters the price to deice an aircraft at Toronto and many other large Canadian airports is ridiculous. Absolutely outrageous. So I would say one of the largest safety risks is the price!!!! We have a policy at our company that we will never deice on the main pad at YYZ. Never Never Never. So the one and only alternative is to go to Sky Service (they are approved for this operation)and get sprayed with Type 4 anti icing in the hangar after the aircraft is deiced in the hangar from the ambient heat. The other option is to apply Type 4 by hand and with a sprayer in our own hangar. This is not allowed by the GTAA so is a bit illegal. There are many companies all over that do this. There should be guideline set out for this procedure. It does work and is very common. Much more common than anyone knows. There are big companies with Large business jets doing this. I think it is a BS way of doing things. Why is it that I can get a Lear deiced in Baltimore and pay 6 to 700 dollars but it costs 3 or 4 thousand dollars in Toronto? This has to change and as far as I am concerned is probably one of the biggest factors affecting safety in this area. I can get deiced in Frobisher Bay by First Air for 7 or 800 dollars but many thousand dollars in Toronto. Come on folks lets get to the crux of the matter. Feel free to contact me personally for more details at crjtrainer@aol.com. I would love to talk about this matter. Someone is making huge profits on this operation. It is the same at many large airports in

Canada. Much more reasonable in the USA. Maybe the government should step in and regulate this because it affects safety so much!;

- I have been flying for 45 years and have encountered Icing conditions that was not predicted or forecasted so you have to deal with it. If it is the Conquest 11. Get out of it as soon as possible. If it was the LearJet with heated anti ice, not a problem climb through it. If there is Freezing Rain, Drizzle or what ever on the ground you going to have a contaminated airplane regardless of the anti Icing fluids you use. If it's Ice pellets, you are going to climb into Icing Conditions. I my old bush flying days,I would stay on the ground, today, flying the Conquest or the LearJet also, stay on the ground. Treat it like a Thunder Storm, wait until it passes over and then go flying. It may save your life;
- In general, my experience in commuter and private operators, there is a lack of guidance on the legality and certification of flight in freezing drizzle or light freezing rain, as well as ice pellets;
- The biggest problem faced by small operators is the availability of de-ice/anti-ice facilities. Most large airports no longer allow the application of fluids anywhere other than one specific ramp on the field, shared by everyone at the airport. At a large cost for the service, many operators are pushing the limits of icing to avoid costs. Even a larger cost is the time taken to use these facilities. All airlines are given priority for these services, while the smaller aircraft wait in line. Furthermore, by the time these aircraft are de/anti-iced and have to taxi a great distance to the runway and likely hold a longer time than normal, the fluid hold-over times have long since expired and a return to the de-ice bay is required at another large cost. This IS causing some operators to continue flights with aircraft contamination. Airports need to expand de/anti-ice services and facilities to allow FBO's to provide them to smaller operators and aircraft; and
- No take-off's in any freezing rain.

**APPENDIX D**

**EXPERIMENTAL PROGRAM  
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM  
SURFACES DURING MIXED PRECIPITATION CONDITIONS  
SNOW AND RAIN**



CM2103.001 (07-08)

**EXPERIMENTAL PROGRAM  
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM  
SURFACES DURING MIXED PRECIPITATION CONDITIONS  
SNOW AND RAIN**

Winter 08

Prepared for

**Transportation Development Centre  
Transport Canada**

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro



March 31, 2008  
Final Version 1.0

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*ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS*

**EXPERIMENTAL PROGRAM  
ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM  
SURFACES DURING MIXED PRECIPITATION CONDITIONS  
SNOW AND RAIN**

March 31, 2008

**1. BACKGROUND**

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

**2. OBJECTIVE**

The objective of this project is to investigate if endurance time testing conducted during mixed precipitation conditions (snow/rain) will demonstrate signs of fluid adhesion to aluminum test surfaces with Neat Type II and Type IV fluids.

**3. TEST PLAN**

A detailed test matrix is shown in Table 3.1. The failure times (estimated based on severity of fluid condition) on test surfaces will be recorded using the standard ET data form (Attachment I). Measurements will be continued beyond the failure time in an attempt to properly document the fluid adherence. Fluid type, fluid appearance, OAT, rate of precipitation and other factors will determine the duration of the test. After fluid failure, the test surface will be examined to determine whether or not adherence occurs. Progressive measurements will be conducted to help in reaching a decision. The methodology for measuring fluid adhesion is described in Section 4.6.

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**ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS**

**Table 3.1: Test Matrix**

Test #	Priority	Fluid Type	Fluid Brand	Dilution	Fluid Temp. [°C]	Precip Type	Test Temp. [°C]	Water Temp. [°C]	Water Temp Increase	Snow Precip Rate [g/dm <sup>2</sup> /h]	Freezing Rain Precip Rate [g/dm <sup>2</sup> /h]	Combined Precip Rate [g/dm <sup>2</sup> /h]	NRC Condition	Timing With HOT Tests
RS1	1	IV	EG 106	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS2	2	IV	ABC-S +	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS3	3	II	Kilfrost 2143-3500	Neat	-3	SN/R	-3	+3	TBD**	12	13	25	R 13, -3	Invasive (following HOT)
RS4	1	IV	EG 106	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction
RS5	2	IV	ABC-S +	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction
RS6	3	II	Kilfrost 2143-3500	Neat	-3	ZR	-3	-	-	-	25	25	ZR 25, -3	in Conjunction

\* Duplicates of each test will be conducted simultaneously. Duplicate tests will be labeled "Test #" A. i.e. RS1-A

\*\* Water temperature must be raised incrementally until rain is no longer freezing on cold soaked surfaces.

ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS

The parameters to be measured during testing are the following: test surface temperature, fluid dilution (Brix), precipitation rate, fluid failure (estimated based on severity of fluid condition), and fluid adhesion. Photo documentation of each test will also be collected. Photos will be taken at set intervals during each test using a digital camera. All of these parameters are to be measured as the test progresses to gain a better understanding of the phenomena that take place as the fluid becomes diluted.

#### 4. PROCEDURE

Endurance time testing will be conducted in the NRC cold chamber using the standard flat plate HOT test procedure. Test plates will be positioned directly underneath the simulated freezing precipitation sprayer assembly. The "Ice Pellet Dispenser" will be positioned approximately 0.3 m (1 ft.) away from, and 0.9 m (3 ft) above the test plate.

##### 4.1 Type II/IV Fluid Application

1L of fluid at OAT will be poured onto the test plate. Fluid dilution, fluid thickness, surface temperature, fluid failure, and adhesion will be documented throughout the test. Photos of the test plate will be taken every 5 minutes for the duration of the test. Rate of precipitation will be verified just prior to the test and immediately following the end of the test.

##### 4.2 Precipitation Rate

To verify that the appropriate rate of precipitation is being produced, the following procedure will be followed. It should be noted that the chamber temperature during the tests will be set to -3°C.

Freezing Rain @ 25 g/dm<sup>2</sup>/h

1. Follow standard protocol for HOT testing in simulated freezing precipitation conditions.

Rain @ 13 g/dm<sup>2</sup>/h

1. Adjust flow meter to setting for ZR/-3/13 conditions;
2. Increase feed water temperature to the sprayer head incrementally by 1°C until the spray produced changes from freezing rain to rain. This can be verified using a cold soaked test plate to -3°C (ideal water temperature is when the precipitation stops freezing on the test plate);

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3. Manually measure rate of precipitation on test plate (see indoor HOT procedure);
4. Verify that light freezing rain rate of precipitation is within a 1 g/dm<sup>2</sup>/h tolerance; and
5. Adjust light freezing rain sprayer assembly to obtain desired rate.

Snow @ 12 g/dm<sup>2</sup>/h

1. Adjust "Ice Pellet Dispenser" to obtain the desired rate;
2. Manually measure the combined rate of precipitation (ZR and IP) on test plate (see indoor HOT procedure); and
3. Verify that combined rate of precipitation is within a 2 g/dm<sup>2</sup>/h tolerance.

#### 4.3 Surface Temperature

Test surface temperature logging is to be implemented using one thermistor probe mounted at the 15 cm (6") line on the underside of the test plate. The connection will be designed to last for the entire test season and to not impede the fluid flow. A SmartReader Eight-Channel temperature logger will be used to measure and record temperature. This temperature logger will run continuously and is independent of any external power supply or computer; the logger constantly measures and records readings from any enabled channels. The sampling rate (how often the logger takes readings) will be set to eight seconds, the smallest possible increment.

#### 4.4 Fluid Dilution

Fluid dilution will be measured at the 15 cm (6") line, using a Misco 10431VP brixometer. These measurements determine the concentration of the fluid on the test surface before and after fluid failure (estimate based on severity of fluid condition). The Brix value will originally be measured in the container before pouring. The second measurement will be taken right after pouring on the test surface, and at set intervals until fluid failure. After fluid failure the dilution measurements will be conducted every 5 minutes. Brix values and corresponding sample times will be recorded on the Brix/Thickness data form (Attachment II).

#### 4.5 Fluid Failure

Previous endurance time testing in simulated ice pellet conditions demonstrated that visual fluid failure was difficult to determine. Fluid failure determination is not

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critical to this project. APS members will use their best judgment in approximating the fluid time of failure.

#### 4.6 Fluid Adherence

The first occurrence of fluid adherence at any location on the surface of the plate will be recorded. Fluid adherence will be determined at the 5<sup>th</sup> crosshair immediately following failure at this location and at location B2 (see Attachment III). When the entire plate (15 crosshairs) has failed, again verify the fluid adherence at the 15 cm (6") line, and at all crosshairs B2, C2, D2, E2 and F2. Adherence will be noted by the plate observer on the Adherence of Fluid Failure data form (Attachment III). In addition to measuring adherence at the time of plate failure and complete plate failure, adherence will be measured progressively following fluid failure to determine the onset of adherence. A narrative description of the appearance of the fluid as it progresses toward failure will also be recorded.

In the absence of a recognized standard method or apparatus for measuring failure adhesion, the degree of bonding will be determined using an electronic dental flossing device. During operation, the device spins a thread of floss. The floss segment extends about 3 to 4 mm from the tip of the unit, and upon spinning could carve out a circle (or not, depending upon whether adhesion had occurred) 3 to 4 mm in radius on a failed surface element. In a layer of non-adhered fluid failure, the force of the spinning floss is sufficient to expose the surface of the test plate. As the rotation speed of the unit is fixed, the applied force will be constant for all tests, providing a basis of comparison among various test conditions, and between different stages of contamination for individual tests. This device proved to be the most satisfactory of the various approaches to establish whether an area had undergone surface bonding to the substrate and to give a measure of the strength of the bond formed.

An analysis of the shearing force exerted by this instrument (presented as Appendix C of the Transport Canada report, TP 14377E, *Adhesion of Aircraft Anti-Icing Fluids on Aluminum Surfaces (2003-04)*, December 2004) determined it to be in the range of  $1.3 \times 10^{-4}$  to  $2.0 \times 10^{-4}$  MPa.

#### 4.7 Test Sequence

The steps to be followed are specific to each precipitation type.

- 1) Synchronize computer and test clocks to the atomic clock;
- 2) Prepare test plate and test stand;
- 3) Initiate temperature logging;

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- 4) Prepare fluids for testing. The fluid types, fluid amounts and application temperatures are specific to each test;
- 5) Monitor precipitation rates;
- 6) Just before pouring the fluid, the test surface will be cleaned of all contamination with a scraper and a squeegee;
- 7) Apply the fluid to the test surfaces according to specific test procedure;
- 8) Determine failure time (estimated based on severity of fluid condition) on test surfaces, and record using standard ET data forms (Attachment I);
- 9) Measure Brix of the fluid and record on Brix/Thickness data form (Attachment II);
- 10) Determine fluid adherence and record on Adherence of Fluid Failure data form (Attachment III); and
- 11) At the end of the testing session save the temperature data on a memory stick or floppy disk. Label the diskette and place in the same envelope with the data forms.

## 5. EQUIPMENT AND FLUIDS

### 5.1 Equipment

The equipment to be used is, in general, the same as for the fluid holdover time tests. A comprehensive description of the equipment can be found in Transport Canada Report *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter*, TP 14144E, December 2004.

- Test plates and test stand;
- SmartReader Eight-Channel temperature logger and thermistor probes will be used for logging test surface temperatures;
- Wet film thickness gauges;
- Misco 10431VP brixometer will be utilized for fluid dilution rate measurements; and
- Ice Pellet Dispenser.

A detailed list of the equipment required for testing at the NRC facility is included in Attachment I.

ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS

**5.2 Fluids**

Tests shall be conducted using Type II/IV fluids as presented in Table 5.1. All fluids tested will be as close as possible to the lowest on wing viscosity and will conform to the viscosities stated in the HOT Guidelines.

**Table 5.1: Fluid Required for Testing**

Fluid Name	Fluid Type	Test Condition OAT [°C]	Tentative # of Tests	Total Litres Required [L]
Dow EG 106	4	-3	4	4
Kilfrost ABC-S+	4	-3	4	4
Kilfrost Type II	2	-3	4	4

**6. PERSONNEL**

Four technicians are needed to conduct the tests:

- Technician one calls failure, and documents adherence (MR);
- Technician two prepares fluids, measures precipitation rates and measures Brix and thickness (JT);
- Technician three will be in charge of running the ice pellet dispenser system and in charge of making simulated ice pellets (YOW 1); and
- Technician four will be in charge of managing the rate station (SB).

**7. DATA FORMS**

Some of the same data forms from the procedure, *Adhesion Of Aircraft De/Anti-Icing Fluids On Aluminum Surfaces* (see Version 1.0 from November 13, 2003, located in Appendix B of TP 14144E) will be used for this project. Some fields of the data forms will not need to be filled out as they are not relevant to this project (refer to Section 3 for pertinent data). The following data forms are included in this procedure:

- End Condition data form (Attachment II);
- Fluid Brix/Thickness data form (Attachment III);
- Adherence of Fluid Failure data form (Attachment IV); and
- Position of Ice Pellet Dispenser System data form (Attachment V).

**ADHESION OF AIRCRAFT DE/ANTI-ICING FLUIDS ON ALUMINUM SURFACES DURING MIXED PRECIP. CONDITIONS**

**ATTACHMENT I  
EQUIPMENT LIST**

***Test Equipment***

- Test Procedure, data forms
- Large clock
- Ice pellets dispensing devices x 6 / stands and adapter
- Desktop/Laptop computer with printer with paper
- Temperature Probe x 2 and spare batteries / immersion and surface probes
- Thickness Gauges (large and small)
- Brixometers x 3
- Adherence Probes
- Weigh scale (NCAR and HOT)
- Large Umbrella x2

***Ice Pellets Fabrication Equipment***

- Styrofoam containers x 20
- Ice bags
- Blenders (x 6)
- Ice pellets sieves (round and square)
- Folding tables
- Scrapers
- Measuring cups
- Rubber mats

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ATTACHMENT II  
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa)	DATE:	RUN NUMBER:	STAND # :
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TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application: \_\_\_\_\_

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

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

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

Time of Fluid Application: \_\_\_\_\_

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

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

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

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

AMBIENT TEMPERATURE: \_\_\_\_\_ °C

COMMENTS: \_\_\_\_\_

\_\_\_\_\_

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

LEADER / MANAGER: \_\_\_\_\_

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ATTACHMENT IV  
ADHERENCE OF FLUID FAILURE

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

Time: \_\_\_\_\_

Plate Location: \_\_\_\_\_

Run #: \_\_\_\_\_

Fluid Name: \_\_\_\_\_

Fluid Dilution: \_\_\_\_\_

t =

	1	2	3
B	o	o	o
C	o	o	o
D	o	o	o
E	o	o	o
F	o	o	o

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**APPENDIX E**

**ROGIDS ADVISORY CIRCULAR**



## 1. PURPOSE

This Advisory Circular (AC) provides the following:

- a. Guidelines and recommendations for certificate holders, deicing service providers, airport authorities and manufacturers of Remote On-Ground Ice Detection Systems (ROGIDS) regarding the use of these systems as a primary means for post deicing inspection of aircraft;
- b. Guidance on how to obtain approval to incorporate ROGIDS in a certificate holder's (or deicing service provider's)<sup>1</sup> approved deicing and anti-icing program; and
- c. Guidance material and recommendations for Principal Operations Inspectors (POIs) when reviewing submissions for operational approval of ROGIDS.

## 2. APPLICABILITY

This document applies to aircraft certificate holders, Aviation Safety Inspectors, manufacturers of ROGIDS, deicing service providers and airport authorities.

The applicant for ROGIDS use must be the holder of an air operator certificate (or the operator of an approved deicing facility)<sup>1</sup>.

## 3. DEFINITIONS

**Applicant:** The holder of an air operator certificate (or the operator of an approved deicing facility)<sup>1</sup>.

**Post Deicing Check:** An examination of an aircraft's wings and/or other critical surfaces after deicing has been performed to determine the presence of any remaining frozen contamination.

**Pre-Deicing Check:** An examination of an aircraft's wings and/or other critical surfaces to check for the presence of frozen contamination. Usually performed to determine the need for deicing.

**Remote On-Ground Ice Detection System (ROGIDS):** A system or device that makes a remote measurement of a monitored surface to determine whether frozen contamination is present. For the purpose of this AC, the intended function of the ROGIDS is the detection of clear ice. ROGIDS may be hand-held, pedestal or vehicle mounted (hereafter referred to as the *platform type*).

For additional definitions see: SAE Aerospace Standard 5681, *Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems*, Section 2.2 "Definitions" and AC 120-60, *Ground Deicing and Anti-icing Program*.

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<sup>1</sup> Text in parentheses to be included in Canadian version only

#### 4. RELATED READING MATERIAL

SAE Aerospace Standard 5681, *Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems*. This document is available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (USA and Canada) or 724-776-4970, [www.sae.org](http://www.sae.org).

*In Canadian version only:* Transport Canada Publication: TP 14052, Guidelines for Aircraft Ground Icing Operations.

FAA Advisory Circular: AC 120-60, Ground Deicing and Anti-icing Program.

#### 5. BACKGROUND

Ice formation on an aircraft critical surface can adversely affect performance, stability, and control during take-off. The pilot-in-command must ensure that aircraft critical surfaces are free from contamination prior to commencing a take-off. Currently, this inspection is done by visual or tactile inspection of the surfaces.

Research has shown that ROGIDS may perform more consistently and reliably than human visual and/or tactile methods of inspection for clear ice. Consequently, industry, FAA and Transport Canada developed SAE Aerospace Standard (AS) 5681 to establish a minimum operational performance specification for ROGIDS.

The deicing process will remove all contaminants (snow, frost, slush) from critical surfaces. These contaminants would normally be identified by a visual and/or tactile Post Deicing Check. The presence of residual clear ice is not easily identified through either a visual or tactile inspection. When approved as part of an applicant's ground deicing and anti-icing program, a ROGIDS may be used as the sole (primary) means of performing the Post Deicing Check for residual clear ice.

ROGIDS may also be used as a supplemental (advisory) means of performing a Pre-Deicing Check; it can only be used to supplement the other normal means of performing this check, such as visual and/or tactile inspections.

At this time, ROGIDS is not approved as a primary means for the detection of frost.

## 6. DISCUSSION

The prerequisite for operational approval to use ROGIDS for post deicing inspections is to document compliance with the mandatory design and performance test requirements in AS 5681. Compliance checklists (see AS 5681 Subsection 3.13) must be provided to facilitate this task. It is acceptable for the compliance checklists to provide a cross reference between requirements in AS 5681 (Sections 3 to 7) and documents from the manufacturer demonstrating compliance.

**Design Requirements (AS 5681, Sections 3 and 4):** The manufacturer must provide to the end user a declaration that the equipment complies with all the design requirements. Any design documentation required in AS 5681 must be made available to the POI upon request.

**Performance Test Requirements (AS 5681, Sections 5 to 7):** There are three types of performance test requirements:

1. Minimum Performance Specification in Environmental Test Conditions (Required tests and recommended tests. The end user and the equipment manufacturer will define which, if any, recommended tests are conducted);
2. Minimum Operational Performance Tests; and
3. Installed Equipment Operational Evaluation.

The manufacturer must provide to the end user a declaration that verification, validation, testing and analysis have demonstrated that the equipment complies with all the test requirements. Any non-compliances must be documented in the declaration. The documentation required in AS 5681 Subsections 3.11 "Test Procedures" and 3.12 "Test Reports" must be made available to the POI upon request.

## 7. ACCEPTANCE PROCESS

This AC describes an acceptable means, but not the only means, of integrating the use of ROGIDS into a certificate holder's Ground Deicing and Anti-Icing Program; another means may be used if it is established as an acceptable means of assuring operational safety.

The applicant initiates the request for use of a ROGIDS by contacting the approving authority, usually the POI. To ensure appropriate coordination and regulatory involvement, it is recommended that the applicant seek POI input during the early stages of the test plan or procedure development specified in AS 5681 Sections 5, 6 and 7.

The POI may witness all or part of the tests specified in AS 5681. Alternatively, the POI may require an independent observer, such as a Designated Engineering Representative (DER), to witness the tests.

Any tests in Sections 4 to 6 of AS 5681 that were failed must be reported to the POI before the Installed Equipment Operational Evaluation. Failed tests may create operational limitations in the use of the ROGIDS. (For example, if the ROGIDS is found to operate only down to temperatures of -27°C instead of -30°C, then it may be reported as an operational limitation.)

There are two acceptance processes: an Initial Acceptance Process and a Subsequent Acceptance Process.

The Initial Acceptance Process must be followed for installations of:

1. ROGIDS models not previously accepted; or
2. New models of previously accepted ROGIDS that incorporate significant / substantial changes.

The Subsequent Acceptance Process must be followed for all other installations.

## 7.1 Initial Acceptance Process

Table 7.1 highlights the specific roles and responsibilities of the applicant, the equipment manufacturer and the POI for each stage of the *Initial Acceptance Process*. Sections 3 to 7 of AS 5681 must be satisfactorily completed for the *Initial Acceptance Process*.

AS 5681 Subsection 7.3.1 states: “The total number of deicing operations that will be evaluated will be provided in separate regulatory guidance material for the initial evaluation and follow on evaluations”. For an initial acceptance, the initial evaluation requires a minimum of 100 deicing operations. These must be conducted in accordance with the criteria in Sections 7.3.2 to 7.3.8 of AS 5681.

**Table 7.1: Roles and Responsibilities Matrix for Initial Acceptance Process**

Stage	Applicant	Equipment Manufacturer	POI	Comments
1. Initiation	Contacts the POI and expresses intentions to incorporate ROGIDS into their deicing program	Supports applicant	Defines regulatory authority involvement in project	Define planned activities and schedule
2. Design	Provides input into design	Presents proposed design	May comment on proposed hardware and software assurance levels and system safety design	
3. Test Plans (Environmental and Operational Performance Tests)	Review and comment as necessary	Prepares test plans	Review and comment as necessary	Prepared in accordance with AS 5681, Section 3.10
4. Conformity Inspection	Supports equipment manufacturer	Conducts conformity inspection	Independent conformity inspection by regulatory authority at the discretion of POI	Purpose is to ensure that ROGIDS being tested is representative of production equipment
5. Environmental Tests	Optional witnessing	Conducts tests	Optional witnessing	See AS 5681, Section 5
6. Operational Performance Tests	Optional witnessing	Conducts tests	Optional witnessing	See AS 5681, Section 6
7. Design Reports	Review and comment as necessary	Prepares reports	Review and comment as necessary	These reports deal with AS 5681, Section 3, "Design Requirements"
8. Test Reports	Review and comment as necessary	Prepares reports	Review and comment as necessary	These reports deal with AS 5681, Sections 5 and 6
9. Operational Evaluation Plan	Review and comment as necessary	Prepares evaluation plan	Review and comment as necessary	
10. Installed Equipment Conformity Inspection	Support equipment manufacturer	Conducts conformity inspection	Independent conformity inspection by regulatory authority at the discretion of POI	Purpose is to ensure that installed equipment is representative of production equipment and installed in accordance with the manufacturer's instructions

**Table 7.1: Roles and Responsibilities Matrix for Initial Acceptance Process (cont'd)**

Stage	Applicant	Equipment Manufacturer	POI	Comments
11. Installed Equipment Operational Evaluation	Conducts evaluations	Supports applicant	Witness all or part of evaluation as appropriate	See AS 5681, Section 7. Prior to beginning the Installed Equipment Operational Evaluation, all testing specified through Chapter 6 in AS 5681 must be completed.
12. Installed Equipment Operational Evaluation Report	Prepares reports	Supports applicant	Review and comment as necessary	See AS 5681, Section 7.2.1
13. Incorporation into Ground Deicing and Anti-icing Program	<p>US version: Submit revision to ground deicing and anti-icing program, including operating, training and maintenance procedures</p> <p>Canadian version: Submit revision to company operations manual (COM) which would include revised deicing and anti-icing program; operating, training and maintenance procedures</p>	Supports applicant	<p>US version: Review by POI for acceptability and approval for inclusion in ground deicing and anti-icing program</p> <p>Canadian version: Review by POI for acceptability and approval of COM.</p>	

## 7.2 Subsequent Acceptance Process

Table 7.2 highlights the specific roles and responsibilities of the applicant, the equipment manufacturer, and the POI for each stage of the Subsequent Acceptance Process.

Data generated from the Initial Acceptance Process falls into two categories and may be reused in the Subsequent Acceptance Process.

The first category includes design and test data showing compliance to AS 5681 Sections 3 to 6. If the data from the Initial Acceptance Process are available, it may be reused for subsequent installations at the discretion of the POI. If the data are not available, the Initial Acceptance Process (see Subsection 7.1) must be completed.

The second category includes operational evaluation data showing compliance to AS 5681 Section 7. Where operational evaluation data from the Initial Acceptance Process are available, only a limited number of additional deicing operations are required for the operational evaluation, as described below.

1. If the only change from the initial installation is the facility where the ROGIDS is located, and there are no significant differences in lighting type, aircraft type<sup>2</sup>, fluid brands, and/or platform types, then transfer of the operational evaluation data may be accepted at the discretion of the POI, and no additional deicing operations would be required.
2. If there are significant differences in lighting type, aircraft type, fluid brands, and/or platform types, then the following additional operational evaluations must be performed:
  - a) Where there are significant differences in lighting type, aircraft type or fluid brands, a minimum of 30 deicing operations are required; these must be conducted in accordance with the criteria in Subsection 7.3.2 of AS 5681; and
  - b) Where a different platform type is used, a minimum of 20 deicing operations are required; these must be conducted in accordance with the criteria in Sections 7.3.3 to 7.3.8 of AS 5681.

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<sup>2</sup> Note: The primary concerns when assessing the impact of various aircraft types on the use of ROGIDS are the aircraft material, the surface finish and/or the surface treatment of the monitored surface.

**Table 7.2: Roles and Responsibilities Matrix for Subsequent Acceptance Process**

Stage	Applicant	Equipment Manufacturer	POI	Comments
1. Initiation	Contacts the POI and expresses intentions to incorporate ROGIDS into their deicing program	Supports applicant	Defines regulatory authority involvement in project	Define planned activities and schedule.
2. Review Existing Design and Test Data	Propose and justify use of previously accepted data and reports	Supports applicant	Confirm the data from the Initial Acceptance Process is available and appropriate prior to initiating operational evaluation testing	
3. Operational Evaluation Plan	Review and comment as necessary	Prepares evaluation plan	Review and comment as necessary	
4. Installed Equipment Conformity Inspection	Support equipment manufacturer	Conducts conformity inspection	Independent conformity inspection by regulatory authority at the discretion of POI	Purpose is to ensure that installed equipment is representative of production equipment and installed in accordance with the manufacturer's instructions
5. Installed Equipment Operational Evaluation	Conducts evaluations in accordance with Sections 7.2, 7.3 and 7.4 of this document	Supports applicant	Witness all or part of evaluation as appropriate	
6. Installed Equipment Operational Evaluation Report	Prepares reports	Supports applicant	Review and comment as necessary	See AS 5681, Section 7.2.1
7. Incorporation into Ground Deicing and Anti-icing Program	US version: Submit revision to ground deicing and anti-icing program, including operating, training and maintenance procedures  Canadian version: Submit revision to company operations manual (COM) which would include revised deicing and anti-icing program; operating, training and maintenance procedures	Supports applicant	US version: Review by POI for acceptability and approval for inclusion in ground deicing and anti-icing program  Canadian version: Review by POI for acceptability and approval of COM.	

### 7.3 Installed Equipment Operational Evaluation Considerations

The Installed Equipment Operational Evaluation must be performed during actual aircraft deicing operations.

A minimum of two qualified deicing operators must participate in both the Initial and the Subsequent Operational Evaluations. The number of deicing operations should be distributed among the operators as evenly as possible.

## 8. APPROVAL

To incorporate ROGIDS into their operations, the applicant must submit:

- a. A revision to the ground deicing and anti-icing program<sup>3</sup> that identifies the intended use and any operational limitations of the ROGIDS, and includes changes to the maintenance and training programs;
- b. A description of ROGIDS equipment and installation; and
- c. Compliance checklists as described in Section 6 of this document.

The ROGIDS may be approved as part of the applicant's approved deicing and anti-icing program once the applicant has demonstrated that the ROGIDS meets the requirements of AS 5681 and this AC.

Ongoing acceptance is contingent on the applicant ensuring that changes to lighting type, aircraft type, fluid brands, and/or platform types have been assessed and addressed.

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<sup>3</sup> Canadian version to use "COM" in place of "ground deicing and anti-icing program"

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**APPENDIX F**

**TRANSPORT CANADA  
HOLDOVER TIME (HOT) GUIDELINES  
WINTER 2008-2009**



# **Transport Canada Holdover Time (HOT) Guidelines Winter 2008-2009**

**Original Issue, July 2008**

This document should be used in conjunction with *Guidelines for Aircraft Ground-Icing Operations* (TP 14052E, second edition, April 2005).

The two documents complement each other and should be used together for a thorough understanding of the subject matter.

**CHANGE CONTROL RECORDS**

This page indicates any changes made to individual pages within the document. Changed pages have the appropriate revision date in the footer. Sidebars are shown to assist in identifying where the changes have been made on these pages.

It is the responsibility of the end user to periodically check the following website for updates on Holdover Time Guidelines:

<http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm>.

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

**Transport Canada Holdover Time Guidelines****Winter 2008-2009****SUMMARY OF CHANGES FROM PREVIOUS YEAR**

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

**Type I Fluid**

The Type I holdover time guideline values are unchanged.

**Type II Fluid**

A fluid-specific table has been created for one new Type II fluid: Kilfrost ABC-K Plus. This fluid is currently in the qualification process. The Type II generic holdover time guideline values are unchanged.

Transport Canada and the FAA have been notified that there were possible viscosity issues with the Aviation Xi'an High-Tech KHF II fluid, which was first commercialized for use in winter 2007-2008.

Specifically, there may still be batches of this fluid on the market that were shipped/delivered with viscosities lower than the published Lowest On-Wing Viscosities for use with the HOT guidelines.

We have been advised that the fluid manufacturer is taking measures to correct this situation.

A fluid-specific holdover time guideline table has been retained for this fluid; however, Table 5 "Currently Qualified Fluids (2008-2009)" was amended to indicate that this fluid is currently in re-qualification.

It is highly recommended that operators intending to utilize holdover time guidelines associated with this fluid:

- 1) Contact the vendor for further details; and
- 2) Carefully assess this fluid's on-wing viscosity at time of use.

**Type III Fluid**

The Type III holdover time guideline values are unchanged.

**Type IV Fluid**

Removal of obsolete Type IV data has resulted in increases to the values in the cold soaked wing cells of the generic holdover time guidelines.

A fluid-specific table has been added for Dow Chemical UCAR™ FlightGuard AD-480. This product is identical to ABAX (ex SPCA) AD-480; therefore, the holdover time guideline values for these tables are the same.

**Holdover Times in Frost Conditions**

A note has been included in the Type II and Type IV generic and fluid-specific tables to advise that radiational cooling during active frost conditions may reduce holdover time when operating close to the lower end of the outside air temperature range.

**Transport Canada Holdover Time Guidelines****Winter 2008-2009****CHANGES TO *Guidelines for Aircraft Ground-Icing Operations*  
(TP 14052E, second ed., April 2005)**

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

**Replace Sub-Paragraph 10.13.3, “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) has been considered and deemed not to affect the HOT.

If there is doubt surrounding the conditions associated with using the lowest time as decision making criteria, an inspection prior to takeoff would be prudent. This inspection should be conducted in accordance with the procedures described in the Air Operator's Approved Ground Icing Program.

**Replace Paragraph 11.1.8 with the following:**

The HOT Guidelines do not include guidelines for all meteorological conditions.

Holdover time guidelines have not been assessed for the following conditions: a) Snow Pellets; b) Hail; c) Moderate and Heavy Freezing Rain; and d) Heavy Snow.

Notes: Operators need to assess whether operations can be safely conducted under these conditions.

Additionally, holdover time guidelines have not been assessed for the ice pellets since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria has yet been identified for ice pellet conditions. Instead, an allowance time based upon research has been developed for operations during ice pellet conditions.

**Replace Paragraph 12.1.2 with the following:**

Holdover time guidelines have not been assessed for ice pellets, since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have yet been identified for ice pellet conditions.

However, comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for allowance times for operations in light and moderate ice pellets, as well as allowance times for operations in light ice pellets mixed with other forms of precipitation.

**Transport Canada Holdover Time Guidelines****Winter 2008-2009****HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2008-2009**

Table 1	SAE Type I Fluid Holdover Guidelines
Table 2-Generic	SAE Type II Fluid Holdover Guidelines
Table 2-A-E26	ABAX (ex SPCA) Type II Fluid Holdover Guidelines Ecowing 26
Table 2-A-KHF-II	Aviation Xi'an High-Tech Type II Fluid Holdover Guidelines KHF-II
Table 2-C-2025	Clariant Type II Fluid Holdover Guidelines Safewing MP II 2025 ECO
Table 2-C-Flight	Clariant Type II Fluid Holdover Guidelines Safewing MP II Flight
Table 2-K-ABC-2000	Kilfrost Type II Fluid Holdover Guidelines ABC-2000
Table 2-K-ABC-II+	Kilfrost Type II Fluid Holdover Guidelines ABC-II PLUS
Table 2-K-ABC-K+	Kilfrost Type II Fluid Holdover Guidelines ABC-K PLUS
Table 2-N-FCY-2	Newave Aerochemical Type II Fluid Holdover Guidelines FCY-2
Table 2-O-EM-II	Octagon Type II Fluid Holdover Guidelines E Max II
Table 3	SAE Type III Fluid Holdover Guidelines
Table 4-Generic	SAE Type IV Fluid Holdover Guidelines
Table 4-A-AD-480	ABAX (ex SPCA) Type IV Fluid Holdover Guidelines AD-480
Table 4-C-2001	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2001
Table 4-C-2012	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2012 Protect
Table 4-C-Launch	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV Launch
Table 4-D-ULTRA+	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ ADF/AAF ULTRA+
Table 4-D-E106	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ Endurance EG106
Table 4-D-AD-480	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ FlightGuard AD-480
Table 4-K-ABC-S	Kilfrost Type IV Fluid Holdover Guidelines ABC-S
Table 4-K-ABC-S PLUS	Kilfrost Type IV Fluid Holdover Guidelines ABC-S PLUS
Table 4-L-ARCTIC Shield	Lyondell Type IV Fluid Holdover Guidelines ARCTIC Shield™
Table 4-O-MF	Octagon Type IV Fluid Holdover Guidelines Max-Flight
Table 4-O-MF-04	Octagon Type IV Fluid Holdover Guidelines Max-Flight 04
Table 4-O-MFLO	Octagon Type IV Fluid Holdover Guidelines MaxFlo
Table 5	Currently Qualified Fluids
Table 6	SAE Type I Deicing Fluid Application Procedures
Table 7	SAE Type II, Type III and Type IV Anti-Icing Fluid Application Procedures
Table 8	Visibility in Snow vs. Snowfall Intensity Chart
Table 9	Lowest On-Wing Viscosity Values for Anti-Icing Fluids
Table 10	Ice Pellet Allowance Times

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

**TABLE 1**

**SAE TYPE I<sup>3</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009**

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-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-Generic

**SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	0:20 – 1:05	0:15 – 0:30	0:15 – 0:45 <sup>3</sup>	0:10 – 0:20 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:20 – 0:55	0:10 – 0:20	0:15 – 0:30 <sup>3</sup>	0:05 – 0:15 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00 <sup>5,6</sup>	0:15 – 0:20 <sup>6</sup>	0:15 – 0:30 <sup>6</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 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
- 6 Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-A-E26

**ABAX (ex SPCA) TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-A-KHF-II

**AVIATION XI'AN HIGH-TECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
KHF-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	1:15 – 2:15	0:45 – 1:20	0:50 – 1:30	0:30 – 0:45	0:10 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:45 – 1:00	0:25 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:45	
		50/50	3:00 <sup>5</sup>	0:20 – 0:30	0:15 – 0:25	0:10 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00 <sup>5</sup>	1:10 – 2:40	0:35 – 1:00	0:20 – 1:35 <sup>3</sup>	0:25 – 0:40 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:45 – 1:20	0:15 – 0:30	0:20 – 0:45 <sup>3</sup>	0:15 – 0:20 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00 <sup>5</sup>	0:35 – 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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-C-2025

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-C-Flight

**CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-K-ABC-2000

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-K-ABC-II+

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-K-ABC-K+

**KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
ABC-K PLUS**

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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	2:15 – 3:45	1:00 – 1:40	1:50 – 2:00	1:00 – 1:25	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:40 – 2:30	0:35 – 1:10	1:25 – 2:00	0:50 – 1:10	0:15 – 2:00	
		50/50	3:00 <sup>5</sup>	0:35 – 1:05	0:05 – 0:15	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	8:00 <sup>5</sup>	0:30 – 1:05	0:50 – 1:25	0:25 – 1:00 <sup>3</sup>	0:15 – 0:35 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:25 – 1:25	0:35 – 1:05	0:20 – 0:55 <sup>3</sup>	0:05 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00 <sup>5</sup>	0:30 – 0:55	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-N-FCY-2

**NEWAVE AEROCHEMICAL TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
FCY-2**

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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	1:15 – 2:25	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:05 – 0:45	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:50 – 1:30	0:20 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:25	
		50/50	3:00 <sup>5</sup>	0:25 – 0:35	0:15 – 0:25	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	8:00 <sup>5</sup>	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45 <sup>3</sup>	0:15 – 0:20 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30 <sup>3</sup>	0:05 – 0:15 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	8:00 <sup>5</sup>	0:25 – 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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 2-O-EM-II

**OCTAGON TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

**TABLE 3**

**SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009**

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

Outside Air Temperature <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	100/0	120	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	60	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	120	20 – 40	30	15 – 30	8 – 15				

**NOTES**

- 1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- 2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
- 3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-Generic

**SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 – 1:05	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 – 0:40	
		50/50	3:00 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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>5,6</sup>	0:15 – 0:40 <sup>6</sup>	0:15 – 0:30 <sup>6</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 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
- 6 Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-A-AD-480

**ABAX (ex SPCA) TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-C-2001

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-C-2012

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
SAFWING 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 <sup>5</sup>	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 <sup>5</sup>	0:45 – 1:45	0:20 – 0:40	0:25 – 0:45 <sup>3</sup>	0:15 – 0:25 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-C-Launch

**CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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	1:05 – 1:45	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	1:00 – 1:45	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45		
		50/50	3:00 <sup>5</sup>	1:25 – 2:45	0:25 – 0:45	0:30 – 0:50	0:20 – 0:25			
below -3 to -14	below 27 to 7	100/0	12:00 <sup>5</sup>	1:00 – 1:55	0:50 – 1:20	0:35 – 1:40 <sup>3</sup>	0:25 – 0:45 <sup>3</sup>			
		75/25	5:00 <sup>5</sup>	0:40 – 1:20	0:45 – 1:25	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-D-ULTRA+

**DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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>5,6</sup>	0:40 – 2:10 <sup>6</sup>	0:20 – 0:45 <sup>6</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 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
- 6 These holdover times only apply to outside air temperatures to -24°C (-11°F).

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-D-E106

**DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-D-AD-480

**DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
UCAR™ FLIGHTGUARD AD-480**

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-K-ABC-S

**KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-K-ABC-S PLUS

**KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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	2:10 – 4:00	1:15 – 2:00	1:50 – 2:00	1:05 – 2:00	0:25 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:25 – 2:40	0:45 – 1:15	1:00 – 1:20	0:30 – 0:50	0:10 – 1:20	
		50/50	3:00 <sup>5</sup>	0:30 – 0:55	0:15 – 0:30	0:15 – 0:40	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	12:00 <sup>5</sup>	0:55 – 3:30	1:00 – 1:45	0:25 – 1:35 <sup>3</sup>	0:20 – 0:30 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:45 – 1:50	0:35 – 1:00	0:20 – 1:10 <sup>3</sup>	0:15 – 0:25 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00 <sup>5</sup>	0:40 – 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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-L-ARCTIC Shield

**LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<sup>1</sup>  
ARCTIC SHIELD™**

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		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 – 3:10	0:50 – 1:25	0:55 – 1:40	0:45 – 1:05	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	5:00	1:20 – 2:15	0:40 – 1:05	0:55 – 1:25	0:30 – 0:45	0:05 – 1:20	
		50/50	3:00 <sup>5</sup>	0:35 – 0:45	0:20 – 0:35	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	12:00 <sup>5</sup>	1:00 – 2:25	0:45 – 1:15	0:25 – 1:30 <sup>3</sup>	0:25 – 0:30 <sup>3</sup>		
		75/25	5:00 <sup>5</sup>	0:50 – 1:45	0:35 – 0:55	0:30 – 1:15 <sup>3</sup>	0:25 – 0:30 <sup>3</sup>		
below -14 to -25	below 7 to -13	100/0	12:00 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-O-MF

**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

TABLE 4-O-MF-04

**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

**TABLE 4-O-MFLO**  
**OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009<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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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 <sup>5</sup>	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.
- 5 Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

## Transport Canada Holdover Time Guidelines

Winter 2008-2009

TABLE 5  
CURRENTLY QUALIFIED FLUIDS (2008-2009)

Table 5-1: Qualified Type I Anti-icing Fluids<sup>(1) (2)</sup>

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
1-1	ABAX Industries (ex SPCA)	ABAX DE-950	12-06-25
1-2	ABAX Industries (ex SPCA)	ABAX DE-950 Colorless	12-06-26
1-3	<i>Arcton Ltd.</i>	<i>Arctica DG</i>	<i>08-04-10<sup>(3)</sup></i>
1-4	Aviation Xi'an High-Tech	Aviation Xi'an KHF-1	11-09-20
1-5	<i>Battelle</i>	<i>D<sup>3</sup>: Degradable by Design Deicer™ ADF 1006A</i>	<i>08-01-13<sup>(3)</sup></i>
1-6	Beijing Wangye Aviation Chemical Product Co. Ltd.	KLA-1	11-09-20
1-7	Beijing Wangye Aviation Chemical Product Co. Ltd.	YJF-1	09-02-23
1-8	Clariant GmbH	Clariant Safewing MP I 1938 TF	08-08-21
1-9	<i>Clariant GmbH</i>	<i>Clariant Safewing MP I 1938 TF Pre-Mix</i>	<i>07-09-14<sup>(3)</sup></i>
1-10	Clariant GmbH	Clariant Safewing MP I 1938 ECO (80)	12-06-10
1-11	Clariant GmbH	Clariant Safewing MP I 1938 ECO (80) Pre-Mix	09-03-01
1-12	Clariant GmbH	Clariant Safewing MP I 1938 ECO	12-06-10
1-13	Clariant GmbH	Clariant Safewing EG I 1996	12-06-10
1-14	<i>Chemical Specialists and Development Inc.</i>	<i>Prist Wing De-Icer</i>	<i>08-05-17<sup>(3)</sup></i>
1-15	Dow Chemical Company	Dow UCAR™ Aircraft Deicing Fluid Concentrate	11-09-10
1-16	Dow Chemical Company	Dow UCAR™ ADF XL-54	09-02-01
1-17	Dow Chemical Company	Dow UCAR™ PG ADF Aircraft Deicing Fluid Concentrate	12-02-05
1-18	Dow Chemical Company	Dow UCAR™ PG ADF Dilute 55/45	12-02-05
1-19	<i>HOC Industries</i>	<i>SafeTemp I ES</i>	<i>07-10-27<sup>(3)</sup></i>
1-20	HOC Industries	SafeTemp ES Plus	11-10-04
1-21	<i>Inland Technologies Inc.</i>	<i>Inland Duragly-P ready to use</i>	<i>05-09-11<sup>(3)</sup></i>
1-22	<i>Inland Technologies Inc.</i>	<i>Inland Duragly-E ready to use</i>	<i>05-10-20<sup>(3)</sup></i>
1-23	Kilfrost Limited	Kilfrost DF Plus	11-09-27
1-24	Kilfrost Limited	Kilfrost DF Plus (80)	08-07-12 <sup>(4)</sup>
1-25	Kilfrost Limited	Kilfrost DF Plus (88)	11-09-27
1-26	Kilfrost Limited	Kilfrost DF <sup>sustain</sup>	09-01-26
1-27	<i>Lyondell Chemical Co.</i>	<i>Lyondell ARCOPlus®</i>	<i>08-02-14<sup>(3)</sup></i>
1-28	<i>Lyondell Chemical Co.</i>	<i>Lyondell ARCTIC Plus®</i>	<i>08-04-10<sup>(3)</sup></i>
1-29	Newave Aerochemical Co. Ltd.	Newave FCY-1A	11-08-21
1-30	Octagon Process Inc.	Octagon EcoFlo	09-07-30
1-31	Octagon Process Inc.	Octagon Octaflo EF	11-07-11
1-32	<i>Octagon Process Inc.</i>	<i>Octagon Octaflo EG</i>	<i>07-05-12<sup>(3)</sup></i>
1-33	<i>Viterbo S.A.</i>	<i>Jarkleer SAE Type I</i>	<i>07-01-20<sup>(3)</sup></i>

<sup>(1)</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.uqac.ca/amil/index.htm>  
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.

<sup>(2)</sup> Concentrate fluids have also been qualified at 50/50 (glycol/water) dilution.

<sup>(3)</sup> Fluids listed in italics have expired and will be removed from this listing four years after expiry.

<sup>(4)</sup> Currently in qualification/re-qualification process.

## Transport Canada Holdover Time Guidelines

Winter 2008-2009

TABLE 5 (cont.)  
CURRENTLY QUALIFIED FLUIDS (2008-2009)

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
2-1	ABAX Industries (ex SPCA)	Ecowing 26	09-08-21
2-2	Aviation Xi'an High-Tech	Aviation Xi'an KHF-II	08-06-15 <sup>(3)</sup>
2-3	Clariant GmbH	Clariant Safewing MP II 1951	09-05-08
2-4	<i>Clariant GmbH</i>	<i>Clariant Safewing MP II 2025 ECO</i>	08-06-28 <sup>(2)</sup>
2-5	Clariant GmbH	Clariant Safewing MP II Flight	10-06-16
2-6	<i>Kilfrost Limited</i>	<i>Kilfrost ABC-II PLUS</i>	05-10-29 <sup>(2)</sup>
2-7	Kilfrost Limited	Kilfrost ABC-3	10-07-16
2-8	Kilfrost Limited	Kilfrost ABC-2000	08-07-12 <sup>(3)</sup>
2-9	Kilfrost Limited	Kilfrost ABC-K PLUS	Y-M-D <sup>(3)</sup>
2-10	Newave Aerochemical Co. Ltd.	Newave FCY-2	09-01-11
2-11	Octagon Process Inc.	Octagon E Max II	08-10-31

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
3-1	Clariant GmbH	Clariant Safewing MP III 2031 ECO	09-05-02
	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	ABAX Industries (ex SPCA)	ABAX AD-480	09-07-30
4-2	<i>Clariant GmbH</i>	<i>Clariant Safewing MP IV 2001</i>	08-06-26 <sup>(2)</sup>
4-3	<i>Clariant GmbH</i>	<i>Clariant Safewing MP IV 2012 Protect</i>	07-07-12 <sup>(2)</sup>
4-4	Clariant GmbH	Clariant Safewing MP IV Launch	10-06-18
4-5	Dow Chemical Company	Dow UCAR ADF/AAF ULTRA+	08-08-21
4-6	Dow Chemical Company	UCAR™ Endurance EG106	09-09-04
4-7	Dow Chemical Company	UCAR FlightGuard AD-480	10-04-30
4-8	<i>Ely Chemical Company</i>	<i>Octagon Max-Flight</i>	06-07-06 <sup>(2)</sup>
4-9	Kilfrost Limited	Kilfrost ABC-S	09-06-29
4-10	Kilfrost Limited	ABC-S PLUS	09-03-07
4-11	Lyondell Chemical Co.	Lyondell ARCTIC Shield™	10-05-21
4-12	<i>Octagon Process Inc.</i>	<i>Octagon Max-Flight</i>	06-07-06 <sup>(2)</sup>
4-13	Octagon Process Inc.	Octagon Max-Flight 04	10-04-29
4-14	<i>Octagon Process Inc.</i>	<i>Octagon MaxFlo</i>	07-03-24 <sup>(2)</sup>

<sup>(1)</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.uqac.ca/amil/index.htm>  
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.

<sup>(2)</sup> Fluids listed in italics have expired and will be removed from this listing four years after expiry.

<sup>(3)</sup> Currently in qualification/re-qualification process.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

**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 (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

- 1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
- 2 To be applied before first step fluid freezes, typically within 3 minutes.

**NOTES**

- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in snow conditions, at least 1 litre/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.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  - b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

**CAUTION**

- Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.

## Transport Canada Holdover Time Guidelines

Winter 2008-2009

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 OAT is at or above the LOU. Consider the use of Type I when Type II/III/IV fluid cannot be used (see Table 6).		

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOU).

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.
- The lowest operational use temperature (LOU) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  - b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).

## CAUTIONS

- Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.
- Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II, III or IV 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 2008-2009**

**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 2008-2009

**TABLE 9**  
**LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS**  
 (See Table 9 endnotes)

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY <sup>a</sup> (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX (ex SPCA) Ecowing 26	100/0	4 900 <sup>e</sup>	4 600 <sup>g</sup>
	75/25	2 200 <sup>g</sup>	2 200 <sup>g</sup>
	50/50	50 <sup>g</sup>	50 <sup>g</sup>
Aviation Xi'An Hi-Tech KHF-II	100/0	8 750 <sup>c</sup>	7 690 <sup>g</sup>
	75/25	6 400 <sup>c</sup>	6 890 <sup>g</sup>
	50/50	2 950 <sup>c</sup>	3 150 <sup>g</sup>
Clariant Safewing MP II 2025 ECO	100/0	5 500 <sup>b</sup>	5 750 <sup>g</sup>
	75/25	10 000 <sup>b</sup>	10 000 <sup>g</sup>
	50/50	3 000 <sup>b</sup>	3 250 <sup>g</sup>
Clariant Safewing MP II Flight	100/0	3 340 <sup>g</sup>	3 340 <sup>g</sup>
	75/25	17 500 <sup>g</sup>	17 500 <sup>g</sup>
	50/50	11 500 <sup>g</sup>	11 500 <sup>g</sup>
Clariant Safewing MP II 1951	100/0	2 500 <sup>b</sup>	2 750 <sup>g</sup>
	75/25	2 900 <sup>b</sup>	3 000 <sup>g</sup>
	50/50	50 <sup>b</sup>	50 <sup>g</sup>
Kilfroast ABC-3	100/0	2 500 <sup>c</sup>	2 500 <sup>j</sup>
	75/25	2 000 <sup>c</sup>	2 000 <sup>j</sup>
	50/50	400 <sup>c</sup>	400 <sup>j</sup>
Kilfroast ABC-2000	100/0	2 350 <sup>c</sup>	2 350 <sup>g</sup>
	75/25	3 000 <sup>c</sup>	3 000 <sup>j</sup>
	50/50	1 000 <sup>c</sup>	1 000 <sup>j</sup>
Kilfroast ABC-II Plus	100/0	3 600 <sup>c</sup>	3 600 <sup>g</sup>
	75/25	4 000 <sup>c</sup>	4 000 <sup>j</sup>
	50/50	1 000 <sup>c</sup>	1 000 <sup>j</sup>
Kilfroast ABC-K Plus	100/0	2 850 <sup>c</sup>	2 640 <sup>g</sup>
	75/25	12 650 <sup>c</sup>	12 650 <sup>c</sup>
	50/50	4 200 <sup>c</sup>	5 260 <sup>g</sup>
Newave Aerochemical FCY-2	100/0	7 000 <sup>c</sup>	8 920 <sup>g</sup>
	75/25	18 550 <sup>c</sup>	18 550 <sup>c</sup>
	50/50	6 750 <sup>c</sup>	7 030 <sup>g</sup>
Octagon E Max II	100/0	13 520 <sup>d</sup>	13 520 <sup>g</sup>
	75/25	11 400 <sup>g</sup>	11 400 <sup>g</sup>
	50/50	2 820 <sup>g</sup>	2 820 <sup>g</sup>

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY <sup>a</sup> (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Clariant Safewing MP III 2031 ECO	100/0	30 <sup>h</sup>	Not Applicable
	75/25	55 <sup>h</sup>	Not Applicable
	50/50	10 <sup>h</sup>	Not Applicable

## Transport Canada Holdover Time Guidelines

Winter 2008-2009

TABLE 9 (cont.)  
 LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS  
 (See Table 9 endnotes)

Table 9-3: Type IV Anti-Icing Fluids			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY <sup>a</sup> (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX (ex SPCA) AD-480	100/0	15 200 <sup>e</sup>	12 800 <sup>c</sup>
	75/25	16 000 <sup>e</sup>	12 400 <sup>c</sup>
	50/50	4 000 <sup>e</sup>	3 800 <sup>g</sup>
Clariant Safewing MP IV 2001	100/0	18 000 <sup>b</sup>	18 000 <sup>c</sup>
	75/25	8 000 <sup>b</sup>	11 500 <sup>g</sup>
	50/50	1 200 <sup>b</sup>	1 750 <sup>g</sup>
Clariant Safewing MP IV 2012 Protect	100/0	7 800 <sup>b</sup>	7 250 <sup>g</sup>
	75/25	17 800 <sup>b</sup>	17 700 <sup>c</sup>
	50/50	4 500 <sup>b</sup>	4 250 <sup>g</sup>
Clariant Safewing MP IV Launch	100/0	7 550 <sup>g</sup>	7 550 <sup>g</sup>
	75/25	18 000 <sup>g</sup>	18 000 <sup>g</sup>
	50/50	17 800 <sup>g</sup>	17 800 <sup>g</sup>
Dow UCAR ADF/AAF ULTRA+	100/0	36 000 <sup>f</sup>	28 000 <sup>c</sup>
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR Endurance EG106	100/0	24 850 <sup>f</sup>	2 230 <sup>g</sup>
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR FlightGuard AD-480	100/0	15 200 <sup>e</sup>	12 800 <sup>c</sup>
	75/25	16 000 <sup>e</sup>	12 400 <sup>c</sup>
	50/50	4 000 <sup>e</sup>	3 800 <sup>g</sup>
Kilfrost ABC-S	100/0	17 000 <sup>c</sup>	17 000 <sup>c</sup>
	75/25	12 000 <sup>c</sup>	12 000 <sup>c</sup>
	50/50	2 000 <sup>c</sup>	2 000 <sup>j</sup>
Kilfrost ABC-S PLUS	100/0	17 900 <sup>c</sup>	17 900 <sup>c</sup>
	75/25	18 300 <sup>c</sup>	18 300 <sup>c</sup>
	50/50	7 500 <sup>c</sup>	7 500 <sup>j</sup>
Lyondell ARCTIC Shield™	100/0	23 150 <sup>i</sup>	28 000 <sup>c</sup>
	75/25	21 700 <sup>i</sup>	22 100 <sup>c</sup>
	50/50	6 400 <sup>i</sup>	7 640 <sup>g</sup>
Octagon Max-Flight	100/0	5 540 <sup>d</sup>	5 540 <sup>g</sup>
	75/25	15 000 <sup>g</sup>	15 000 <sup>g</sup>
	50/50	5 200 <sup>g</sup>	5 200 <sup>g</sup>
Octagon Max-Flight 04	100/0	5 540 <sup>d</sup>	5 540 <sup>g</sup>
	75/25	15 000 <sup>g</sup>	15 000 <sup>g</sup>
	50/50	5 200 <sup>g</sup>	5 200 <sup>g</sup>
Octagon MaxFlo	100/0	8 670 <sup>g</sup>	8 670 <sup>g</sup>
	75/25	8 200 <sup>g</sup>	8 200 <sup>g</sup>
	50/50	2 200 <sup>g</sup>	2 200 <sup>g</sup>

**Transport Canada Holdover Time Guidelines****Winter 2008-2009**

**TABLE 9 (cont.)  
LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS**

**NOTES**

- a The Aerospace Information Report (AIR) 9968 Revision A (December 2004) viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method.
- b Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 15 minutes 0 seconds.
- c Brookfield Spindle LV2-disc with guard leg, 150 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
- d Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 20 seconds.
- e Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 30 minutes 0 seconds.
- f Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 0°C, 0.3 rpm, for 10 minutes 0 seconds.
- g Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
- h Brookfield Spindle LV0, UL-Adapter, 16 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
- i Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 0 seconds.
- j Brookfield Spindle LV1 with guard leg, 150 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.

**SIGNIFICANCE OF THIS TABLE**

The viscosity values of the fluids in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing is not lower than that listed.

**Transport Canada Holdover Time Guidelines****Winter 2008-2009****ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009**

Comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light or moderate) and light ice pellets mixed with other forms of precipitation.

Results of this research provide the basis for allowance times for operations in ice pellets (light or moderate) and operations in light ice pellets when mixed with other forms of precipitation.

Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times.

**Operational Guidelines**

- 1) Tests have shown that ice pellets generally remain in the frozen state embedded in Type IV anti-icing fluid, and are not dissolved by the fluid in the same manner as other forms of precipitation. Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not dissolved by the fluid (remaining embedded) would be an indication that the fluid has failed. These embedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination inspection procedures.
- 2) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and light ice pellets mixed with other forms of precipitation in Type IV fluid will not prevent the fluid from flowing off the aerodynamic surfaces during takeoff.
- 3) The allowance times were developed based on this aerodynamic testing and are contained in Table 10.
- 4) The ice pellet allowances are contingent on the operator's approved ground icing program being updated to incorporate the ice pellet information contained herein, including the following conditions and restrictions that must be satisfied:
  - a) The aircraft critical surfaces must be properly deiced before the application of Type IV anti-icing fluid;
  - b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid;
  - c) These allowance times are from the start of the Type IV anti-icing fluid application;
  - d) The allowance time is limited to aircraft with a rotation speed of 100 knots or greater;
  - e) If the takeoff is not accomplished within the applicable allowance time in Table 10, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff;
  - f) The allowance time cannot be extended by an inspection of the aircraft critical surfaces from either inside or outside the aircraft;

**Transport Canada Holdover Time Guidelines****Winter 2008-2009**

- g) If the temperature decreases below the temperature on which the allowance time was based, where the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit;
  - h) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used;
  - i) If the precipitation condition stops at or before the time limits of the applicable allowance time in Table 10 and does not restart, the aircraft may takeoff up to 90 minutes after the start of the application of the Type IV anti-icing fluid. However, under conditions of light ice pellets mixed with light freezing rain, the OAT must not decrease during the 90-minute period.
- 5) Examples:
- a) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50 the aircraft may takeoff without any further action up to 11:30.
  - b) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, and stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25, however, provided no precipitation restarts after the end of the allowance time at 10:25, the aircraft may takeoff without any further action up to 11:30.
  - c) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with light freezing rain falls until 10:10, and stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25, however, provided that the OAT remains constant or increases and that no precipitation restarts after the end of the allowance time at 10:25, the aircraft may takeoff without any further action up to 11:30.
  - d) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, and stops and restarts at 10:30 with the allowance time stopping at 10:25, the aircraft may not takeoff, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

**Transport Canada Holdover Time Guidelines**

**Winter 2008-2009**

**TABLE 10  
ICE PELLETT ALLOWANCE TIMES FOR WINTER 2008-2009**

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
<b>Light Ice Pellets</b>	50 minutes	30 minutes	30 minutes
<b>Moderate Ice Pellets</b>	25 minutes	10 minutes	10 minutes
<b>Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle</b>	25 minutes	10 minutes	<b>Caution: No allowance times currently exist</b>
<b>Light Ice Pellets Mixed with Light Freezing Rain</b>	25 minutes	10 minutes	
<b>Light Ice Pellets Mixed with Light Rain</b>	25 minutes		
<b>Light Ice Pellets Mixed with Light or Moderate Snow</b>	25 minutes		

**APPENDIX G**

**PHOTO DOCUMENTATION OF TEMPERED STEAM TEST PHOTOS**



**TEST #1 – MARCH 19, 2008**



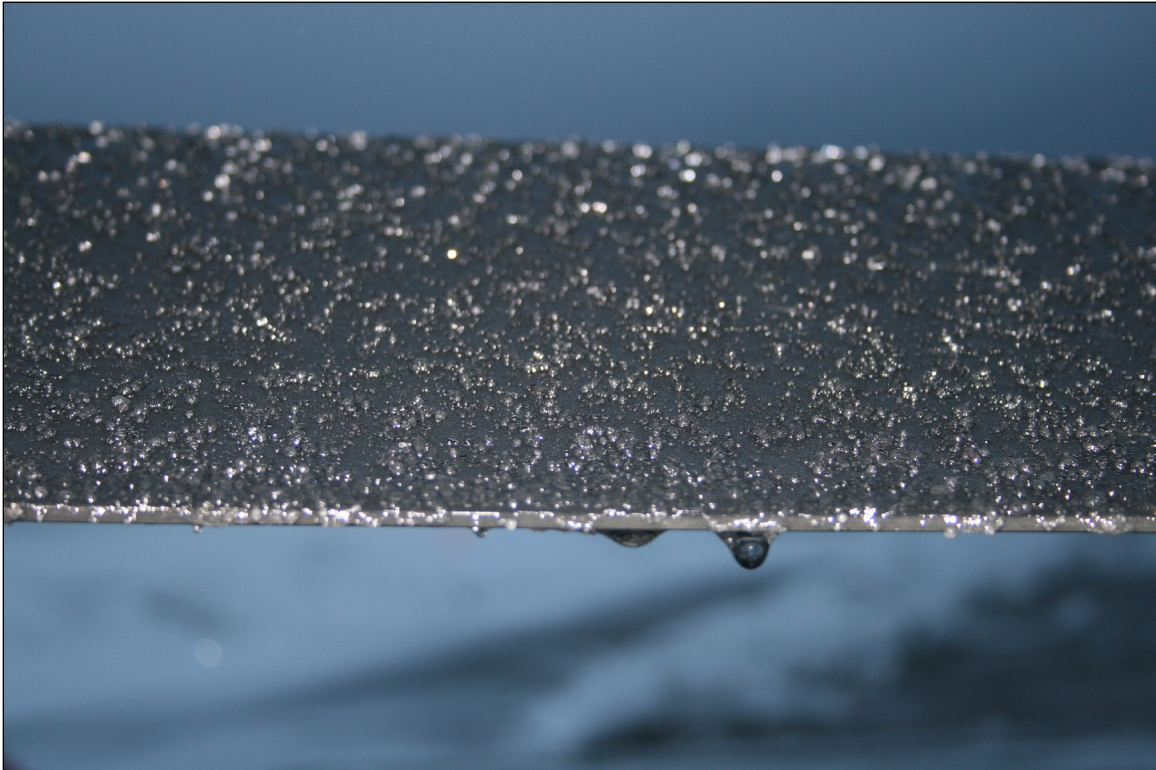
### Bell CH-146 Griffon



### Residual ZR on Blade



### Residual ZR on Blade



### Main Rotor Assembly



### ZR Accumulation on Main Rotor Assembly



### Contamination on Internal Components



### TST Deicing of Rotor Assembly



### TST Deicing – Movement Down Blade



### TST – Movement Down Blade



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**TEST #2 – MARCH 19, 2008**



### TST Deicing of Rotor Assembly Starting Position



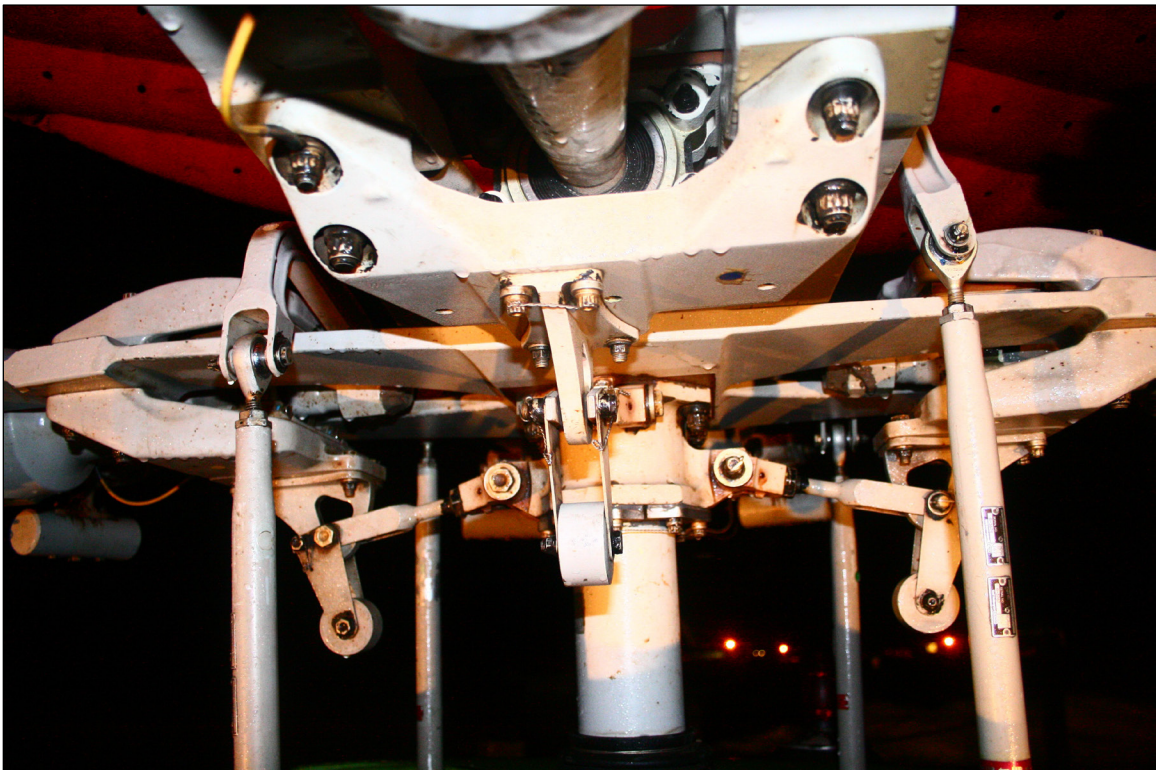
### TST Deicing Movement Down Blade



### Blade Temperature Measurement



### Post Deicing Verification: Main Rotor



**TEST #3 – MARCH 19, 2008**



### TS System Connected to Lower Hatch



### Internal Components Temperature Measurement



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**APPENDIX H**

**EVALUATION OF TEMPERED STEAM TECHNOLOGY FOR  
DEICING OPERATIONAL AIRCRAFT  
CH-146 GRIFFON  
CC-144 CHALLENGER**



CM2103.001

**EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR  
DEICING OPERATIONAL AIRCRAFT**

**CH-146 GRIFFON  
CC-144 CHALLENGER**

Prepared for

**Transportation Development Centre  
Transport Canada**

Prepared by: David Youssef

Reviewed by: Michael Chaput



March 31, 2008  
Version 1.0

## **EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT**

### **1. BACKGROUND**

APS will coordinate and conduct a series of tests to evaluate the Tempered Steam Technology (TST) for aircraft deicing applications.

Previous testing performed on behalf of Chinook and Transport Canada with the TST in 2006-07 clearly demonstrated the ability of the TST to defrost a wing test bed in all temperature ranges. Some testing has been performed on live operational aircraft including an Air Canada Embraer 170 and Airbus A320.

Tests described in this document will be performed at CFB Petawawa and Ottawa on a CH-146 Griffon helicopter and a CC-144 Challenger aircraft. Tests will evaluate the ability of the TST to deice operational aircraft. In addition to this, these tests will examine operational issues related to the use of TST for general ground deicing applications.

### **2. OBJECTIVES**

- Evaluate the TST's ability to deice aircraft;
- Determine the times required to deice and dry aircraft;
- Examine whether or not residual water is created by the application of TST to contaminated aircraft, and determine whether or not residual water propagates to and accumulates in quiet areas;
- Examine the temperature decay profiles of the aircraft surfaces subjected to TST; and
- Determine procedural requirements and limitations of using TST for deicing aircraft.

### **3. TEST PROCEDURES**

Attachment I contains a general procedure for testing.

*EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT*

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#### **4. EQUIPMENT**

Equipment required for the conduct of testing with the TST is shown in Attachment II.

#### **5. TEST PLAN**

A Test Plan for the deicing tests with Canadian Forces aircraft is shown in Attachment III. It is noteworthy that the Test Plan is provided as a guide and deviations from the Test Plan are likely to occur.

Tentative tests dates will be as follows:

- CH-146: March 17<sup>th</sup> – March 20<sup>th</sup> 2008; and
- CC-144 : March 25<sup>th</sup> – March 28<sup>th</sup> 2008

#### **6. PERSONNEL**

APS personnel will coordinate the TST tests. Canadian Forces personnel will be responsible for positioning of the aircraft, as well as providing access to the aircraft. Personnel responsibilities are shown in Attachment IV.

#### **7. DATA FORMS**

- Figure 1 consists of the General Data Form – Chinook TST Testing (Bell CH-146 Griffon);
- Figure 2 consists of the Temperature Logging Data Form for the Bell CH-146 Griffon;
- Figure 3 consists of the Description of Locations form for the Bell CH-146 Griffon;
- Figure 4 consists of the General Data Form – Chinook TST Testing (CC-144 Challenger)
- Figure 5 consists of the Temperature Logging Data Form for CC-144 Challenger; and
- Figure 6 consists of the Description of Locations form for the CC-144 Challenger.

**ATTACHMENT I  
TEST PROCEDURE – CHINOOK TST TESTING**

**1. PRE-TEST SETUP**

- Arrange for delivery of TST vehicle to CFB Petawawa or Ottawa;
- Arrange Chinook personnel travel to CFB Petawawa I or Ottawa;
- Arrange hotel accommodations for test personnel
- Prepare and arrange transport of test equipment to CFB Petawawa or Ottawa;
- Monitor weather for ideal test conditions;
- Communicate with all parties listed on Contact List;
- Rent cube van for APS equipment; and
- Arrange with Canadian Forces for the required security clearance.

**2. CONTACT LIST**

- **APS Aviation:** (514) 878-4388
  - Michael Chaput: (514) 878-4388 ext 228, (514) 261-5558
  - David Youssef: (514) 878-4388 ext 225, (514) 967-3947
  - Dany Posteraro: (514) 878-4388 ext 236, (514) 531-8988
  - George Balaban: (514) 878-4388 ext 235, (514) 691-5301
- **Chinook Mobile Heating and Deicing Corporation:** (613) 822-6323
  - Mike Sparrow: (613) 822-6323 ext. 222, (613) 797-2342
  - Dr. Pierre Bourgault: (613) 822-6323 ext. 300, (613) 841-3923, (613) 850-5940
  - Mike Burling: (613) 822-6323 ext. 224, (613) 720-8001
  - Ron Thompson: (613) 859-7447
  - CoilTech (Smiths Falls): (613) 283-8835 ext. 0
- **Department of National Defence**
  - Laird McKinnon: (613) 949-2093
  - Major Fernand Seguin: (613) 687-5511 ext. 7630
- **Transport Canada**
  - Hugh Billings: (613) 998-3595
- **Diesel Fuel :** Jean Claude Gervais (Ottawa West): (613) 797-1059
- **Harvey Airfield :** Harvey (613) 794-6884 and Dale (613)296-1660

EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT

### 3. CONDUCT TESTS

Prior to the Start of Each Test:

- Conduct briefing with APS, Chinook, and Canadian Forces personnel to discuss particulars of the test;
- Install thermistors on aircraft surfaces, if applicable; or locate and mark target for Infrared temperature reading;
- If employing thermistors, back-up or clear temperature logger (as applicable) and ensure proper functioning of PC and logger equipment;
- Record manual observations of outside air temperature, wind speed, direction, relative humidity and sky condition;
- Synchronize all timepieces;
- Map locations of frost or ice on aircraft surfaces;
- Conduct spot measurements of surface temperature for comparison with thermistor data, if applicable; and
- Install all required equipment.

Prior to Application of TST/Hot Air:

- Position deicing vehicle and delivery head;
- Ensure temperature loggers are functional; and
- Photograph and videotape condition of the aircraft surfaces.

During Application of TST/Hot Air:

- Record start time of application of TST;
- Record end time of application of TST;
- Record start time of hot air application;
- Record end time of hot air application;
- Monitor and communicate surface temperatures during application of TST and hot air; and
- Photograph and videotape deicing process and any residual water following the deicing process.

Following Application of TST/Hot Air:

- Remove deicing vehicle and delivery head from the test area; move the delivery head as required to deice other locations as per instructions contained herein;
- Inspect aircraft surfaces for any accumulation of residual water;
- Map areas of remaining frost or ice, if applicable;
- If not using thermistors, record spot measurements of surface temperature

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EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT

on one minute-intervals with the Infrared temperature sensor, to enable development of temperature decay profile; and

- Photograph and videotape surfaces.

Following Each Test:

- If employing thermistors allow temperature logging to run until temperatures attain ambient air temperature;
- Ensure all data forms are completed; and
- Back-up loggers and save files on PC.

**ATTACHMENT II  
EQUIPMENT LIST - CHINOOK TST TESTING**

**Camera Equipment**

- Digital video camera (with accessories and batteries); and
- Digital still camera (with accessories and batteries).

**Test Equipment**

- Cube van to house test equipment;
- Cherry picker to enable inspections or rolling stairs;
- Test procedures, data forms;
- Mast lighting;
- Clipboards, pencils, markers;
- Isopropyl to remove markings (if applicable);
- Thickness gauges (octagonal and rectangular) x 5;
- Heat gun;
- Long tape measure;
- Speed tape;
- Extension cords x 5;
- Surface temperature probe x 2 and spare batteries;
- Step ladders (short x 2, tall x 3);
- Stopwatches and/or digital clocks;
- VHF radio;
- Handheld anemometer;
- RH meter;
- Generator to run equipment from cube truck x2;
- Fuel for generator;
- 30 cm ruler;
- Portable lights;
- Two-way radios;
- Infrared thermometers;
- CDs or floppy disks for temperature data logged on laptop PC;
- Shovels;
- Rate pan;
- Weigh scale; and
- Inverter.

EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT

ATTACHMENT III  
TEST PLAN – CHINOOK TST TESTING

Test #	Test Platform	Outside Ambient Temperature (°C)	Condition
1	CH-146 Griffon	-10	Natural Frost
2	CH-146 Griffon	-5	Natural Frost
3	CH-146 Griffon	0	Natural Frost
4	CH-146 Griffon	-10	Ice/Snow
5	CH-146 Griffon	-5	Ice/Snow
6	CH-146 Griffon	0	Ice/Snow
7	CC-144 Challenger	-10	Natural Frost
8	CC-144 Challenger	-5	Natural Frost
9	CC-144 Challenger	0	Natural Frost
10	CC-144 Challenger	-10	Ice/Snow
11	CC-144 Challenger	-5	Ice/Snow
12	CC-144 Challenger	0	Ice/Snow

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**ATTACHMENT IV  
PERSONNEL TASK LIST - CHINOOK TST TESTING**

**Test Manager (MC)**

- Coordinate tests with Chinook;
- Provide direction as required during the tests;
- Maintain data forms for every test;
- Coordinate application of thermistors to test surfaces prior to testing, if applicable;
- Obtain and record ATIS reported weather for each test;
- Record Start and End Times for TST/Hot Air;
- Record meteorological data pertaining to each run; and
- Conduct post-application inspection for each run and record findings.

**APS Tester #1 (DP)**

- Ensure generator functionality;
- Ensure that all required equipment is available and functional;
- Ensure all timepieces are synchronized prior to each test;
- Ensure data logging equipment is functional, if applicable;
- Measure wind speed using anemometer;
- Record spot measurements of surface temperature prior to each TST/Hot Air application and communicate information to Test Manager;
- Record Infrared temperature data, if applicable; and
- Back-up thermistor data from test surface and deicing vehicle, if applicable.

**APS Tester #2 (DY)**

- Ensure generator functionality;
- Ensure that all required equipment is available and functional;
- Ensure all timepieces are synchronized prior to each test;
- Ensure data logging equipment is functional, if applicable;
- Measure wind speed using anemometer;
- Record spot measurements of surface temperature prior to each TST/Hot Air application and communicate information to Test Manager;
- Record Infrared temperature data, if applicable; and
- Back-up thermistor data from test surface and deicing vehicle, if applicable.

*EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT*

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**Photographer/Videographer (GB)**

- Ensure timestamps are functioning on photo and video equipment;
- Photograph and videotape condition of surface during all phases of testing;  
and
- Assist in general set-up and tear down of equipment.

**Canadian Forces**

- Provide escorted access to aircraft;
- Provide instruction as to limitations of testing with Canadian Forces Aircraft;  
and
- Provide rolling stairs or similar equipment to permit access to test surfaces,  
if required.

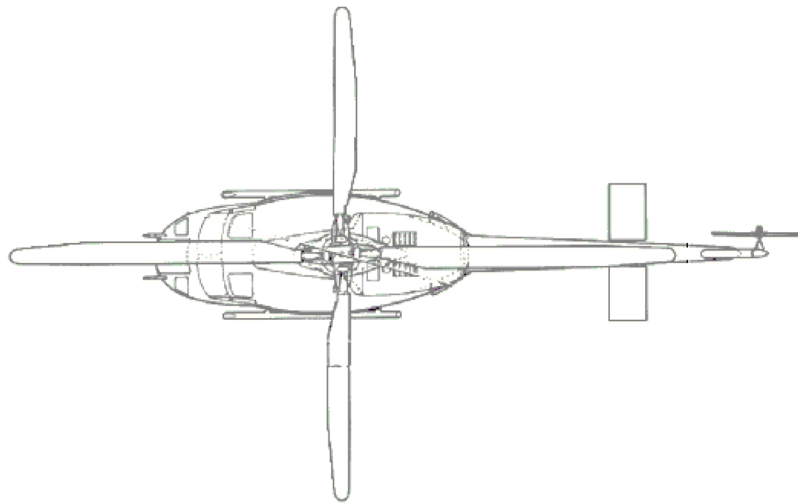
*EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT*

**Figure 1  
General Data Form – Chinook TST Testing  
Bell CH-146 Griffon**

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Run#: \_\_\_\_\_

TST/Hot Air: \_\_\_\_\_ Test Condition: \_\_\_\_\_ TST Temp: \_\_\_\_\_

YUL ATIS: \_\_\_\_\_ Temp. / RH: \_\_\_\_\_ Winds: \_\_\_\_\_



Start TST: \_\_\_\_\_ End TST: \_\_\_\_\_ Start Hot Air: \_\_\_\_\_ End Hot Air: \_\_\_\_\_

Aircraft Inspection:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Comments:

\_\_\_\_\_  
\_\_\_\_\_

Measurements recorded by: \_\_\_\_\_

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EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT

**Figure 3**

**Description of Locations Form  
Aircraft Deicing Tests with Tempered Steam Technology  
Bell CH-146 Griffon**

Location #	Blade / Rotor Hub / Internal	Location*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

**\*If location is marked on Schematic, label box "see schematic", otherwise describe in detail location.**

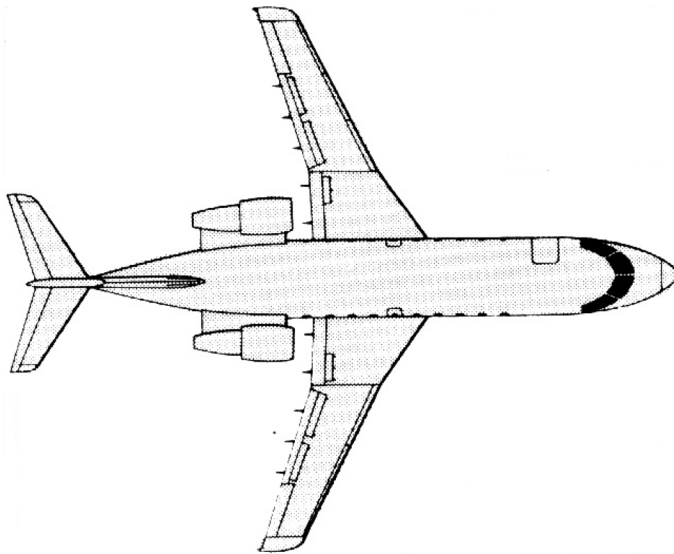
EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT

**Figure 4**  
**General Data Form – Chinook TST Testing**  
**Bombardier CC-144 Challenger**

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Run#: \_\_\_\_\_

TST/Hot Air: \_\_\_\_\_ Test Condition: \_\_\_\_\_ TST Temp: \_\_\_\_\_

YUL ATIS: \_\_\_\_\_ Temp. / RH: \_\_\_\_\_ Winds: \_\_\_\_\_



Start TST: \_\_\_\_\_ End TST: \_\_\_\_\_ Start Hot Air: \_\_\_\_\_ End Hot Air: \_\_\_\_\_

Aircraft Inspection:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Comments:

\_\_\_\_\_  
\_\_\_\_\_

M:\GROUPS\PM2103.001 (TC-DEICING 07-08)\PROCEDURES\TEMPERED STEAM\TEMPERED STEAM FINAL VERSION 1.0.DOC  
Final Version 1.0, March 08





*EVALUATION OF THE TEMPERED STEAM TECHNOLOGY FOR DEICING OPERATIONAL AIRCRAFT*

**Figure 6**

**Description of Locations Form  
Aircraft Deicing Tests With Tempered Steam Technology  
Bombardier CC-144 Challenger**

Location #	Wing	Location*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

**\*If location is marked on Schematic, label box "see schematic", otherwise describe in detail location.**

**APPENDIX I**

**EXEMPTION FROM SUBSECTION 602.11(4) OF THE CANADIAN AVIATION  
REGULATIONS AND SECTIONS 1.0, 3.0, 6.0, 6.2, 6.3 AND 7.1.1.1 OF  
STANDARD 622.11 GROUND ICING OPERATIONS  
DECEMBER 2007**



**Exemption from Subsection 602.11(4) of the *Canadian Aviation Regulations* and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 *Ground Icing Operations***

**WHEN A HOLDOVER TIME DETERMINATION REPORT (HOTDR), GENERATED BY A HOLDOVER TIME DETERMINATION SYSTEM (HOTDS) is being utilized as part of an approved Ground Icing Operations Program,**

pursuant to subsection 5.9(2) of the *Aeronautics Act*, and after taking into account that the exemption is in the public interest and is not likely to affect aviation safety, I hereby exempt **WestJet, 5055 11 Street NE, Calgary, Alberta, T2E 8N4, Canada**, from the requirements related explicitly to the element of Holdover Timetables (HOT) forming part of the Ground Icing Operations Program as stipulated in sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11, *Ground Icing Operations*, made pursuant to subsection 602.11(4) of the *Canadian Aviation Regulations* (CARs). The above provisions are attached at Appendix A to this exemption.

**PURPOSE**

The purpose of this exemption is to permit **WestJet**, to utilize HOTDR generated by a HOTDS, in addition to or in lieu of their current HOT procedures, as part of their approved Ground Icing Operations Program.

**APPLICATION**

This exemption applies to **WestJet** when using a HOTDR generated from a HOTDS as part of their approved Ground Icing Operations Program, at Canadian airports identified in the Program.

**CONDITIONS**

This exemption is subject to the following conditions:

1. When not utilizing the HOTDS, all requirements/elements of Standard 622.11 *Ground Icing Operations*, shall continue to apply as part of the approved Ground Icing Operations Program;
2. When utilizing the HOTDS, every requirement/element of Standard 622.11 *Ground Icing Operations*, not explicitly exempted from in, or not related to, this Ministerial exemption, including those stipulated in sections 1.0, 3.0, 6.0, 6.2, 6.3, 7.1.1.1, shall continue to apply as part of the approved Ground Icing Operations Program;
3. Prior to using the HOTDS, WestJet shall ensure that the HOTDS has been declared by the service provider and/or the manufacturer as applicable, to have met the applicable minimum performance specification attached at Appendix C to this exemption;
4. WestJet shall revise the Company Operations Manual (COM) to include operational procedures associated with the use of the HOTDS. The revised COM shall be approved by Transport Canada Civil Aviation prior to the utilization of the HOTDR;

5. WestJet shall have a contingency plan in the COM to address the possible outage of the HOTDS;
6. WestJet shall develop and provide a training program for their flight crew and operations personnel as approved by Transport Canada Civil Aviation on the use of the applicable HOTDS and associated reports;
7. When using a HOTDS (during active Freezing Fog, Rain on Cold Soaked Wing, Freezing Drizzle or Freezing Rain precipitation conditions) that outputs a single value Hold Over Time, the single value Hold Over Time shall be considered limiting. Under these conditions, take-off after the single value Hold Over Time is exceeded shall be prohibited unless an external tactile inspection is conducted and the aircraft is deemed acceptable for flight or the aircraft is re-deiced/anti-iced as required;
8. When using a HOTDS (during active snow precipitation conditions) that outputs a single value Hold Over Time, the single value Hold Over Time shall be considered limiting unless WestJet has identified acceptable procedures and inspections to ensure that contamination is not adhering to the critical surfaces;
9. Except where superseded in this exemption, all notes, cautions, conditions, lists of qualified fluids and application procedures contained in the Holdover Time Guidelines, published by Transport Canada, on an annual basis shall continue to apply (for example, respecting the de/anti-icing fluid Lowest Operational Use Temperature (LOUT)); and
10. WestJet shall identify in the COM, the airports where it intends on using a HOTDS for HOT decision-making information.

#### VALIDITY

This Exemption is valid until the earliest of the following:

- (a) June 30, 2009, at 23:59 EDT;
- (b) the date on which any of the conditions of this exemption is breached; or
- (c) the date on which this exemption is cancelled, in writing, by the Minister of Transport, Infrastructure and Communities, where he is of the opinion that it is no longer in the public interest or that it is likely to affect aviation safety.

#### CANCELLATION

The exemption from subsection 602.11(4) and sections 1.0, 3.0, 6.0, 6.2 and 7.1.1.1 of Standard 622.11 of the *Canadian Aviation Regulations* issued to WestJet on March 30, 2007, at Ottawa, Ontario, Canada, by the Director Standards on behalf of the Minister of Transport, Infrastructure and Communities is hereby canceled because it is the opinion of the Minister that it is no longer in the public interest or is likely to affect aviation safety.

Dated at Ottawa, Ontario, Canada this 21<sup>st</sup> day of DEC 2007, on behalf of the **Minister of Transport, Infrastructure and Communities.**

  
Don Shorritt  
Director Standards

*Appendix A*

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**APPENDIX A**

*Canadian Aviation Regulations*

**602.11(4)**

(4) Where conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft, no person shall conduct or attempt to conduct a take-off in an aircraft unless

(a) for aircraft that are not operated under [Subpart 5](#) of Part VII,

- (i) the aircraft has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces, or
- (ii) the operator has established an aircraft inspection program in accordance with the *Operating and Flight Rules Standards*, and the dispatch and take-off of the aircraft are in accordance with that program; and

(b) for aircraft that are operated under [Subpart 5](#) of Part VII, the operator has established an aircraft inspection program in accordance with the *Operating and Flight Rules Standards*, and the dispatch and take-off of the aircraft are in accordance with that program.

**622.11 Ground Icing Operations**

**1.0 Introduction**

In order to operate an aircraft under icing conditions in accordance with the requirements of [CAR Section 602.11](#), an operator must have a program as specified in these standards and the dispatch and take-off of the aircraft shall comply with that program. These Ground Icing Operations Standards specify the program elements, for both operations and training, that shall be addressed in an operator's Ground Icing Operations Program and described in the appropriate operator's manuals. As applied to Canadian operators, these Standards outline a Program's minimum requirements, which may be adapted according to the needs of the individual operator. Foreign operators should use this Standard as a guideline for the development of their Ground Icing Operations Program in Canada.

**3.0 Program Elements**

The following elements, which are described in the sections below, will be included in an operator's Ground Icing Operations Program and described in the appropriate manual(s):

- The Operator's Management Plan;
- Aircraft De-icing/Anti-icing Procedures;
- Holdover Timetables;
- Aircraft Inspection and Reporting Procedures; and
- Training and Testing.

*Appendix A*

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**6.0 Holdover Timetables**

The use of holdover timetables is not mandatory. Holdover timetables, as approved by the Director, Air Carrier, may be used either as guidelines or decision-making criteria in assessing whether it is safe to take off. When holdover timetables are used as decision-making criteria, only high confidence level times shall be used and the procedures to be followed after holdover time has expired must be clearly documented. Where applicable in a Program, an operator's manual will cover the following areas with regard to holdover timetables:

**6.2 Use of Holdover Timetables**

Holdover timetables provide an estimate of the length of time de-icing/anti-icing fluids are effective. Because holdover time is influenced by a number of factors, established times may be adjusted by the pilot-in-command according to the weather or other conditions. Operators' manuals must describe the procedures to be followed for using holdover timetables. When the tables are used as decision-making criteria, the procedures to be followed by the pilot-in-command (PIC) for varying the established values must also be specified.

**6.3 Take-off after Holdover Times have been Exceeded**

When holdover timetables are used as decision-making criteria, take-off after holdover times have been exceeded can occur only if a pre-take-off contamination inspection is conducted or the aircraft is de-iced/anti-iced again. The operator's Program must specify the procedures to be followed when holdover time is exceeded, and these procedures must appear in the appropriate manuals.

**7.1.1.1**

Holdover timetables, approved according to the conditions outlined in section 6 of these Standards, may be used to determine, without a tactile or visual Pre-take-off Contamination Inspection, that critical surfaces are not contaminated.

*Appendix B***Appendix B****DEFINITIONS**

- **Anti-Icing Fluid** means a fluid applied to an aircraft as a precautionary procedure that provides protection against the formation of frost or ice and the accumulation of snow on treated surfaces of an aircraft for a period of time;
- **Deicing Fluid** means a fluid applied to an aircraft to remove contamination in the form of frost, ice or snow;
- **Glycol Pan Measurements** means a process to determine precipitation rate by using a glycol-wetted pan that is weighed precisely before and after a timed exposure to precipitation. This methodology has been included in SAE Aerospace Recommended Practice (ARP) 5485 and 5945, and has been historically employed by Transport Canada in the development of fluid holdover time tables for de/anti-icing fluids;
- **Holdover Time** means the determined time that an application of de/anti-icing fluid applied to an aircraft is nominally effective in preventing frost, ice or snow from adhering to the treated surfaces based on using Holdover timetables published by Transport Canada or based on a Holdover Time Determination System Report;
- **Holdover Time Determination System Report (HOTDR)** means a Holdover Time generated by a Holdover Time Determination System.
- **Holdover Time Determination System (HOTDS)** means a near real-time system that samples a number of atmospheric inputs and uses these in conjunction with HOT regression curves and associated coefficients for specific de/anti-icing fluids to produce a holdover time determination report;
- **Holdover Timetables** means tables of holdover times for de/anti-icing fluids published as Holdover Time (HOT) Guidelines, by Transport Canada;
- **LOUT means Lowest Operational Use Temperature**
- **Manufacturer** means the producer of a Holdover Time Determination System;
- **Regression Analysis** means a data analysis protocol used by Transport Canada to analyze fluid endurance time data for the generation of holdover times for de/anti-icing fluids; and
- **Service Provider**, in this context, means a person or organization that:
  1. provides holdover time reports using a Holdover Time Determination System that meets the application of this exemption; or
  2. provides precipitation rate, type and temperature information for use by a Holdover Time Determination System in computing Holdover Time Determination System reports that meet the application of this exemption.

*Appendix C*

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**APPENDIX C**

**MINIMUM ASSURANCE REQUIREMENTS AND PERFORMANCE SPECIFICATIONS FOR HOLDOVER TIME DETERMINATION SYSTEMS**

Sections 1, 2 and 3 of this appendix specify the minimum assurance requirements and sections 4 and 5 the minimum performance specifications for the Holdover Time Determination Systems.

In this document, the “Air Operator” means **WestJet**.

**1. QUALITY MANAGEMENT SYSTEM**

1.1 The Air Operator shall ensure that the service provider or manufacturer, establish, document, implement and maintain a quality management system that comprises procedures, processes and resources necessary to provide for the quality management of the Holdover Time Determination System and reports to be supplied.

1.2 The quality management system required by Subsection 1.1 shall at a minimum:

- a) Establish and maintain operational manuals and documentation;
- b) Establish and maintain system commissioning protocols;
- c) Establish and maintain system inspection requirements and methods;
- d) Establish quality control and quality monitoring to include software integrity and data dissemination;
- e) Specify qualifications and training requirements for personnel who commission, inspect or maintain the system, and
- f) If non-conformance is identified, ensure that action is initiated to determine and correct the cause.

1.3 The documentation in Subsection 1.2 shall be made available to the Minister, upon reasonable notice by the Minister.

**2. TRAINING AND QUALIFICATIONS**

2.1 The Air Operator shall ensure and document that the manufacturer or service provider maintains records to demonstrate that all persons providing installation, commissioning, inspection and maintenance services of a Holdover Time Determination System are qualified persons who have received appropriate training and have demonstrated sufficient knowledge, skills and competence to perform their assigned duties.

*Appendix C*

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Note: The Air Operator shall ensure and document that the manufacturer or service provider has specified the minimum training requirements applicable to persons engaged in these duties.

- 2.2 The Air Operator shall make a copy of the documentation referenced in 2.1 available to the Minister, upon reasonable notice by the Minister.

**3. INSTALLATION, SITING, OPERATION & MAINTENANCE OF DEICING AND ANTI-ICING FLUID HOLDOVER TIME DETERMINATION SYSTEMS**

- 3.1 The Air Operator shall ensure that the service provider or manufacturer as applicable, has established and followed practices, procedures and specifications for the siting, installation, commissioning, operation and maintenance of the Holdover Time Determination Systems, including the co-ordination of activities with the aerodrome operator.

Note: Specifications concerning the siting and installation of equipment on aerodromes are contained in TP312, Aerodrome Standards and Recommended Practices.

- 3.2 The input instruments shall be sited in sufficient proximity of each other to provide coherent sampling of meteorological inputs for holdover time determination in transitional weather conditions.
- 3.3 The Air Operator shall document the requirements of Subsection 3.1 and make a copy available to the Minister, upon reasonable notice by the Minister.

**4. ACCURACY OF HOLDOVER TIME INPUT INSTRUMENTS AND DETERMINATION SYSTEMS**

- 4.1 The Air Operator shall verify that the manufacturer obtains test data and establish practices and procedures that demonstrate that the data inputs and Holdover Time Determinations meet the accuracy requirements established for each element.
- 4.2 The Air Operator shall make the documentation required by Subsection 4.1 available to the Minister, upon reasonable notice by the Minister.
- 4.3 The Air Operator shall verify that the manufacturer has test data that demonstrates compliance of the data inputs and Holdover Time Determinations with Subsection 4.1 in accordance with the following requirements:

a) The test data shall be sufficiently complete to assure that the results are representative of the design and performance specifications of the system and include the following:

i. For those instruments for which it is practical, the relationship between the value indicated by an instrument and the corresponding known value of a measurand;

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*Appendix C*

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- ii. The testing of instruments over a range that is representative of the expected environmental conditions (regardless of whether in a controlled environment or in the field); and
  - iii. Testing of instruments in comparison with other instruments or human observations, in the outdoor operational environment, where practical.
- b) The test data shall consist of the following:
  - i. Raw data collected during testing, and
  - ii. The results of the reduction and analysis of the data.
- c) The Air Operator shall verify that the person verifying the test data in accordance with paragraph (d) confirms that the results of the reduction and analysis of the test data demonstrate that the data inputs and Holdover Time Determinations meet the accuracy requirements set out in this Appendix under operational conditions encountered by the Holdover Time Determination System;
- d) The Air Operator shall confirm that the manufacturer's test data have been verified as meeting the accuracy requirements of this Appendix by a person who is:
  - i. Independent from the manufacturer of the Holdover Time Determination System and from the service provider and has a degree in the natural or applied sciences of mathematics from a recognized university and experience in: instrumental references, standards and traceability, methods of statistical analysis and an understanding of the operating principles and use of the instruments involved; or
  - ii. A licensed professional engineer (P.Eng) in Canada.
- e) The Air Operator shall verify that the manufacturer obtains a written confirmation of the verification of the test data from the person who verified the test data pursuant to paragraph (d) and shall, upon reasonable notice by the Minister, provide a copy to the Minister;
- f) The Air Operator shall ensure that the manufacturer demonstrates and confirms that the HOTDS has built-in fault detection checks that, in the event of system input/output failure (such as loss of an input instrument or corruption of data in a HOTDR) or other critical system hardware or software failure, prevent a misleading report from being issued. Demonstration shall be carried out on an end-to-end basis from input instruments in the field to delivery of Holdover Time Determination System Reports to the Air Operator.
- g) The Air Operator shall ensure that the manufacturer demonstrates initial and ensures ongoing quality assurance of the computational software, hardware and end to end data integrity as follows:
  - i. The software must be designed, developed, produced and maintained in accordance with appropriate software assurance standards.

Appendix C

- ii. The hardware must be designed, developed, produced and maintained in accordance with appropriate hardware assurance standards.
- iii. End-to-end data integrity shall include means of minimizing misleading data caused by all sources (ex: corrupted fluid coefficients, corrupted data transmissions, etc.) through the use of CRC checks or similar safeguards.
- h) The Air Operator shall ensure that the manufacturer confirms that the accuracy of the timing methods or device used to establish the time of the report is sufficient for the intended purpose; and
- i) The Air Operator shall ensure that the manufacturer documents the processes and procedures used to comply with the requirements of paragraphs (a) and (h) and shall make them available to the Minister, upon reasonable notice by the Minister.

**5. TECHNICAL REQUIREMENTS FOR DATA INPUTS AND HOLDOVER TIME DETERMINATIONS**

5.1 The Air Operator shall ensure that the manufacturer establishes and document practices and procedures for compliance with the provisions of Subsections 5.1.1 thru 5.1.23, which are applicable to the manufacturer's Holdover Time Determination System, and make a copy available to the Minister, upon reasonable notice by the Minister.

Wind

5.1.1 If required by the HOTDS, surface wind data inputs shall meet the following requirements:

- a) Wind instruments shall be ice resistant by design;
- b) The instruments shall be sited so as to provide representative input to any compensation factors that are generated to correct precipitation accumulation rates during high wind conditions; and
- c) The instruments shall function for winds of at least 100 knots.

5.1.2 The accuracy of wind sensors and outputs shall be such that;

- a) The direction, if utilized, is correctly measured within  $\pm 10$  degrees; and
- b) The mean speed is correctly measured within  $\pm 2$  knots up to 20 knots and with 10% above 20 knots.

5.1.3 The accuracy of the wind instruments shall be established in accordance with Subsection 5.1.2, paragraphs (a) and (b), to at least a 95% confidence in wind tunnel testing.

Appendix C**Precipitation**

5.1.4 Systems used for the determination of precipitation shall:

- a) Meet or exceed accuracy requirements as follows with reference to human observations:
  - i. Correctly detect the presence of precipitation of a water equivalent rate of at least 2.0 g/dm<sup>2</sup>/h, other than drizzle, at least 90% of the time;
  - ii. Correctly detect the presence of and distinguish between liquid or frozen precipitation, of a water equivalent rate of at least 2.0 g/dm<sup>2</sup>/h, at least 80% of the time; and
  - iii. Correctly detect the presence of ice accretion or freezing precipitation, of at least 2.0 g/dm<sup>2</sup>/h, with at least a 90% probability.
- b) Except as addressed in accordance with (c), differentiate between and, where applicable determine the intensity of rain, freezing rain freezing drizzle and snow;
- c) Accurately detect the presence of fog or freezing fog conditions;
- d) Indicate that type of precipitation is “unknown”, if the type cannot be determined; and
- e) In the event of unknown precipitation, the equipment shall report that a holdover time is unavailable.

**Temperature**

5.1.5 Temperature measurements shall be accurate to within 1°C.

5.1.6 The accuracy requirements of Subsection 5.1.5 shall be demonstrated with at least a 95% confidence level during laboratory testing that is traceable to a reference standard.

**Precipitation Rate**

5.1.7 Precipitation rate measurements shall be analyzed in reference to simultaneously recorded glycol pan measurements for all precipitation types, excluding freezing fog.

5.1.8 The Holdover Time Determination System precipitation rate measurements shall conform to the glycol pan measurements ( ref.: SAE ARP 5485), within the following tolerances:

- a) From 0 to 10 g/dm<sup>2</sup>/h: +/- 3.0 g/dm<sup>2</sup>/h
- b) Above 10 g/dm<sup>2</sup>/h to 25 g/dm<sup>2</sup>/h: +/- 6.0 g/dm<sup>2</sup>/h
- c) Above 25 g/dm<sup>2</sup>/h: +/- 14.0 g/dm<sup>2</sup>/h

5.1.9 The accuracy requirements of Subsection 5.1.8 shall be demonstrated with at least a 95% confidence level during comparative tests with the HOTDS and glycol pans.

Appendix C

- 5.1.10 The precipitation rate input for the purpose of computing fluid holdover time (Subsections 5.1.12 to 5.1.18) shall be:
- a) the precipitation rate determined by the HOTDS; plus
  - b) the tolerance (within a 95% confidence level) that has been demonstrated for each precipitation type and range in 5.1.8, specific to that HOTDS.
- 5.1.11 Notwithstanding section 5.1.10, the precipitation rate input for the purpose of computing fluid holdover time (Subsections 5.1.12 to 5.1.18) shall not be less than 2.0 g/dm<sup>2</sup>/h.

**Holdover Time Determinations**

- 5.1.12 The HOTDS shall incorporate the most current regression curves and associated coefficients. These regression curves and associated coefficients are:
- 5.1.12.1 those obtained from or published by TC, or
  - 5.1.12.2 those where traceability and validity has been demonstrated to be equivalent to those in 5.1.12.1.
- 5.1.13 Holdover Time Determinations from the system for all de/anti-icing fluids shall be computed using the regression curves and associated coefficients referenced in 5.1.12.
- 5.1.14 Holdover Time Determinations from the system, shall be verified, for each fluid, against known fluid dilution, precipitation type, rate and temperature inputs to ensure that regression curves and associated coefficients have been correctly implemented within the system.
- As a minimum this verification will include:
- 5.1.14.1 normal range test cases; and
  - 5.1.14.2 test cases outside the normal range to verify robustness.
- 5.1.15 Holdover Time Determinations for Freezing Drizzle or Freezing Rain conditions shall be based on computing the associated Holdover Time for each one of those precipitation conditions and using the resulting lowest value.
- 5.1.16 Holdover Time Determinations shall be inhibited in Freezing Precipitation (Freezing Fog, Freezing Drizzle or Freezing Rain) conditions exceeding of 25 g/dm<sup>2</sup>/h.
- 5.1.17 Holdover Time Determinations shall be inhibited in Snow conditions exceeding 50 g/dm<sup>2</sup>/h.
- 5.1.18 Holdover Time Determinations shall be inhibited in Rain on Cold Soaked Wing conditions exceeding 75 g/dm<sup>2</sup>/h.
- 5.1.19 In accordance with the currently accepted practice for HOT table development, Holdover Time Determinations from the system for Type II and IV de/anti-icing fluids shall be capped as follows:

Appendix C

Freezing Fog	4 hrs;
Snow	2 hrs;
Freezing Drizzle	2 hrs;
Light Freezing Rain	2 hrs;
Rain on Cold Soaked Wing	2 hrs.

5.1.20 Where applicable, the notes, conditions, cautions incorporated into the annually published holdover time guidelines shall be respected in computation outputs by the HOTDS.

**Holdover Time Determination Reports**

5.1.21 A Holdover Time Determination Report shall contain as a minimum de/anti-icing Holdover Time(s) and fluid type. The report may contain additional items such as:

- a) Precipitation type;
- b) Precipitation intensity;
- c) Precipitation trend; and
- d) Fluid brand

These additional items shall be as agreed to with the service provider and/or the aircraft operator.

5.1.22 The service provider shall retain a copy of each Holdover Time Determination Report for at least 24 months.

5.1.23 The service provider shall provide a copy of the Holdover Time Determination Reports required by 5.1.21 to the Minister, upon reasonable notice by the Minister.

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**APPENDIX J**

**PRESENTATIONS AT VARIOUS MEETINGS**



## PRESENTATIONS AT VARIOUS MEETINGS

- 1. SAE Aircraft & Engine Icing International Conference, Seville, Spain, September 24, 2007**
  - a. Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
  - b. Implementation of Holdover Time Determination Systems.
  
- 2. Standing Committee Meeting, Winnipeg, Manitoba, October 10, 2007**
  - a. Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
  - b. De/Anti-Icing Fluid Holdover Time Update, 2007/08 Winter Operations.
  
- 3. SAE G-12 HOT Subcommittee Meeting, Montreal, Canada, November 14, 2007**
  - a. Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions;
  - b. Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets; and
  - c. Implementation of Holdover Time Determination Systems into Canadian Air Operations, Update for 2007-08 Operations.
  
- 4. SAE G-12 HOT Subcommittee Meeting, Warsaw, Poland, May 14, 2008**
  - a. Aircraft De/Anti-Icing Fluid Endurance Time Results for the 2007-08 Winter Test Season;
  - b. Aircraft Ground De/Anti-Icing Research Using Composite Materials;
  - c. Substantiation of Aircraft Ground De/Anti-Icing Holdover Times in Frost Conditions;
  - d. Answers to AEA De/Anti-Icing Working Group Questions (prepared but not presented);
  - e. Aircraft Deicing Research in Simulated Mixed Conditions with Ice Pellets;
  - f. Aircraft Ground De/Anti-Icing Fluid Endurance Times in Snow Pellet Conditions; and
  - g. Implementation of Holdover Time Determination Systems

**5. SAE G-12 HOT Subcommittee Meeting, Montreal, Canada, November 14, 2008**

- a. Proposed Changes to Frost HOT Guidelines;
- b. Examination of Effect of Heat on Endurance Times of Anti-Icing Fluids;
- c. Holdover Times Below -25°C for Anti-Icing Fluids;
- d. Holdover Times in Conditions of Rain mixed with Snow;
- e. Preparation of Holdover Time Guidelines Regression Coefficient Data; and
- f. Holdover Time Guidelines Update Fall 2008.

**APS**  
Aviation Inc.

# **AIRCRAFT DEICING RESEARCH IN SIMULATED MIXED CONDITIONS WITH ICE PELLETS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.  
*For*

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**

**ISO 9001:2000**

**SAE 2007 AIRCRAFT & ENGINE ICING INTERNATIONAL CONFERENCE  
SEVILLE - SEPTEMBER 24, 2007**

**adga**

**APS**  
Aerodynamic Performance Solutions

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**APS**  
Aerodynamic Performance Solutions

### BACKGROUND

- Recent industry need to provide aircraft operators with holdover times for ice pellet conditions
- During the winter of 2006, FAA provided a 25-minute allowance as a preliminary guideline
- Allowance based on the previous research conducted during the winter of 2005-06, primarily as a result of Falcon 20 aerodynamic research (SAE Lisbon 2006)
- Allowance was followed by a list of conditions restricting operations
  - i.e. Ice pellets alone, no mixed conditions

**APS**  
Aerodynamic Performance Solutions

### BACKGROUND

- Due to the high occurrence of ice pellets combined with rain, freezing rain, or snow, industry requested additional guidance material for operations in mixed ice pellet conditions
- Additional endurance time testing and aerodynamic research was conducted in simulated ice pellet conditions during the Winter of 2006-07
- Testing was directed by TC and FAA

**APS**  
Aerodynamic Performance Solutions

### PRESENTATION OUTLINE

- BACKGROUND
- **PREVIOUS RESEARCH (2005-06)**
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

### APS SIMULATED ICE PELLETS

APS Manufactured Ice Pellets

Natural Ice Pellets

### 2005-06 FALCON 20 FULL-SCALE RESEARCH



**APS**  
Aerodynamic Systems

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**APS**  
Aerodynamic Systems

**OVERVIEW OF WINTER 2006-07  
GENERAL OBJECTIVES**

- Conduct research to substantiate and possibly expand current 25-minute ice pellet only allowance time
- Flat plate testing was conducted to investigate fluid adherence in mixed ice pellet conditions
- Aerodynamic research was conducted to investigate fluid flow-off of contaminated fluid following simulated ice pellet and mixed conditions
  - NRC open circuit wind tunnel
  - NRC Falcon 20 aircraft

**APS**  
Aerodynamic Systems

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**APS**  
Aerodynamic Systems

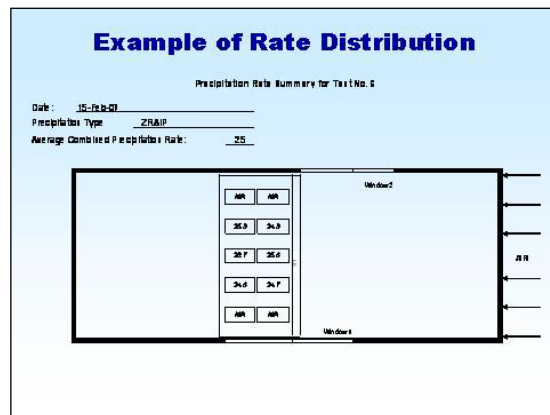
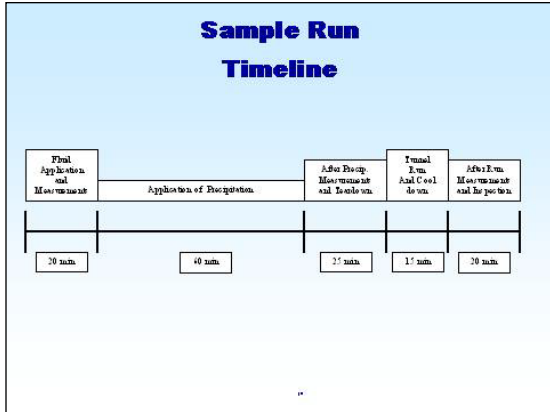
**Wind Tunnel Testing**

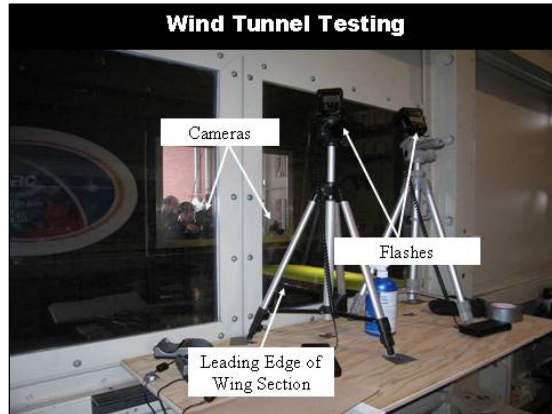
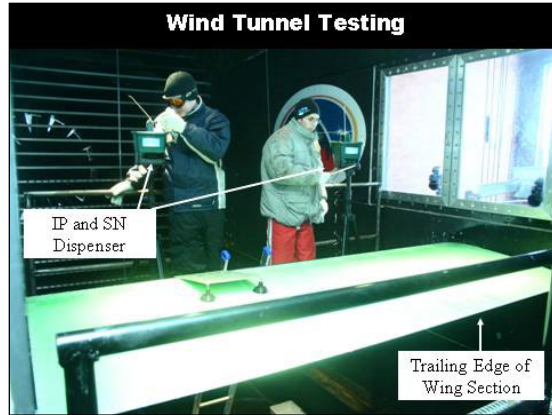
- Objective: To determine the level of contamination of anti-icing fluid at which the aerodynamic shear forces during take-off ground roll, rotation and lift off fails to remove the resultant slush.
- 22 tests conducted over a period of 2 weeks
- A NACA 23012 wing section was used for testing
- OAT varied during testing – open circuit tunnel

**APS**  
Aerodynamic Systems

**Wind Tunnel Testing**

- Fluid was applied to wing section approximately 20 minutes prior to the start of precipitation
- The wind tunnel was started approximately 20-25 minutes following the end of precipitation
- Wind tunnel test profile:
  - Initial angle of attack 0°
  - 0-100 Knots in 30-35 seconds
  - At 100 Knots, Pitch wing to 8° in 3 sec
  - Pitch wing back to 4° in 16 sec
  - Hold wing at 4° for 1 minute and stop test





**Wind Tunnel Testing**

- Conditions Tested:
  - Mixed ZR and IP (5 tests)
  - Mixed SN and IP (4 tests)
  - IP only (4 tests)
  - Fluid only and dry tests (5 tests)
- Also investigated:
  - ZR only (1 test)
  - Simulated stall runs (3 tests)

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### Wind Tunnel Summary Test Log

Wind Tunnel Tests										
Test #	Feb day	Type of Fluid	Condition	ZR Max g/inch <sup>2</sup>	IP Max g/inch <sup>2</sup>	IS Max g/inch <sup>2</sup>	Pre-Test (psi)	Tunnel (psi)	Wing Area (ft <sup>2</sup> )	Visual Assembly Rating (1-3)
1	14	Dry	Dry	0	0	0	-	-1.7	-2	-
1A	18	Dry	Dry	0	0	0	-	-7	NA	-
2	14	PS	Baseline	0	0	0	-	-10	-8	-
3	14	PS	Baseline	0	0	0	-	-11	-8	-
4	14	PS	ZR	16	0	0	80	-2	-1	1
5	18	PS	IP	0	26	0	20	-15.5	-10	4.5
6	18	PS	ZR/IP	20	6	0	40	-6	-7	6
6A	18	PS	ZR/IP	20	6	0	20	-6	-7	1
7	22	PS	IP	0	26	0	80	1	-6.6	1
8	22	PS	IP	0	26	0	80	1	-6	1
9	22	PS	IP (wet)	0	16	0	30	3.2	-7	2.6
10	23	PS	IP/SN	7	20	0	40	-7.2	-7	3
11	23	PS	ZR/IP	10	6	0	40	-1.8	-4	2
12	23	PS	ZR/IP	20	6	0	40	-6.5	-4	1
13	23	PS	Baseline	0	0	0	-	-6.7	-6	-
SP1	20	PS	IP/SN	0	20	6	40	-2	-7	2
SP2	20	PS	IP/SN	0	6	20	40	-3	-6	1
SP3	20	PS	IP/SN	0	20	6	40	1.2	-6	1
SP4	23	PS	IP/SN	0	26	26	30	3.2	-7	2
A1	21	PS	Real Run	0	0	0	-	3.7	1	-
A2	21	PS	Real Run	0	0	0	-	-4.6	6.8	-
A3	21	Dry	Real Run	0	0	0	-	2.3	NA	-

1 = best  
3 = worst

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- **FALCON 20 TESTING**
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

### Falcon 20 Testing

- Objective: To determine the level of contamination of anti-icing fluid at which the aerodynamic shear forces during take-off ground roll and rotation fails to remove the resultant slush.
- 6 tests conducted over a period of 4 days
- Tests conducted at YOW

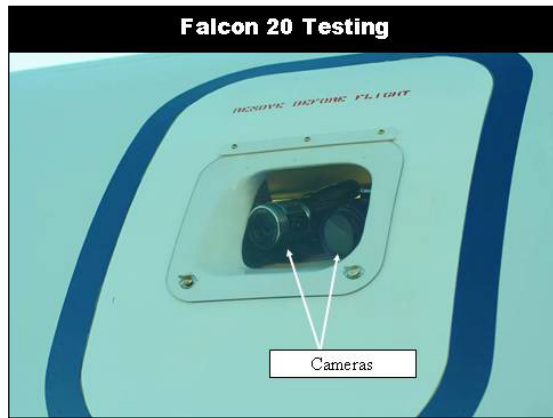
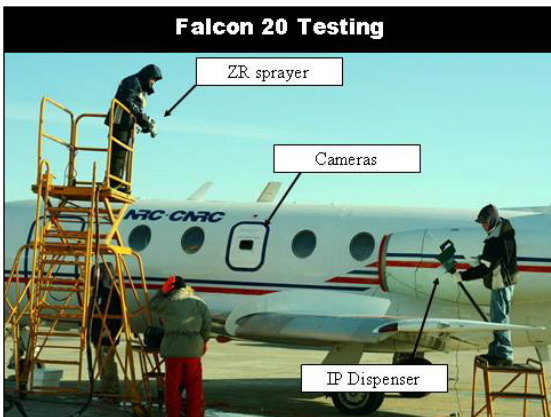
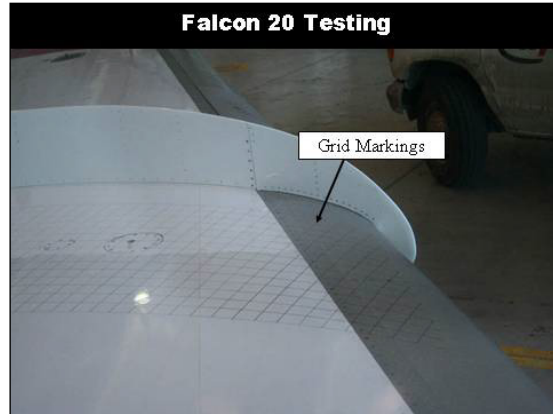
### Falcon 20 Testing

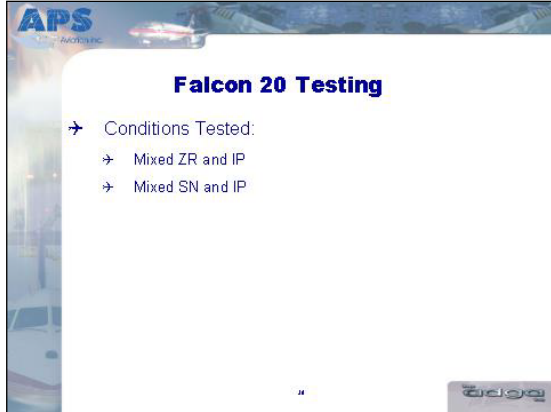
- Wing test surface area was approximately 3m<sup>2</sup>
- Two wings were tested per run
  - Baseline wing (fluid only)
  - Test wing (contamination)

### Falcon 20 Testing

- Fluid was applied approximately 20 minutes prior to the start of precipitation
- Break release approximately 20-25 minutes following the end of precipitation
- Aircraft take-off run profile:
  - 0-120 knots in approx. 20-25 sec
  - Engines Cut-off at 120 knots
  - Rotate to approx. 8°
  - Keep nose up until 3000ft of runway left
  - Rotate down to 0°
  - Apply brakes (no spoilers)





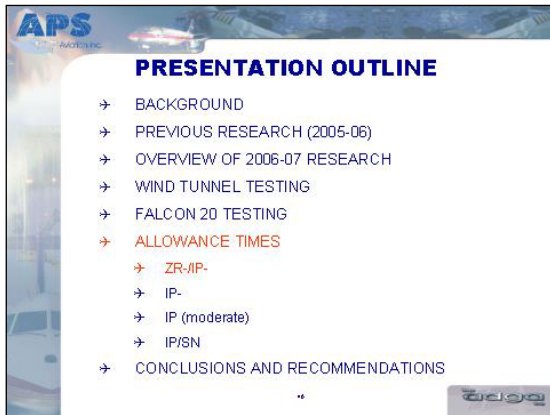


**Falcon 20 Testing**

- Conditions Tested:
  - Mixed ZR and IP
  - Mixed SN and IP

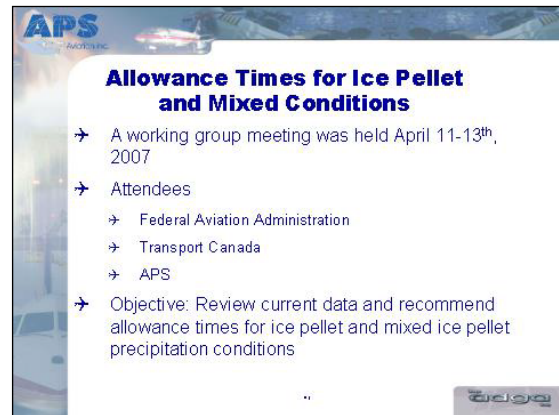
**Falcon 20 Summary Test Log**

Falcon 20 Tests									
Test #	Date	Type / Fluid	Condition	ZR Rate (g/min/h)	IP Rate (g/min/h)	SN Rate (g/min/h)	Precep. Time (min)	OAT (°C)	Wing Avg Temp (°C)
3S	Feb-28	PG	IP/SN	-	25	25	30	-8	-11
3P	Feb-28	PG	Baseline	-	-	-	-	-8	-10.5
4S	Feb-28	PG	Baseline	-	-	-	-	-10	-8
4P	Feb-28	PG	ZR/IP	20	5	-	40	-10	-8
5S	Mar-01	EG	Baseline	-	-	-	-	-11	-14
6P	Mar-01	PG	IP/SN	-	20	20	30	-11	-13



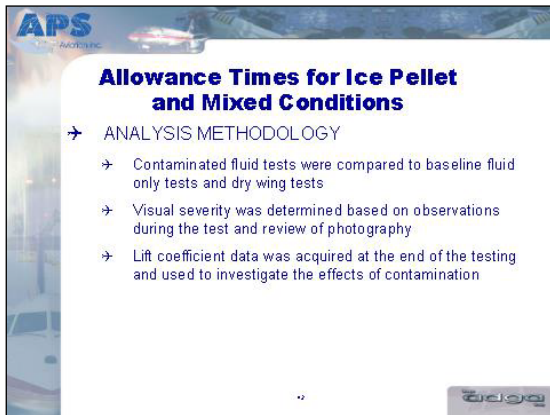
**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR/IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS



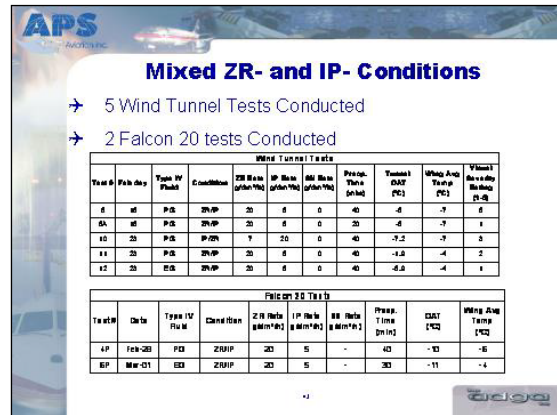
**Allowance Times for Ice Pellet and Mixed Conditions**

- A working group meeting was held April 11-13<sup>th</sup>, 2007
- Attendees
  - Federal Aviation Administration
  - Transport Canada
  - APS
- Objective: Review current data and recommend allowance times for ice pellet and mixed ice pellet precipitation conditions



**Allowance Times for Ice Pellet and Mixed Conditions**

- ANALYSIS METHODOLOGY
  - Contaminated fluid tests were compared to baseline fluid only tests and dry wing tests
  - Visual severity was determined based on observations during the test and review of photography
  - Lift coefficient data was acquired at the end of the testing and used to investigate the effects of contamination



**Mixed ZR- and IP- Conditions**

- 5 Wind Tunnel Tests Conducted
- 2 Falcon 20 tests Conducted

Wind Tunnel Tests										
Test #	Feb day	Type / Fluid	Condition	ZR Rate (g/min/h)	IP Rate (g/min/h)	SN Rate (g/min/h)	Precep. Time (min)	Tunnel OAT (°C)	Wing Avg Temp (°C)	Visual Severity Rating (1-5)
6	01	P.D.	SN/IP	20	5	0	40	-8	-7	2
6A	01	P.D.	SN/IP	20	5	0	20	-8	-7	1
10	28	P.D.	IP/SN	5	20	0	40	-7.2	-7	2
11	28	P.D.	SN/IP	20	5	0	40	-1.0	-4	2
12	28	P.D.	SN/IP	20	5	0	40	-4.0	-4	1

Falcon 20 Tests									
Test#	Date	Type / Fluid	Condition	ZR Rate (g/min/h)	IP Rate (g/min/h)	SN Rate (g/min/h)	Precep. Time (min)	OAT (°C)	Wing Avg Temp (°C)
4P	Feb-28	PG	ZR/IP	20	5	-	40	-10	-8
6P	Mar-01	PG	ZR/IP	20	5	-	30	-11	-4

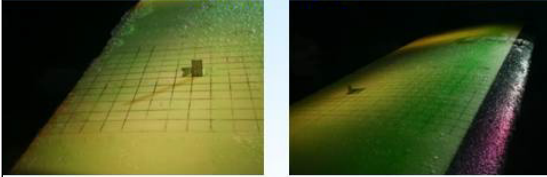
**Test #11**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-2°C, Wing -4°C  
[Photos](#)

..

**Test #2**  
Type IV PG, No Contamination  
OAT-10°C, Wing -9°C  
[Photos](#)


..

**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**Start of Test**



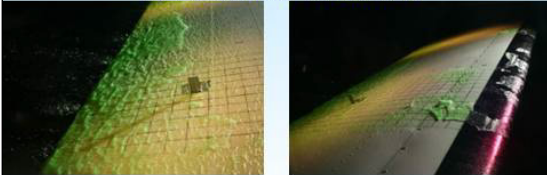
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**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**Before Rotation**



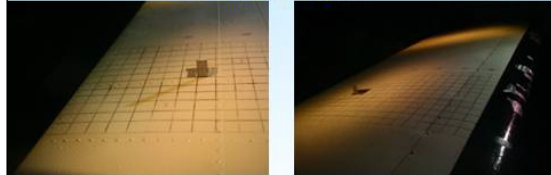
..

**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**10 sec After Rotation**

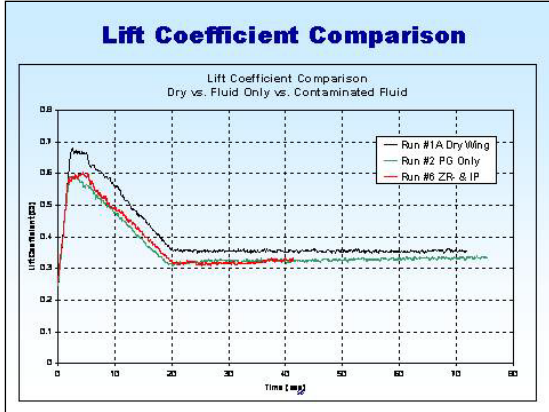


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**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**End of Test**



..



### Mixed ZR- and IP- Conditions

- Observations and Recommendations
  - ZR is the primary concern due to adherence and increased roughness with presence of IP
  - Generic lower ZR HOT referenced and modified
  - Use temperature -5 °C (instead of -3 °C) to allow for increased latitude to operators
  - Allow operations down to -10°C

### Mixed ZR- and IP- Conditions

- Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes	10 Minutes	Caution: No Allowance Times currently exist

### Mixed ZR- and IP- Conditions

- Allowance times were presented in May 2007 at the SAE meeting in San Diego
- Industry requested additional guidance material
  - Mixed Freezing Drizzle and Ice pellets
  - Mixed Rain and Ice Pellets
- Additional flat plate testing and analysis was conducted
- ZR/IP Allowance times were referenced and modified

### Mixed ZR- and IP- Conditions

- Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes	10 Minutes	Caution: No Allowance Times currently exist
Light Ice Pellets Mixed with Light Rain	25 Minutes		

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-/IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

### IP- Only Conditions

- 3 Wind Tunnel Tests Conducted
- IP only tests were NOT conducted with the Falcon 20 this year
- 2005-06 Falcon 20 tests were referenced

Wind Tunnel Tests										
Test#	Feb day	Type IV Fluid	Contd (hrs)	ZR (hr) (g/min/hr)	IP (hr) (g/min/hr)	IR (hr) (g/min/hr)	Pres. Time (min)	Tunnel OAT (°C)	Wing Avg Temp (°C)	Visual Residue Rating (1-5)
5	15	FD	IP	0	25	0	60	-15.0	-13	4.5
7	22	FD	IP	0	25	0	60	1	-5.5	1
8	22	ED	IP	0	25	0	60	1	-5	1

### IP- Only Conditions

- Observations and Recommendations
  - Wind Tunnel 60min exposure tests at warmer temperatures demonstrated positive results
  - Test #5 for 60 min at colder temperature showed residual contamination
  - -5°C temperature cut-off suggested to be consistent with ZR/IP Allowance Times

### IP- Only Conditions

- Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets	30 Minutes	30 Minutes	30 Minutes

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/ISN
- CONCLUSIONS AND RECOMMENDATIONS

### Moderate IP Only Conditions

- 1 Wind Tunnel Test Conducted
- Moderate IP tests were NOT conducted with Falcon 20 this year
- 2005-06 Falcon 20 tests were referenced

Wind Tunnel Tests										
Test#	Feb day	Type IV Fluid	Contd (hrs)	ZR (hr) (g/min/hr)	IP (hr) (g/min/hr)	IR (hr) (g/min/hr)	Pres. Time (min)	Tunnel OAT (°C)	Wing Avg Temp (°C)	Visual Residue Rating (1-5)
9	22	FD	IP (mod)	0	15	0	30	3.2	-7	2.5

### Moderate IP Only Conditions

- Observations and Recommendations
  - Wind Tunnel test demonstrated positive results (i.e. lift loss and minimal visual contamination following run)
  - IP- Allowance times were referenced and modified

### Moderate IP Only Conditions

→ Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

### IP-/SN Conditions

→ 4 Wind Tunnel Tests Conducted

→ 2 Falcon 20 tests Conducted

Wind Tunnel Tests										
Test #	Run Day	Type IV Fluid	Condition	ZR Rate (g/min/ft)	IP Rate (g/min/ft)	SN Rate (g/min/ft)	Prep. Time (min)	Tunnel OAT (°C)	Wind Ave Temp (°C)	WIND Speed (kts)
WP1	20	FD	IP/SN	0	20	5	40	-3	-3	2
WP2	20	FD	IP/SN	0	5	20	40	-3	-6	1
WP3	20	SD	IP/SN	0	20	5	40	1.2	-8	1
WP4	23	FD	IP/SN	0	25	25	30	3.2	-9	2

Falcon 20 Tests									
Test #	Date	Type IV Fluid	Condition	ZR Rate (g/min/ft)	IP Rate (g/min/ft)	SN Rate (g/min/ft)	Prep. Time (min)	OAT (°C)	Wind Ave Temp (°C)
300	Feb-08	FD	IP/SN	-	25	25	30	-8	-11
5P	Mar-01	FD	IP/SN	-	20	20	30	-11	-13

### IP-/SN Conditions

→ Observations and Recommendations

- Wind tunnel tests demonstrated minimal lift loss and minimal visual contamination following run at warmer temperatures
- Testing at colder temperatures showed contamination at end of run
- No allowance for temperatures below -5°C due to lack of data collected

### IP-/SN Conditions

→ Recommended Allowance Times


	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes	Caution: No Allowance times currently exist	

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- WIND TUNNEL TESTING
- FALCON 20 TESTING
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

### Summary of Ice Pellet Allowance Times

	OAT -5° C and above	OAT Less than -5°C to -10°C	OAT Less than -10° C
Light Ice Pellets	50 Minutes	30 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes	Caution: No Allowance times currently exist	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes		
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes		
Light Ice Pellets Mixed with Light Rain	25 Minutes		



### Recommendations

- Future Wind Tunnel Work
  - Additional testing to refine allowance times
  - Conduct testing with different wings (maybe super critical.)
  - Verify results at lower speeds
  - Conduct testing at lower temperatures
  - Conduct testing with bare wing contamination (no fluid)
  - Conduct aerodynamic tests in mixed Rain and Ice pellet conditions
  - Conduct aerodynamic tests in mixed Freezing Drizzle and Ice pellet conditions

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# IMPLEMENTATION OF HOLDOVER TIME DETERMINATION SYSTEMS



**2007 SAE AIRCRAFT & ENGINE ICING  
INTERNATIONAL CONFERENCE AND EXHIBITION**

**SEVILLE, SPAIN  
SEPTEMBER 24-28, 2007**

**MICHAEL CHAPUT**  
 MANAGER, PROJECTS AND BUSINESS  
 DEVELOPMENT

APS AVIATION INC.  
 MONTREAL, QUEBEC, CANADA  
 MCHAPUT@ADGA.CA  
 WWW.APSAVIATION.CA


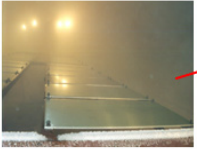


**PORTION OF THE WORK PRESENTED  
 HEREIN WAS FUNDED BY:**


TRANSPORTATION DEVELOPMENT  
 CENTRE  
 TRANSPORT CANADA



**FLUID HOLDOVER TIME TESTING AND TABLE  
 DEVELOPMENT**





SAE Grade	SAE Viscosity Index	Application: General Purpose		Application: Turbine Engine		Application: Turbine Engine	
		Low Temp.	High Temp.	Low Temp.	High Temp.	Low Temp.	High Temp.
AW-50	150	100	150	100	150	100	150
AW-100	150	100	150	100	150	100	150
AW-150	150	100	150	100	150	100	150
AW-200	150	100	150	100	150	100	150
AW-250	150	100	150	100	150	100	150
AW-300	150	100	150	100	150	100	150
AW-350	150	100	150	100	150	100	150
AW-400	150	100	150	100	150	100	150
AW-450	150	100	150	100	150	100	150
AW-500	150	100	150	100	150	100	150
AW-550	150	100	150	100	150	100	150
AW-600	150	100	150	100	150	100	150
AW-650	150	100	150	100	150	100	150
AW-700	150	100	150	100	150	100	150
AW-750	150	100	150	100	150	100	150
AW-800	150	100	150	100	150	100	150
AW-850	150	100	150	100	150	100	150
AW-900	150	100	150	100	150	100	150
AW-950	150	100	150	100	150	100	150
AW-1000	150	100	150	100	150	100	150

Transport Canada 


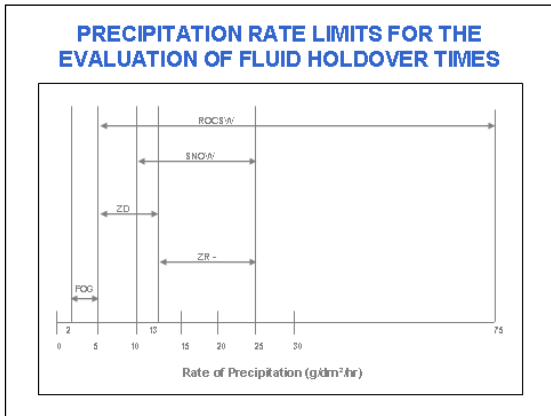
**HOLDOVER TIME TABLES**

- 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 Equivalent (LWE)
- 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



### 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.**

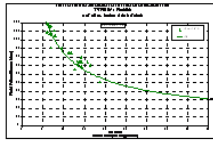


### DISCONNECT?

SIZE TYPE IV FLUID HOLOVER TIME BASED ON RATE

THE RESPONSIBILITY OF THE APPLICATION OF THESE VALUES REMAINS WITH THE USER

Category	Type IV	Type I	Temperature Range	Rate	Intensity	Visibility	Remarks
Light	100	100	-10 to -15	0.5 to 1.0	Very Light	3/4	
Medium	100	100	-10 to -15	1.0 to 2.0	Light	3/4	
Heavy	100	100	-10 to -15	2.0 to 5.0	Medium	3/4	
Very Heavy	100	100	-10 to -15	5.0 to 10.0	Heavy	3/4	
Extreme	100	100	-10 to -15	10.0 to 20.0	Very Heavy	3/4	



Category	Temperature Range	Rate	Intensity	Visibility	Remarks
Light	-10 to -15	0.5 to 1.0	Very Light	3/4	
Medium	-10 to -15	1.0 to 2.0	Light	3/4	
Heavy	-10 to -15	2.0 to 5.0	Medium	3/4	
Very Heavy	-10 to -15	5.0 to 10.0	Heavy	3/4	
Extreme	-10 to -15	10.0 to 20.0	Very Heavy	3/4	

### INFORMATION GAP



EXCELLENT FLUID HOT INFORMATION EXISTS  
AIR CARRIERS AND FLIGHT CREWS HAVE ACCESS TO THE INFORMATION  
FLIGHT CREWS CANNOT GET FULL VALUE OF THE HOT INFORMATION

TC / FAA PUBLISH THE HOT INFORMATION ANNUALLY

**REASON: FLIGHT CREWS HAVE NO WAY TO DETERMINE THE INTENSITY OF THE PRECIPITATION THAT IS FALLING**

### OPERATIONAL STUDY

### 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)

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

<p>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></p>	<p>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></p>
<p>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></p>	

**FLIGHT CREW DECISIONS**

SAME DAY, SAME AIRLINE, WITHIN 20-MINUTE WINDOW  
 4 AIRCRAFT, 3 TREATMENTS

<p>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></p>	<p>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></p>
<p>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></p>	<p>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></p>

**FLIGHT CREW DECISIONS**

SAME DAY, SAME AIRLINE, WITHIN 20-MINUTE WINDOW  
 4 AIRCRAFT, 3 TREATMENTS

<p>Regional Jet                  ATIS: ¼ SM, -SN DRSN, -14                  Rate of precipitation: 2.6 g/dm<sup>2</sup>/h                  Fluid Treatment: None                  Aircraft holdover time: N/A  <b>DID NOT DEICE</b></p>	<p>Narrowbody                  ATIS: 1 SM, -SN, -14                  Rate of precipitation: 5.1 g/dm<sup>2</sup>/h                  Fluid Treatment: Type I                  Aircraft holdover time: 17.5 minutes  <b>EXCEEDED HOLDOVER TIME</b></p>
<p>Regional Jet                  ATIS: 1 SM, -SN, -14                  Rate of precipitation: 4.9 g/dm<sup>2</sup>/h                  Fluid Treatment: Type IV                  Aircraft holdover time: 9.5 minutes  <b>GOOD FLUID SELECTION</b></p>	<p>Narrowbody                  ATIS: 1 SM, -SN, -14                  Rate of precipitation: 5.1 g/dm<sup>2</sup>/h                  Fluid Treatment: Type I                  Aircraft holdover time: 18 minutes  <b>EXCEEDED HOLDOVER TIME</b></p>

**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, including 7 with exceeded holdover times



**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  
 Current holdover time table range (HS): No HOT guidelines exist  
 Aircraft heldover time: 45 minutes

HOLDOVER TIME BASED ON RATE

Type IV: 15 minutes



**EXAMPLE – EXCEEDED HOLDOVER TIME**

16 DECEMBER 2005

Turboprop  
 METAR Temperature, Precipitation: -6.0°C, -SN BLSN  
 METAR Visibility: 5/8 SM  
 Calculated rate of precipitation: 79.8 g/dm<sup>2</sup>/h  
 Fluid treatment: Type I  
 Current holdover time table range (MS): 5 to 8 minutes  
 Current holdover time table range (LS): 8 to 14 minutes  
 Aircraft heldover time: 16 minutes

HOLDOVER TIME BASED ON RATE

Type I: 2 minutes



**OPERATIONAL STUDY SUMMARY**

- Departures with exceeded fluid holdover times occur frequently
  - Safety concern
- Significant number of departures do not employ the most adequate fluid treatment for the conditions that characterize the departure
  - Economic issue
    - Cost of fluids
    - Environmental impacts and costs
    - Airport throughput and time management



**TECHNICAL  
 EVALUATION  
 OF A  
 HOLDOVER TIME  
 DETERMINATION  
 SYSTEM (HOTDS)**

**TECHNICAL EVALUATION**

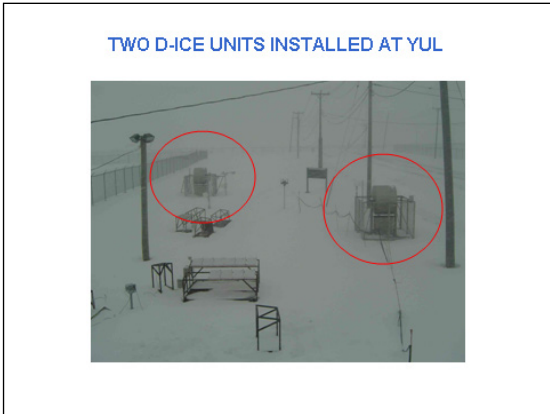
- In August 2003, APS was contracted by D-Ice A/S to conduct an independent technical evaluation of the D-Ice A/S Information System
- Testing performed over four winters
- Evaluate the system's ability to:
  - Compute a precipitation rate
  - Determine the prevailing meteorological conditions
  - Determine a holdover time based on the prevailing conditions and computed rate



**TECHNICAL EVALUATION**

- APS compared D-Ice A/S System outputs (rate, precipitation classification, temperature) with:
  - Manual data collections (using historical holdover time precipitation rate methodology)
  - Environment Canada / NAV CANADA weather outputs





**TEST SUMMARY – WINTER 2003-07  
D-ICE A/S DEICING INFORMATION SYSTEM**

- 2003-04: 409 data points were collected during 24 data collection events
- 2004-05: 424 data points were collected during 20 data collection events
- 2005-06: 700 data points collected during 23 data collection events; data collected with two units
- 2006-07: Approx. 400 data points during 15+ data collection events

**TEST RESULTS SUMMARY**

- Analysis of the rate outputs of the D-Ice A/S System is excellent: rates measured in snow, freezing rain, freezing drizzle, snow pellets, ice pellets compared well to those measured using historical methodology
- Ability of the D-Ice A/S System to measure accurate temperature and detect and identify precipitation type is excellent

→ **SYSTEM IS READY FOR OPERATIONAL USE**

**DEVELOPMENT OF  
PERFORMANCE SPECIFICATION  
AND EXEMPTION  
DOCUMENTATION FOR  
HOLDOVER TIME  
DETERMINATION SYSTEMS**

**ISSUE OF CERTIFICATION**

- Air carriers and airports, when approached about using a HOTDS, invariably ask if the system is "certified"
- The issue of "certification" was discussed in great detail with Transport Canada, Environment Canada and NAV CANADA

**IMPLEMENTATION OF HOTDS**

- HOTDS output is an operational aviation product for use under ground icing operations, and therefore falls under CAR 622.11
- Methodology to achieve use of HOTDS:
  - Development of a performance specification for HOTDS
  - Exemption from CAR 622.11 for operational use of the holdover time information provided by the HOTDS

## EXEMPTION DEVELOPMENT

- As part of its contract with TC, APS produced:
  - Draft Performance Specification document for Holdover Time Determination Systems (HOTDS)
  - Draft Exemption document from Subsection 602.11(4) of the *Canadian Aviation Regulations* and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 *Ground Icing Operations*



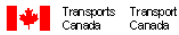
## EXEMPTION CONTENTS

- Exemption
- Appendices
  - Appendix A: Description of the applicable Canadian Aviation Regulations and Standard
  - Appendix B: Definitions of terms employed in the Exemption
  - Appendix C: Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems



## APPENDIX C CONTENTS

1. Quality Management System
2. Training and Qualifications
3. Installation, Siting, Operation and Maintenance of HOTDS
4. Accuracy of Holdover Time Input Instruments and Determination Systems
5. Technical requirements for Data Inputs and Holdover Time Determinations
  - Wind
  - Precipitation Type
  - Temperature
  - Precipitation Rate
  - Holdover Time Determinations
  - Holdover Time Determination Reports



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# **AIRCRAFT DEICING RESEARCH IN SIMULATED MIXED CONDITIONS WITH ICE PELLETS**

By  
**Marco Ruggi**



*For*

**Transportation Development Centre  
Transport Canada**

**and the**

**Federal Aviation Administration**



**SCOUIC 2007  
WINNIPEG - OCTOBER 10, 2007**

**APS**  
Aerodynamic Systems

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- ALLOWANCE TIMES
  - ZR-/IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**APS**  
Aerodynamic Systems

### BACKGROUND

- Recent industry need to provide aircraft operators with holdover times for ice pellet conditions
- During the winter of 2006, FAA provided a 25-minute allowance as a preliminary guideline
- Allowance based on the previous research conducted during the winter of 2005-06, primarily as a result of Falcon 20 aerodynamic research (SAE Lisbon 2006)
- Allowance was followed by a list of conditions restricting operations
  - i.e. Ice pellets alone, no mixed conditions

**APS**  
Aerodynamic Systems

### BACKGROUND

- Due to the high occurrence of ice pellets combined with rain, freezing rain, or snow, industry requested additional guidance material for operations in mixed ice pellet conditions
- Additional endurance time testing and aerodynamic research was conducted in simulated ice pellet conditions during the Winter of 2006-07
- Testing was directed by TC and FAA

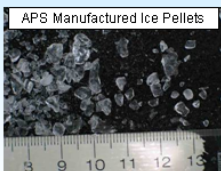
**APS**  
Aerodynamic Systems

### PRESENTATION OUTLINE

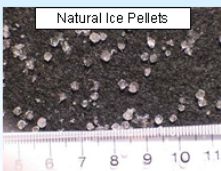
- BACKGROUND
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  - ZR-/IP-
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  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**APS SIMULATED ICE PELLETS**

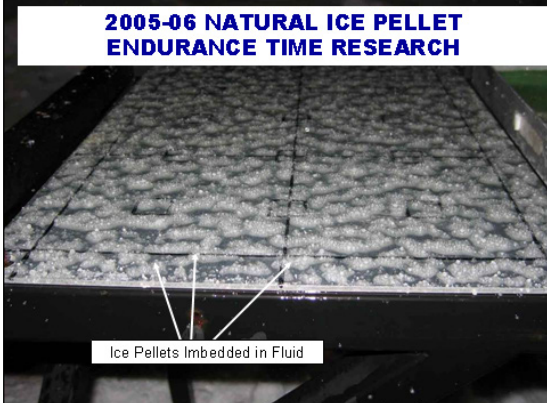
APS Manufactured Ice Pellets



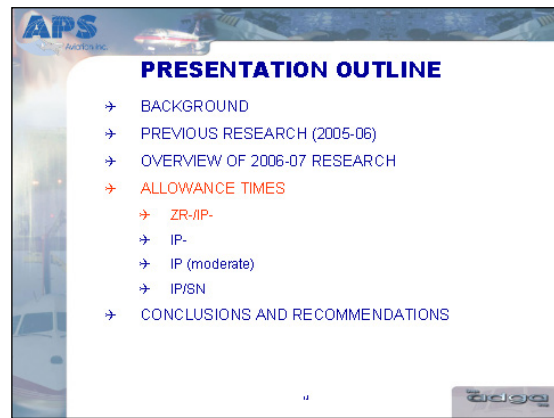
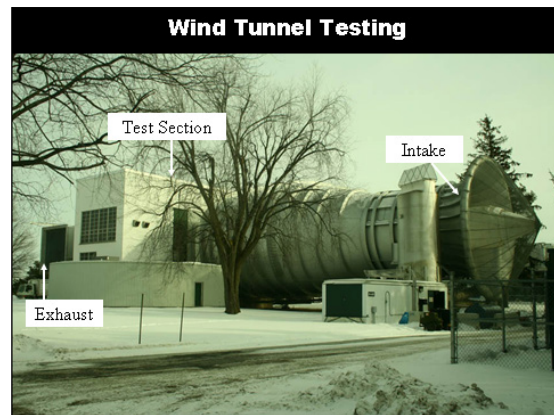
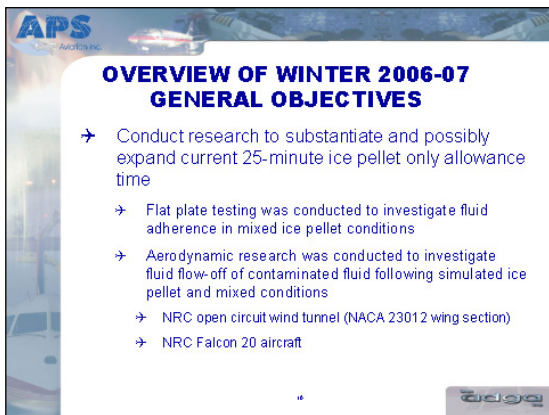
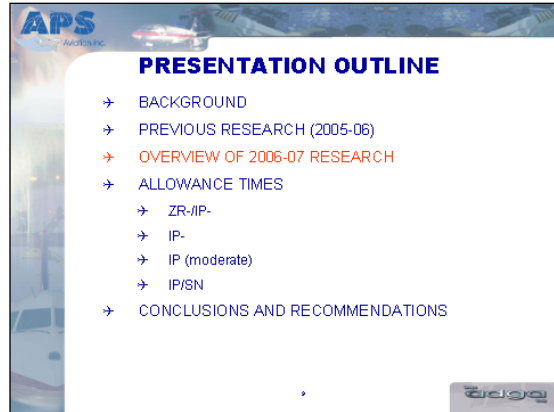
Natural Ice Pellets



**2005-06 NATURAL ICE PELLET ENDURANCE TIME RESEARCH**



Ice Pellets Imbedded in Fluid



**APS**  
Aerobatic Systems

### Allowance Times for Ice Pellet and Mixed Conditions

- A working group meeting was held April 11-13<sup>th</sup>, 2007
- Attendees
  - Federal Aviation Administration
  - Transport Canada
  - APS
- Objective: Review current data and recommend allowance times for ice pellet and mixed ice pellet precipitation conditions

**APS**  
Aerobatic Systems

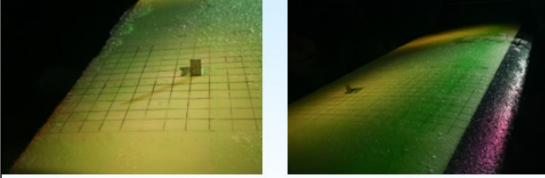
### Allowance Times for Ice Pellet and Mixed Conditions

- ANALYSIS METHODOLOGY
  - Contaminated fluid tests were compared to baseline fluid only tests and dry wing tests
  - Visual severity was determined based on observations during the test and review of photography
  - Lift coefficient data was acquired at the end of the testing and used to investigate the effects of contamination

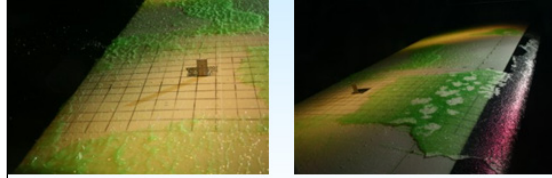
**Test #11**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-2°C, Wing -4°C  
[Photos](#)

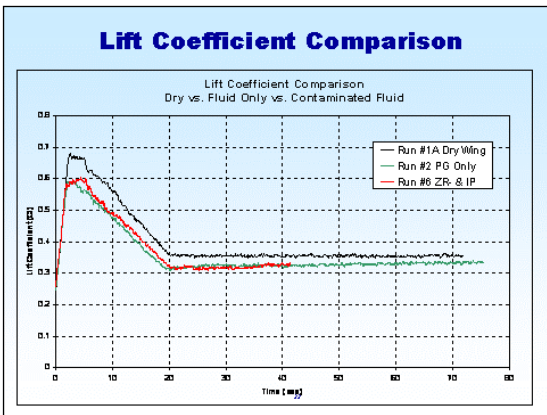
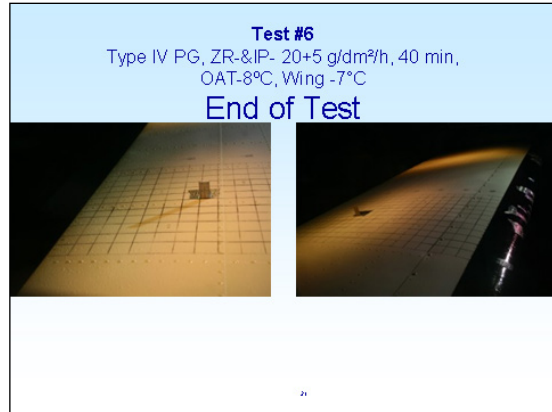
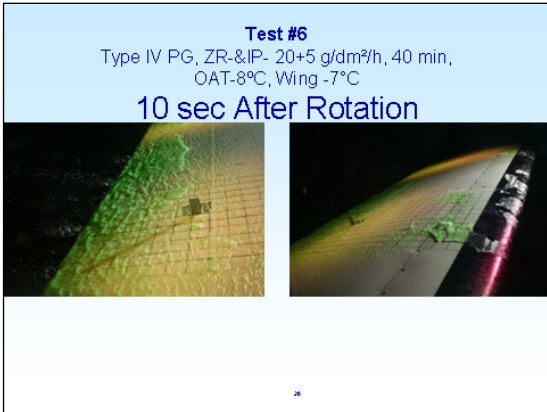
**Test #2**  
Type IV PG, No Contamination  
OAT-10°C, Wing -9°C  
[Photos](#)

**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**Start of Test**



**Test #6**  
Type IV PG, ZR-&IP- 20+5 g/dm<sup>2</sup>/h, 40 min,  
OAT-8°C, Wing -7°C  
**Before Rotation**





**Mixed ZR- and IP- Conditions**

- 5 Wind Tunnel Tests Conducted
- 2 Falcon 20 tests Conducted
- Observations and Recommendations
  - Freezing rain is the primary concern due to adherence and resulting increased roughness with the presence of ice pellets
  - Generic lower ZR HOT referenced and modified
    - -5°C cut-off recommended to allow for increased latitude to operators
    - Operations restricted to above -10°C

**Mixed ZR- and IP- Conditions**

→ Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5°C to -10°C	OAT Less than -10° C
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes	10 Minutes	Cutback: No Allowance times currently exist

**Mixed ZR- and IP- Conditions**

- Allowance times were presented in May 2007 at the SAE meeting in San Diego
- Industry requested additional guidance material
  - Mixed Freezing Drizzle and Ice pellets
  - Mixed Rain and Ice Pellets
- Additional flat plate testing and analysis was conducted
- ZR/IP Allowance times were referenced and modified

**Mixed ZR- and IP- Conditions**

- Recommended Allowance Times

	DAT -5° C and above	DAT Less than -5°C to -10°C	DAT Less than -10° C
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes	10 Minutes	Caution: No Allowance times currently exist
Light Ice Pellets Mixed with Light Rain	25 Minutes		

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**IP- Only Conditions**

- 3 Wind Tunnel Tests Conducted
- Previous 2005-06 Falcon 20 tests were referenced
- Observations and Recommendations
  - Testing at warmer conditions showed positive results
    - I.e. lift loss and residual contamination
  - Testing at colder conditions showed some signs of residual contamination on trailing edge
  - -5°C temperature cut-off suggested to be consistent with ZR/IP Allowance Times

**IP- Only Conditions**

- Recommended Allowance Times

	DAT -5° C and above	DAT Less than -5°C to -10°C	DAT Less than -10° C
Light Ice Pellets	30 Minutes	30 Minutes	30 Minutes

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**Moderate IP Only Conditions**

- 1 Wind Tunnel Test Conducted
- Previous 2005-06 Falcon 20 tests were referenced
- Observations and Recommendations
  - Test conducted demonstrated positive results
    - I.e. lift loss and residual contamination
  - Light Ice Pellet Only Allowance times were referenced and reduced accordingly
  - -5°C temperature cut-off suggested to be consistent with ZR/IP Allowance Times

**Moderate IP Only Conditions**

→ Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**IP-/SN Conditions**

- 4 Wind Tunnel Tests Conducted
- 2 Falcon 20 tests Conducted
- Observations and Recommendations
  - Testing at warmer conditions showed positive results
    - I.e. lift loss and residual contamination
  - Testing at colder temperatures showed contamination at end of run
  - Further testing at colder temperatures was recommended
  - No allowance times were issued for temperatures below -5°C due to the lack of data collected

**IP-/SN Conditions**

→ Recommended Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes	Caution: No Allowance Times currently exist	

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2005-06)
- OVERVIEW OF 2006-07 RESEARCH
- ALLOWANCE TIMES
  - ZR-IP-
  - IP-
  - IP (moderate)
  - IP/SN
- CONCLUSIONS AND RECOMMENDATIONS

**Recommendations**

- Future Wind Tunnel Work
  - Additional aerodynamic testing to refine allowance times
  - Conduct testing with different wings
    - Super critical wing
  - Verify results at lower speeds
  - Bare wing contamination tests (no fluid)

### Summary of Ice Pellet Allowance Times

	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets	25 Minutes	30 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes	10 Minutes	Caution: No Allowance Times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes	10 Minutes	
Light Ice Pellets Mixed with Light Rain	25 Minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes		

..

### Conditions and Restrictions

a) The aircraft critical surfaces must be properly deiced before the application of Type IV anti-icing fluid;

b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid;

c) These allowance times are from the start of the Type IV anti-icing fluid application;

d) The allowance time is limited to aircraft with a rotation speed of 100 knots or greater;

..

### Conditions and Restrictions

e) If the takeoff is not accomplished within the applicable allowance time in Table 10, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff.

f) The allowance time cannot be extended by an inspection of the aircraft critical surfaces from either inside or outside the aircraft;

g) If the temperature decreases below the temperature on which the allowance time was based, where the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit;

..

### Conditions and Restrictions

h) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used;

i) If the precipitation condition stops at or before the time limits of the applicable allowance time in Table 10 and does not restart the aircraft may takeoff up to 90 minutes after the start of the application of the Type IV anti-icing fluid.

However, under conditions of light ice pellets mixed with light freezing rain, the OAT must not decrease during the 90-minute period.

..

### Operational Example (a)

- **Light Ice Pellets**
- Type IV fluid
- Start of application time is 10:00
- OAT is 0°C
- Allowance time stops at 10:50,
- Light ice pellets fall until 10:20 and stop and do not restart

→ **Provided that no precipitation restarts after the end of the allowance time at 10:50 the aircraft may takeoff without any further action up to 11:30**

..

### Operational Example (b)

- **Light Ice Pellet** mixed with **Freezing Drizzle**
- Type IV fluid
- Start of application time is 10:00
- OAT is 0°C
- Allowance time stops at 10:25
- Light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:15 and stops at 10:20

→ **Provided that no precipitation restarts after the end of the allowance time at 10:25 the aircraft may takeoff without any further action up to 11:30**

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**Operational Example (c)**

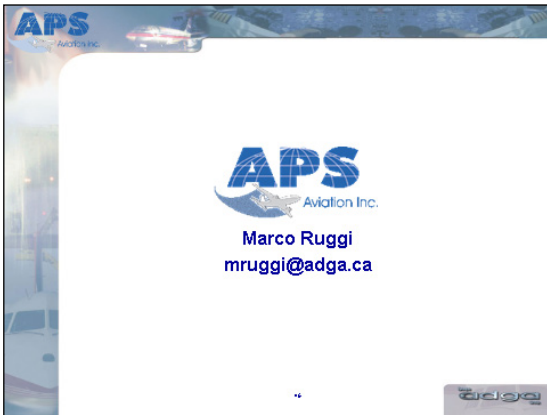
- **Light Ice Pellets** mixed with **Light Freezing Rain**
- Type IV fluid
- Start of application time is 10:00
- OAT is 0°C
- Allowance time stops at 10:25
- Light ice pellets mixed with light freezing rain falls until 10:10 and stops and restarts at 10:15 and stops at 10:20
  
- **Provided that the OAT remains constant or increases and that no precipitation restarts after the allowance time at 10:25 the aircraft may takeoff without any further action up to 11:30**

..

**Operational Example (d)**

- **Light Ice Pellets** mixed with **Freezing Drizzle**
- Type IV fluid
- Start of application time is 10:00
- OAT is 0°C
- Allowance time stops at 10:25
- Light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:30
  
- **The aircraft may not takeoff, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present**

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# DE/ANTI-ICING FLUID HOLDOVER TIME UPDATE

## 2007-08 WINTER OPERATIONS





**TRANSPORT CANADA SCOUIC  
WINNIPEG, MANITOBA  
OCTOBER 10, 2007**





### DE/ANTI-ICING FLUIDS TESTED WINTER 2006-07

	<b>TYPE I</b> KILFROST DF88USTAN OCTAGON (BATTELLE) ECOFLO
	<b>TYPE II</b> AVIATION XI'AN HI-TECH KHFI-II NEWAWE AEROCHEMICAL FCY-2
	<b>TYPE IV</b> KILFROST ABC-S PLUS LYONDELL ARCTIC SHIELD CLARIANT SAFEWING MP IV LAUNCH

## SUMMARY OF HOLDOVER TIME CHANGES

## TYPE I

### FAA/TC TYPE I HOT GUIDELINES 2007-08


**NO CHANGES**

FAA TYPE I HOLDOVER TIME GUIDELINE  
TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUIDS VARY AS A FUNCTION OF WEATHER  
CONDITIONS AND OUTSIDE AIR TEMPERATURE

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (Minutes)						
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wings	Other <sup>1</sup>
-3 and above	27 and above	0-45	0-10	0-15	0-15	0-15	0-15	0-15
below 0 to 0	below 32 to 32	0-45	0-10	0-15	0-15	0-15	0-15	0-15
below 0 to -5	below 32 to 23	0-45	0-10	0-15	0-15	0-15	0-15	0-15
below -5 to -10	below 23 to 14	0-45	0-10	0-15	0-15	0-15	0-15	0-15
below -10 to -15	below 14 to 7	0-45	0-10	0-15	0-15	0-15	0-15	0-15

SAE TYPE I HOLDOVER GUIDELINES FOR WINTER 2007-2008  
CAUTION: THE APPLICATION OF THESE DATA REQUIRES THE USER

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)						
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wings	Other <sup>1</sup>
-3 and above	27 and above	45	11-17	15	11-16	6-11	6-13	4-6
below -3 to 0	below 27 to 32	45	6-13	14	6-14	6-8	6-9	4-6
below -6 to -10	below 21 to 14	45	6-10	11	6-11	4-6	4-7	2-5
below -10 to -15	below 14 to 7	45	5-9	7	4-7	2-4		



## TYPE II

### FAA/TC TYPE II HOT GUIDELINES 2007-08

**FAA TYPE II HALDOVER TIME GUIDELINE**

Outside Air Temperature		Type II Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:30-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:45	
		7500	8:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
3 to -14	below 27	1000	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15		
		7500	8:00	0:20-1:05	0:10-0:20	0:10-0:40	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15		
		7500	8:00	0:20-1:05	0:10-0:20	0:10-0:40	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	SAE Type II fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type II fuel cannot be used.						

**SAE TYPE II FLUID HALDOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**

Outside Air Temperature		Type II Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:30-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40	
		7500	8:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
3 to -14	below 27	1000	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15		
		7500	8:00	0:20-1:05	0:10-0:20	0:10-0:40	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00 <sup>1</sup>	0:15-0:30 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>		
		7500	8:00	0:20-1:05	0:10-0:20	0:10-0:40	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	Type II fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type II fuel cannot be used.						

- ### TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2007-08
- 1) AVIATION XI'AN HI-TECH KHF-II (NEW)
  - 2) CLARIANT SAFEWING MP II 2025 ECO
  - 3) CLARIANT SAFEWING MP II FLIGHT
  - 4) KILFROS T ABC-2000
  - 5) KILFROS T ABC-II PLUS
  - 6) NEWAVE AEROCHEMICAL FCY-II (NEW)
  - 7) OC TAGON E-MAX II
  - 8) SPCA ECOWING 26
- KILFROS T ABC-TF2 (REMOVED)

# TYPE III

### FAA/TC TYPE III HOT GUIDELINES 2007-08

**FAA TYPE III HALDOVER TIME GUIDELINE**

TABLE 3. FAA GUIDELINES FOR HALDOVER TIMES SAE TYPE III FLUID MIXTURE AS A FUNCTION OF WEATHER CONDITIONS AND FUEL/AIR TEMPERATURE.

CAUTION: THIS TABLE IS FOR OPERATIVE CLASSIFIED ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRE-SETBACK CHECK PROCEDURES.

Outside Air Temperature		Type III Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:20-0:45	0:15-0:30	0:15-0:30	0:10-0:25	0:05-0:15	
		7500	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:15	
3 to -14	below 27	1000	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00 <sup>1</sup>	0:15-0:30 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	SAE Type III fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type III fuel cannot be used.						

**SAE TYPE III FLUID HALDOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**

Outside Air Temperature		Type III Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:20-0:45	0:15-0:30	0:15-0:30	0:10-0:25	0:05-0:15	
		7500	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:15	
3 to -14	below 27	1000	8:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:15		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00 <sup>1</sup>	0:15-0:30 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>	0:05-0:15 <sup>1</sup>		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	Type III fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type III fuel cannot be used.						

# TYPE IV

### FAA/TC TYPE IV HOT GUIDELINES 2007-08

**FAA TYPE IV HALDOVER TIME GUIDELINE**

Outside Air Temperature		Type IV Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:15-0:30	0:10-0:20	0:10-0:20	0:05-0:15	0:05-0:15	
		7500	8:00	0:10-0:20	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:15	
3 to -14	below 27	1000	8:00	0:15-0:30	0:10-0:20	0:10-0:20	0:05-0:15		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00 <sup>1</sup>	0:15-0:30 <sup>1</sup>	0:10-0:20 <sup>1</sup>	0:10-0:20 <sup>1</sup>	0:05-0:15 <sup>1</sup>		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	SAE Type IV fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type IV fuel cannot be used.						




**SAE TYPE IV FLUID HALDOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**

Outside Air Temperature		Type IV Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power (Watts/cm <sup>2</sup> /ft <sup>2</sup> )	Active Front	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
3 and above	27 and above	1000	8:00	0:15-0:30	0:10-0:20	0:10-0:20	0:05-0:15	0:05-0:15	
		7500	8:00	0:10-0:20	0:05-0:15	0:05-0:15	0:05-0:15	0:05-0:15	
3 to -14	below 27	1000	8:00	0:15-0:30	0:10-0:20	0:10-0:20	0:05-0:15		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -14 to -25	below 27	1000	8:00 <sup>1</sup>	0:15-0:30 <sup>1</sup>	0:10-0:20 <sup>1</sup>	0:10-0:20 <sup>1</sup>	0:05-0:15 <sup>1</sup>		
		7500	8:00	0:20-0:45	0:10-0:20	0:10-0:20	0:10-0:20		CAUTION: No holdover time guidelines exist
below -25	below -13	1000	Type IV fuel may be used below -25°C (-13°F) provided the freezing point of the fuel is at least 7°C (45°F) below the C <sub>10</sub> and the aerodynamic acceptance criteria are met. Consider use of Type I when SAE Type IV fuel cannot be used.						

**TC/FAA TYPE IV FLUID-SPECIFIC  
HOT GUIDELINES 2007-08**

- 1) CLARIANT SAFEWING MP IV 2001
- 2) CLARIANT SAFEWING MP IV PROTECT 2012 (REVISED)
- 3) CLARIANT SAFEWING MP IV LAUNCH (REVISED)
- 4) DOW UCAR ULTRA +
- 5) DOW UCAR ENDURANCE EG106
- 6) KILFROST ABC-S
- 7) KILFROST ABC-S PLUS (REVISED)
- 8) LYONDELL ARCTIC SHIELD (NEW)
- 9) OCTAGON MAX-FLIGHT
- 10) OCTAGON MAX-FLIGHT 04
- 11) OCTAGON MAXFLO
- 12) SPCA AD-480


CLARIANT SAFEWING MP IV 2030 ECO (REMOVED)

 Transports Canada    Transport Canada     

**TC HOLDOVER TIME GUIDANCE  
MATERIAL**

[http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/  
menu.htm](http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm)

Guidance for Aircraft Ground Icing Operations –  
TP14052

 Transports Canada    Transport Canada



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**APS**  
Aviation Inc.

# **SUBSTANTIATION OF AIRCRAFT GROUND DEICING HOLDOVER TIMES IN FROST CONDITIONS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

For

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE  
MONTREAL - NOVEMBER 14, 2007

edge

**APS**  
Aircraft

### PURPOSE

- Data collected by APS in natural frost conditions was presented at the G-12 meeting in San Diego
- Attention was focused on:
  - **Reduced Endurance Times in Frost Conditions due to Fluid Freeze Point Issues**
- Purpose of this presentation is to briefly review test results and:
  - **Propose Alternatives to rectify the issues**
  - **Reach a consensus on "Plan of Action"**

**APS**  
Aircraft

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST TEST PARAMETERS
- TYPE I TESTS
- TYPE II/III/IV TESTS
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

**APS**  
Aircraft

### BACKGROUND

- A survey of deicing activities at airports was conducted by APS
- Data was collected from airports in North America, Europe and Asia
- Results showed removal of frost contamination represents a significant portion of deicing operations.
  - 90% of operations for airports with warmer climates
    - I.e. London and Paris
  - 25% of operations for airports with colder climates
    - I.e. Montreal

**APS**  
Aircraft

### BACKGROUND

→ Frequency of Deicing Operations Airport Survey 2000-03

Category	Percentage
Snow	56%
Frost	33%
Other	11%

TC report TP 14375E

**APS**  
Aircraft

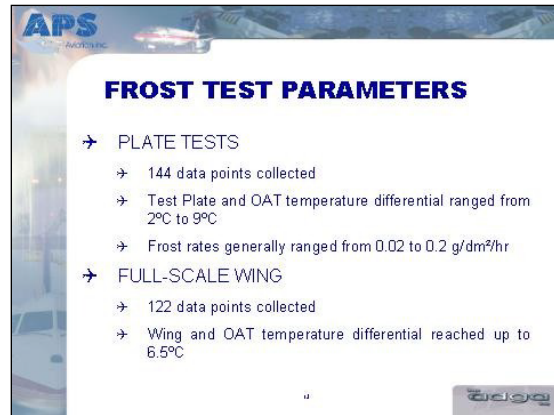
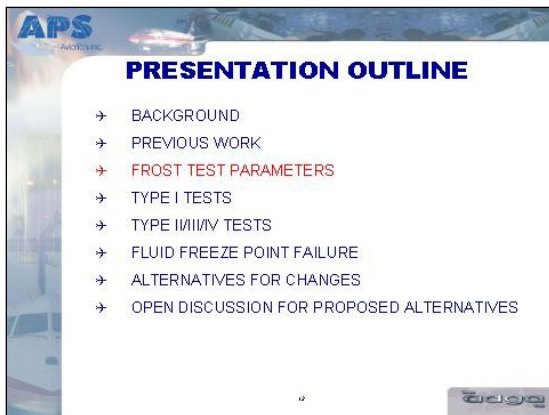
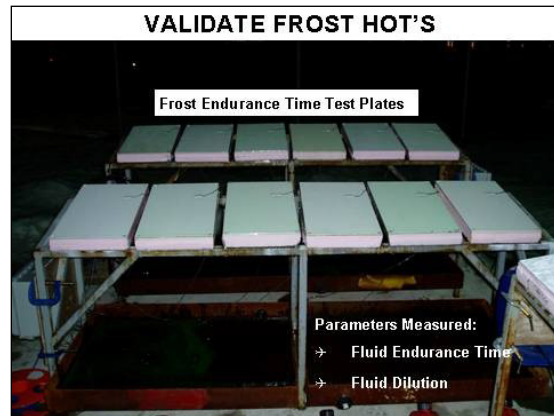
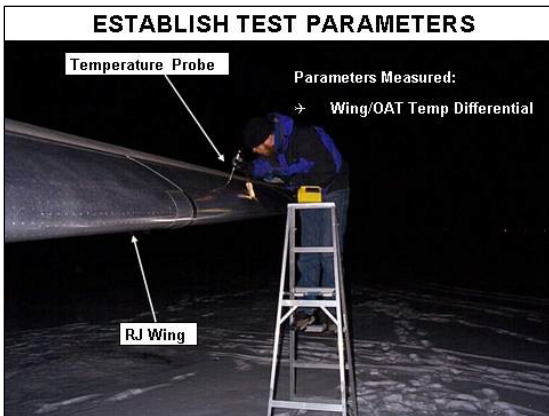
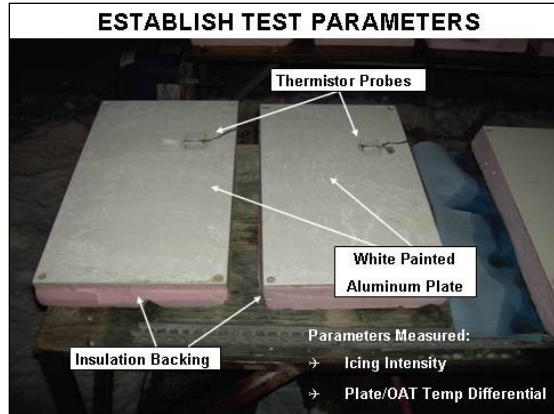
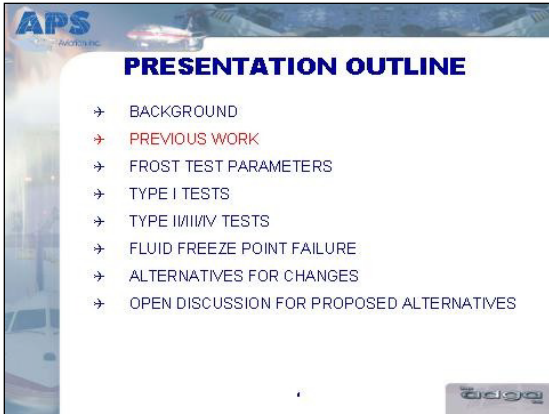
### BACKGROUND

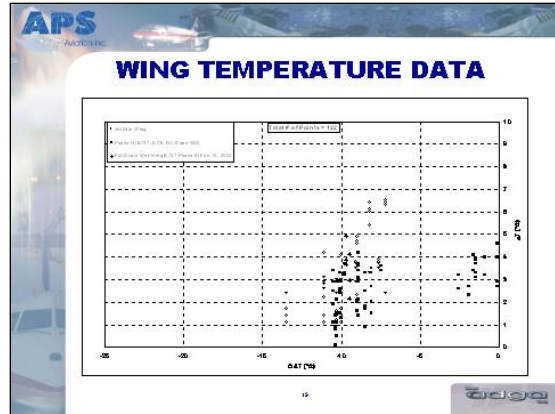
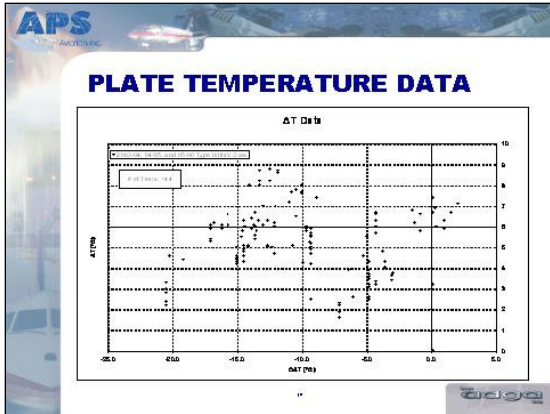
- Frost HOT have always been a part of the HOT guidelines, however fluid endurance times in frost conditions have never been measured.
- Outdoor endurance time testing in natural frost conditions for Type I,II,III,IV fluids was recommended

**APS**  
Aircraft

### BACKGROUND

- Testing was conducted by APS to:
  - Establish Appropriate Test Parameters
    - Flat Plate Testing
    - Full Scale Aircraft Tests
  - Validate Type I HOT for Frost Conditions
  - Validate Type II/III/IV HOT for Frost Conditions





- ### PRESENTATION OUTLINE
- BACKGROUND
  - PREVIOUS WORK
  - FROST TEST PARAMETERS
  - **TYPE I TESTS**
  - TYPE II/III/IV TESTS
  - FLUID FREEZE POINT FAILURE
  - ALTERNATIVES FOR CHANGES
  - OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

- ### TYPE I TESTS
- 47 tests were conducted with 4 Type I fluids
  - The measured endurance times did not violate the long used HOT of 45 minutes.
  - Based on the data collected, the Type I HOTs have been substantiated.
  - *It is recommended that a note be included in ARP 5945 indicating that testing is not required for frost if the fluid meets the certification requirements*

- ### PRESENTATION OUTLINE
- BACKGROUND
  - PREVIOUS WORK
  - FROST TEST PARAMETERS
  - TYPE I TESTS
  - **TYPE II/III/IV TESTS**
  - FLUID FREEZE POINT FAILURE
  - ALTERNATIVES FOR CHANGES
  - OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

- ### TYPE II/III/IV TESTS
- 62 tests were conducted with 5 Type II fluids
  - 16 tests were conducted with 1 Type III fluid
  - 90 tests were conducted with 8 Type IV fluids
  - Type II,III,IV fluids were tested at neat, 75/25, and 50/50 dilutions

**TYPE II/III/IV TESTS**

- 15 Type II tests and 21 Type IV tests generated reduced endurance times in comparison to the current frost values issued in the HOT Guidelines
- Discrepancy in endurance times was attributed to fluid freeze point issues for 86% of the cases

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS WORK
- FROST TEST PARAMETERS
- TYPE I TESTS
- TYPE II/III/IV TESTS
- **FLUID FREEZE POINT FAILURE**
- ALTERNATIVES FOR CHANGES
- OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

**FLUID FREEZE POINT FAILURE**

- Reduced fluid endurance times were experienced when OAT approached fluid LOUT
- The plate surface temperature would cool closer to the fluid freeze point causing fluid failure
- Fluid dilution and erosion did not significantly contribute to the failure

**FLUID FREEZE POINT FAILURE**

- EXAMPLE
  - Type IV 75/25 Fluid
  - OAT = **-13.9°C** (within operational limit)
  - Plate Temperature =  $-13.9°C - (7°C) = -20.9°C$
  - Fluid Freeze Point = **-21°C**
    - Fluid would be designed with 7°C buffer based on LOUT of -14°C
- **Plate temperature is cooled to LOUT**
- **Fluid experiences contamination as ice crystals begin to form sporadically in fluid**

**FLUID FREEZE POINT FAILURE**

- Fluid freeze point failure can be experienced with dilutions when operating close to the LOUT
  - Assuming  $\Delta T = 9°C$

Type I/IV Dilution	LOUT	Approximate FFP	Possible Surface Temp. During Frost Conditions at LOUT
Neat	-25	-36	-32
75/25	-14	-21	-21
50/50	-3	-10	-10

**FLUID FREEZE POINT FAILURE**

- The HOT table provides operational ranges specifying limits based on OAT
- In frost conditions, the skin temperature of an aircraft may be several degrees lower than the OAT
- If operating with a fluid close to the LOUT during frost conditions, the skin temperature of the aircraft could reach the fluid freeze point potentially causing ice to form in the fluid
- **FROST HOT'S NEED TO REFLECT SKIN TEMPERATURE**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST TEST PARAMETERS
- TYPE I TESTS
- TYPE III/IV TESTS
- FLUID FREEZE POINT FAILURE
- **ALTERNATIVES FOR CHANGES**
- OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

### ALTERNATIVES FOR CHANGES

- Based on the data collected, changes to the Frost HOT's are required to account for:
  - Endurance Time Data Collected
  - Fluid Freeze Point Failure
- 3 Options have been developed:
  - CURRENT FORMAT / REDUCED HOT'S
  - SEPARATE FROST TABLE
  - CURRENT FORMAT / OAT FOOTNOTES

### ALTERNATIVES FOR CHANGES

- **OPTION 1 – CURRENT FORMAT / REDUCED HOT'S**
  - Use current temperature breakdowns for Frost HOT's
  - Issue reduced HOT changes in current HOT table format
  - **Pros**
    - No change in table format required
    - Allows for fluid specific frost numbers to be easily incorporated in the event that this is needed
  - **Cons**
    - Reduction in HOT in frost conditions for Type II and Type IV fluids

### OPTION 1 CURRENT FORMAT / REDUCED HOT'S

Outside Air Temperature		Type IV Fluid Concentration Heat Fluid/Min/hr	Approximate Holdover Times Under Various Active Frost (Hours:minutes)			
Degrees Celsius	Degrees Fahrenheit	(Volume %/Volume %)	Type I	Type II	Type III	Type IV
-3 and above	27 and above	100.0	0.15	8:00	2:00	12:00
		15.25		5:00	1:00	5:00
		50.50		3:00 1:30	0:30	3:00 2:00
below -3 to -11 (-10 for TM)	below 27 to 7 (14 for TM)	100.0		8:00	2:00	12:00 6:00
		15.25		5:00 1:00	1:00	5:00 1:00
below -11 (-10 for TM) to -25	below 7 (14 for TM) to -13	100.0		8:00 2:00	2:00	12:00 2:00

### OPTION 1 CURRENT FORMAT / REDUCED HOT'S

Outside Air Temperature		Type IV Fluid Concentration Heat Fluid/Min/hr	Approximate Holdover Times Under Various Active Frost (Hours:minutes)			
Degrees Celsius	Degrees Fahrenheit	(Volume %/Volume %)	Type I	Type II	Type III	Type IV
-3 and above	27 and above	100.0	0.15	8:00	2:00	12:00
		15.25		5:00	1:00	5:00
		50.50		3:00 1:30	0:30	3:00 2:00
below -3 to -11 (-10 for TM)	below 27 to 7 (14 for TM)	100.0		8:00	2:00	12:00 6:00
		15.25		5:00 1:00	1:00	5:00 1:00
below -11 (-10 for TM) to -25	below 7 (14 for TM) to -13	100.0		8:00 2:00	2:00	12:00 2:00

Use Current OAT Breakdown      Reduce HOT's

### ALTERNATIVES FOR CHANGES

- **OPTION 2 – SEPARATE FROST TABLE**
  - Issue frost HOT's on a separate table
  - Remove frost HOT's from generic and fluid specific tables
  - Change temperature ranges to reflect skin temp. differential experienced during frost conditions
  - **Pros**
    - Would facilitate operations (33% of total def/anti-icing operations)
    - Logical because frost HOT's are generic
  - **Cons**
    - Additional table to be added to HOT Guidelines
    - Additional training required

### OPTION 2 SEPARATE FROST TABLE

Outside Air Temperature		Type M Fluid Concentration Net Fluid/Water %	Approximate Holdover Time Under Various			
Degree Celsius	Degree Fahrenheit		(Hours:minutes)			
			Active Frost			
			Type I	Type II	Type III	Type IV
-3 and above	21 and above	100.0		8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
		50.0%		3:00 2:00*	0:30*	3:00*
below -3 to -11 (-10.0 to -7.0) below -3 to -7	below 27 to 19 (27.0 to 24.0) below 27 to 19	100.0	0.15	8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
below -11 to -25 (-10.0 to -7.0) below -7 to -21	below 7 to -5 (27.0 to 24.0) below 19 to 5	100.0		8:00 6:30**	2:00	12:00 6:30**

\* This holdover time only applies to outside air temperatures to -1°C (32°F) under active frost.  
\*\* This holdover time only applies to outside air temperatures to -1°C (32°F) under active frost.

### OPTION 2 SEPARATE FROST TABLE

Outside Air Temperature		Type M Fluid Concentration Net Fluid/Water %	Approximate Holdover Time Under Various			
Degree Celsius	Degree Fahrenheit		(Hours:minutes)			
			Active Frost			
			Type I	Type II	Type III	Type IV
-3 and above	21 and above	100.0		8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
		50.0%		3:00 2:00*	0:30*	3:00*
below -3 to -11 (-10.0 to -7.0) below -3 to -7	below 27 to 19 (27.0 to 24.0) below 27 to 19	100.0	0.15	8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
below -11 to -25 (-10.0 to -7.0) below -7 to -21	below 7 to -5 (27.0 to 24.0) below 19 to 5	100.0		8:00 6:30**	2:00	12:00 6:30**

\* This holdover time only applies to outside air temperatures to -1°C (32°F) under active frost.  
\*\* This holdover time only applies to outside air temperatures to -1°C (32°F) under active frost.

Change OAT Breakdown

Less Reduced HOT's

## ALTERNATIVES FOR CHANGES

- ➔ **OPTION 3 - CURRENT FORMAT / OAT FOOTNOTES**
  - ➔ Issue changes in current HOT Tables
  - ➔ Restrict use of fluids to reflect skin temp. differential experienced during frost conditions
  - ➔ Include notes in tables to describe temperature restrictions
- ➔ **Pros**
  - ➔ No change in table format required
  - ➔ Allows for fluid specific frost numbers to be easily incorporated in the event that this is needed
- ➔ **Cons**
  - ➔ Additional footnotes required in tables
  - ➔ Additional training required

### OPTION 3 CURRENT FORMAT / OAT FOOTNOTES

Outside Air Temperature		Type M Fluid Concentration Net Fluid/Water %	Approximate Holdover Time Under Various			
Degree Celsius	Degree Fahrenheit		(Hours:minutes)			
			Active Frost			
			Type I	Type II	Type III	Type IV
-3 and above	21 and above	100.0		8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
		50.0%		3:00 2:00*	0:30*	3:00*
below -3 to -11 (-10 for TM)	below 27 to 19 (24 for TM)	100.0	0.15	8:00**	2:00**	12:00**
		15.0%		5:00**	1:00**	5:00**
below -11 (-10 for TM) to -25	below 7 (24 for TM) to -13	100.0		8:00*** 6:30***	2:00***	12:00 6:30***

\* These holdover times apply to outside air temperatures down to -1°C (32°F) under active frost.  
\*\* These holdover times apply to outside air temperatures down to -2°C (28°F) under active frost.  
\*\*\* These holdover times apply to outside air temperatures between -2°C (28°F) and -21°C (-4°F) under active frost.

### OPTION 3 CURRENT FORMAT / OAT FOOTNOTES

Outside Air Temperature		Type M Fluid Concentration Net Fluid/Water %	Approximate Holdover Time Under Various			
Degree Celsius	Degree Fahrenheit		(Hours:minutes)			
			Active Frost			
			Type I	Type II	Type III	Type IV
-3 and above	21 and above	100.0		8:00	2:00	12:00
		15.0%		5:00	1:00	5:00
		50.0%		3:00 2:00*	0:30*	3:00*
below -3 to -11 (-10 for TM)	below 27 to 19 (24 for TM)	100.0	0.15	8:00**	2:00**	12:00**
		15.0%		5:00**	1:00**	5:00**
below -11 (-10 for TM) to -25	below 7 (24 for TM) to -13	100.0		8:00*** 6:30***	2:00***	12:00 6:30***

\* These holdover times apply to outside air temperatures down to -1°C (32°F) under active frost.  
\*\* These holdover times apply to outside air temperatures down to -2°C (28°F) under active frost.  
\*\*\* These holdover times apply to outside air temperatures between -2°C (28°F) and -21°C (-4°F) under active frost.

Use Current OAT Breakdown

Footnotes Required

## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ PREVIOUS WORK
- ➔ FROST TEST PARAMETERS
- ➔ TYPE I TESTS
- ➔ TYPE III/IV TESTS
- ➔ FLUID FREEZE POINT FAILURE
- ➔ ALTERNATIVES FOR CHANGES
- ➔ OPEN DISCUSSION FOR PROPOSED ALTERNATIVES

**OPTION 1**  
**CURRENT FORMAT / REDUCED HOT'S**

Schedule de Température	Type de Température	Description	Aire de Peinture			
			Temp. 1	Temp. 2	Temp. 3	Temp. 4
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00

The Current OAT is 0°C. Reduce HOT's

**OPTION 2**  
**SEPARATE FROST TABLE**

Schedule de Température	Type de Température	Description	Aire de Peinture			
			Temp. 1	Temp. 2	Temp. 3	Temp. 4
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00

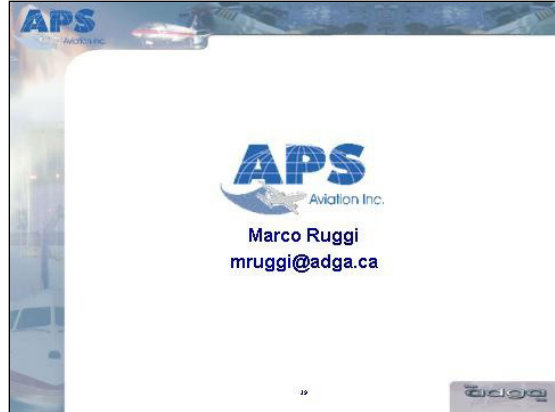
Change OAT to 0°C. Less Reduce HOT's

**OPTION 3**  
**CURRENT FORMAT / OAT FOOTNOTES**

Schedule de Température	Type de Température	Description	Aire de Peinture			
			Temp. 1	Temp. 2	Temp. 3	Temp. 4
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00
0°C	0°C	0°C	1.00	1.00	1.00	1.00

The Current OAT is 0°C. Reduce Footnotes





# **AIRCRAFT DEICING RESEARCH IN SIMULATED MIXED CONDITIONS WITH ICE PELLETS**

By  
**Marco Ruggi**



*For*

**Transportation Development Centre  
Transport Canada**

**and the**

**Federal Aviation Administration**



**SAE G-12 HOT SUBCOMMITTEE  
MONTREAL – NOVEMBER 14, 2007**

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETT TESTS
- FUTURE WORK
- CURRENT ICE PELLETT GUIDANCE MATERIAL

**BACKGROUND**

- Recent industry need to provide aircraft operators with holdover times for ice pellet conditions
- During the winter of 2006, FAA provided a 25-minute allowance as a preliminary guideline
- Allowance based on the previous research conducted during the winter of 2005-06, primarily as a result of Falcon 20 aerodynamic research (SAE Lisbon 2006)
- Allowance was followed by a list of conditions restricting operations
  - i.e. Ice pellets alone, no mixed conditions

**BACKGROUND**

- Due to the high occurrence of ice pellets combined with rain, freezing rain, or snow, industry requested additional guidance material for operations in mixed ice pellet conditions
- Additional endurance time testing and aerodynamic research was conducted in simulated ice pellet conditions during the Winter of 2006-07
- Testing was directed by TC and FAA

**PRESENTATION OUTLINE**

- BACKGROUND
- **PREVIOUS RESEARCH (2006-07)**
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETT TESTS
- FUTURE WORK
- CURRENT ICE PELLETT GUIDANCE MATERIAL

**PREVIOUS RESEARCH**

- Conduct research to substantiate and possibly expand current 25-minute ice pellet only allowance time
- Flat plate testing was conducted to investigate fluid adherence in mixed ice pellet conditions
- Aerodynamic research was conducted to investigate fluid flow-off of contaminated fluid following simulated ice pellet and mixed conditions
  - NRC open circuit wind tunnel (NACA 23012 wing section)
  - NRC Falcon 20 aircraft





**Test #11**  
 Type IV PG, ZR-&IP- 20+5 g/dm<sup>3</sup>/h, 40 min,  
 OAT-2°C, Wing -4°C

[Photos](#)

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETT TESTS
- FUTURE WORK
- CURRENT ICE PELLETT GUIDANCE MATERIAL

**REGULATORY GUIDANCE MATERIAL**

- Allowance times were presented in May 2007 at the G-12 HOT Subcommittee meeting in San Diego
- Allowance times provided guidance material for
  - Light Ice Pellets Only
  - Moderate Ice Pellets Only
  - Light Freezing Rain and Light Ice Pellets
  - Snow and Light Ice Pellets

**REGULATORY GUIDANCE MATERIAL**

	OAT -5° C and above	OAT Less than -5°C to -10°C	OAT Less than -10° C
Light Ice Pellets	50 Minutes	30 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes	10 Minutes	Caution: No Allowance times currently exist
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes		

**REGULATORY GUIDANCE MATERIAL**

- Industry requested additional guidance material
- Mixed Freezing Drizzle and Light Ice pellets
- Mixed Light Rain and Light Ice Pellets

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETS TESTS
- FUTURE WORK
- CURRENT ICE PELLETS GUIDANCE MATERIAL

**FOLLOW-UP RESEARCH**

- Additional flat plate testing and analysis was required
- Testing was conducted at the NRC Climatic Engineering Chamber in July 2007

**FOLLOW-UP RESEARCH OBJECTIVES**

- VALIDATION OF ALLOWANCE TIMES
  - To investigate the level of contamination observed at the end of the allowance period.
- FLUID AGING TESTS
  - Investigate effects of fluid "aging" following the end of the allowance time (*done in conjunction with Validation tests*)
- MIXED LIGHT RAIN AND ICE PELLETS TESTING
  - To provide a basis for an allowance time recommendation

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETS TESTS
- FUTURE WORK
- CURRENT ICE PELLETS GUIDANCE MATERIAL

**VALIDATION OF ALLOWANCE TIMES**

- Flat plate testing was conducted at the upper precipitation limits for each of the allowance time conditions.
- At the end of the allowance time, the fluid was inspected to verify for fluid adherence.

**LIGHT FREEZING RAIN AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- Fluid condition at the end of the Allowance Period

OAT = -5°C

OAT = -10°C

**Adherence**

**LIGHT ICE PELLETS ONLY**

- Type IV EG Fluid
- Fluid condition at the end of the Allowance Period

OAT = -5°C

OAT = -25°C

**MODERATE ICE PELLETS ONLY**

- Type IV EG Fluid
- Fluid condition at the end of the Allowance Period

OAT = -5°C

OAT = -25°C

**SNOW AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- Fluid condition at the end of the Allowance Period

OAT = -5°C

**VALIDATION OF ALLOWANCE TIMES**

- Fluid adherence was only observed during testing conducted in mixed light freezing rain and light ice pellets at warmer temperatures (-5°C)
- These results are typical with freezing rain at warmer temperatures (as seen in standard HOT testing)
- Adherence was not observed during mixed light freezing rain and light ice pellets at -10°C

**VALIDATION OF ALLOWANCE TIMES**

- No adherence was documented during light and moderate ice pellet only tests, as well as during snow and light ice pellet tests
- At the colder temperatures, the ice pellets embedded in the fluid took a significantly longer time to dissolve in comparison to tests conducted at warmer temperatures.

**APS**

### VALIDATION OF ALLOWANCE TIMES

- The fluid condition at the end of the allowance time for all conditions demonstrated acceptable amounts of contamination
- **The allowance times issued for the winter of 2007-08 were deemed acceptable**

**APS**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
    - **FLUID AGING TESTS**
    - LIGHT RAIN AND LIGHT ICE PELLETS TESTS
- FUTURE WORK
- CURRENT ICE PELLETS GUIDANCE MATERIAL

**APS**


### FLUID AGING TESTS

- Flat plate testing was conducted at the upper precipitation limits for each of the allowance time conditions.
- At the end of the allowance time, the precipitation was stopped and the plates were left in the cold chamber for an additional 30 minutes
- At the end of the aging period, the fluid was inspected to verify for any changes in the fluid condition


**SNOW AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT = -5°C

END OF ALLOWANCE




END OF AGING




**LIGHT FREEZING RAIN AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT = -5°C

END OF ALLOWANCE



END OF AGING



**APS**

### FLUID AGING TESTS

- When the precipitation was stopped, the visual condition of the contaminated fluid would improve
- Imbedded or bridging frozen precipitate would further dissolve resulting in a visual improvement of the fluid condition

**FLUID AGING TESTS**

- During light freezing rain mixed with light ice pellets tests, the fluid diluted close to the freeze point by the end of the allowance time
- The fluid condition improved slightly during the aging period
  - Adhered patches diminished in size.
- In the event of a drop in temperature, the adhered patches may be conducive to further freezing and adhering of the diluted fluid

**FLUID AGING TESTS**

- Fluid aging generally demonstrated positive effects on the fluid condition
  - Reduced contamination at the end of aging period
- **Fluid protection was deemed acceptable for aging period of 30 minutes following end of the allowance time precipitation period**

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - **LIGHT RAIN AND LIGHT ICE PELLETS TESTS**
- FUTURE WORK
- CURRENT ICE PELLETS GUIDANCE MATERIAL

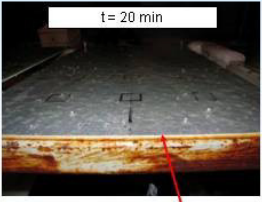
**LIGHT RAIN AND LIGHT ICE PELLETS**

- Flat plate testing was conducted at the upper precipitation limits for mixed light rain and light ice pellets
- Testing was conducted at 0°C, 1°C, and 2°C
- Fluid was exposed to precipitation for 40 minutes and was inspected to verify for fluid adherence.

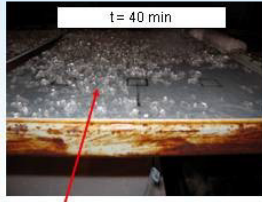
**LIGHT RAIN AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT 1°C

t = 20 min



t = 40 min



**Adherence**

**LIGHT RAIN AND LIGHT ICE PELLETS**

- Adhered patches of ice were observed in the fluid for tests conducted at 0°C and 1°C.
- Latent heat of cooling generated by the melting ice pellets caused the plate temperature to drop below zero
- Allowed for the fluid to freeze once the required fluid freeze point was reached
- Testing conducted at 2°C did not show signs of adherence
  - Plate temperature did not sufficiently drop below 0°C to allow for solid adherence.

**LIGHT RAIN AND LIGHT ICE PELLETS**

- Level of adherence at the end of the test for 0°C and 1°C was comparable to light freezing rain and ice pellets test results
- **The current allowance times for light freezing rain and light ice pellets were deemed appropriate as a conservative guideline**

**FREEZING DRIZZLE AND LIGHT ICE PELLETS**

- Testing in freezing drizzle and ice pellets was not conducted
- **The current allowance times for light freezing rain and light ice pellets were deemed appropriate as a conservative guideline**

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETT TESTS
- **FUTURE WORK**
- CURRENT ICE PELLETT GUIDANCE MATERIAL

**FUTURE WORK**

- Additional aerodynamic testing to refine and possibly expand current allowance times
- Aerodynamic testing with different wings
  - Super critical wing
- Verify results at lower rotation speeds
- Develop repeatable protocol for ice pellet allowance time testing

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - LIGHT RAIN AND LIGHT ICE PELLETT TESTS
- FUTURE WORK
- **CURRENT ICE PELLETT GUIDANCE MATERIAL**

**CURRENT ICE PELLETT GUIDANCE MATERIAL**

- TC and FAA issued guidance material for operations in ice pellet conditions for the winter of 2007-08
- Both versions essentially provide the same data and information
- Differentiating exception is treatment of "fluid aging" following the end of the allowance time

**APS**  
AUTOMATIC

### VALIDATION OF ALLOWANCE TIMES

- The fluid condition at the end of the allowance time for all conditions demonstrated acceptable amounts of contamination
- **The allowance times issued for the winter of 2007-08 were deemed acceptable**

**APS**  
AUTOMATIC

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - **FLUID AGING TESTS**
  - LIGHT RAIN AND LIGHT ICE PELLETS TESTS
- FUTURE WORK
- CURRENT ICE PELLETS GUIDANCE MATERIAL

**APS**  
AUTOMATIC


### FLUID AGING TESTS

- Flat plate testing was conducted at the upper precipitation limits for each of the allowance time conditions.
- At the end of the allowance time, the precipitation was stopped and the plates were left in the cold chamber for an additional 30 minutes
- At the end of the aging period, the fluid was inspected to verify for any changes in the fluid condition


**SNOW AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT = -5°C

END OF ALLOWANCE




END OF AGING




**LIGHT FREEZING RAIN AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT = -5°C

END OF ALLOWANCE



END OF AGING



**APS**  
AUTOMATIC

### FLUID AGING TESTS

- When the precipitation was stopped, the visual condition of the contaminated fluid would improve
- Imbedded or bridging frozen precipitate would further dissolve resulting in a visual improvement of the fluid condition

**APS**  
Automotive

### FLUID AGING TESTS

- During light freezing rain mixed with light ice pellets tests, the fluid diluted close to the freeze point by the end of the allowance time
- The fluid condition improved slightly during the aging period
  - Adhered patches diminished in size.
- In the event of a drop in temperature, the adhered patches may be conducive to further freezing and adhering of the diluted fluid

**APS**  
Automotive

### FLUID AGING TESTS

- Fluid aging generally demonstrated positive effects on the fluid condition
  - Reduced contamination at the end of aging period
- **Fluid protection was deemed acceptable for aging period of 30 minutes following end of the allowance time precipitation period**

**APS**  
Automotive

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH (2006-07)
- REGULATORY GUIDANCE MATERIAL
- FOLLOW UP RESEARCH
  - VALIDATION OF ALLOWANCE TIMES
  - FLUID AGING TESTS
  - **LIGHT RAIN AND LIGHT ICE PELLETS TESTS**
- FUTURE WORK
- CURRENT ICE PELLET GUIDANCE MATERIAL

**APS**  
Automotive


### LIGHT RAIN AND LIGHT ICE PELLETS

- Flat plate testing was conducted at the upper precipitation limits for mixed light rain and light ice pellets
- Testing was conducted at 0°C, 1°C, and 2°C
- Fluid was exposed to precipitation for 40 minutes and was inspected to verify for fluid adherence.


**LIGHT RAIN AND LIGHT ICE PELLETS**

- Type IV EG Fluid
- OAT 1°C

t = 20 min



t = 40 min



**Adherence**

**APS**  
Automotive

### LIGHT RAIN AND LIGHT ICE PELLETS

- Adhered patches of ice were observed in the fluid for tests conducted at 0°C and 1°C.
- Latent heat of cooling generated by the melting ice pellets caused the plate temperature to drop below zero
- Allowed for the fluid to freeze once the required fluid freeze point was reached
- Testing conducted at 2°C did not show signs of adherence
  - Plate temperature did not sufficiently drop below 0°C to allow for solid adherence.

# IMPLEMENTATION OF HOLDOVER TIME DETERMINATION SYSTEMS INTO CANADIAN AIR OPERATIONS

## UPDATE FOR 2007-08 OPERATIONS



**SAE G-12 HOLDOVER TIME  
SUBCOMMITTEE MEETING**


**MONTREAL, CANADA  
NOVEMBER 14, 2007**

**MICHAEL CHAPUT**  
 MANAGER, PROJECTS AND BUSINESS DEVELOPMENT  
 APS AVIATION INC.  
 MONTREAL, QUEBEC, CANADA  
 MCHAPUT@ADGA.CA  
 WWW.APSAVIATION.CA



## CURRENT SITUATION

- The industry has long sought specialized tools to assist flight crews in assessing winter weather and making fluid holdover time decisions
- Currently, flight crews must rely on experience, training and limited tools to:
  - Interpret winter weather conditions;
  - Interpret horizontal visibility and assess precipitation intensity;
  - Interpret the meaning of the holdover time range for each condition; and
  - Determine an appropriate holdover time based solely on the reported weather conditions and/or visual observations



## CURRENT TOOLS

**DE/ANTI-ICING FLUID HOLDOVER TIME TABLES**

**METAR**

**VISIBILITY TABLES**

## DE/ANTI-ICING FLUID HOLDOVER TIME TABLES

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

Degrees Celsius	Degrees Fahrenheit	Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other <sup>2</sup>
			Light Precipitation	Light Snow	Light Ice Crystals	Light Mixed Precipitation	Light Heavy Precipitation	Light Heavy Snow	
3 and above	47 and above	100%	10:00	10:00	10:00	10:00	10:00	10:00	10:00
Below -3 to -14	below 23 to 5	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -14 to -25	below 7 to -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -25	below -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist

Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 1°C (32°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I/II/III fluid if fluid can be used.


## HOLDOVER TIME TABLES

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

Degrees Celsius	Degrees Fahrenheit	Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions						Other <sup>2</sup>
			Light Precipitation	Light Snow	Light Ice Crystals	Light Mixed Precipitation	Light Heavy Precipitation	Light Heavy Snow	
3 and above	47 and above	100%	10:00	10:00	10:00	10:00	10:00	10:00	10:00
Below -3 to -14	below 23 to 5	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -14 to -25	below 7 to -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -25	below -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist

Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 1°C (32°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I/II/III fluid if fluid can be used.

- Anti-icing performance guidelines for de/anti-icing fluids
- Generic Tables for Types I, II, III and IV
- Brand-Specific Tables for Types II and IV
- Published annually by Transport Canada / FAA



## HOLDOVER TIME TABLES


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

Degrees Celsius	Degrees Fahrenheit	Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions						Other <sup>2</sup>
			Light Precipitation	Light Snow	Light Ice Crystals	Light Mixed Precipitation	Light Heavy Precipitation	Light Heavy Snow	
3 and above	47 and above	100%	10:00	10:00	10:00	10:00	10:00	10:00	10:00
Below -3 to -14	below 23 to 5	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -14 to -25	below 7 to -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist
Below -25	below -13	100%	10:00	10:00	10:00	10:00	10:00	10:00	CAUTION: No holdover time guidelines exist

Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 1°C (32°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I/II/III fluid if fluid can be used.

Variables: Temperature, Dilution, Precipitation Type

Holdover Time Range = 0:35 to 1:15




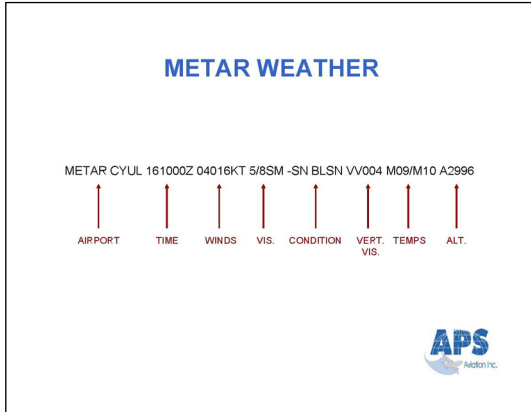
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2002/05/03 19:00:00 UTC
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2002/05/03 13:00:00 UTC
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2002/05/03 00:00:00 UTC
RPTF 031900Z 1700MKT 5000 BR FEW020 BKN045 23/21 01015 NOSIG=
    
```

## METAR WEATHER

→ METAR: Aviation routine weather report

→ In Canada, METAR are generated by computer software based on hourly or special observations taken at staffed or automatic sites


## VISIBILITY TABLES

Lighting	Temperature Range		Visibility in Snow ( statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	32 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 32	≤¾	>¾ to 1½	>1½ to 3	>3
Daylight	-1 and above	32 and above	≤½	>½ to 1½	>1½ to 3	>3
	Below -1	Below 32	≤¾	>¾ to 7/8	>7/8 to 2	>2

## VISIBILITY TABLES


→ 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



## TC VISIBILITY TABLE

Lighting	Temperature Range		Visibility in Snow ( statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	32 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 32	≤¾	>¾ to 1½	>1½ to 3	>3
Daylight	-1 and above	32 and above	≤½	>½ to 1½	>1½ to 3	>3
	Below -1	Below 32	≤¾	>¾ to 7/8	>7/8 to 2	>2



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# OTHER CONSIDERATIONS

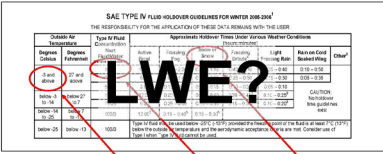
## DE/ANTI-ICING FLUID HOLDOVER TIME TABLES

### 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



**LWE?**


Variables: Temperature, Dilution, Precipitation Type

Holdover Time Range = 0:35 to 1:15




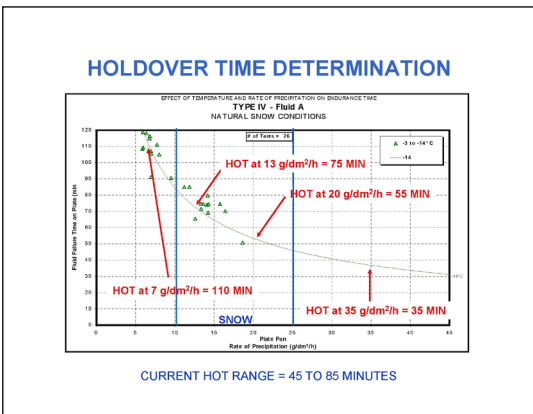
### HOLDOVER TIME TABLES

- 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
- Holdover times are derived from tests performed at specific rates of precipitation for each meteorological condition
- Liquid Water Equivalent (LWE)



### DE/ANTI-ICING FLUID HOLDOVER TIMES

→ If the precise rate of precipitation (LWE) is known, a "single-value" fluid holdover time can be computed for any de/anti-icing fluid





# OTHER CONSIDERATIONS

## METAR


### METAR WEATHER OBSERVATIONS

- Surface weather observations at Canadian airports are recorded according to the Manual of Surface Weather Observations (MANOBS)
- MANOBS is an Environment Canada document that was published in 1977, and was incorporated by Transport Canada as a CARs Standard in 1996




### DEFICIENCIES OF MANOBS

- MANOBS predates a number of major changes to aviation weather services and was not developed with aviation weather reporting in mind
- Written at a time when weather observers were government employees and the provision of the aviation weather services was the responsibility of the government
- Manual is prescriptive about what procedures are to be followed but is silent in many other areas:
  - Training of observers
  - Establishment of performance goals such as accuracy of observations



### DEFICIENCIES OF METAR

- No quantitative measurement of precipitation intensity
- No correlation between holdover time definitions of precipitation intensity and those reported by METAR
- Frequency of METAR reports
  - Hourly
  - SPECI
- Poor at identifying changing weather, especially as it pertains to aircraft ground deicing




### CHANGING CONDITIONS

March 5, 2004, 15-16 GMT, YUL

Time (GMT)	Condition According to ATIS	Rate Measured by Precipitation Pan (g/dm <sup>2</sup> /h)	Rate Obtained by DIS (g/dm <sup>2</sup> /h)
14:57	Rain, Fog	9.1	9
15:12	Rain, Fog	3.6	4.3
15:27	Rain, Fog	20.4	21.2
15:42	Rain, Fog	20.1	22.8

METAR DID NOT CHANGE FOR THE HOUR PERIOD  
METAR: 05009KT 1 1/2SM -RA BR



# OTHER CONSIDERATIONS

## VISIBILITY TABLES

### VISIBILITY TABLES

- 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
- Industry experts agree this method is not accurate

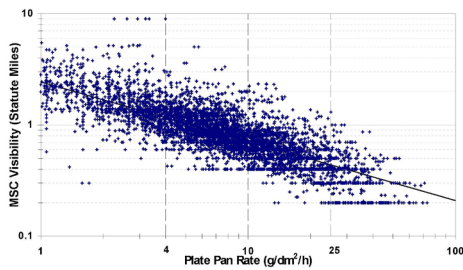


### TC VISIBILITY TABLE

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



### VISIBILITY vs. RATE (1995-96 to 2001-02) (BELOW -1°C)



### USE OF VISIBILITY TABLES

- Use of visibility tables will only enable a general classification of snowfall intensity
- Not useful for other precipitation conditions
- Doesn't provide a LWFE, and thus won't eliminate interpretation of holdover time range



### 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**

HOLD-OVER TIME BASED ON VISIBILITY (MODERATE)

Type IV: 25 to 55 min.  
Type I: 4 to 6 min.

ACTUAL HOLD-OVER TIME BASED ON RATE

Type IV: +/- **10 min.**  
Type I: +/- **2 min.**



### 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**

HOLD-OVER TIME BASED ON VISIBILITY (MODERATE)

Type IV: 25 to 55 min.  
Type I: 4 to 6 min.

ACTUAL HOLD-OVER TIME BASED ON RATE


Type IV: +/- **90 min.**  
Type I: +/- **14 min.**



# HOLDOVER TIME DETERMINATION SYSTEMS


## TECHNICAL EVALUATION OF HOTDS

- APS compared D-Ice A/S System outputs (rate, precipitation classification, temperature) with:
  - Manual data collections (using historical holdover time precipitation rate methodology)




## TECHNICAL EVALUATION OF HOTDS

- In August 2003, APS was contracted by D-Ice A/S to conduct an independent technical evaluation of the D-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




## HOLDOVER TIME DETERMINATION SYSTEM (HOTDS)

- System consists of numerous sensors enabling the determination of:
  - Rate of precipitation
  - Type of precipitation
  - Ambient temperature
- System outputs can generate a "single-value" holdover time for each departing aircraft





### TEST SUMMARY – WINTER 2003-07 D-ICE A/S DEICING INFORMATION SYSTEM




- 2003-04: 409 data points were collected during 24 data collection events
- 2004-05: 424 data points were collected during 20 data collection events
- 2005-06: 700 data points collected during 23 data collection events; data collected with two units
- 2006-07: Approx. 400 data points during 15+ data collection events

### TEST RESULTS SUMMARY

- Analysis of the rate outputs of the D-ice A/S System is excellent: rates measured in snow, freezing rain, freezing drizzle, snow pellets, ice pellets compared well to those measured using historical methodology
- Ability of the D-ice A/S System to measure accurate temperature and detect and identify precipitation type is excellent


→ **SYSTEM IS READY FOR OPERATIONAL USE**




## IMPLEMENTATION OF HOLDOVER TIME DETERMINATION SYSTEMS INTO CANADIAN AIR OPERATIONS

### ISSUE OF CERTIFICATION

- Air carriers and airports, when approached about using a HOTDS, invariably asked if the system was "certified"
- The issue of "certification" was discussed in great detail with Transport Canada, Environment Canada and NAV CANADA




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### IMPLEMENTATION OF HOTDS

- HOTDS output is an operational aviation product for use under ground icing operations, and therefore falls under CAR 622.11
- Methodology to achieve use of HOTDS in short term:
  - Development of a performance specification for HOTDS
  - Exemption from CAR 622.11 for operational use of the holdover time information provided by the HOTDS




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## EXEMPTION DEVELOPMENT

- As part of a contract with TC, APS produced:
  - Draft Performance Specification document for Holdover Time Determination Systems (HOTDS)
  - Draft Exemption document from Subsection 602.11(4) of the *Canadian Aviation Regulations* and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 *Ground Icing Operations*



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## EXEMPTION CONTENTS

- Exemption
- Appendices
  - Appendix A: Description of the applicable Canadian Aviation Regulations and Standard
  - Appendix B: Definitions of terms employed in the Exemption
  - Appendix C: Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems




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## APPENDIX C CONTENTS

1. Quality Management System
2. Training and Qualifications
3. Installation, Siting, Operation and Maintenance of HOTDS
4. Accuracy of Holdover Time Input Instruments and Determination Systems
5. Technical requirements for Data Inputs and Holdover Time Determinations
  - Wind
  - Precipitation Type
  - Temperature
  - Precipitation Rate
  - Holdover Time Determinations
  - Holdover Time Determination Reports




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## AIR CARRIER EXEMPTION

- First version of the TC Air Carrier Exemption (for operational use of the HOTDS outputs) was issued to WestJet in March 2007




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## CURRENT STATUS OF AIR CARRIER EXEMPTION

- Exemption was rescinded in October 2007 to make modifications
- Modifications consisted primarily of tightening of operational limitations
  - Example: limitation of HOT outputs in freezing precipitation above 25 g/dm<sup>2</sup>/h
- Anticipated date for Exemption to be re-issued: December 2007
- Process to document compliance with the conditions of the Exemption is underway
- WestJet intends to use the system outputs in YYZ and YUL in 2007-08



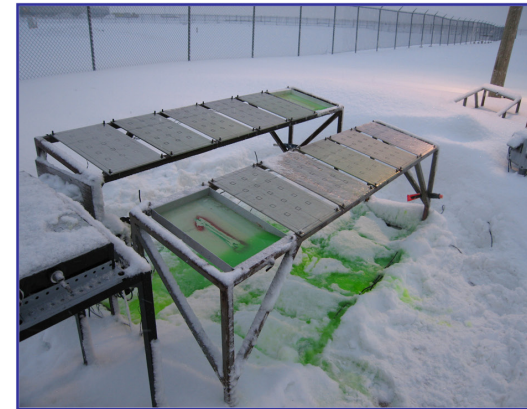
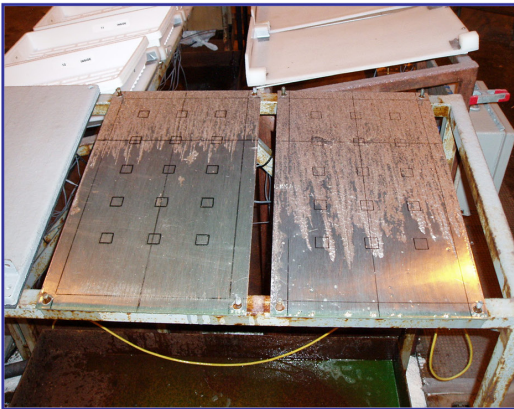
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# AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS FOR THE 2007-08 WINTER TEST SEASON



**SAE G-12 HOLDOVER TIME  
SUBCOMMITTEE  
WARSAW - MAY 13, 2008**

*Presented by Stephanie Bendickson*



PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA







AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE

## OUTLINE





- ➔ Type I: Test results and 2008-09 holdover time guidelines
- ➔ Type II: Test results and 2008-09 holdover time guidelines
- ➔ Type III: 2008-09 holdover time guidelines
- ➔ Type IV: 2008-09 holdover time guidelines

# TYPE I





## TYPE I FLUIDS TESTED

- ➔ No new Type I products were tested by APS for endurance times in 2007-08
- ➔ However, one new Type I fluid was tested in June 2007 (after San Diego meeting)
- ➔ Octagon EcoFlo was submitted for testing because it is a hybrid PG/non-glycol fluid
- ➔ Regulators require endurance times of Type I non-glycol fluids be measured to ensure they are similar to grandfathered data

## SUMMARY OF TYPE I TESTING

- ➔ Endurance time results of Octagon EcoFlo compared well with grandfathered Type I fluid endurance time results
- ➔ The fluid was added to the list of qualified fluids for winter of 2007-08
- ➔ No changes will be made to the generic Type I guidelines for the winter of 2008-09

## FAA/TC TYPE I HOT GUIDELINES 2008-09




**NO CHANGES**

Outside Air Temperature <sup>1</sup>		Approximate Holdover Times Under Various Weather Conditions (Hours: minutes)									
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow/Snow Grains <sup>2</sup>			Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wings <sup>4</sup>	Other <sup>5</sup>	
				Very Light	Light	Moderate					
-3 and above	27 and above	0-40	0:15-0:17	0:15-0:20	0:15-0:18	0:08-0:11	0:05-0:13	0:02-0:08	0:02-0:08		
below -3 to 6	below 27 to 21	0-40	0:08-0:13	0:15-0:21	0:08-0:14	0:04-0:09	0:05-0:09	0:02-0:08			
below 6 to -10	below 21 to 14	0-40	0:06-0:10	0:11-0:16	0:06-0:11	0:04-0:08	0:04-0:07				
below -10	below 14	0-40	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:06					

Outside Air Temperature <sup>1</sup>		Approximate Holdover Times Under Various Weather Conditions (minutes)									
Degrees Celsius	Degrees Fahrenheit	Active Frost	Freezing Fog	Snow or Snow Grains <sup>2</sup>			Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wings <sup>4</sup>	Other <sup>5</sup>	
				Very Light	Light	Moderate					
-3 and above	27 and above	40	11-17	18	11-18	6-11	9-13	4-6	3-5		
below -3 to 6	below 27 to 21	40	8-13	14	8-14	5-9	5-9	4-6			
below 6 to -10	below 21 to 14	40	8-10	11	8-11	4-6	4-7	2-5			
below -10	below 14	40	5-9	7	4-7	2-4					

CAUTION: No holdover time guidelines exist

### FAA/TC VISIBILITY TABLES 2008-09

TABLE 08. SUMMARY OF EVENTS AS A FUNCTION OF PREVALENT VISIBILITY

Type of Day	Category	Type	Visibility ( statute miles )				
			< 1/2	1/2	3/4	1	> 1
VFR	Normal	Clear	Green	Yellow	Yellow	Yellow	Yellow
		Light	Green	Yellow	Yellow	Yellow	Yellow
IFR	Normal	Clear	Red	Red	Red	Red	Red
		Light	Red	Red	Red	Red	Red

**NO CHANGES**

TABLE 9. VISIBILITY IN METERS OR KILOMETERS (WHICH?)

Lighting	Temperature Range		Visibility in Miles			
	°C	°F	Heavy	Medium	Light	Very Light
Daylight	Cloud	30 and above	1/2	1/2 to 2/3	2/3 to 1/2	1/2
	Station 1	Station 20	2000	1000 to 1750	1750 to 3000	1000
Daylight	Cloud	30 and above	1/2	1/2 to 1/3	1/3 to 1/2	1/2
	Station 1	Station 20	2000	1000 to 1750	1750 to 3000	1000

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# TYPE II

## TYPE II FLUIDS TESTED

- ➔ Endurance time tests were conducted with two new Type II fluids in 2007-08
- ➔ One of these fluids, **Kilfrost ABC-K Plus**, will be commercialized

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## FLUID VISCOSITY

Fluid	Manufacturer's Method	AIR Method
Kilfrost ABC-K Plus	2,850 mPa.s	2,640 mPa.s
	Spindle LV2-disc with guard, eg. 150 m L fluid, 20°C, 0.3 rpm, 10 m/s flow	Spindle LV1, 500 m L fluid, 20°C, 0.3 rpm, 10 m/s flow

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## WSET RESULTS - AMIL

**KILFROST ABC-K PLUS NEAT FLUID**

62 min.

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## ENDURANCE TIME TESTING

- ➔ Natural Snow
- ➔ Freezing Fog
- ➔ Freezing Drizzle
- ➔ Light Freezing Rain
- ➔ Rain on Cold-Soak Wing

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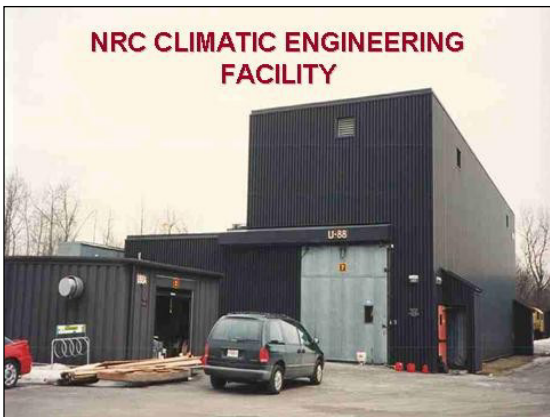
### NATURAL SNOW



- ➔ No control over rate, temperature, wind
- ➔ Entire snow data set is considered when analyzing the performance of any fluid
- ➔ Snow holdover time range is determined at 10 and 25 g/dm<sup>2</sup>/h










### FREEZING FOG


- ➔ Tests are conducted at 13 and 25 g/dm<sup>2</sup>/h
- ➔ Test temperatures: -3 and -10°C







### FREEZING FOG


- ➔ Tests are conducted at 13 and 25 g/dm<sup>2</sup>/h
- ➔ Test temperatures: -3 and -10°C








### LIGHT FREEZING RAIN

- ➔ Tests are conducted at 13 and 25 g/dm<sup>2</sup>/h
- ➔ Test temperatures: -3 and -10°C





### FREEZING DRIZZLE



- ➔ Tests are conducted at 5 and 13 g/dm<sup>2</sup>/h
- ➔ Test temperatures: -3 and -10°C


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### RAIN ON A COLD-SOAKED WING





- ➔ Drizzle and moderate rain were simulated:
- ➔ Drizzle (low end) rate: 5 g/dm<sup>2</sup>/h
- ➔ Moderate rain (high end) rate: 75 g/dm<sup>2</sup>/h


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### RAIN ON A COLD-SOAKED WING

- ➔ Boxes were filled with 85/35 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
- ➔ Tests were started when the skin temperature was -10°C
- ➔ Ambient air temperature was +1°C


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### ENDURANCE TIME DATA ANALYSIS METHODOLOGY

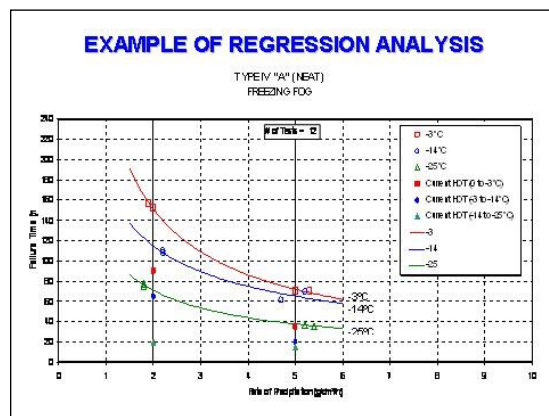
- ➔ Endurance times are derived using regression analysis that provides a power law relationship
- ➔ General form of the equation for light freezing rain, freezing drizzle, freezing fog, and rain on a cold-soaked wing is:  $t = cR^a$
- ➔ General form of the equation for snow is:  $t = cR^b(2-T)^c$
- ➔ Where
  - t = Time
  - R = Rate of precipitation
  - T = Temperature
  - a, b, c = Coefficients determined from the regression

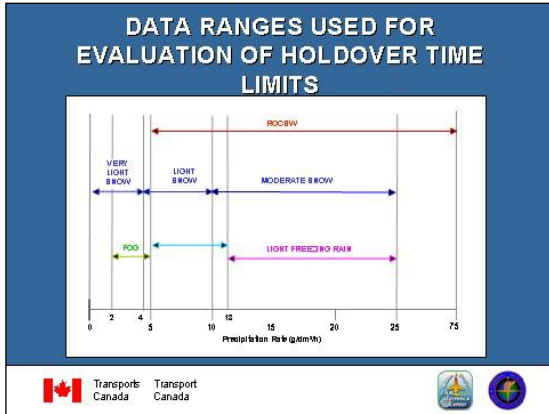

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### SUMMARY OF PROCEDURE USED TO DETERMINE HOLDOVER TIME LIMITS

- ➔ Curves are plotted for each fluid and each cell of the holdover time table using the MOST RESTRICTIVE TEMPERATURE in that cell
- ➔ Upper and lower holdover time values are determined using the specific precipitation rate ranges for each condition
- ➔ Numbers are rounded to the nearest whole "5" value
- ➔ For safety reasons, holdover times below 10 minutes are always rounded down


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### FLUID FAILURE

Fluid failure occurs when:

- Accumulation of snow bridging on top of the fluid or plate, or
- Accumulation of ice on top of the fluid or plate, or ice suspended within the fluid

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### PLATE END CONDITION

Plate end condition is achieved when fluid failures occur:

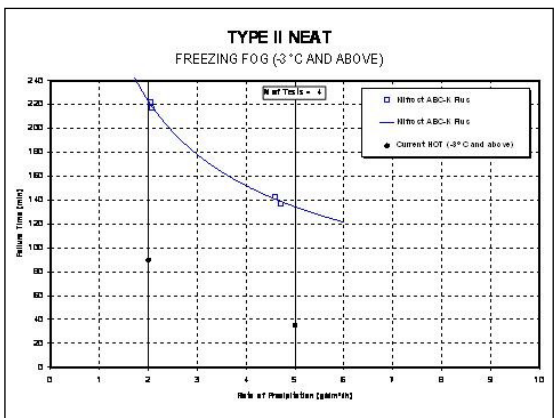
- At any 5 of the crosshair markings on the panel; or
- On more than 30% of the entire plate surface

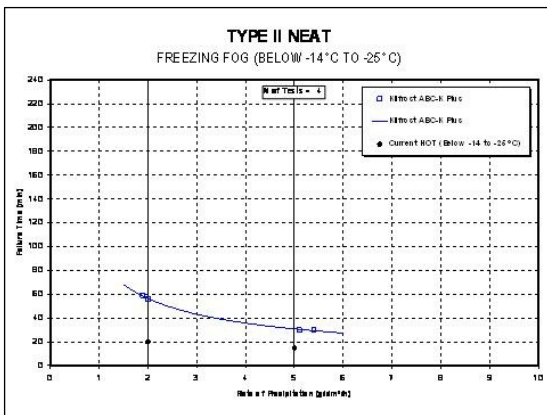
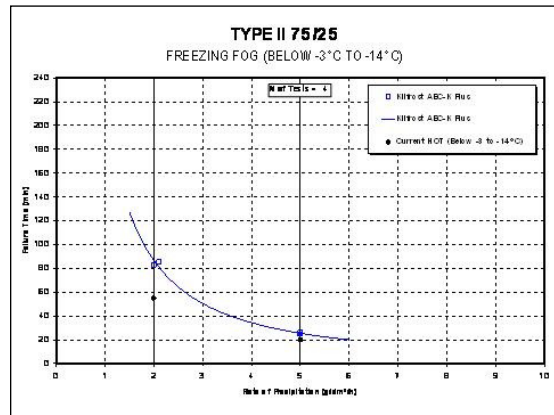
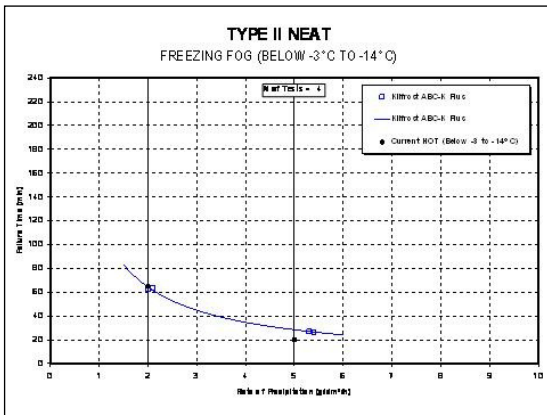
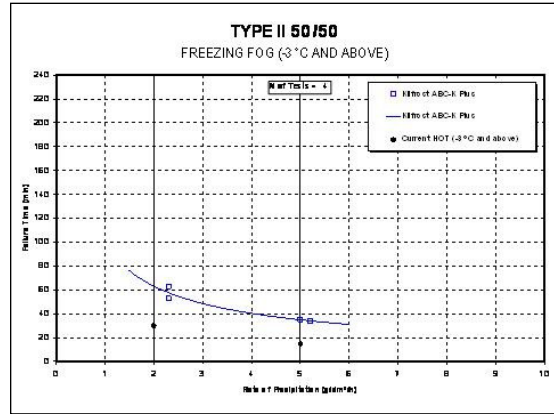
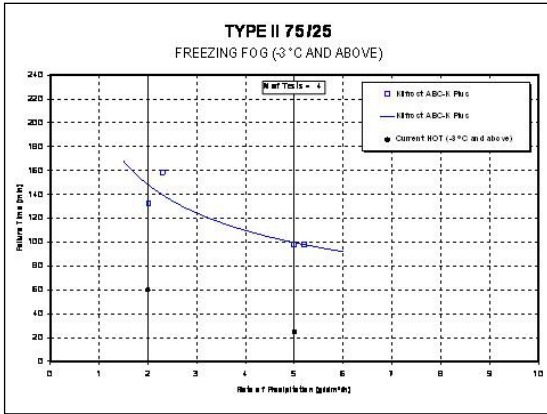
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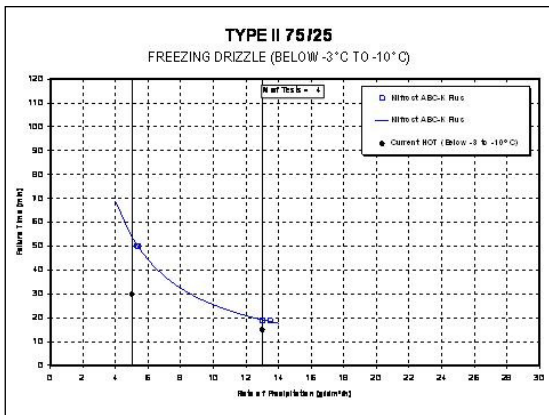
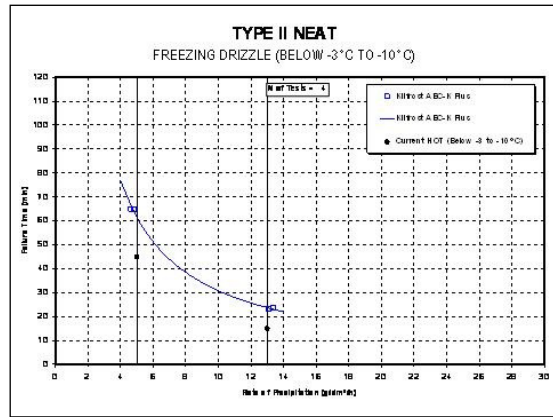
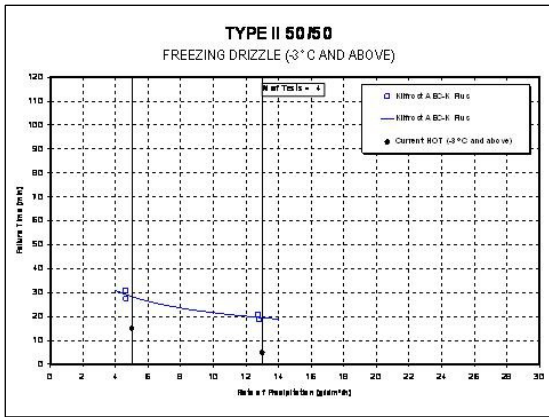
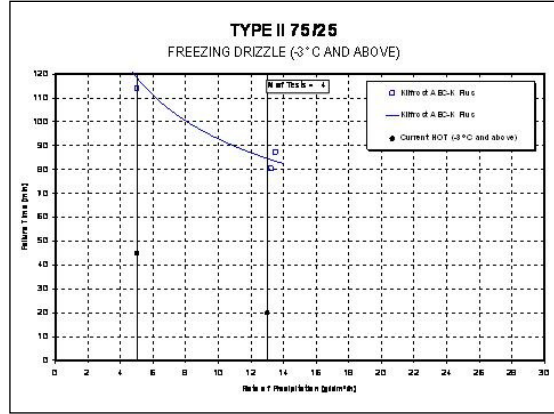
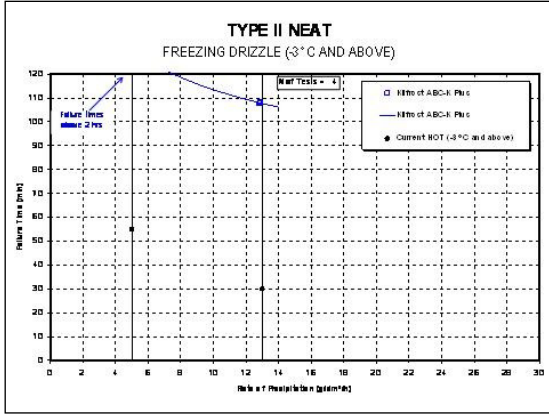
### TYPE II TESTS CONDUCTED IN 2007-08

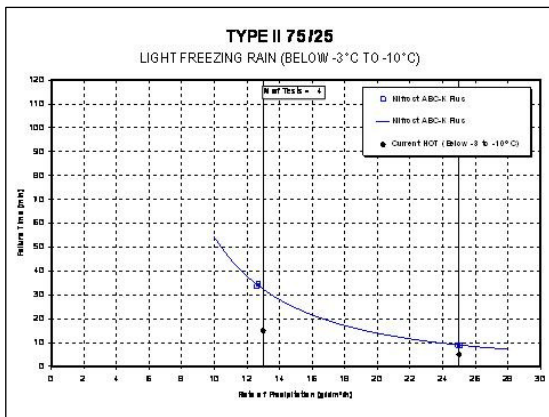
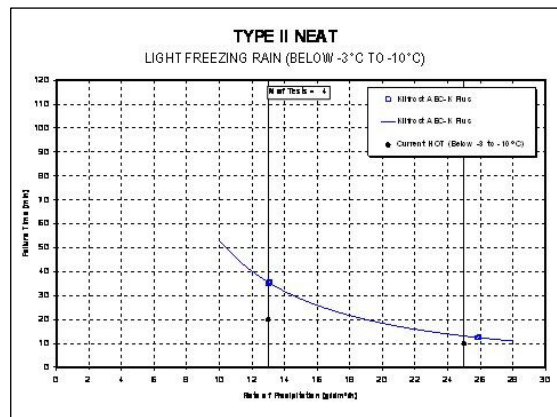
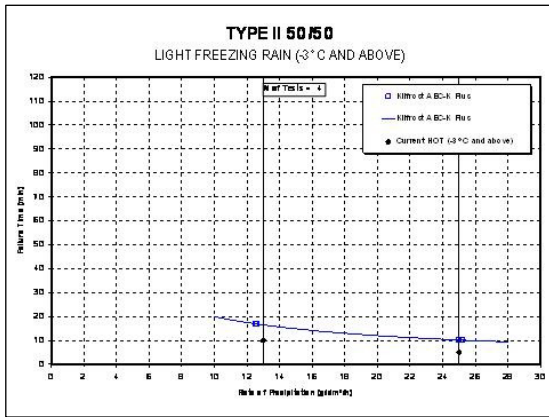
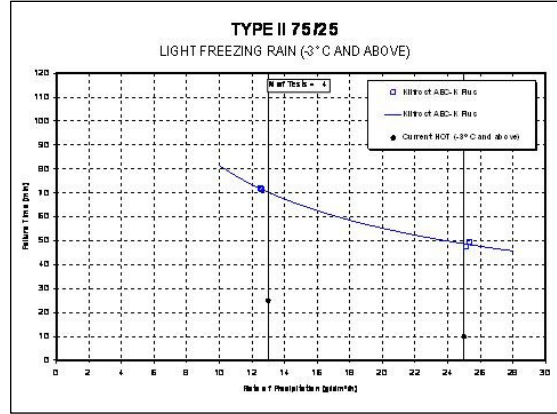
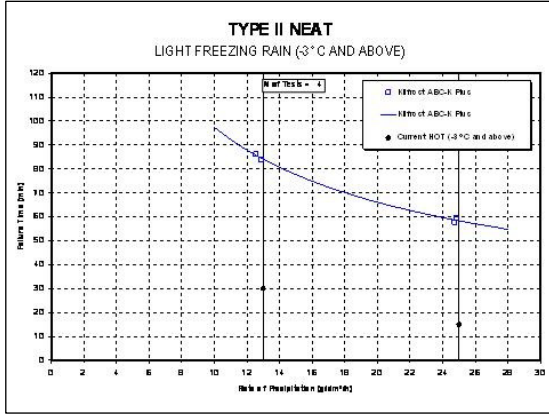
FLUID TYPE	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FREEZING RAIN	COLD SOAK	TOTAL
Type II (Neat)	24	52	16	16	8	<b>116</b>
Type II (75/25)	16	33	16	16	8	<b>89</b>
Type II (50/50)	8	37	8	8	n/a	<b>61</b>
<b>TOTAL</b>	<b>48</b>	<b>122</b>	<b>40</b>	<b>40</b>	<b>16</b>	<b>266</b>

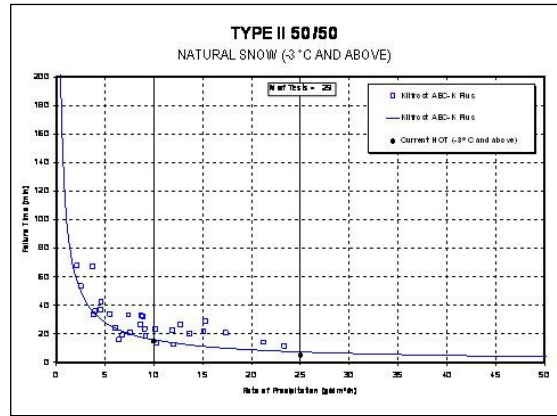
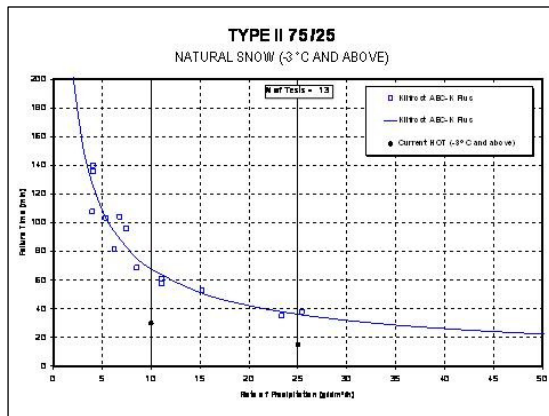
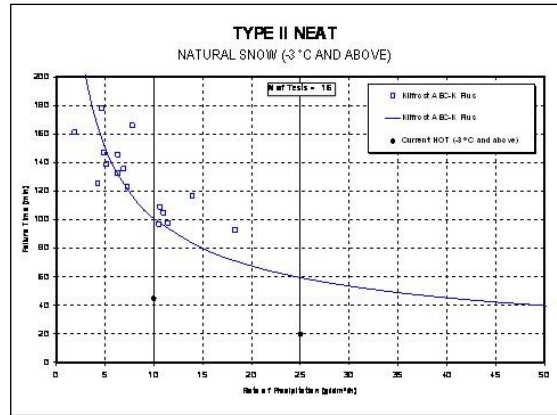
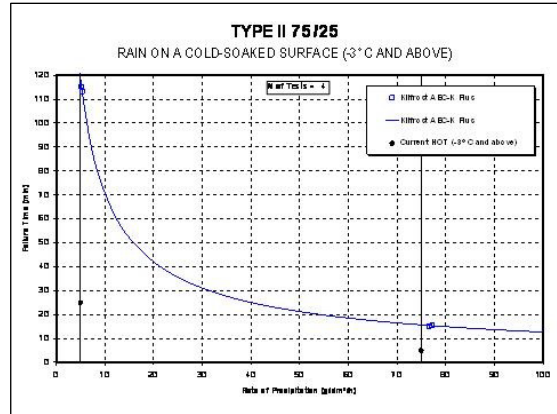
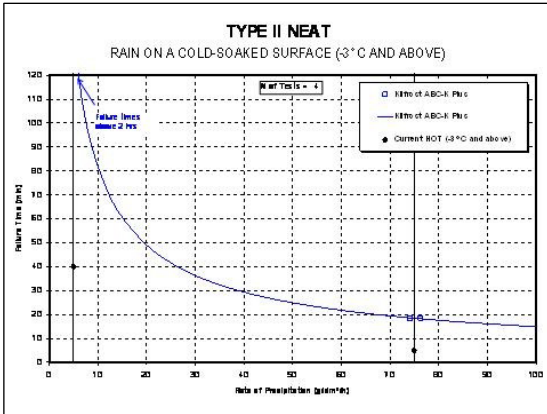
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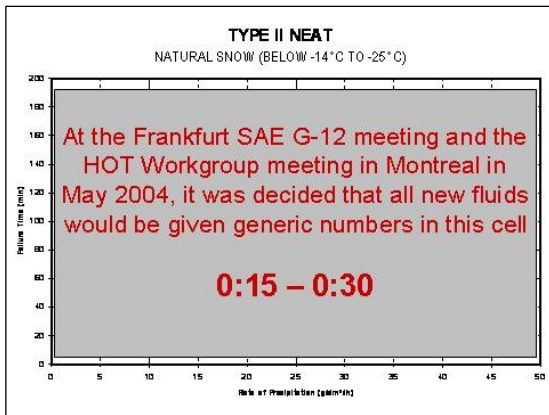
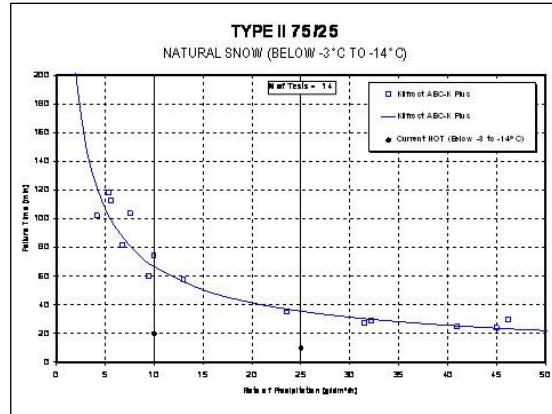
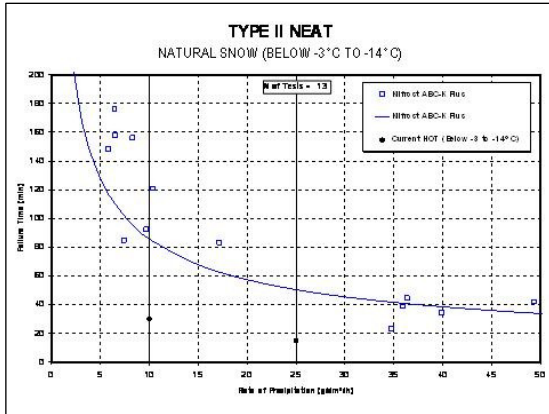












### SUMMARY OF TYPE II ENDURANCE TIME TESTING

- ➔ One new Type II fluid will be produced commercially for use in 2008-09 winter operations
- ➔ The new fluid meets or exceeds current generic Type II holdover times in all cells
- ➔ No changes will be made to the generic Type II holdover time guidelines for use in 2008-09 winter operations, based on this testing

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### 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)
- ➔ Conditions for removal:
  - ➔ Fluid qualification expires and is not re-certified
  - ➔ Fluid is not available for 4 years
- ➔ No Type II fluids appear to meet the conditions of Resolution #1 in 2008; therefore no changes will be made to the generic Type II holdover time guidelines

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### TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2008-09

- 1) AVIATION XI'AN HI-TECH KH-F-II
- 2) CLARIANT SAFEWING MP II 2025 ECO
- 3) CLARIANT SAFEWING MP II FLIGHT
- 4) KILFROST ABC-2000
- 5) KILFROST ABC-II PLUS
- 6) KILFROST ABC-K PLUS (NEW)
- 7) NEWAVE AERO-CHEMICAL FCY-2
- 8) OCTAGON E-MAX II
- 9) SPCA ECOWING 26

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### FAA/TC TYPE II HOT GUIDELINES 2008-09

**FAA TYPE II HALDOVER TIME GUIDELINE**

Outside Air Temperature		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power Density (W/cm <sup>2</sup> )	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
-3 and above	27 and above	1000	8:00	0:35-1:00	0:20-0:45	0:30-0:55	0:15-0:30	0:00-0:45	
		7000	8:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:00-0:45	
below -3 to -14	below 27 to 5.7	1000	8:00	0:15-0:30	0:00-0:15	0:00-0:15	0:00-0:15	0:00-0:15	
		7000	8:00	0:20-1:00	0:10-0:30	0:10-0:45	0:10-0:25	0:00-0:20	
below -14 to -20	below 5.7 to -13	1000	8:00	0:00-0:05	0:00-0:20	0:10-0:30	0:10-0:25	0:00-0:15	CAUTION: No holdover time guidelines exist.
below -20	below -13	1000	8:00	0:15-0:20	0:10-0:20	0:10-0:20	0:10-0:20	0:10-0:20	CAUTION: No holdover time guidelines exist.

**SAE TYPE III FLUID HALDOVER TIME GUIDELINES FOR WINTER 2008-2009**

Outside Air Temperature		Type III Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power Density (W/cm <sup>2</sup> )	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
-3 and above	27 and above	1000	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:00-0:45	
		7000	8:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:00-0:25	
below -3 to -14	below 27 to 5.7	1000	8:00	0:20-1:00	0:10-0:30	0:10-0:45	0:10-0:25	0:00-0:20	
		7000	8:00	0:25-1:00	0:15-0:30	0:15-0:45	0:10-0:25	0:00-0:15	
below -14 to -20	below 5.7 to -13	1000	8:00	0:15-0:20	0:10-0:20	0:10-0:20	0:10-0:20	0:10-0:20	CAUTION: No holdover time guidelines exist.
below -20	below -13	1000	8:00	0:15-0:20	0:10-0:20	0:10-0:20	0:10-0:20	0:10-0:20	CAUTION: No holdover time guidelines exist.

**NO CHANGES**



### TYPE III FLUIDS TESTED

- ➔ Endurance time tests were performed with one Type III fluid in 2007-08
- ➔ The fluid will not be commercialized in 2008-09
- ➔ No changes will be made to the generic Type III guidelines for 2008-09 winter operations

**NO CHANGES**

### FAA/TC TYPE III HOT GUIDELINES 2008-09

**FAA TYPE III HALDOVER TIME GUIDELINE**

Outside Air Temperature		Type III Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)						
Degrees Celsius	Degrees Fahrenheit	Heat Flux/Power Density (W/cm <sup>2</sup> )	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>1</sup>
-3 and above	27 and above	1000	8:00	0:35-1:45	0:20-0:45	0:30-0:55	0:15-0:30	0:00-0:45	
		7000	8:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:00-0:25	
below -3 to -14	below 27 to 5.7	1000	8:00	0:20-1:00	0:10-0:30	0:10-0:45	0:10-0:25	0:00-0:20	
		7000	8:00	0:25-1:00	0:15-0:30	0:15-0:45	0:10-0:25	0:00-0:15	
below -14 to -20	below 5.7 to -13	1000	8:00	0:15-0:20	0:10-0:20	0:10-0:20	0:10-0:20	0:10-0:20	CAUTION: No holdover time guidelines exist.
below -20	below -13	1000	8:00	0:15-0:20	0:10-0:20	0:10-0:20	0:10-0:20	0:10-0:20	CAUTION: No holdover time guidelines exist.

**NO CHANGES**

### TYPE IV

### TYPE IV FLUIDS TESTED

- ➔ Endurance time tests were performed with one Type IV fluid in 2007-08
- ➔ The fluid will not be commercialized in 2008-09

### TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2008-09

- 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 EG108
- 7) KILFROST ABC-S
- 8) KILFROST ABC-S PLUS
- 9) LYONDELL ARCTIC SHIELD
- 10) OCTAGON MAX-FLIGHT
- 11) OCTAGON MAX-FLIGHT 04
- 12) OCTAGON MAXFLO
- 13) SPCA AD-480

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### CHANGES TO THE TYPE IV GENERIC HOLDOVER TIME GUIDELINES

#### 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)
- ➔ Conditions for removal:
  - ➔ Fluid qualification expires and is not re-certified
  - ➔ Fluid is not available for 4 years
- ➔ No Type IV fluids appear to meet the conditions of Resolution #1 in 2008, therefore no changes are required to the Type IV holdover time guidelines

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### CHANGES TO THE TYPE IV GENERIC HOLDOVER TIME GUIDELINES

#### COLD SOAK WING DATA

- ➔ Values in the Type IV generic table are based on the weakest performing available Type IV fluid
- ➔ "Available" Fluids = Qualified Fluids + Fluids with qualifications expired in the last 4 years

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### CHANGES TO THE TYPE IV GENERIC HOLDOVER TIME GUIDELINES

#### COLD SOAK WING DATA

- ➔ Initial cold soak data was developed in the mid-1990s and was not fluid-specific
- ➔ In later years, fluid-specific data was developed for all fluids submitted for holdover time testing
- ➔ Some of the fluids used to produce initial data have since been discontinued

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### CHANGES TO THE TYPE IV GENERIC HOLDOVER TIME GUIDELINES

#### COLD SOAK WING DATA

- ➔ All 2008-09 "available" fluids have fluid-specific values; therefore the old generic data can be removed from the generic Type IV analysis
- ➔ Increases will be made to two cells in the 2008-09 generic Type IV holdover time guidelines, based on the removal of the old cold soak data

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### TC/FAA GENERIC TYPE IV HOT GUIDELINES 2008-09

Outside Air Temperature		Fluid Qualifier	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Frosting Fog	Snow or Snow Grains	Frosting Drizzle	Light Freezing Rain	Wet or Cold Soaked Wing	Other
3 and above	27 and above	100/0	8:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:40	1:05
		70/24	5:00	1:05 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35	0:40
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10		
below 3	below 27	100/0	8:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45	0:10 - 0:25		CAUTION No holdover time guidelines exist
		70/24	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30	0:10 - 0:20		
below -14/4	below 7	100/0	8:00	0:15 - 0:40	0:15 - 0:30				
		70/24	5:00						
below -20	below -3	100/0	8:00						
		70/24	5:00						

Type IV fluids may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (45°F) below the outside air temperature and the aircraft manufacturer's instructions, where applicable. Consult user's Type IV fluid for exact holdover time.

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### FAA/TC TYPE IV HOT GUIDELINES 2008-09

FAA TYPE IV HOLDOVER TIME GUIDELINE

Outside Air Temperature		Type IV Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions (Hours: Minutes)						
Degrees Celsius	Degrees Fahrenheit	Head Fuel/Power (Gross Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Surfaces/Wing	Other <sup>1</sup>
-3 and above	27 and above	1000	12:00	1:15-2:30	0:35-1:15	0:45-1:10	0:25-0:40	0:10-1:00	
	7025	0:00	1:05-1:45	0:25-0:55	0:35-0:50	0:15-0:30	0:05-0:45		
below -3	below 27	1000	0:00	0:15-0:35	0:00-0:10	0:10-0:20	0:00-0:10		CAUTION: No holdover time guidelines exist.
	7025	0:00	0:25-0:30	0:00-0:40	**0:20-0:45	**0:10-0:25			
below -13	below -13	1000	12:00	0:15-0:45	0:15-0:30				


<sup>1</sup> SAE Type IV fuel may be used below -25 °C (-13 °F) provided the freezing point of the fuel is at least 1 °C (1.8 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fuel cannot be used.

### SAE TYPE IV FUEL HOLDOVER GUIDELINES FOR WINTER 2008-2009

Outside Air Temperature		Type IV Fuel Concentration	Approximate Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit	Head Fuel/Power (Gross Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Surfaces/Wing	Other <sup>1</sup>
-3 and above	27 and above	1000	12:00	1:15-2:30	0:35-1:15	0:45-1:10	0:25-0:40	0:10-1:00	
	7025	0:00	1:05-1:45	0:25-0:55	0:35-0:50	0:15-0:30	0:10-0:30	0:05-0:45	
below -3	below 27	1000	0:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		CAUTION: No holdover time guidelines exist.
	7025	0:00	0:25-0:30	0:05-0:40	0:25-0:45*	0:10-0:25*			
below -13	below -13	1000	12:00 <sup>2</sup>	0:15-0:40 <sup>2</sup>	0:15-0:30 <sup>2</sup>	0:15-0:30 <sup>2</sup>	0:10-0:25 <sup>2</sup>		

<sup>1</sup> Type IV fuel may be used below -25 °C (-13 °F) provided the freezing point of the fuel is at least 1 °C (1.8 °F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fuel cannot be used.

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# **AIRCRAFT GROUND DE-/ANTI-ICING RESEARCH USING COMPOSITE MATERIALS**

By  
**Marco Ruggi**



*For*

**Transportation Development Centre  
Transport Canada**

**and the**

**Federal Aviation Administration**



**SAE G-12 HOT SUBCOMMITTEE  
WARSAW – MAY 13, 2008**

**APS**

### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
- OUTDOOR NATURAL FROST PLATE TESTS
- INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS
- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE

**APS**

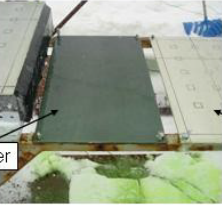
### BACKGROUND – PREVIOUS WORK

- COMPARATIVE ENDURANCE TIME TESTING
  - Preliminary testing was conducted during the winter of 2004-05
  - OBJECTIVE: investigate the impact of non-aluminum test plate material on fluid endurance time
  - Testing was conducted in
    - Natural Snow
    - Simulated Freezing Precipitation
    - Natural Frost Conditions

**APS**

### BACKGROUND – PREVIOUS WORK

- MATERIALS USED
  - Cross weave carbon fiber test plate
  - Baseline standard aluminum test plate
  - Test plates were not painted for testing



**APS**

### BACKGROUND – PREVIOUS WORK

- CONCLUSIONS
  - Radiation effects on different colored surfaces created discrepancies in the results obtained
  - Additional testing was recommended with painted comparative plates

**APS**

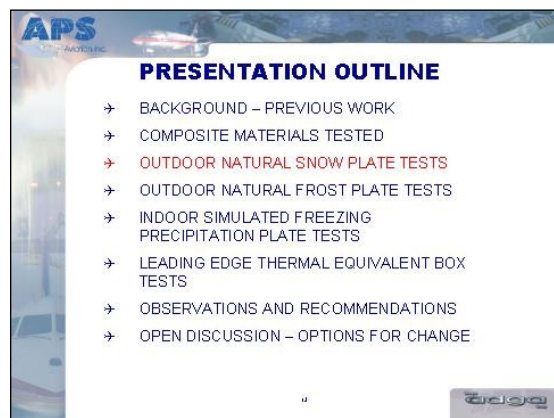
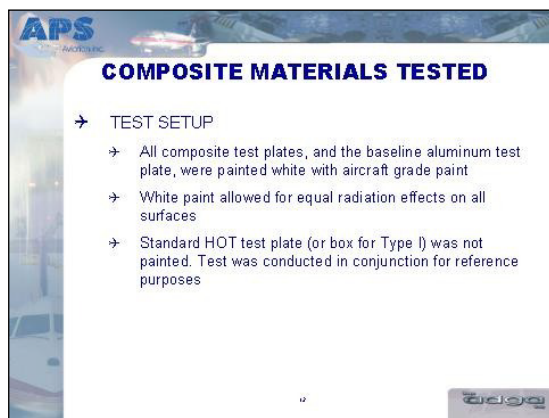
### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
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- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE

**APS**

### COMPOSITE MATERIALS TESTED

- CARBON FIBER PLAIN WEAVE FABRIC
  - 0.32 cm thick panel (will be referred to as Carbon 05)
- CARBON FIBER UNIDIRECTIONAL TAPE
  - 0.35 cm thick panel (will be referred to as Carbon 06 Thin)
  - 0.57 cm thick panel (will be referred to as Carbon 06 Thick)
- GLARE (Hybrid material using alternating layers of aluminum and glass fiber)
  - 0.38 cm thick panel (will be referred to as GLARE)



### OUTDOOR NATURAL SNOW TESTING

→ METHODOLOGY:

- Comparative endurance time testing was conducted using the same fluid and dilution, applied at the same temperature to each of the composite plates
- Baseline tests were conducted following standard HOT protocol

### OUTDOOR NATURAL SNOW TESTING

→ OUTDOOR TEST SETUP

### OUTDOOR NATURAL SNOW TESTING

→ SUMMARY OF COMPARATIVE TEST RUNS

Test Objective	# of Comparative Test Runs
Type I Heated (60°C)	5
Type II Heated (60°C)	1
Type III Heated (60°C)	1
Type IV at OAT	4
Type IV Heated (60°C)	4
<b>TOTAL</b>	<b>15</b>

### OUTDOOR NATURAL SNOW TESTING

→ TYPE I APPLIED AT 60°C

Fluid Temp (°C)	White Aluminum	Carbon 05	Carbon 06 Thin	Carbon 06 Thick	GLARE
17°C	~10	~10	~10	~10	~10
11°C	~10	~10	~10	~10	~10
5°C	~10	~10	~10	~10	~10
-1°C	~10	~10	~10	~10	~10
-7°C	~10	~10	~10	~10	~10
-13°C	~10	~10	~10	~10	~10

### OUTDOOR NATURAL SNOW TESTING

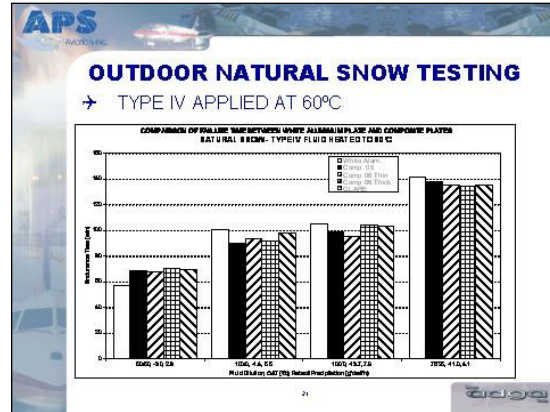
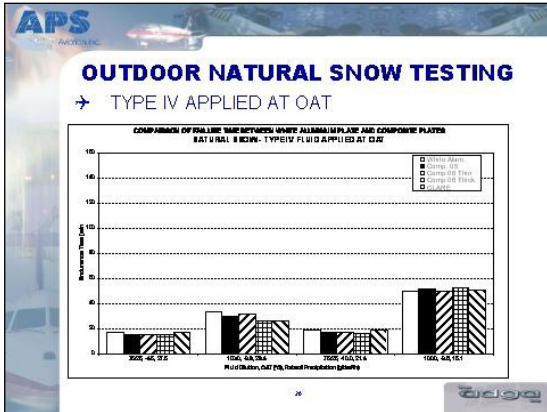
→ TYPE II APPLIED AT 60°C

Fluid Temp (°C)	White Aluminum	Carbon 05	Carbon 06 Thin	Carbon 06 Thick	GLARE
17°C	~10	~10	~10	~10	~10
11°C	~10	~10	~10	~10	~10
5°C	~10	~10	~10	~10	~10
-1°C	~10	~10	~10	~10	~10
-7°C	~10	~10	~10	~10	~10
-13°C	~10	~10	~10	~10	~10

### OUTDOOR NATURAL SNOW TESTING

→ TYPE III APPLIED AT 60°C

Fluid Temp (°C)	White Aluminum	Carbon 05	Carbon 06 Thin	Carbon 06 Thick	GLARE
17°C	~10	~10	~10	~10	~10
11°C	~10	~10	~10	~10	~10
5°C	~10	~10	~10	~10	~10
-1°C	~10	~10	~10	~10	~10
-7°C	~10	~10	~10	~10	~10
-13°C	~10	~10	~10	~10	~10



### OUTDOOR NATURAL SNOW TESTING

→ ANALYSIS OF RESULTS

- Similar endurance time trends were observed amongst all composite materials
- Analysis was conducted using:
  - White painted carbon fiber plain weave fabric (Carbon 05)
  - White painted aluminum test plate
- Percentage ratio and endurance time difference was calculated for each test

Test #	Comp. or Al. Endurance Time [min.]	Al. or Comp. Endurance Time [min.]	Endurance Time % Ratio (Comp. or Al. / Al. or Comp.)	Al. or Comp. Endurance Time Difference (min.)
<b>Type I Fluid Heated to 60°C</b>				
2-9	2.2	2.6	91%	-1.6
32-33	4.3	5.1	100%	-1.4
89-89	4.5	8.2	180%	-3.7
82-89	12.2	12.3	91%	-0.1
104-105	5.9	8.2	119%	-2.4
<b>Type II Fluid Heated to 60°C</b>				
89-89	39.8	40.2	100%	-0.4
<b>Type III Fluid Heated to 60°C</b>				
89-89	60.4	62.9	106%	-2.5
<b>Type IV Fluid Heated to 60°C</b>				
30-30	69.0	91.3	132%	-11.7
89-91	99.3	103.3	104%	-10.0
89-91	98.9	104.8	106%	-5.9
99-99	137.9	141.3	102%	-3.3
<b>Type IV Fluid at OAT</b>				
8-8	15.8	16.9	107%	-1.1
14-16	30.3	33.3	110%	-3.4
20-21	16.8	19.2	114%	-2.4
26-20	52.0	60.3	116%	-1.9

### OUTDOOR NATURAL SNOW TESTING

→ SUMMARY OF RESULTS

- Type I Tests
  - 29% reduction in composite ET observed with Type I tests conducted
  - Reduction in Type I endurance times up to 3.7 minutes
- Type II, III, IV Tests
  - In general, composite endurance times were comparable to aluminum endurance times
  - Similar endurance time trends were observed amongst all composite materials

### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
- **OUTDOOR NATURAL FROST PLATE TESTS**
- INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS
- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE

### NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

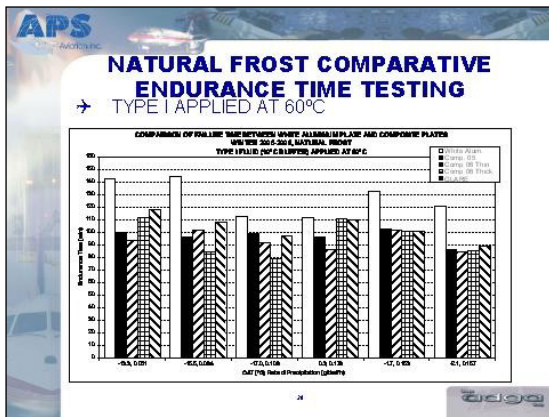
→ METHODOLOGY:

- Comparative endurance time testing with Type I fluids applied at 60°C
- Styrofoam insulation adhered to back of test plates
- Current outdoor frost endurance time testing protocol

### NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

→ SUMMARY OF COMPARATIVE TEST RUNS

Test Objective	# of Comparative Test Runs
Type I Heated (60°C)	6
<b>TOTAL</b>	<b>6</b>



### NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

→ SUMMARY OF RESULTS

- Similar endurance time trends were observed amongst all composite materials (as was seen in natural snow)
- Analysis was conducted using:
  - White painted carbon fiber plain weave fabric (Carbon 05)
  - White painted aluminum test plate
- Percentage ratio and endurance time difference was calculated for each test

Test #	Comp 05 Endurance Time (min)	White Alum. Endurance Time (min)	Endurance Time % Ratio (Comp05 / White Alum.)	Endurance Time Time Difference (min)
Type I Fluid Heated to 60°C				
1-5	100.3	142.8	70%	-42.2
6-10	96.1	144.4	67%	-48.3
11-15	99.1	112.3	88%	-13.3
16-20	96.7	112.2	86%	-15.4
21-25	102.5	133.0	77%	-30.5
26-30	88.4	120.9	71%	-34.5

### NATURAL FROST COMPARATIVE ENDURANCE TIME TESTING

→ SUMMARY OF RESULTS

- Type I Tests
  - 23% reduction in composite ET observed with Type I tests conducted
  - Reduction in Type I endurance times between 13 and 48 minutes
- Similar endurance time trends were observed amongst all composite materials

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
- OUTDOOR NATURAL FROST PLATE TESTS
- **INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS**
- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE

**INDOOR SIMULATED FREEZING PRECIPITATION TESTING**

→ METHODOLOGY:

- In comparison to the white aluminum test plate, similar results amongst all composite materials were obtained in outdoor natural snow testing and natural frost testing
- One representative composite test plate chosen to reduce testing in indoor conditions (Comp 05)
- Indoor comparative endurance time testing was conducted with
  - White painted carbon fiber plain weave fabric (Carbon 05)
  - White painted aluminum test plate
  - Standard HOT test plate (in conjunction with HOT testing)

**INDOOR SIMULATED FREEZING PRECIPITATION TESTING**

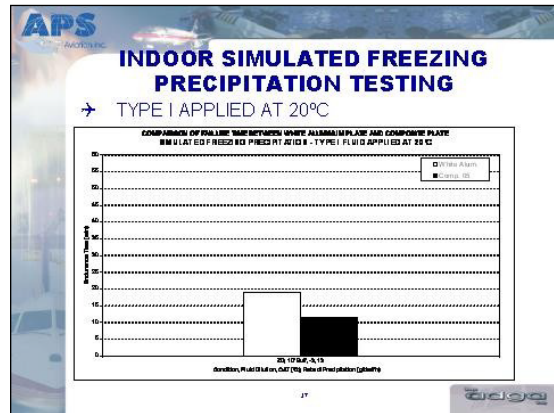
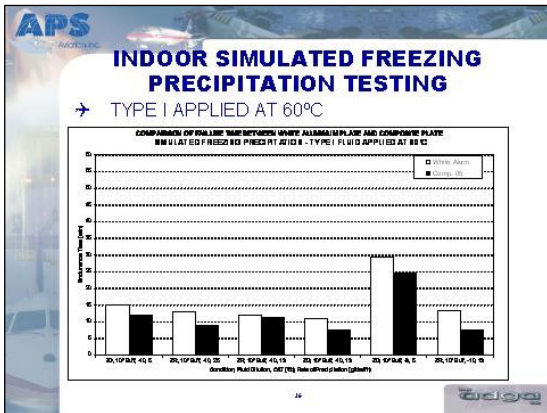
→ INDOOR TEST SETUP

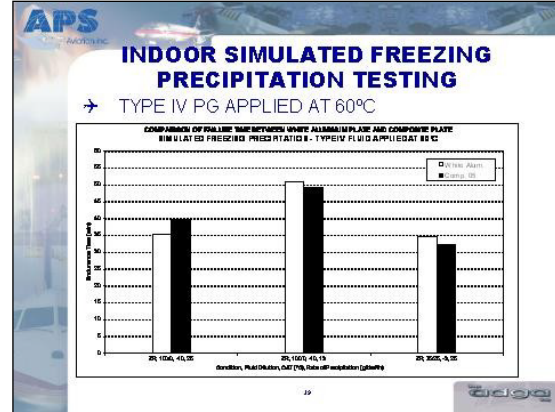
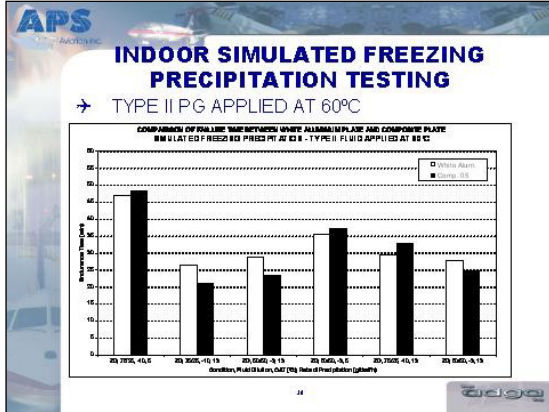


**INDOOR SIMULATED FREEZING PRECIPITATION TESTING**

→ SUMMARY OF COMPARATIVE TEST RUNS

Test Objective	# of Comparative Test Runs
Type I Heated (80°C)	6
Type I Heated (20°C)	1
Type II Heated (80°C)	7
Type IV Heated (80°C)	2
TOTAL	16



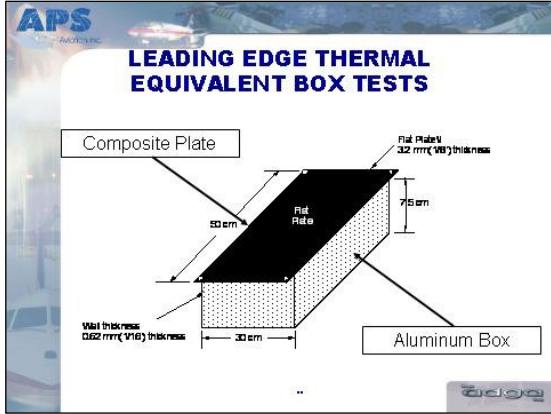


Test#	Comp 05 Endurance Time (min)	White Alum. Endurance Time (min)	Endurance Time % Ratio (Comp 05 / White Alum.)	Endurance Time Time Difference (min)
<b>Type I Fluid Heated to 60°C</b>				
3940	11.3	19.2	59%	-7.9
<b>Type II Fluid Heated to 60°C</b>				
56	11.9	15.0	79%	-3.1
1314	9.0	13.0	69%	-4.0
2122	11.3	12.0	94%	-0.7
2526	7.7	13.3	58%	-5.6
3122	7.0	10.0	70%	-3.0
4348	24.5	29.5	83%	-5.0
<b>Type III Fluid Heated to 60°C</b>				
12	46.5	47.2	100%	-0.7
2126	21.0	26.5	79%	-5.5
3526	28.1	29.0	97%	-0.9
4344	30.3	35.5	100%	-5.2
5122	33.0	29.5	112%	3.5
5960	21.9	21.0	104%	-0.9
<b>Type IV Fluid Heated to 60°C</b>				
310	30.0	35.3	110%	-5.3
1110	42.4	51.0	83%	-8.6
5566	32.3	31.0	104%	-1.3

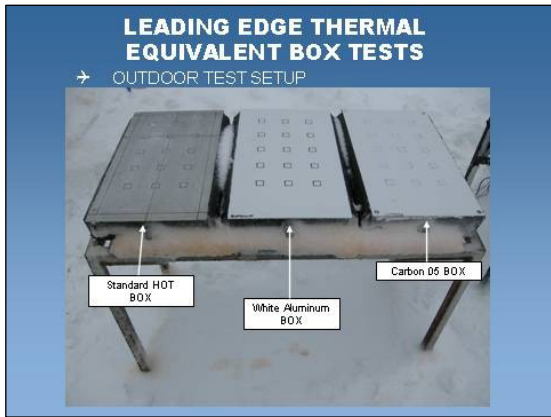
- ### INDOOR SIMULATED FREEZING PRECIPITATION TESTING
- SUMMARY OF RESULTS
- Similar trend to snow data
  - Type I Tests
    - 26% reduction in composite ET observed with Type I tests conducted
    - Reduction in Type I endurance times up to 7.5 minutes
  - Type II,III,IV Tests
    - In general, composite endurance times were comparable to aluminum endurance times
    - Discrepancy in endurance time was less than 6 minutes

- ### PRESENTATION OUTLINE
- BACKGROUND – PREVIOUS WORK
  - COMPOSITE MATERIALS TESTED
  - OUTDOOR NATURAL SNOW PLATE TESTS
  - OUTDOOR NATURAL FROST PLATE TESTS
  - INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS
  - LEADING EDGE THERMAL EQUIVALENT BOX TESTS
  - OBSERVATIONS AND RECOMMENDATIONS
  - OPEN DISCUSSION – OPTIONS FOR CHANGE

- ### LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- Based on testing conducted during 2005-06, it was recommended, that Type I testing be conducted using Leading Edge Thermal Equivalent Boxes (LETEB)
  - Testing required to validate endurance time reduction measured using composite test plates
  - A LETEB was constructed using a composite test surface on an aluminum box
  - Composite material used
    - CARBON FIBER PLAIN WEAVE FABRIC (CARBON 05)



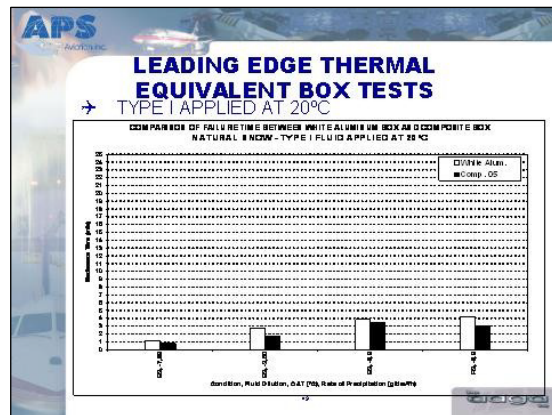
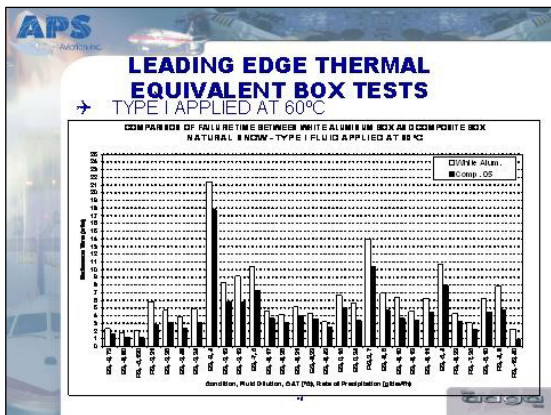
- ### LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- METHODOLOGY:
- Testing was conducted in natural snow conditions
  - Three LETEB were used to testing
    - Unpainted Aluminum Box
    - Baseline White Painted Aluminum Box
    - White Painted Composite Box
  - Comparative endurance time testing was conducted using the same fluid and dilution, applied at the same temperature to each of the boxes
  - Tests were conducted following standard Type I HOT protocol



### LEADING EDGE THERMAL EQUIVALENT BOX TESTS

→ SUMMARY OF COMPARATIVE TEST RUNS

Test Objective	# of Comparative Test Runs
Type I Heated (80°C)	29
Type I Heated (20°C)	4
TOTAL	33



### LEADING EDGE THERMAL EQUIVALENT BOX TESTS

**SUMMARY OF RESULTS**

- Analysis was conducted using:
  - White painted carbon fiber plain weave fabric (Carbon 05)
  - White painted aluminum test plate
- Percentage ratio and endurance time difference was calculated for each test

Test#	Composite Box Endurance Time (min)	White Aluminum Box Endurance Time (min)	Endurance Time % Ratio (Comp/White Alum.)	Endurance Time Difference (min.) (Comp - White Alum.)
TYPE I FLUID ENRICHMENT TESTS				
2-3	1.8	2.2	82%	-0.4
11-12	1.2	1.8	67%	-0.6
11-15	2.0	2.8	71%	-0.8
11-20	2.1	3.0	70%	-0.9
20-21	2.3	3.0	77%	-0.7
22-24	2.1	3.0	70%	-0.9
29-30	11.7	21.1	56%	-9.4
30-31	9.8	18.1	54%	-8.3
35-36	5.1	8.1	63%	-3.0
36-37	7.2	10.1	71%	-2.9
11-12	3.7	4.8	77%	-1.1
11-15	3.1	4.1	76%	-1.0
11-18	4.0	5.1	78%	-1.1
11-20	3.8	4.9	77%	-1.1
11-21	2.8	3.7	76%	-0.9
11-22	5.0	6.1	82%	-1.1
11-23	2.9	3.8	76%	-0.9
11-24	10.3	11.0	93%	-0.7
11-25	1.1	1.4	79%	-0.3
11-26	2.6	3.3	79%	-0.7
12-11	1.1	1.6	69%	-0.5
12-17	1.5	2.3	65%	-0.8
12-18	0.9	1.3	70%	-0.4
12-19	0.9	1.3	70%	-0.4
12-20	1.5	2.2	68%	-0.7
12-21	1.5	2.2	68%	-0.7
12-22	1.1	1.7	65%	-0.6
12-23	0.9	1.3	70%	-0.4
Average			75%	-1.1
TYPE II FLUID ENRICHMENT TESTS				
0-9	0.9	1.2	75%	-0.3
28-29	1.1	1.5	73%	-0.4
12-11	2.1	2.8	75%	-0.7
02-09	3.0	4.0	75%	-1.0
Average			75%	-0.7

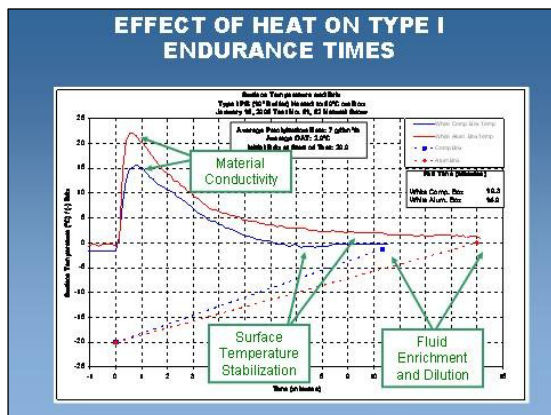
### LEADING EDGE THERMAL EQUIVALENT BOX TESTS

**SUMMARY OF RESULTS**

- Similar trend as seen during plate tests
- Type I Tests
  - 31% - 36% endurance time reduction observed with Type I tests conducted on composite box
  - Reduction in Type I endurance times up to 3.7 minutes

### EFFECT OF HEAT ON TYPE I ENDURANCE TIMES

- Four factors influence the reduction in endurance times using Type I fluids on composite surfaces
  - Material Conductivity
    - Amount of heat absorbed from the fluid
  - Surface Temperature Stabilization
    - Ability to retain heat absorbed from the fluid
  - Fluid Enrichment and Dilution
    - Increase in glycol due to evaporation of water when applying heated; a function of fluid temperature
    - Dilution to FFP will occur quicker with lower levels of fluid enrichment



### PRESENTATION OUTLINE

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
- OUTDOOR NATURAL FROST PLATE TESTS
- INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS
- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE

**GENERAL OBSERVATIONS**

- Similar fluid endurance time trends amongst the different composite materials tested
- 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 lower in comparison to aluminum surfaces

**POTENTIAL OPTIONS FOR CHANGE**

- Potential changes to HOT Guidelines
  - Separate table for Type I with reduced HOT #'s specific to aircraft with critical surfaces made of composite materials
  - Requirement to follow Type I with Type IV for aircraft with critical surfaces made entirely of composite materials
  - Note or Caution in Type I table to advise of shorter HOT's on composite surfaces
  - Reduced Type I HOT #'s

**FUTURE WORK**

- Future work to investigate aerodynamic impact of reduced Type I endurance times on composite surfaces
- Full-scale comparison test with VLJ and current aluminum material aircraft

**PRESENTATION OUTLINE**

- BACKGROUND – PREVIOUS WORK
- COMPOSITE MATERIALS TESTED
- OUTDOOR NATURAL SNOW PLATE TESTS
- OUTDOOR NATURAL FROST PLATE TESTS
- INDOOR SIMULATED FREEZING PRECIPITATION PLATE TESTS
- LEADING EDGE THERMAL EQUIVALENT BOX TESTS
- OBSERVATIONS AND RECOMMENDATIONS
- OPEN DISCUSSION – OPTIONS FOR CHANGE


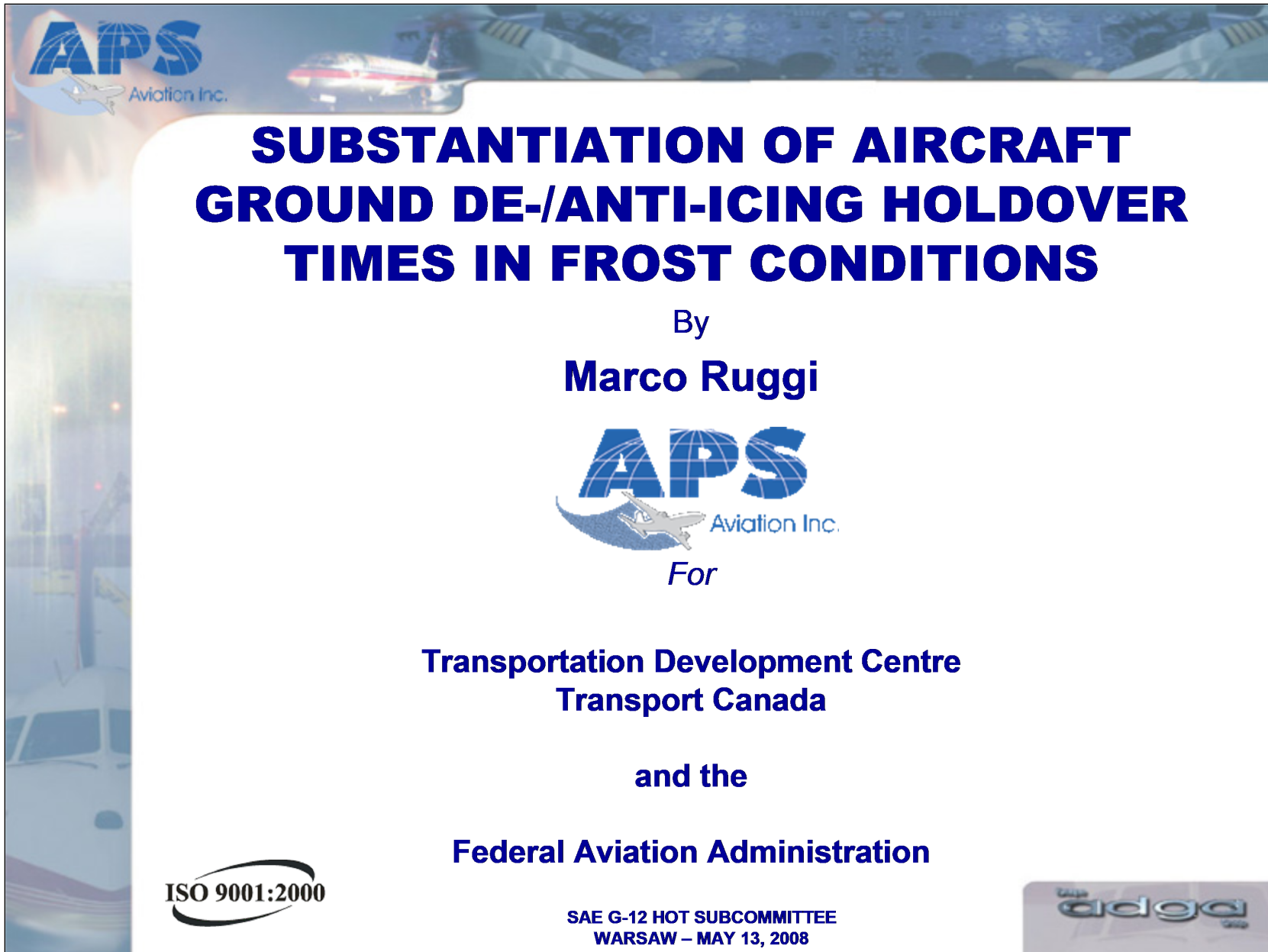
**POTENTIAL OPTIONS FOR CHANGE**

- Potential changes to HOT Guidelines
  - Separate table for Type I with reduced HOT #'s specific to aircraft with critical surfaces made of composite materials
  - Requirement to follow Type I with Type IV for aircraft with critical surfaces made entirely of composite materials
  - Note or Caution in Type I table to advise of shorter HOT's on composite surfaces
  - Reduced Type I HOT #'s

**APS**  
Aviation Inc.


Marco Ruggi  
mruggi@adga.ca

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# **SUBSTANTIATION OF AIRCRAFT GROUND DE-/ANTI-ICING HOLDOVER TIMES IN FROST CONDITIONS**

By  
**Marco Ruggi**






For

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**



**APS**

### PURPOSE

- Data collected by APS in natural frost conditions was presented at several meetings including the G-12 meeting in San Diego and in Montreal
- Attention was focused on:
  - **Reduced Endurance Times in Frost Conditions due to Fluid Freeze Point Issues**

**APS**

### PURPOSE

- Several working group meetings have been held between January and April 2008
- Attendees
  - Federal Aviation Administration
  - Transport Canada
  - APS
  - 2 Aircraft Operators
  - 1 Fluid Manufacturer
- Objective: Review current data available and scrutinize the proposed changes to the Frost HOT Guidelines

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### PURPOSE

- Purpose of this presentation is to briefly review test results and present the proposed "Plan of Action"

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### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST ΔT PARAMETERS
- TYPE I TESTS
- TYPE II/III/IV TESTS
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

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### BACKGROUND

- A survey of deicing activities at airports was conducted by APS
- Data was collected from airports in North America, Europe and Asia
- Results showed removal of frost contamination represents a significant portion of deicing operations.
  - 90% of operations for airports with warmer climates
    - I.e. London and Paris
  - 25% of operations for airports with colder climates
    - I.e. Montreal

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### BACKGROUND

- Frequency of Deicing Operations Airport Survey 2000-03

Category	Percentage
Snow	56%
Frost	33%
Other	11%

TC report TP 14375E

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### BACKGROUND

- Frost HOT have always been a part of the HOT guidelines, however fluid endurance times in frost conditions have never been measured.
- Outdoor endurance time testing in natural frost conditions for Type I,II,III,IV fluids was recommended

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### BACKGROUND

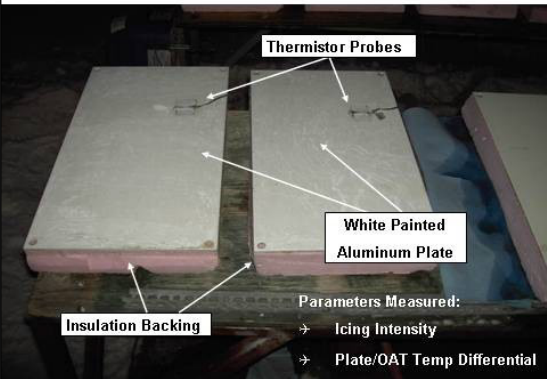
- Testing was conducted by APS to:
  - Establish Appropriate Test Parameters
    - Flat Plate Testing
    - Full Scale Aircraft Tests
  - Validate Type I HOT for Frost Conditions
  - Validate Type III/IV HOT for Frost Conditions

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Aerodynamic Systems, Inc.

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST  $\Delta T$  PARAMETERS
- TYPE I TESTS
- TYPE III/IV TESTS
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

### ESTABLISH TEST PARAMETERS



**Thermistor Probes**

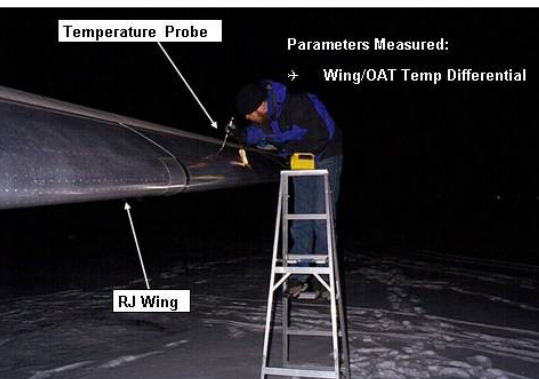
**White Painted Aluminum Plate**

**Insulation Backing**

Parameters Measured:

- Icing Intensity
- Plate/OAT Temp Differential

### ESTABLISH TEST PARAMETERS



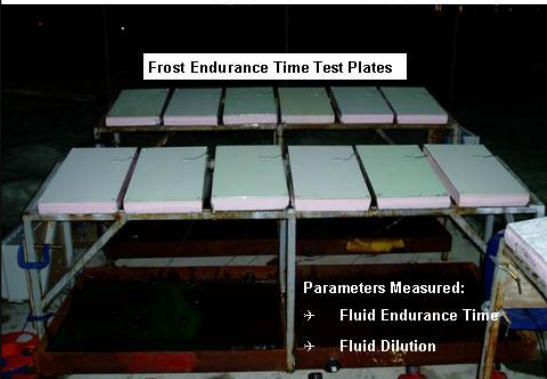
**Temperature Probe**

**RJ Wing**

Parameters Measured:

- Wing/OAT Temp Differential

### VALIDATE FROST HOT'S



**Frost Endurance Time Test Plates**

Parameters Measured:

- Fluid Endurance Time
- Fluid Dilution

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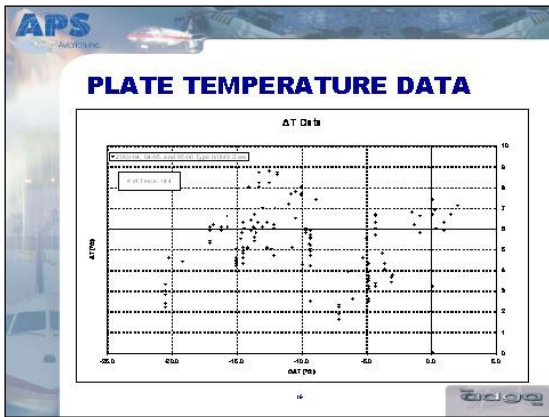
### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- **FROST  $\Delta T$  PARAMETERS**
- TYPE I TESTS
- TYPE III/IV TESTS
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

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### FROST $\Delta T$ PARAMETERS

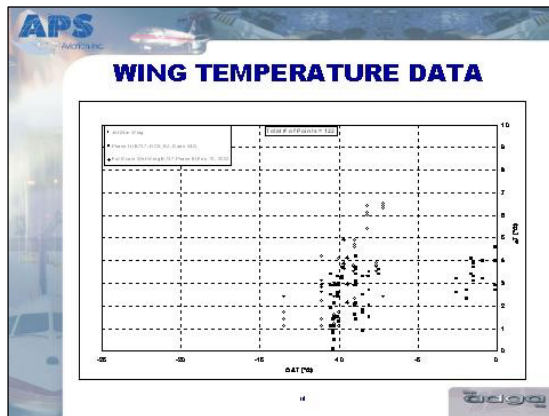
- PLATE TESTS
  - 144 data points collected
  - Test Plate and OAT temperature differential ranged from 2°C to 9°C



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### FROST $\Delta T$ PARAMETERS

- FULL-SCALE WING
  - 122 data points collected
  - Wing and OAT temperature differential reached up to 6.5°C



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### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST  $\Delta T$  PARAMETERS
- **TYPE I TESTS**
- TYPE III/IV TESTS
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

**APS**

### TYPE I TESTS

- 47 tests were conducted with 4 Type I fluids
- The measured endurance times did not violate the long used HOT of 45 minutes.
- Based on the data collected, the Type I HOTs have been substantiated.

→ *It is recommended that a note be included in ARP 5945 indicating that testing is not required for frost if the fluid meets the certification requirements*

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### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST ΔT PARAMETERS
- TYPE I TESTS
- **TYPE II/III/IV TESTS**
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

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### TYPE II/III/IV TESTS

- 62 tests were conducted with 5 Type II fluids
- 16 tests were conducted with 1 Type III fluid
- 90 tests were conducted with 8 Type IV fluids

→ Type II,III,IV fluids were tested at neat, 75/25, and 50/50 dilutions

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### TYPE II/III/IV TESTS

- 15 Type II tests and 21 Type IV tests generated reduced endurance times in comparison to the current frost values issued in the HOT Guidelines
- Discrepancy in endurance times was attributed to fluid freeze point issues for 86% of the cases

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### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST ΔT PARAMETERS
- TYPE I TESTS
- TYPE II/III/IV TESTS
- **FLUID FREEZE POINT FAILURE**
- ALTERNATIVES FOR CHANGES
- PLAN OF ACTION

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### FLUID FREEZE POINT FAILURE

- Reduced fluid endurance times were experienced when OAT approached fluid LOUT
- The plate surface temperature would cool closer to the fluid freeze point causing fluid failure
- Fluid dilution and erosion did not significantly contribute to the failure

### FLUID FREEZE POINT FAILURE

- EXAMPLE
  - Type IV 75/25 Fluid
  - OAT =  $-13.9^{\circ}\text{C}$  (within operational limit)
  - Plate Temperature =  $-13.9^{\circ}\text{C} - (7^{\circ}\text{C}) = -20.9^{\circ}\text{C}$
  - Fluid Freeze Point =  $-21^{\circ}\text{C}$ 
    - Fluid would be designed with  $7^{\circ}\text{C}$  buffer based on LOUT of  $-14^{\circ}\text{C}$
  - **Plate temperature is cooled to LOUT**
  - **Fluid experiences contamination as ice crystals begin to form sporadically in fluid**

### FLUID FREEZE POINT FAILURE

- Fluid freeze point failure can be experienced with dilutions when operating close to the LOUT
  - Assuming  $\Delta T = 7^{\circ}\text{C}$

Type II/IV Dilution	LOUT	Approximate FFP	Possible Surface Temp. During Frost Conditions at LOUT
Neat	-25	-36	-32
75/25	-14	-21	-21
50/50	-3	-10	-10

### FLUID FREEZE POINT FAILURE

- The HOT table provides operational ranges specifying limits based on OAT
- In frost conditions, the skin temperature of an aircraft may be several degrees lower than the OAT
- If operating with a fluid close to the LOUT during frost conditions, the skin temperature of the aircraft could reach the fluid freeze point potentially causing ice to form in the fluid
- **FROST HOT'S SHOULD CONSIDER THE EFFECT OF SKIN TEMPERATURE**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FROST  $\Delta T$  PARAMETERS
- TYPE I TESTS
- TYPE II/III/IV TESTS
- FLUID FREEZE POINT FAILURE
- **ALTERNATIVES FOR CHANGES**
- PLAN OF ACTION

### ALTERNATIVES FOR CHANGES

- Changes to the Frost HOT's are necessary to account for:
  - Endurance Time Data Collected
  - Fluid Freeze Point Failure
- 4 Options were developed and evaluated:
  - **CURRENT HOT FORMAT / REDUCED HOT'S**
  - **CURRENT HOT FORMAT / OAT FOOTNOTES**
  - **SEPARATE FROST HOT TABLE**
  - **NOTE IN HOT TABLE (INTERIM SOLUTION)**

### ALTERNATIVES FOR CHANGES

- Workgroup conclusions:
  - Reductions were apparent during natural frost ET testing, however,
  - Further work is required to substantiate current ET testing protocol for natural frost conditions
- Workgroup proposal:
  - HOT reductions will not be issued until further work is conducted, however,
  - A note will be included in the Type II and Type IV HOT tables to advise of possible reduced HOT's

## WORKING GROUP

- ➔ APS has had discussions with a working group consisting of industry operators and regulators
- ➔ It is anticipated that this working group approach will be continued during the coming winter

## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ PREVIOUS WORK
- ➔ FROST ΔT PARAMETERS
- ➔ TYPE I TESTS
- ➔ TYPE III/IV TESTS
- ➔ FLUID FREEZE POINT FAILURE
- ➔ ALTERNATIVES FOR CHANGES
- ➔ PLAN OF ACTION

## PROPOSED NOTE

“Radiational cooling during active frost conditions may reduce HOT when operating close to the lower end of the OAT range.”

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

**TABLE 1**  
**SAE TYPE I<sup>1</sup> FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008**  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature <sup>2</sup>	Degrees Celsius	Degrees Fahrenheit	Approximate Holdover Times Under Various Weather Conditions (minutes)						Other <sup>3</sup>
			Active Frost	Freezing Fog	Snow or Snow Grains <sup>4</sup>			Light Freezing Rain	
					Very Light	Light	Moderate	Heavy	
-3 and above	27 and above	45	11-17	16	11-18	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	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**

- To use these times, the fluid must be heated to a minimum temperature providing 80°C (140°F) at the nozzle and an average rate of at least 1 liter<sup>3</sup> or gal/100 sq ft must be applied to aircraft surfaces. OTHERWISE, TIMES WILL BE SHORTER.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and hail.
- Type I Fluid: Heater Malfunction is assumed so that the heating point of the mixture is at least 10°C (18°F) below outside air temperature.
- 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-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

**TABLE 2- Generic**  
**SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature	Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration Heat Fluid/Water mixture (wt-%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other <sup>3</sup>
				Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>2</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	
-3 and above	27 and above	75/25	9.00	0.15-1.30	0.20-0.45	0.30-0.55	0.15-0.30	0.35-0.40		
below -3 to -14	below 27 to 5	75/25	5.00 <sup>4</sup>	0.15-0.30	0.05-0.15	0.05-0.10	0.10-0.20 <sup>5</sup>		CAUTION: No holdover time guidelines exist	
below -14 to -25	below 7 to -13	100/0	0.00 <sup>5</sup>	0.15-0.30	0.10-0.20	0.15-0.30 <sup>6</sup>	0.05-0.15 <sup>6</sup>			
below -25	below -13	100/0	0.00 <sup>5</sup>	0.15-0.20 <sup>6</sup>	0.15-0.30 <sup>6</sup>					

**NOTES**

- Based on the lowest holdover times of the Type II fluids listed in Table 2-2.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to surfaces at temperatures 5°C (41°F) under heating drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of heating drizzle is not possible.
- Radiational cooling during active frost conditions may reduce HOT when operating close to the lower end of the OAT range.
- Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

**TABLE 3**  
**SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2007-2008**  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature <sup>2</sup>	Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration Heat Fluid/Water mixture (wt-%)	Approximate Holdover Times Under Various Weather Conditions (minutes)						Other <sup>3</sup>	
				Active Frost	Freezing Fog	Snow or Snow Grains			Freezing Drizzle		Light Freezing Rain
-3 and above	27 and above	75/25	100/0	120	20-40	35	20-35	10-20	18-20	8-10	6-20
below -3 to -10	below 27 to 14	75/25	50/50	30	10-20	15	8-15	4-5	5-9	4-6	CAUTION: No holdover time guidelines exist
below -10	below 14	100/0	100/0	120	20-40	30	15-30	9-15	10-20	8-10	

**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 hail.
- Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST-HOT GUIDELINES

TABLE 4-Generic  
**SAE TYPE IV FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**  
 THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

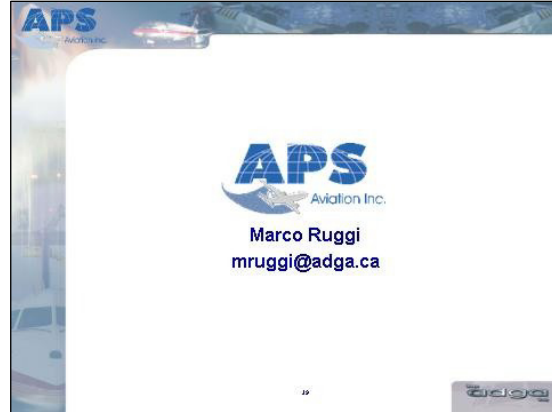
Outside Air Temperature Degrees Celsius	Type IV Fluid Concentration NaCl Fluid/Water (weight/weight %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							Other <sup>2</sup>	
		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold 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	500	1:05 - 1:45	0:30 - 0:55	0:30 - 0:50	0:15 - 0:30	0:05 - 0:35			
	50/50	3:00 <sup>3</sup>	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10				
below -3 to -14	below 27 to 7	1000	12:00 <sup>4</sup>	0:25 - 1:20	0:20 - 0:40	0:25 - 0:45 <sup>5</sup>	0:10 - 0:25 <sup>6</sup>		CAUTION: No holdover time guidelines exist	
	75/25	500 <sup>3</sup>	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>7</sup>	0:10 - 0:20 <sup>8</sup>				
below -14 to -25	below 7 to -13	1000	12:00 <sup>4</sup>	0:15 - 0:40 <sup>9</sup>	0:15 - 0:30 <sup>7</sup>					
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, where Type IV fluid cannot be used.							


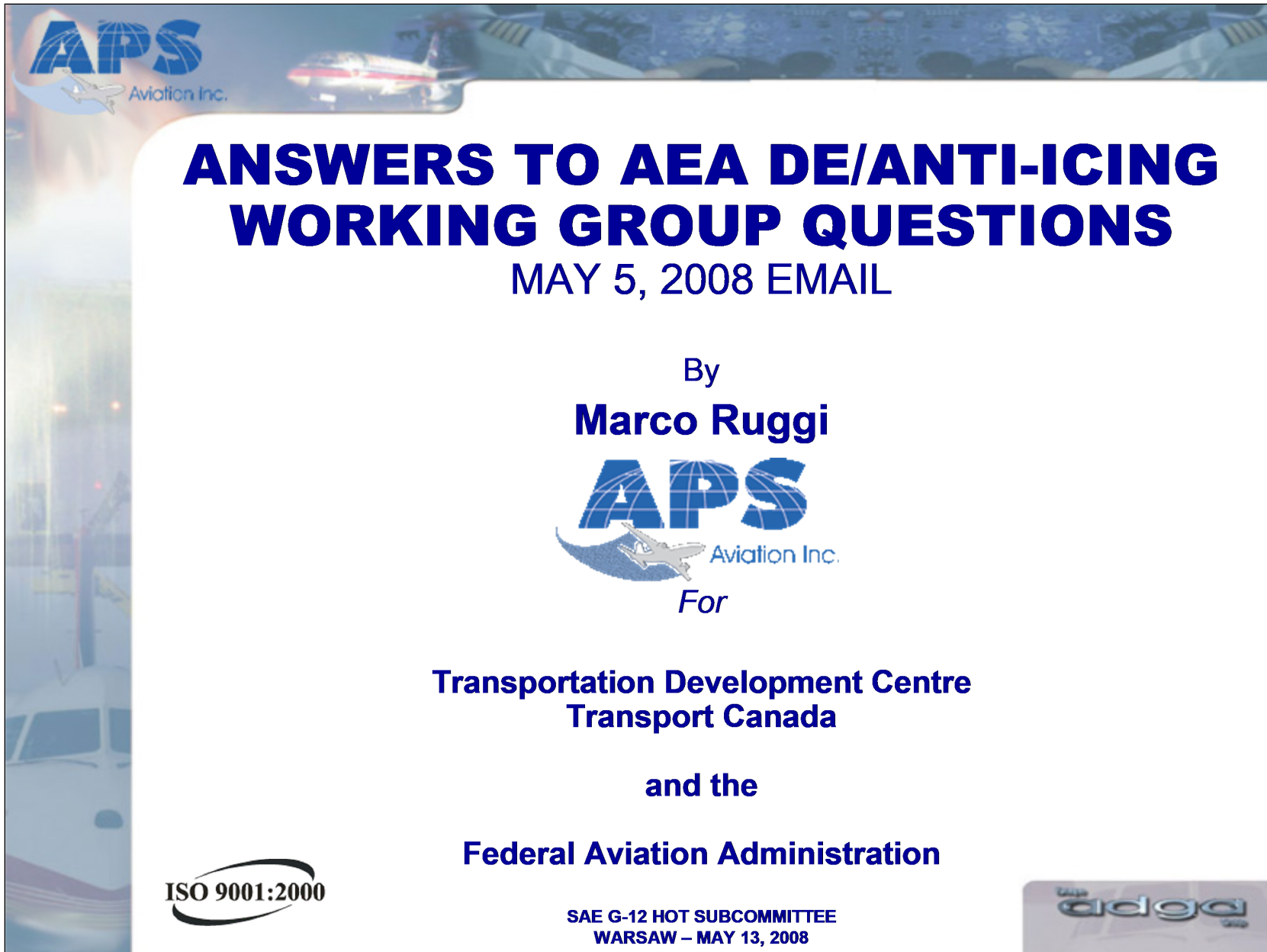
**NOTES**

- Based on the lowest holdover times of the Type IV fluids listed in Table 9.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10 C (14 F) under heating static and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Operational testing during and in fluid conditions may require frost, when operating close to the lower end of the OAT range.
- Ensure that the lowest operational use temperature (LOUT) is respected.
- 
- 
- 
- 

**CAUTIONS**


- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight wing protection.





**ANSWERS TO AEA DE/ANTI-ICING  
WORKING GROUP QUESTIONS**  
MAY 5, 2008 EMAIL

By  
**Marco Ruggi**




For

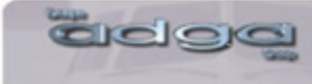
**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**



**SAE G-12 HOT SUBCOMMITTEE  
WARSAW – MAY 13, 2008**



**Q6.2**

→What should the preferred test procedure be for frost substantiation, i.e., lab tests (APR 5485), outdoor panel tests or wing tests?

**Q6.2 - Answer**

→ Previous attempts at laboratory substantiation of frost HOT's produced restrictive results (IREQ)

- Laboratory parameters did not appear to be appropriate

→ Therefore, future laboratory testing would be costly and would require correlation with natural frost conditions

**Q6.2 - Answer**

→ Outdoor testing for Type I and Type II/III/IV fluids was presented and proposed to G-12 HOT working group in September 2003

→ Outdoor testing was generally accepted by the G-12 HOT working group, and it was recommended that ARP 5485 be modified to reflect the test methodology

**Q5**

→ For simulated laboratory frost tests, a review of the main test parameters obtained from natural frost tests should be made, i.e., TD versus OAT and RH versus OAT, and these values rigorously applied.

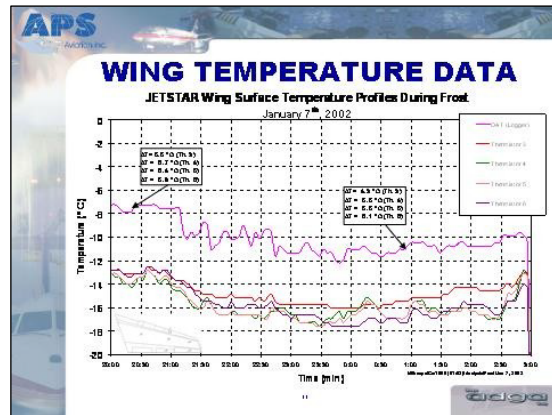
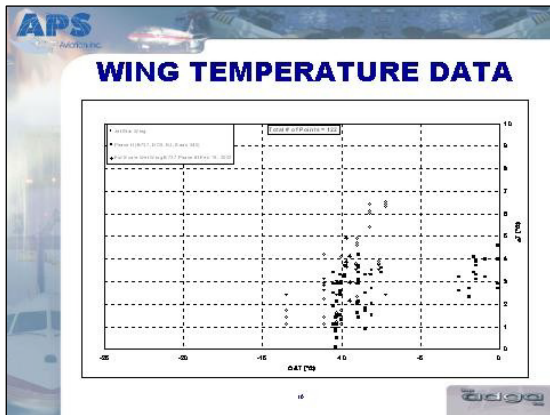
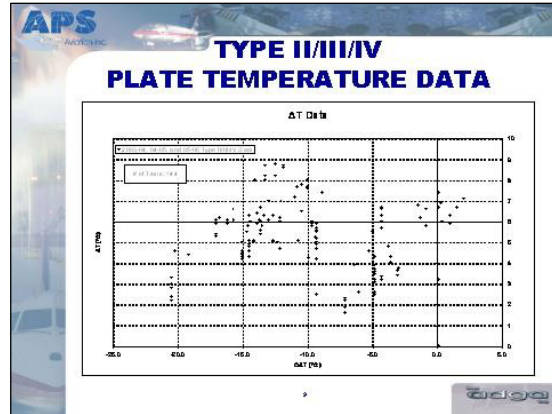
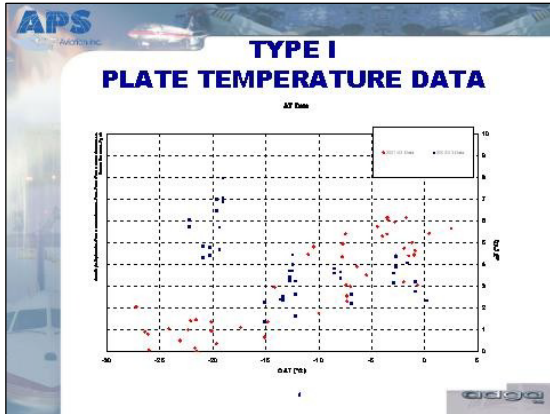
**Q5 - Answer**

→ No requirement to reproduce conditions in laboratory environment.

→ In September 2003, G-12 HOT Working group generally accepted outdoor natural frost methodology for testing Type I and Type II/III/IV fluids.

**Q6.4**

→ OAT and Plate Surface TD plots (Figs 3.7 and 3.8, page 45); (a) separation of wing versus plate data is necessary and (b) clarification regarding the rationale for TD = 6°C cross the temperature range



**Q1**

→ The choice of TD is confused and should be clarified, i.e., APS proposed TD = 9.5°C in San Diego and subsequently TD = 6°C APS in Montréal, whereas TD = 5°C has been the undisputed basis for frost tests during the previous 25 years.

→ General agreement regarding a realistic TD for frost substantiation tests is essential.

**Q1- Answer**

→ 9°C ΔT was observed on test plates

→ 6.5°C ΔT was observed during aircraft wing tests

→ G-12 HOT working group recommended the use of 7°C (max observed on aircraft) as 9°C may be too restrictive

**Q2**

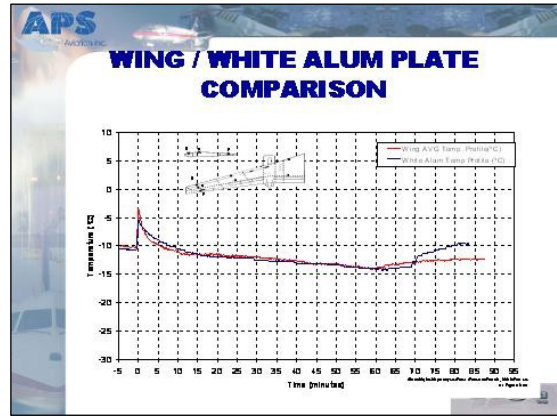
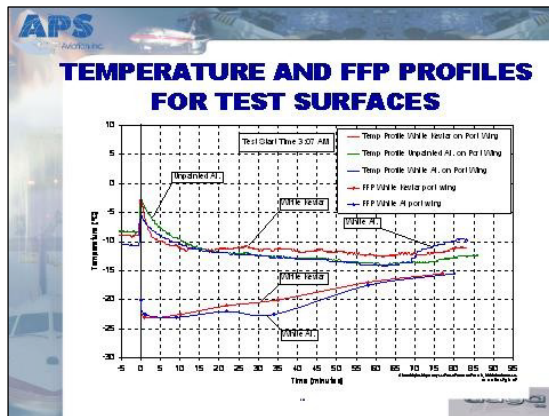
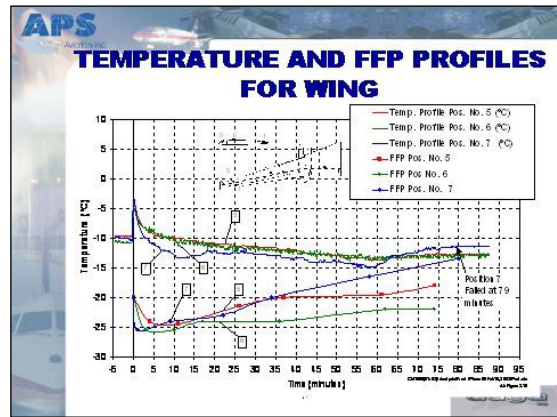
→ The structure of the highly insulated APS frosticator plate is not representative of an aircraft's wing and needs to be reconsidered.

**Q2 - Answer**

→ Full scale comparison between frosticator plate and operational aircraft has been conducted

→ Results showed that white painted insulated aluminum test plate (with and without fluid) was representative of:

- Painted aluminum aircraft skin (with or without fluid)
- Deiced unpainted aluminum aircraft skin



### COMPARISON WING VERSUS TEST PLATES FROST GENERATION

RUN #	SURFACE	FIRST APPEARANCE OF FROST (min)	PLATE ENDURANCE TIME (min)
1	Port Wing	80	
	White aluminum plate on port wing	70	78

### INFLUENCE OF TYPE I FLUID ON FROST GENERATION

	Surface Treatment		White Aluminum	Unpainted Aluminum	White Kevlar
<b>Test 1</b>	Dry	ΔT (°C)	5.6	1.2	3.5
<b>Average OAT - -6.3°C</b>		Frost Rate (g/dm <sup>2</sup> /h)			
<b>Average RH - 85%</b>	Type I fluid-covered	ΔT (°C)	5.3	5.0	4.4
		Endurance Time (min)	158	160	109
<b>Test 2</b>	Dry	ΔT (°C)	5.4	1.5	3.8
<b>Average OAT - -7.5°C</b>		Frost Rate (g/dm <sup>2</sup> /h)	0.09	0.01	0.07
<b>Average RH - 10%</b>	Type I fluid-covered	ΔT (°C)	5.3	5.3	4.7
		Endurance Time (min)	119	139	111

### Q4

→ Fluid application temperatures have not been used consistently i.e., 20°C to 60°C for Type I's.

→ Also during normal winter operations Type II/IV 75/25 and 50/50 mixtures are typically applied hot, which has not been considered in current APS frost test methodology.

### Q4 - Answer

→ Temperature profile on frosticator plate was found to be representative of aircraft wing

→ Heated 20°C tests (conservative compared to 60°C) were conducted for Type I tests

- Type I HOT was validated and no issues

→ Heated thickened fluids have not been tested, however worst case (applied at OAT) provides conservative ET

### Q3

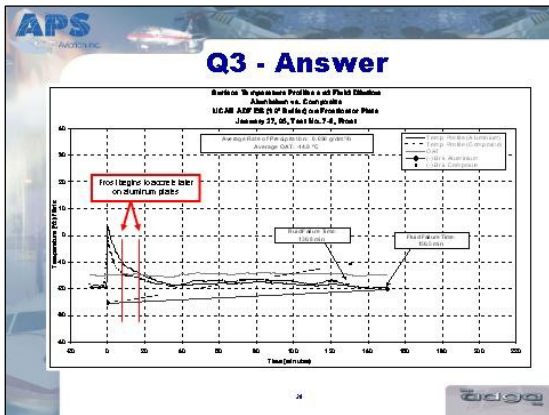
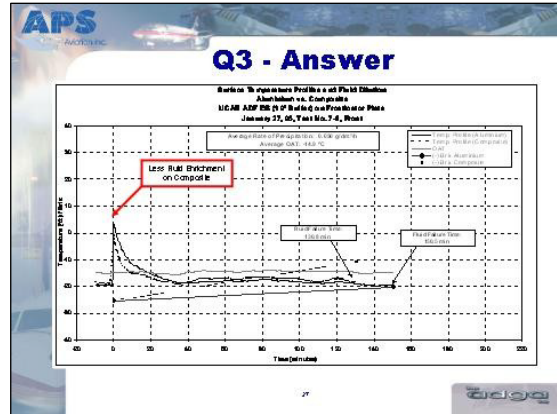
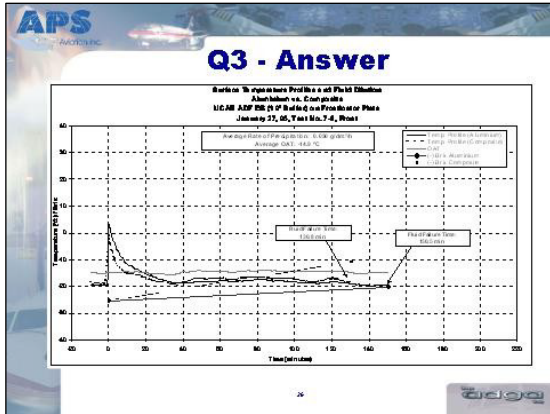
→ The current APS study concentrates heavily on aluminum surfaces. It is believed that more consideration should be given to composites, in order to determine the most critical test surface for frost.

### Q3 - Answer

→ Recent endurance time research using composite materials has shown:

- Reduced ET for Type I
- Similar ET for thickened fluids

→ Using composite surfaces may generate more conservative results for Type I.



**Q6.1**

→ Rationalise the choice of cell test temperature; this should be the same for Type I's and thickened fluids.

**Q6.1 - Answer**

→ Type I HOT's have been substantiated.  
 → 10°C buffer and effect of heat do not make them subject to "fluid freeze point" issue

- Fluid enrichment increases glycol concentration
- Heat prevents frost accretion for several minutes following application
- 10°C buffer on sliding scale for Type I's vs. 7°C minimum buffer for thickened diluted fluids

**Q6.3**

→ Question regarding Table 3.1, Test No. 60; TD = 12.4°C, Type I with 10° buffer, Endurance Time = 72 min; how is this possible (enrichment)?

**Q6.3 - Answer**

- Heated Type I fluid experiences enrichment as water evaporates upon application
- $\Delta T$  reported is in error.
- Correction
  - Temperature data was only available from 23:18:01 to 23:50:00.
  - Avg Plate Temp = -10.4
  - $\Delta T = -3.7 - (-10.4) = 6.7^{\circ}\text{C}$  (similar to following tests)
  - Correction will be issued in next version

**Q7**

- One thing is not completely clear: is the APS data from outdoor panel tests or cold chamber tests?
- In particular how did they collect the data for the lower temperatures (did they test outside in true frost conditions at minus 25C, or did they just perform a test chamber WSET with the plate at minus 31/34/36C?)

**Q7 - Answer**


- All endurance time testing was conducted outdoors
- Outdoor testing was conducted using insulated frosticator plates
- Lowest OAT = -21°C

**Comments Regarding Working Group**

- Possibly the best way forward would be to form a working group to discuss and resolve the concerns regarding the methodology.

**Comments Regarding Working Group**

- APS has had discussions with a working group consisting of industry operators and regulators
- It is anticipated that this working group approach will be continued during the coming winter

  
**Marco Ruggi**  
 mruggi@adga.ca

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**APS**  
Aviation Inc.

**AIRCRAFT DEICING RESEARCH  
IN SIMULATED MIXED  
CONDITIONS WITH ICE PELLETS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.  
*For*

**Transportation Development Centre  
Transport Canada**


and the

**Federal Aviation Administration**

**ISO 9001:2000**


**SAE G-12 HOT SUBCOMMITTEE  
WARSAW – MAY 13, 2007**

**adga**



## PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- SUMMARY OF RESULTS
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK




## BACKGROUND

- Recent industry need to provide aircraft operators with holdover times for ice pellet conditions
- Ongoing research has been conducted during the winters of 2005-06, 2006-07, and 2007-08
- Work consisted of
  - Full scale aircraft tests
  - Wind tunnel testing
  - Flat plate testing

### Summary of Ice Pellet Allowance Times

**TABLE 10**  
ICE PELLET ALLOWANCE TIMES FOR WINTER 2007-2008


	OAT -5° C and above	OAT Less than -5° C to -10° C	OAT Less than -10° C
Light Ice Pellets	50 Minutes	30 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 Minutes	10 Minutes	Caution: No Allowance Times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes	10 Minutes	
Light Ice Pellets Mixed with Light Rain	25 Minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes		



 Transports Canada    Transport Canada

### Summary of Ice Pellet Allowance Times

Chart 1. Ice Pellet Allowance Times Winter 2007-2008


	OAT -5° C or Warmer	OAT Colder Than -5° C
Light Ice Pellets	50 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes
Light Ice Pellets Mixed with Light or Moderate Snow	25 Minutes	Operations Not Authorized
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle, or Light Freezing Rain (Operations not authorized below -10° C OAT)	25 Minutes	10 Minutes (Operations Not Authorized below -10° C OAT)
Light Ice Pellets Mixed with Light Rain (Operations not authorized below 0° C OAT)	25 Minutes (Operations Not Authorized below 0° C OAT)	(Operations Not Authorized below 0° C OAT)





## BACKGROUND

- Guidance material was followed by a list of conditions and restrictions which include
  - Type IV Neat Fluid Only
  - Rotation speed of 100 knots or greater
- Industry requested additional guidance material for operations with low rotation aircraft



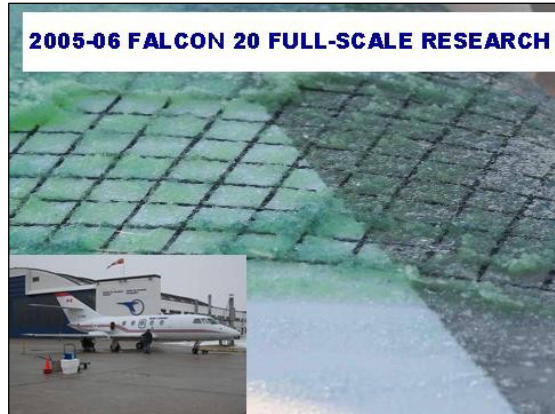
## PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
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- CONCLUSIONS AND FUTURE WORK

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### PREVIOUS RESEARCH

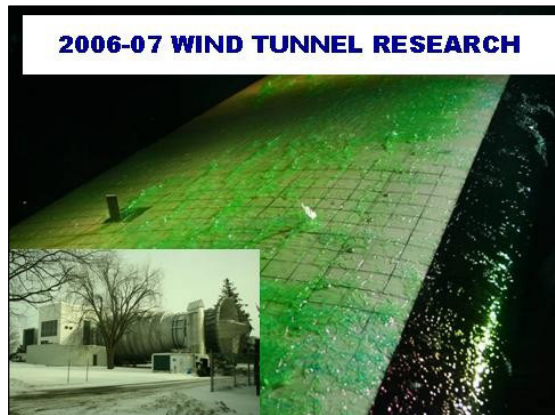
- 2005-06 Research
  - Falcon 20 testing conducted in ice pellets alone
  - FAA issued 25-minute allowance time for ice pellet conditions only
  - Work presented at G-12 in Lisbon 2006



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### PREVIOUS RESEARCH

- 2006-07 Research
  - Wind Tunnel testing conducted in mixed conditions with ice pellets
  - Limited Falcon 20 tests conducted to validate results
  - TC and FAA issued allowance time guidance material for mixed condition with ice pellets for the winter of 2007-08
  - Work presented at G-12 in San Diego 2007



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### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
- **2007-08 TEST PLAN**
- SUMMARY OF RESULTS
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

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### 2007-08 TEST PLAN

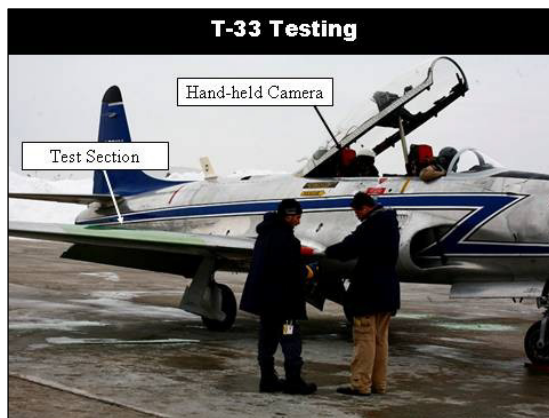
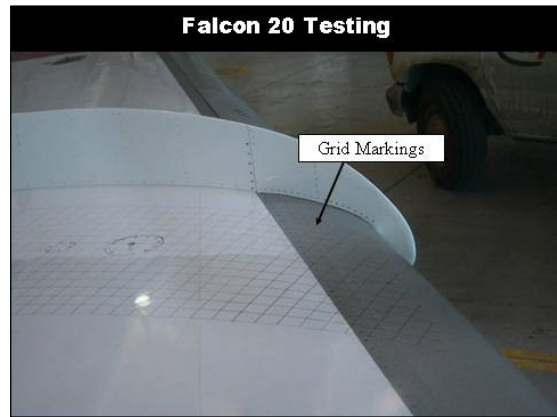
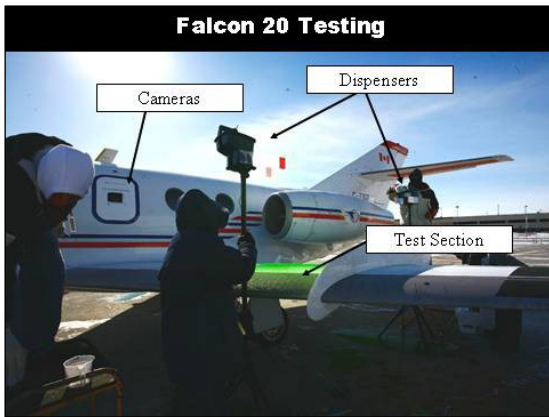
- Objective
  - Ice Pellet Allowance Time Expansion
    - 80 knot rotation speed
    - Different fluid types
    - SN/IP at lower temperatures

**2007-08 TEST PLAN**

- NRC Wind Tunnel was not available for the 2007-08 winter season
  - Would have been conducted prior to Falcon 20 testing
- Falcon 20 (and T-33) testing was conducted over a 2 week period in Feb/Mar 2008
  - Purpose was to conduct preliminary research to support future wind tunnel testing in 2008-09

**2007-08 TEST PLAN**

- 16 Tests were conducted with the Falcon 20
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- 2 Tests were also conducted with the T-33
  - Validation of Falcon 20 low speed results



**ACKNOWLEDGMENTS**



**APS**

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/ISN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**APS**

**HIGH VS. LOW SPEED ROTATION**

- Low speed tests (4 @ 80 knots and 1 @ 100 knots) were compared to Falcon 20 and Wind Tunnel tests @ 120 knots
- Results with Type IV fluid demonstrated fluid elimination problems at lower rotation speeds.

**APS**


**HIGH VS. LOW SPEED ROTATION**

- Fluid elimination problems appear to be a fluid issue rather than a contamination issue
  - Fluid only tests showed residual fluid post run at low rotation speeds.
- Extended flaps significantly helped fluid elimination at rotation;
- However TE contamination was still greater than 120 knots tests by factor of 2 or more.
- 100 knot tests were better in comparison to 80 knot tests.

**APS**

**Test #7s**  
**Type IV PG**  
**No Contamination, -15°C**


**LOW SPEED RUN**



**APS**

**Test #8p**  
**Type IV PG Neat**  
**No Contamination, -17°C**

**HIGH SPEED RUN**



**APS**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - **Flaps Up vs. Flaps Down**
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**APS**

### FLAPS UP VS. FLAPS DOWN

- Fluid elimination seemed to be greatly improve with flaps down (extended to 15°) in comparison to flaps up (fully retracted)
- Visually Observations
  - Fluid sheared 1/3 aft of LE with flaps up
  - Fluid sheared up to 2/3 aft of LE with flaps down.
- In general, residual fluid on TE was twice as large with flaps up compared to flaps down.
- Thickness measurements post take-off run confirmed visual observations.

**APS**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - **Type III fluid**
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**APS**

### TYPE III FLUID

- Testing conducted at 80 knots in following conditions:
  - Fluid Only
  - Ice Pellet Contamination
  - Ice Pellet/Snow Contamination
- Residual fluid on contaminated wing was less compared to fluid only.
- Fluid and contamination was almost completely sheared off at time of rotation during low speed runs.

**APS**

**Test #2S  
Type III PG  
No Contamination, -13°C**

**LOW SPEED RUN**

**APS**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - **Slats Up vs. Slats Down**
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**SLATS UP VS. SLATS DOWN**

- Outboard Slatted Section (5.5' chord) was compared to Inboard Flaps Down Section (9.5' chord)
- Fluid elimination seemed to be hampered by slats in comparison to flapped section
- Visually, at time of rotation:
  - Slatted section generally sheared to 1/2 aft of LE
  - Flapped section generally sheared to 2/3 aft of LE
- Considering shorter chord on the slatted section, smaller residual TE thicknesses were expected, however they were often greater in comparison to the 9.5' chord TE section. "

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - **Effect of Chord Length**
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/ISN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**EFFECT OF CHORD LENGTH**

- Outboard Section (5.5' chord) was compared to Inboard Section (9.5' chord)
- LE and TE devices were retracted for comparison
- Length of the chord had a significant effect on fluid elimination;
  - The shorter the chord, the better the fluid elimination.
- Visually, at time of rotation:
  - 5.5' chord generally completely sheared
  - 9.5' chord generally sheared between 1/2 to 2/3 aft of LE.

**PRESENTATION OUTLINE**

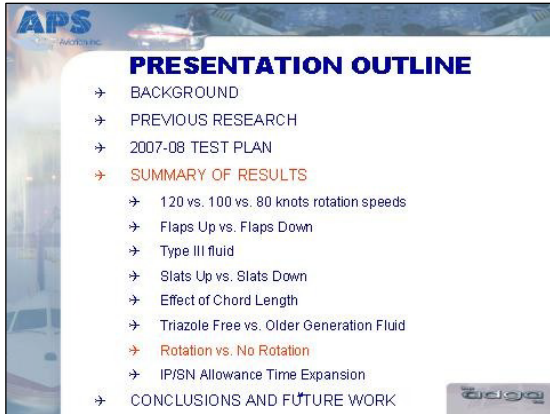
- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - **Effect of Chord Length**
  - **Triazole Free vs. Older Generation Fluid**
  - Rotation vs. No Rotation
  - IP/ISN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK

**ABC-S PLUS vs. ABC-S**

- 80 knot and 120 knot comparison runs were conducted
  - ABC-S Plus applied to Port wing
  - ABC-S applied to Starboard wing
- Visually, ABC-S Plus and ABC-S behaved similarly aerodynamically.
- Discrepancies in residual fluid thickness were minor and mostly on trailing edge.

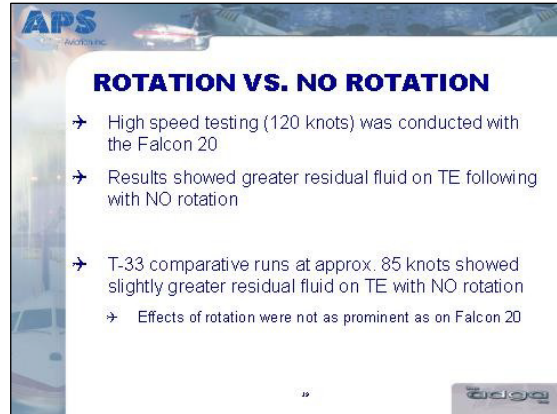
**EG 106 vs. ULTRA+**

- 80 knot comparison run was conducted
  - EG 106 applied to Port wing
  - Ultra+ applied to Starboard wing
- Results showed reduced residual thicknesses for EG 106 in comparison to Ultra+.
- Residual fluid on TE was almost double for Ultra+
- Visually, EG 106 demonstrated better flow-characteristics in comparison to U+.



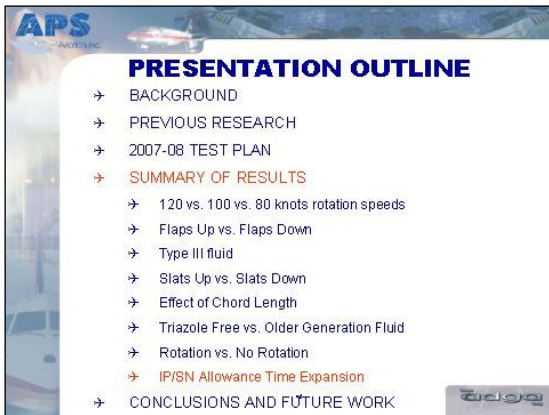
**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - **Rotation vs. No Rotation**
  - IP/SN Allowance Time Expansion
- CONCLUSIONS AND FUTURE WORK



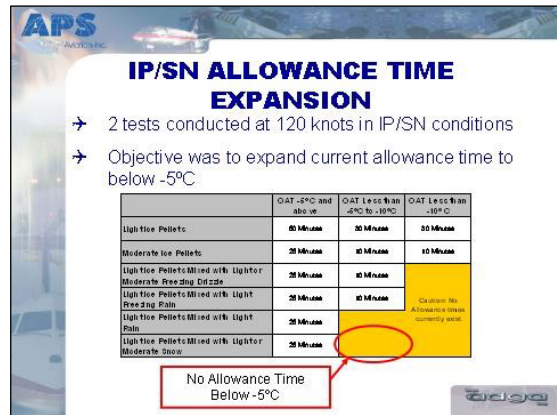
**ROTATION VS. NO ROTATION**

- High speed testing (120 knots) was conducted with the Falcon 20
- Results showed greater residual fluid on TE following with NO rotation
- T-33 comparative runs at approx. 85 knots showed slightly greater residual fluid on TE with NO rotation
  - Effects of rotation were not as prominent as on Falcon 20



**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - **IP/SN Allowance Time Expansion**
- CONCLUSIONS AND FUTURE WORK

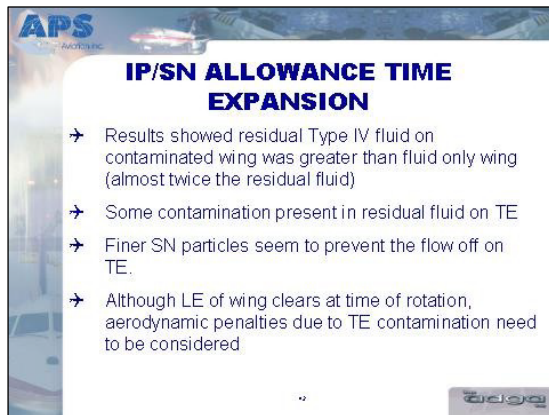


**IP/SN ALLOWANCE TIME EXPANSION**

- 2 tests conducted at 120 knots in IP/SN conditions
- Objective was to expand current allowance time to below -5°C

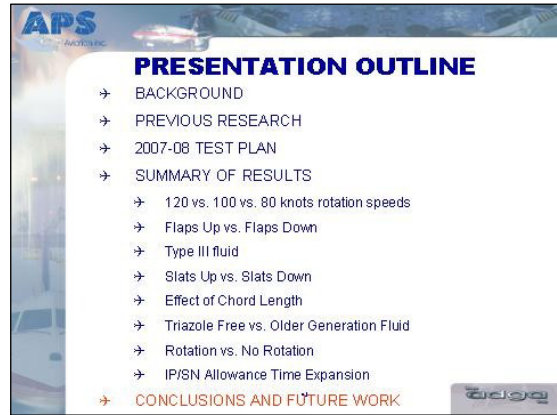
	OAT -5°C and above	OAT Less than -5°C to -10°C	OAT Less than -10°C
Light Ice Pellets	60 Minutes	30 Minutes	30 Minutes
Moderate Ice Pellets	25 Minutes	10 Minutes	10 Minutes
Light Ice Pellets Mixed with Lighter Moderate Freezing Outside	25 Minutes	10 Minutes	Checked No Allowance time (numbering error)
Light Ice Pellets Mixed with Light Freezing Rain	25 Minutes	10 Minutes	
Light Ice Pellets Mixed with Light Rain	25 Minutes	10 Minutes	
Light Ice Pellets Mixed with Lighter Moderate Snow	25 Minutes	10 Minutes	

No Allowance Time Below -5°C



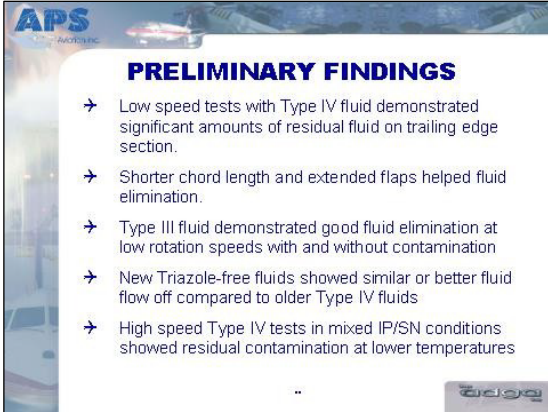
**IP/SN ALLOWANCE TIME EXPANSION**

- Results showed residual Type IV fluid on contaminated wing was greater than fluid only wing (almost twice the residual fluid)
- Some contamination present in residual fluid on TE
- Finer SN particles seem to prevent the flow off on TE.
- Although LE of wing clears at time of rotation, aerodynamic penalties due to TE contamination need to be considered



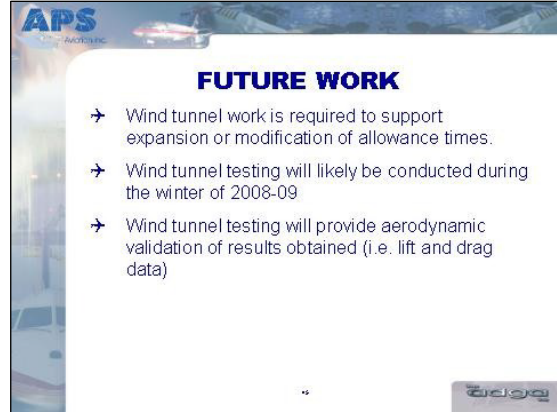
**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS RESEARCH
- 2007-08 TEST PLAN
- **SUMMARY OF RESULTS**
  - 120 vs. 100 vs. 80 knots rotation speeds
  - Flaps Up vs. Flaps Down
  - Type III fluid
  - Slats Up vs. Slats Down
  - Effect of Chord Length
  - Triazole Free vs. Older Generation Fluid
  - Rotation vs. No Rotation
  - IP/SN Allowance Time Expansion
- **CONCLUSIONS AND FUTURE WORK**



**PRELIMINARY FINDINGS**

- Low speed tests with Type IV fluid demonstrated significant amounts of residual fluid on trailing edge section.
- Shorter chord length and extended flaps helped fluid elimination.
- Type III fluid demonstrated good fluid elimination at low rotation speeds with and without contamination
- New Triazole-free fluids showed similar or better fluid flow off compared to older Type IV fluids
- High speed Type IV tests in mixed IP/SN conditions showed residual contamination at lower temperatures



**FUTURE WORK**

- Wind tunnel work is required to support expansion or modification of allowance times.
- Wind tunnel testing will likely be conducted during the winter of 2008-09
- Wind tunnel testing will provide aerodynamic validation of results obtained (i.e. lift and drag data)



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**APS**  
Aviation Inc.

# **AIRCRAFT GROUND DE/ANTI-ICING 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**

**SAE G-12 HOT SUBCOMMITTEE  
WARSAW – MAY 13, 2007**

**dgg**

## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ SIMULATED SNOW PELLETS
- ➔ ENDURANCE TIME TESTING CONDUCTED
- ➔ OBSERVATIONS AND 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

TABLE 4-Generic  
SAE TYPE IV FLUID HOLOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>

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

Outside Air Temperature Degrees Celsius Degrees Fahrenheit	Type IV Fluid Concentration Heat Fluid/Water Volume to Volume %	Approximate Holdover Times Under Various Weather Conditions (Hours - minutes)						
		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>2</sup>	Light Freezing Rain	Rain on Cold Surfaces <sup>3</sup>	Other <sup>4</sup>
-3 and above	100%	12:00	1:15 - 2:30	0:35 - 1:45	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 - 0:30	
	50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10		
below -3 to -14	100%	4:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 <sup>5</sup>	0:10 - 0:20 <sup>5</sup>		CAUTION: No holdover time guidelines exist
	75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>5</sup>	0:10 - 0:20 <sup>5</sup>		
	50/50	12:00 <sup>6</sup>	0:15 - 0:40 <sup>6</sup>	0:15 - 0:30 <sup>6</sup>				
below -14 to -25	100%	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**

- Based on the same holdover times of the Type IV fluids listed in Table 5.
- Heavy snow (less than) has pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10°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-making criterion, for takeoff without a pre-takeoff contamination inspection, is the starter 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 inflight icing protection.

Page 17 of 40      October 2007

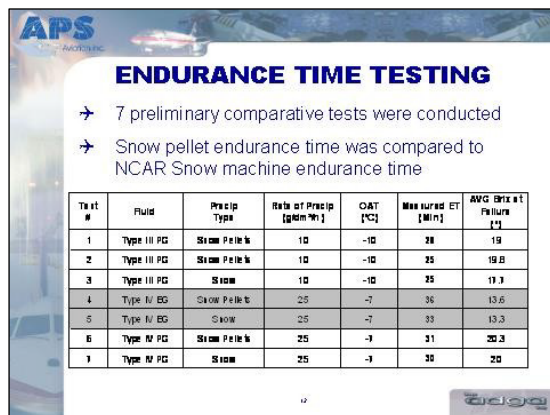
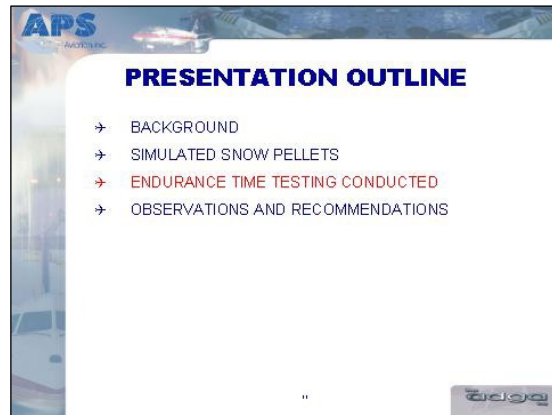
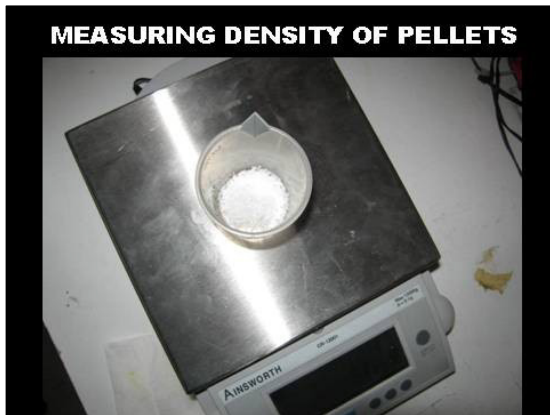
## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ SIMULATED SNOW PELLETS
- ➔ ENDURANCE TIME TESTING CONDUCTED
- ➔ OBSERVATIONS AND RECOMMENDATIONS

## SIMULATED SNOW PELLETS

- ➔ Simulated snow pellets were manufactured using the NCAR snow
- ➔ NCAR snow was hand formed into snow balls
  - ➔ Approx 3" in diameter
- ➔ Snow ball was mashed through various calibrated sieves to obtain desired size
- ➔ Density of the snow pellets was calculated to be 0.3 to 0.4;





**PRESENTATION OUTLINE**

- BACKGROUND
- SIMULATED SNOW PELLETS
- ENDURANCE TIME TESTING CONDUCTED
- **OBSERVATIONS AND RECOMMENDATIONS**

**GENERAL OBSERVATIONS**

- Fluid endurance times in simulated snow pellet conditions were similar to simulated snow
- Average final brix indicated similar levels of fluid dilution

**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

**ADDITIONAL INFORMATION**

- 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

**FUTURE WORK**

- Wind tunnel testing to investigate flow off de/anti-icing fluid contaminated with snow pellets
- Further ET testing with different fluids, dilutions, temperatures and rates
- Intra-laboratory comparison of simulated ET results

**APS**  
Aviation Inc.

**Marco Ruggi**  
mruggi@adga.ca

# IMPLEMENTATION OF HOLDOVER TIME DETERMINATION SYSTEMS



**SAE G-12 HOLDOVER TIME  
SUBCOMMITTEE**

**WARSAW, POLAND  
MAY 13, 2008**

## MICHAEL CHAPUT

MANAGER, PROJECTS AND BUSINESS  
DEVELOPMENT

APS AVIATION INC.  
MONTREAL, QUEBEC, CANADA  
MCHAPUT@ADGA.CA  
WWW.APSAVIATION.CA



## HOLDOVER TIME DETERMINATION SYSTEM (HOTDS)

- System consists of numerous sensors enabling the determination of:
  - Rate of precipitation
  - Type of precipitation
  - Ambient temperature
- System measurements can be employed to generate a "single-value" holdover time for each departing aircraft



## MY EXPERIENCE

- Endurance time test procedure development and testing of de/anti-icing fluids
- Development of fluid holdover time tables and operational guidelines
- De/anti-icing optimization strategies
- Evaluation of new de/anti-icing technologies
- Evaluation of Holdover Time Determination Systems (HOTDS)
- Development of Minimum Quality Assurance Requirements, Performance Specifications and Regulatory Framework for HOTDS implementation



## ACKNOWLEDGEMENTS

- Transport Canada
- Airport Cooperative Research Program (ACRP)
- D-Ice A/S
- WestJet



## PRESENTATION OUTLINE

- Current de/anti-icing decision support tools available to flight crews
- Making the case for HOTDS
- Regulatory framework for implementation of HOTDS
- Current state of HOTDS technology
- Recent work on airport siting of HOTDS




# CURRENT DE/ANTI-ICING DECISION SUPPORT TOOLS

## CURRENT FLIGHT CREW TOOLS

### DE/ANTI-ICING FLUID HOLDOVER TIME TABLES

### METAR WEATHER

### VISIBILITY TABLES



## CURRENT FLIGHT CREW TOOLS

### DE/ANTI-ICING FLUID HOLDOVER TIME TABLES

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER USE ONLY  
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)						
		Advis. Frost	Freezing Fog	Snow or Sleet	Freezing Rain	Light Freezing Rain	Rain on Cold Surface (Wing)	Other*
-1 and above	100%	12:00	1:15-2:30	0:30-1:15	0:45-1:15	0:35-0:45	0:10-0:30	
	75%	8:00	1:00-1:45	0:20-0:50	0:30-0:30	0:15-0:30	0:10-0:30	
Below -1	100%	8:00	0:15-0:30	0:10-0:15	0:10-0:30	0:05-0:10		
	75%	12:00	0:30-1:30	0:20-0:40	0:20-0:40	0:10-0:20		CAUTION: No holdover time guidelines exist
Below -14	100%	12:00	0:30-1:30	0:20-0:20	0:15-0:20	0:10-0:20		
Below -20	Below -13	100%	0:15-0:45	0:15-0:30				Use 100% fluid for use below -20°C (-4°F) provided the freezing point of the fluid is at least -1°C (32°F) below the outside air temperature and the manufacturer's acceptance criteria are met. Consult user of Type I when Type IV fluid cannot be used.

- Anti-icing performance guidelines for de/anti-icing fluids
- Generic Tables for Types I, II, III and IV
- Brand-Specific Tables for Types II and IV
- Published annually by Transport Canada / FAA

## CURRENT FLIGHT CREW TOOLS

### METAR WEATHER

METAR CYUL 161000Z 04016KT 5/8SM -SN BLSN VV004 M09M10 A2996

- Aviation Routine Weather Report
- Computer-generated based on observations from staffed or automated weather stations

## CURRENT FLIGHT CREW TOOLS

### VISIBILITY TABLES


Lighting	Temperature Range		Visibility in Snow ( statute miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	0.1	>10 to 20	>20 to 4	>4
	Below -1	Below 30	0.25	>30 to 15	>15 to 3	>3
Daylight	-1 and above	30 and above	0.5	>10 to 15	>15 to 3	>3
	Below -1	Below 30	0.25	>30 to 7.5	>7.5 to 2	>2

- Horizontal visibility versus snowfall intensity tables
- Published annually by Transport Canada / FAA

## POSITIVE ATTRIBUTES

## CURRENT DE/ANTI-ICING DECISION-SUPPORT TOOLS

## DE/ANTI-ICING FLUID HOLDOVER TIME TABLES



### HOLDOVER TIME TABLES 1990-91

OAT [°C]	WEATHER CONDITIONS			
	Frost	Freezing Fog	Steady Snow	Freezing Rain
+ 5 and above	45 min.	30 min.	15 min.	5 min.
0 to - 7	45 min.	15 min.	15 min.	3 min.
- 8 and below	30 min.	15 min.	15 min.	

WATER TEMPERATURE [°C]	WEATHER CONDITIONS			
	Frost	Freezing Fog	Steady Snow	Freezing Rain
+ 5 and above	45 min.	30 min.	15 min.	5 min.
0 to - 7	45 min.	15 min.	15 min.	3 min.
- 8 and below	30 min.	15 min.	15 min.	

### HOLDOVER TIME TABLES TODAY

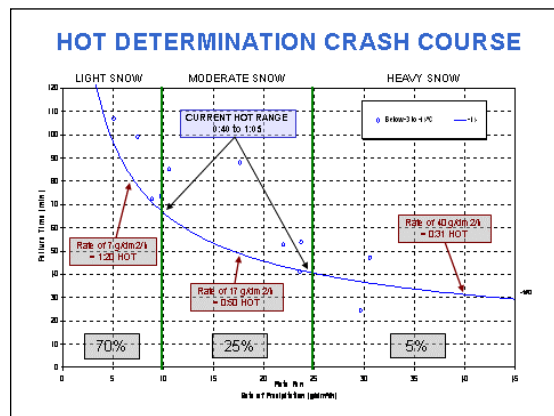
- ### HOLDOVER TIME TABLES
- Quality of the data employed to generate the various holdover time tables is excellent
  - Content is derived from standardized test methodologies using defined meteorological and scientific inputs
  - Data in the tables has been correlated to operational aircraft



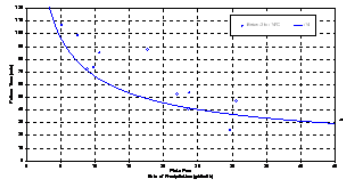
- ### HOLDOVER TIME TABLES
- Holdover times are a range of times and not a single value
  - Values obtained from tests performed at low end and high end of the rate spectrum for each condition
  - Holdover times are derived from tests performed at specific rates of precipitation for each meteorological condition
  - Liquid Water Equivalent (LWE)



- ### HOLDOVER TIME TABLES
- Despite the quality of the holdover time information, the paper format of the tables limits them to being vague guidelines
  - Flight crew's ability to extract the proper information from the tables has not advanced



### BUILDING THE TABLE



REGRESSION ANALYSIS TAKES ACCOUNT OF ALL RATES

### BUILDING THE TABLE

Outside Air Temperature		Type II Hold Chamber/Run Rate	Approximate Holdover Times Under Various Weather Conditions (Permanently)						
Degrees Celsius	Degrees Fahrenheit	Run Rate (g/min)	Freezing Fog	Snow or Snow Drizzle	Freezing Drizzle	Light Freezing Rain	Rain on Cold Wetted Wing	Ch hr <sup>2</sup>	
-3 and above	23 and above	10000	0:00	3:30 - 4:00	1:00 - 1:30	1:20 - 2:00	0:45 - 1:25	0:10 - 1:30	
		15000	0:00	2:30 - 4:00	0:40 - 1:20	1:15 - 2:00	0:30 - 0:55	0:05 - 1:20	
		20000	0:00	0:55 - 1:45	0:10 - 0:25	0:20 - 0:30	0:10 - 0:15		
between -3 and -14	between 23 and 5	10000	0:00	0:55 - 1:45	0:10 - 1:05	0:25 - 1:30*	0:25 - 0:45*	CAUTION: No holdover time subtraction rule!	
		15000	0:00	0:40 - 1:10	0:20 - 0:40	0:25 - 1:10*	0:20 - 0:40*		
between -14 and -25	between 5 and -13	10000	0:00	0:30 - 0:50	0:15 - 0:30				
between -25 and below	between -13 and below	10000	Type II hold may be used between -25°C (-13°F) provided the freezing point of the fuel is allowed 1°F (-1°C) below the outside air temperature and the aerodynamic ice accretion rate is low. Consider use of Type I when Type II hold cannot be used.						

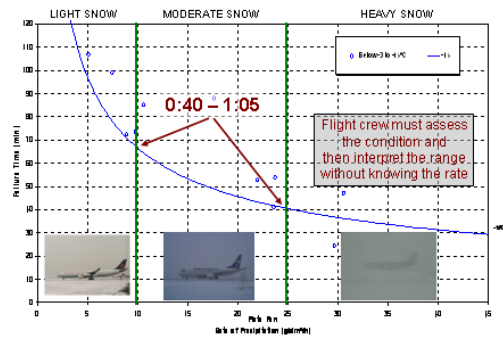
HOLDOVER TIME TABLE ONLY TAKES ACCOUNT OF A DEFINED RANGE OF RATES

### BUILDING THE TABLE

Outside Air Temperature		Type II Hold Chamber/Run Rate	Approximate Holdover Times Under Various Weather Conditions (Permanently)						
Degrees Celsius	Degrees Fahrenheit	Run Rate (g/min)	Freezing Fog	Snow or Snow Drizzle	Freezing Drizzle	Light Freezing Rain	Rain on Cold Wetted Wing	Ch hr <sup>2</sup>	
-3 and above	23 and above	10000	0:00	3:30 - 4:00	1:00 - 1:30	1:20 - 2:00	0:45 - 1:25	0:10 - 1:30	
		15000	0:00	2:30 - 4:00	0:40 - 1:20	1:15 - 2:00	0:20 - 0:55	0:05 - 1:20	
		20000	0:00	0:55 - 1:45	0:10 - 0:25	0:20 - 0:30	0:10 - 0:15		
between -3 and -14	between 23 and 5	10000	0:00	0:55 - 1:45	0:40 - 1:05	0:35 - 1:30*	0:25 - 0:45*	CAUTION: No holdover time subtraction rule!	
		15000	0:00	0:40 - 1:10	0:20 - 0:40	0:25 - 1:10*	0:20 - 0:40*		
between -14 and -25	between 5 and -13	10000	0:00	0:30 - 0:50	0:15 - 0:30				
between -25 and below	between -13 and below	10000	Type II hold may be used between -25°C (-13°F) provided the freezing point of the fuel is allowed 1°F (-1°C) below the outside air temperature and the aerodynamic ice accretion rate is low. Consider use of Type I when Type II hold cannot be used.						



### HOLDOVER TIMES FOR SNOW OPERATIONS



### METAR WEATHER



### METAR WEATHER

- ➔ Primary source of weather information employed by flight crews
- ➔ General format of METAR reports is a global standard
- ➔ Information is updated hourly (or every 30 minutes)
  - ➔ If conditions change significantly, an update is provided (SPECI)
- ➔ METAR contains all the information (temperature, precipitation type and intensity) required to assess holdover time



### DEFICIENCIES OF METAR

- METAR provides no quantitative measurement of precipitation intensity
- No correlation between holdover time definitions of precipitation intensity and those reported by METAR
- Frequency of METAR reports updates is insufficient for holdover time applications
- Poor at identifying changing weather conditions, especially as they pertain to aircraft ground deicing



### EXAMPLE #1

#### EXAMPLE #1 - ACTUAL REPORTED EVENT

16 DECEMBER 2005 0903Z

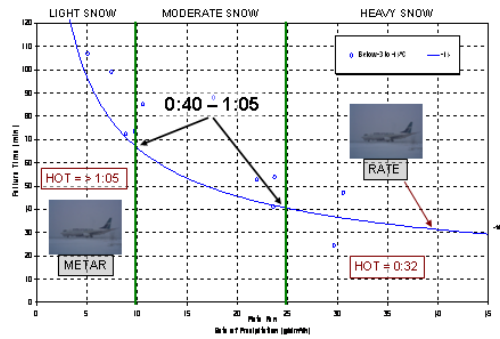
METAR CYUL 160900Z 05014KT 5/8SM -SN DRSN VV004  
M09/M11 A3000

APS MEASURED RATE OF PRECIPITATION: 38.5 g/dm<sup>2</sup>/h

SNOW INTENSITY BASED ON RATE: **HEAVY**



#### HOLDOVER TIMES FOR EXAMPLE #1



### EXAMPLE #2

#### EXAMPLE #2 - ACTUAL REPORTED EVENT

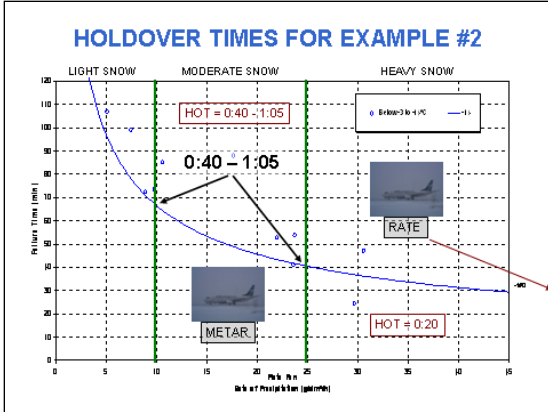
16 DECEMBER 2005 1137Z

SPECI CYUL 161137Z 05017KT 1/2SM SN BLSN VV003 M08/M09

APS MEASURED RATE OF PRECIPITATION: 74.3 g/dm<sup>2</sup>/h

SNOW INTENSITY BASED ON RATE: **HEAVY**





## EXAMPLE #3

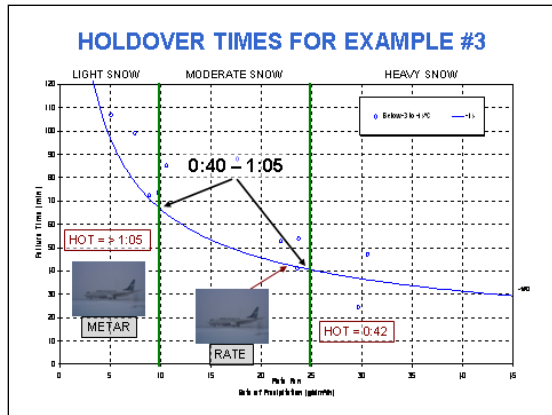
### EXAMPLE #3 - ACTUAL REPORTED EVENT

**15 JANUARY 2007 1301Z**

METAR CYUL 151300Z 05014KT 3/4SM -SN DRSN OV014  
M08/M11 A3019

APS MEASURED RATE OF PRECIPITATION: 22.8 g/dm<sup>2</sup>/h

SNOW INTENSITY BASED ON RATE: **MODERATE**



## EXAMPLE #4

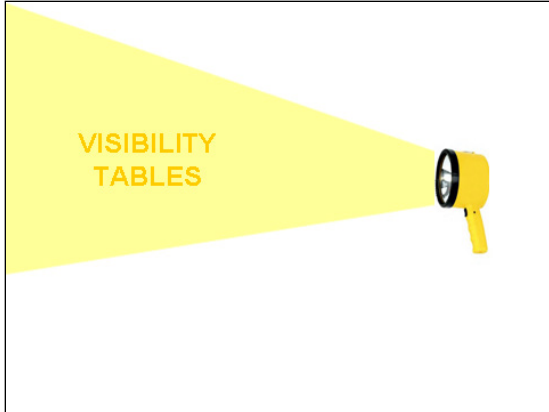
### EXAMPLE #4 - CHANGING CONDITIONS

March 5, 2004, 1500-1600Z, YUL HOTDS

Time (GMT)	Condition According to ATIS	Rate Measured by Precipitation Pans (g/dm <sup>2</sup> /h)	Rate obtained by DIM (g/dm <sup>2</sup> /h)
14:57	Rain, Fog	9.1	9
15:12	Rain, Fog	3.8	4.3
15:27	Rain, Fog	20.4	21.2
15:42	Rain, Fog	20.1	22.8

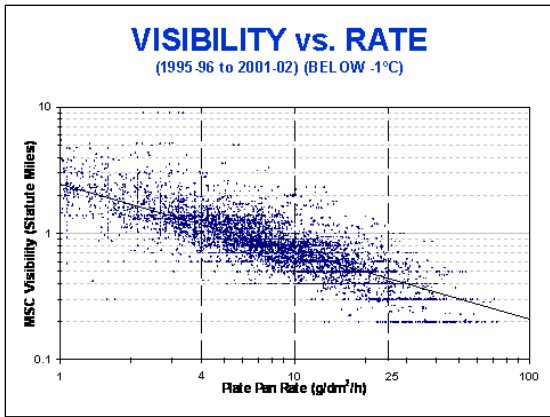
METAR DID NOT CHANGE FOR THE HOUR PERIOD

METAR: 05009KT 1 1/2SM -RA BR



## VISIBILITY TABLES

- 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



## EXAMPLE #5

### EXAMPLE #5 - ACTUAL REPORTED EVENT

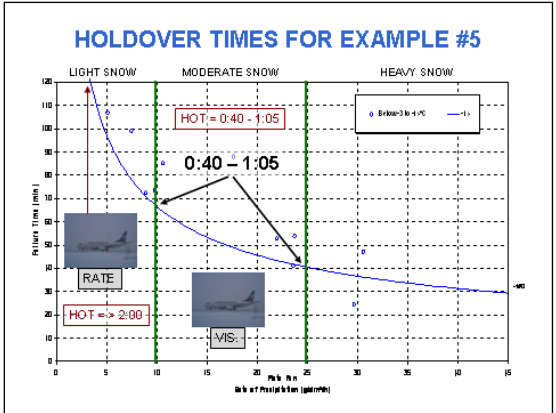
**4 JANUARY 2006 1306Z**

VISIBILITY = ¼ SM

SNOWFALL INTENSITY BASED ON VISIBILITY TABLE: MODERATE

APS MEASURED RATE OF PRECIPITATION: 2.9 g/dm²/h

SNOW INTENSITY BASED ON RATE: **LIGHT**



## USE OF VISIBILITY TABLES

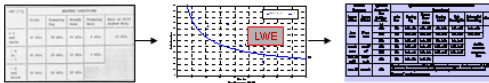
- Use of visibility tables will only enable a general classification of snowfall intensity
- Not useful for other precipitation conditions
- Doesn't provide a LWE, and thus won't eliminate interpretation of holdover time range



# MAKING THE CASE FOR HOLDOVER TIME DETERMINATION SYSTEMS

## SIMPLISTIC SUMMARY

SCIENCE

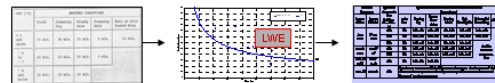


OPERATIONS



## LOGICAL SCENARIO

SCIENCE



OPERATIONS



## BUSINESS CASE FOR USING LWE

FLIGHT CREW DE/ANTI-ICING DECISIONS AT YUL

OPERATIONAL DATA COLLECTION 2004-06

1459 Total Data Points (Departures)

- Type IV fluid was unnecessary: **27%** → COST SAVINGS, ENVIRONMENTAL IMPACT REDUCTIONS, IMPROVED OPERATIONAL EFFICIENCY
- Good fluid decision: **61%**
- Aircraft did not deice: **8%** → SAFETY ENHANCEMENT
- Took off with Exceeded Holdover Times: **4%**



## POTENTIAL BENEFITS


- More frequent winter weather information for winter flight planning
  - More accurate identification of deicing conditions
  - Better identification of icing weather
- Accurate determination of fluid holdover times
  - Enable better fluid selection
  - Enable expanded use of current holdover time information
  - Reduction of time factor involved in the holdover time assessment
  - Reduction of departures with exceeded fluid holdover times
- Economic Savings
  - Cost of fluid
  - Cost of glycol recovery and recycling
- Source Reduction of Glycol
  - Reduction of environmental impact and costs
- Operational Improvement
  - Airport congestion
  - Time management



# REGULATORY FRAMEWORK FOR IMPLEMENTATION OF HOTDS


## IMPLEMENTATION OF HOTDS INTO CANADIAN AIR OPERATIONS

- Transport Canada has been a strong supporter of HOTDS initiatives
- HOTDS output is an operational aviation product for use under ground icing operations, and therefore fell under CAR 622.11
- Methodology to achieve use of HOTDS in short term:
  - Development of a performance specification for HOTDS
  - Exemption from CAR 622.11 for operational use of the holdover time information provided by the HOTDS




## EXEMPTION DEVELOPMENT

- As part of a contract with TC, APS produced:
  - Draft Performance Specification document for Holdover Time Determination Systems (HOTDS)
  - Draft Exemption document from Subsection 602.11(4) of the *Canadian Aviation Regulations* and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 *Ground Icing Operations*




## EXEMPTION CONTENTS

- Exemption
- Appendices
  - Appendix A: Description of the applicable Canadian Aviation Regulations and Standard
  - Appendix B: Definitions of terms employed in the Exemption
  - Appendix C: Minimum Assurance Requirements and Performance Specifications for Holdover Time Determination Systems




## APPENDIX C CONTENTS

1. Quality Management System
2. Training and Qualifications
3. Installation, Siting, Operation and Maintenance of HOTDS
4. Accuracy of Holdover Time Input Instruments and Determination Systems
5. Technical requirements for Data Inputs and Holdover Time Determinations
  - Wind
  - Precipitation Type
  - Temperature
  - Precipitation Rate
  - Holdover Time Determinations
  - Holdover Time Determination Reports



## EXEMPTION STATUS


- First version of the TC Air Carrier Exemption (for operational use of the HOTDS outputs) was issued to WestJet in March 2007
- Revised version of the TC Air Carrier Exemption was issued to WestJet on December 21, 2007



# CURRENT STATE OF HOTDS TECHNOLOGY


## CURRENT STATE OF TECHNOLOGY

- HOTDS equipment has been in the research and development phase for several years
- In August 2003, APS was contracted by a HOTDS manufacturer to conduct an independent technical evaluation of the 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 OF HOTDS

- APS compared D-Ice A/S System outputs (rate, precipitation classification, temperature) with:
  - Manual data collections (using historical holdover time precipitation rate methodology)




## TEST SUMMARY – WINTER 2003-08

### D-ICE A/S DEICING INFORMATION SYSTEM



Approximately 2400 data points collected with the DIIS in approximately 90 data collection events



### TECHNICAL COMPLIANCE

- Technical compliance of the D-Ice system with the TC minimum performance specifications for HOTDS is currently being documented



## RECENT WORK ON AIRPORT SITING OF HOTDS

### ACRP PROJECT 10-01

- In March 2007, APS was contracted by the Airport Cooperative Research Program (ACRP) to undertake Project 10-01: *Optimizing the Use of De/Anti-Icing Fluids*
- Objective of the ACRP 10-01 project is to examine and research technologies and procedures that could optimize current de/anti-icing practices
- One area of interest for the ACRP 10-01 Project was the future implementation of HOTDS technology



### AIRPORT SITING ISSUES WITH HOTDS

- De/anti-icing holdover time is directly dependent on precipitation intensity
- Vital that the intensity measured and employed for holdover time determination is indicative of what the aircraft will be exposed to during taxi
- It was unknown whether a HOTDS at a single airport location can provide data with enough reliability for this application



### AIRPORT SITING ISSUES WITH HOTDS

- Objective: Perform a preliminary study to examine if a single location HOTDS can reliably report precipitation conditions for an entire airport
- Objective was met by measuring precipitation rate, as well as other meteorological parameters affecting fluid holdover time, at two different airport locations simultaneously
  - Understand variances between test locations and determine the impact on the holdover times provided by the HOTDS



### PROCEDURES

- Testing was performed at Montreal-Trudeau International Airport; agreement was also reached in March 2008 to run testing at Boston-Logan International Airport
- Test procedure was based on the rate measurement methodology included in ARP 5485
  - Far more stringent version of the procedure was applied
- Test procedure consisted of measuring precipitation catch in four collection pans of a known area over a known period of time

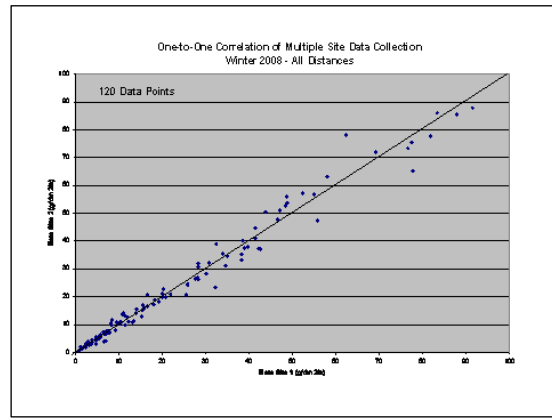
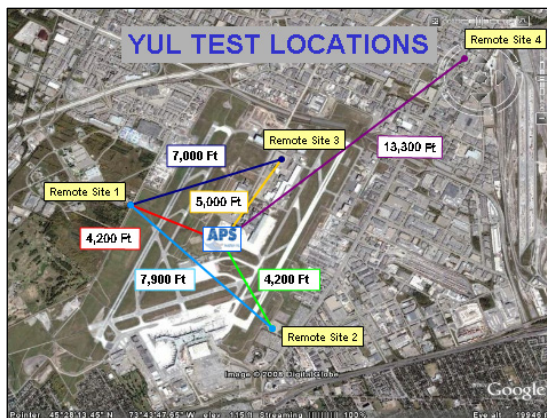
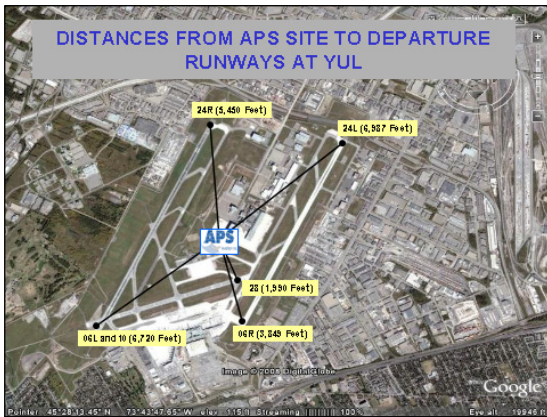
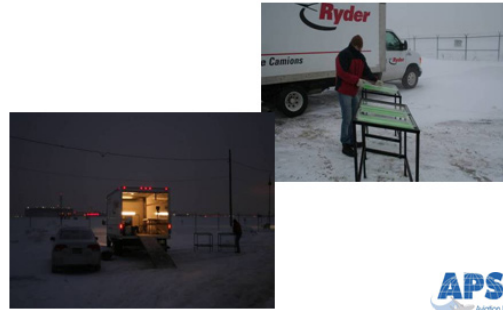


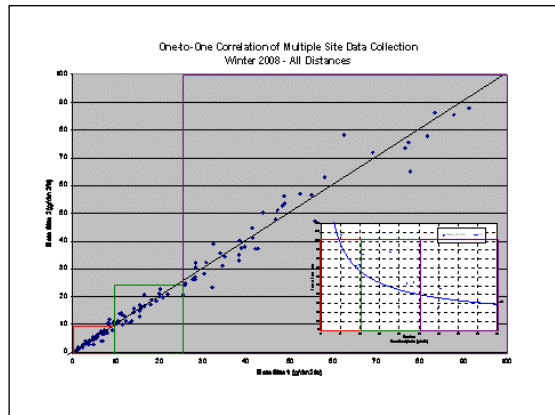
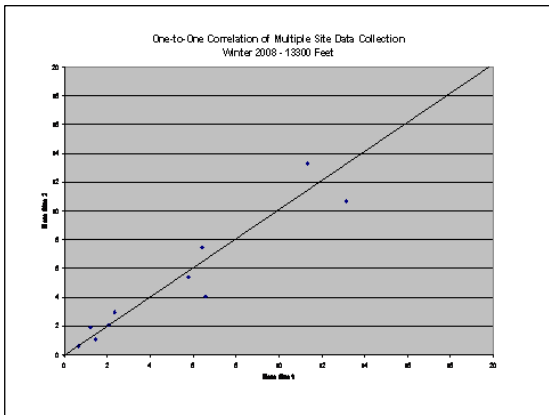
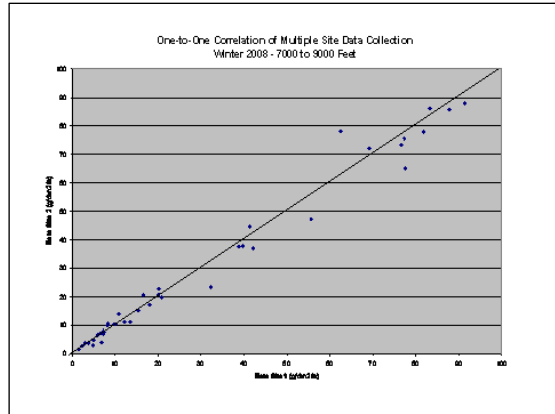
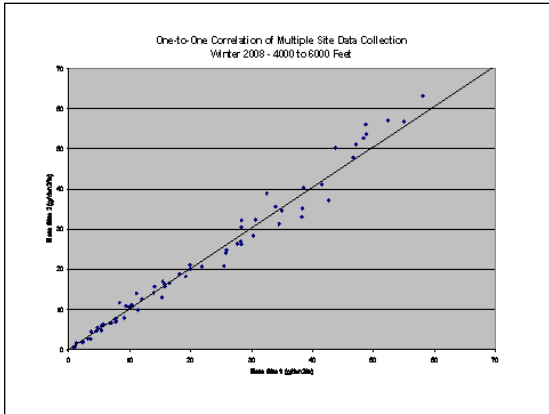
## PROCEDURES

- Data collections were performed at 10-minute intervals
  - Eliminate errors associated with data collections over short periods of time
  - To simulate what an aircraft could be subjected to during taxi
- Data collection teams performed the procedure at precisely the same time intervals at two different locations at the airport site
  - Distances ranged from 4,200 feet to 13,300 feet of separation



## PROCEDURES





## DATA ANALYSIS

- Data collection ended in March 2008
- Rate data from the various sites at YUL were similar
- Data analysis is currently ongoing
  - Statistical analysis of the data collected
  - Rate variance
  - Holdover time variance for different fluids
  - Add safeguards from the TC Minimum Performance Specifications to the data collected and examine variance of holdover times
  - Report will be provided to ACRP in Fall 2008


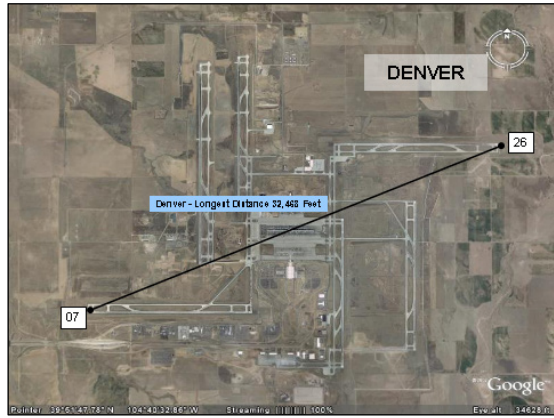
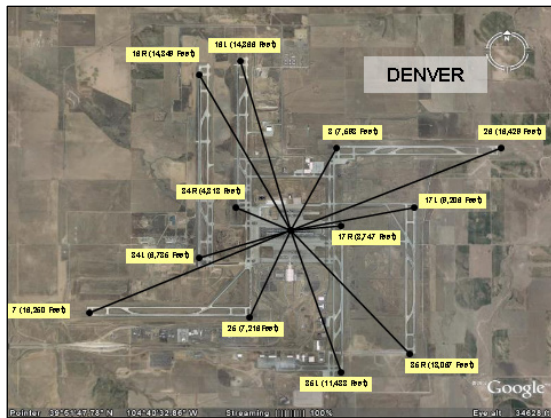
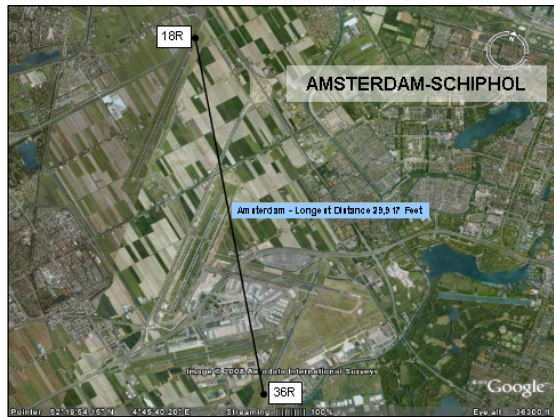


## AIRPORT CONSIDERATIONS



## AIRPORT-SPECIFIC CONSIDERATIONS


- The longest distance from the central location at YUL to an active departure runway was 7,000 feet
- Many other airports have significantly larger surface area than YUL
- Larger surface area may result in larger impact on the computed holdover times from HOTDS
  - May require installation of additional HOTDS near departure runways



### ADDITIONAL WORK


- Additional work should be performed to:
  - Gather more data
  - Examine effect of longer distances between data collection sites
  - Examine different weather types, temperature ranges, precipitation rates
    - Different airports
  - Potentially develop recommended practices (ARP) for implementing HOTDS at airport sites



### ONE IMPORTANT POINT!!!


- The current tools employed for de/anti-icing decision support (holdover time tables, METAR, visibility tables) are not optimized
  - Lack of LWE measurement does not enable defined holdover time determination or improved fluid selection
  - Frequency and content of weather updates for de/anti-icing operations are inadequate
  - Visibility is not an appropriate tool for advancing de/anti-icing decision support

Even a single HOTDS positioned at a central location at an airport site is a VAST improvement over the current status quo



### PRESENTATION CONCLUSIONS

- Current de/anti-icing support tools are not optimal
- Numerous benefits could be achieved through use of HOTDS measurements and outputs
- Regulatory framework and minimum performance specifications (TC) have been developed for use of HOTDS
- Technical assessment of HOTDS equipment has been completed and compliance is documented
- Airport siting considerations for HOTDS equipment are currently being examined





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# PROPOSED CHANGES TO FROST HOT GUIDELINES

By  
**Marco Ruggi**



*For*

**Transportation Development Centre  
Transport Canada**

*and the*

**Federal Aviation Administration**

SAE G-12 HOT SUBCOMMITTEE  
MONTREAL – NOVEMBER 5, 2008

**APS**

### PURPOSE

- Data collected by APS in natural frost conditions was presented at several meetings including the G-12 meeting in
  - San Diego (May 2007)
  - Montreal (November 2007)
  - Warsaw (May 2008)
- Attention was focused on:
  - **Reduced Endurance Times in Frost Conditions due to Fluid Freeze Point Issues**

**APS**

### PURPOSE

- Several meetings have been held between January and October 2008
- Attendees
  - Federal Aviation Administration
  - Transport Canada
  - APS
  - 2 Aircraft Operators
  - 1 Fluid Manufacturer
- Objective: Review current data available and scrutinize and further develop the proposed changes to the Frost HOT Guidelines

**APS**

### PURPOSE

- Present proposed options for changes to frost HOT guidelines
- Obtain industry feedback to focus the direction for change

**APS**

### PRESENTATION OUTLINE

- **BACKGROUND**
- PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

**APS**

### BACKGROUND

- A survey of deicing activities at airports was conducted by APS
- Data was collected from airports in North America, Europe and Asia
- Results showed removal of frost contamination represents a significant portion of deicing operations.
  - 90% of operations for airports with warmer climates
    - I.e. London and Paris
  - 25% of operations for airports with colder climates
    - I.e. Montreal

**APS**

### BACKGROUND

→ Frequency of Deicing Operations Airport Survey 2000-03

Category	Percentage
Snow	56%
Frost	33%
Other	11%

TC report TP 14375E

**APS**  
Aircraft Performance Solutions

## BACKGROUND

- Frost HOT have always been a part of the HOT guidelines, however fluid endurance times in frost conditions have never been measured.
- Outdoor endurance time testing in natural frost conditions for Type I,II,III,IV fluids was recommended

**APS**  
Aircraft Performance Solutions

## BACKGROUND

- Testing was conducted by APS to:
  - Monitor Test Parameters
    - Flat Plate Testing
    - Full Scale Aircraft Tests
  - Validate Type I HOT for Frost Conditions
  - Validate Type II/III/IV HOT for Frost Conditions

**APS**  
Aircraft Performance Solutions

## PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

**ESTABLISH TEST PARAMETERS**

Thermistor Probes

White Painted Aluminum Plate

Insulation Backing

Parameters Measured:

- Icing Intensity
- Plate/OAT Temp Differential

**ESTABLISH TEST PARAMETERS**

Temperature Probe

Parameters Measured:

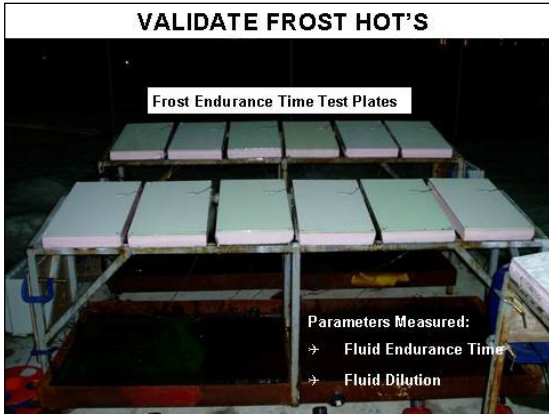
- Wing/OAT Temp Differential

RJ Wing

**APS**  
Aircraft Performance Solutions

## FROST $\Delta T$ PARAMETERS

- PLATE TESTS
  - 144 endurance time data points collected
  - Test Plate and OAT temperature differential ranged from 2°C to 9°C
  - Temperature differential calculated as:
    - Average OAT – Average Plate Temp. = Temp. Differential
- FULL-SCALE WING
  - 122 data points collected
  - Wing and OAT temperature differential reached up to 6.5°C
  - Temperature differential calculated as:
    - Instant OAT – Instant Wing Temp. = Temp. Differential



**APS**

**ENDURANCE TIME RESULTS**

- **Type I fluids**
  - The measured endurance times did not violate the long used HOT of 45 minutes.
  - Based on the data collected, the Type I HOTs were substantiated.

**APS**

**ENDURANCE TIME RESULTS**

- **Type III fluids**
  - Endurance time data collected exceeded the current frost HOT guidelines for Type III fluids
  - Based on the data collected, reductions to the Type III frost HOT's are not required

**APS**

**ENDURANCE TIME RESULTS**

- **Type II and Type IV fluids**
  - Reduced endurance times were observed when compared to the current frost HOT guidelines for Type II/IV fluids
  - Discrepancy in endurance times was attributed to fluid freeze point issues for the majority of the reductions observed

**APS**

**PRESENTATION OUTLINE**

- BACKGROUND
- PREVIOUS WORK
- **FLUID FREEZE POINT FAILURE**
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

**APS**

**FLUID FREEZE POINT FAILURE**

- Reduced fluid endurance times were experienced when OAT approached fluid LOUT
- The plate surface temperature would cool closer to the fluid freeze point causing fluid failure
- Fluid dilution and erosion did not significantly contribute to the failure

### FLUID FREEZE POINT FAILURE

→ EXAMPLE

- Type IV 75/25 Fluid
- OAT = -13.9°C (within operational limit)
- Plate Temperature = -13.9°C – (7 °C) = -20.9°C
- Fluid Freeze Point (FFP) = -21°C
  - Fluid would be designed with 7°C buffer based on operational limit of -14°C
- **Plate temperature is cooled to FFP**
- **Fluid experiences contamination as ice crystals begin to form sporadically in fluid**

### FLUID FREEZE POINT FAILURE

→ Fluid freeze point failure can be experienced with dilutions when operating at the lower end of the temperature ranges

→ Assuming  $\Delta T = 7^\circ\text{C}$

Type III/IV Dilution	Lowest Possible Condition Temperature (°C)	Approximate FFP (°C)	Possible Surface Temp. During Frost Conditions (°C)
Neat	-25	-36	-32
75/25	-14	-21	-21
50/50	-3	-10	-10

### FLUID FREEZE POINT FAILURE

- The HOT table provides operational ranges specifying limits based on OAT
- In frost conditions, the skin temperature of an aircraft may be several degrees lower than the OAT
- If operating with a fluid close to the lower end of the temperature range during frost conditions, the skin temperature of the aircraft could reach the fluid freeze point potentially causing ice to form in the fluid
- **FROST HOT'S SHOULD CONSIDER THE EFFECT OF SKIN TEMPERATURE**

### PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- **ALTERNATIVES FOR CHANGES**
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

### ALTERNATIVES FOR CHANGES

- Changes to the Frost HOT's are necessary to account for:
  - Endurance Time Data Collected
  - Fluid Freeze Point Failure
- 4 Options were developed and evaluated:
  - **SEPARATE FROST HOT TABLE**
  - **NOTE IN HOT TABLE (INTERIM SOLUTION)**
  - **CURRENT HOT FORMAT / REDUCED HOT'S**
  - **CURRENT HOT FORMAT / OAT FOOTNOTES**

### OPTION 3 SEPARATE FROST TABLE

- Issue frost HOT's on a separate table
- Remove frost HOT's from generic and fluid specific tables
- Change temperature ranges to reflect skin temp. differential experienced during frost conditions

PROPOSED OPTIONS FOR CHANGES TO FROST HOLD GUIDELINES

TABLE 1 - FROST

SAE TYPE I<sup>1</sup>, II, III, IV FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008

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

Degrees Celsius	Degrees Fahrenheit	Type IV Fluid Concentration (Neat Fluid/Water) (Volume/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
			Active Frost			
			Type I <sup>2</sup>	Type II	Type III	Type IV
above -1	above 30	1000	8:00	2:00	12:00	
		75/25	5:00	1:00	5:00	
		50/50	3:00	0:30	3:00	
		1000	8:00	2:00	12:00	
below -1	below 30	75/25	5:00	1:00	5:00	
to -3	to 27	50/50	3:00	0:30	3:00	
		1000	8:00	2:00	12:00	
below -3	below 27	75/25	5:00	1:00	5:00	
to -10	to 14	50/50	3:00	0:30	3:00	
		1000	8:00	2:00	12:00	
below -10	below 14	75/25	5:00	1:00	5:00	
to -14	to 7	50/50	3:00	0:30	3:00	
		1000	8:00	2:00	12:00	
below -14	below 7	75/25	5:00	1:00	5:00	
to -21	to 0	50/50	3:00	0:30	3:00	
		1000	8:00	2:00	12:00	
below -21	below -10	75/25	5:00	1:00	5:00	
to -25	to -13	50/50	3:00	0:30	3:00	

NOTES (TO BE DEVELOPED FURTHER)

- 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.
- Must be used below -20°C (-13°F) provided the OAT of the fluid is respected.

CAUTIONS (TO BE DEVELOPED FURTHER)

- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOLD GUIDELINES

TABLE 3- Generic

SAE TYPE II FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>

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

Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration (Neat Fluid/Water) (Volume/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
			Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>2</sup>	Light Freezing Rain	Rain on Cold Soaked Wing	Other <sup>3</sup>
-3 and above	27 and above	1000	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	
		75/25	0:25 - 1:00	0:15 - 0:30	0:20 - 0:45	0:10 - 0:25	0:05 - 0:25	
		50/50	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10		
below -3	below 27	1000	0:20 - 1:05	0:15 - 0:30	0:15 - 0:45 <sup>2</sup>	0:10 - 0:20 <sup>2</sup>		CAUTION: No holdover time guidelines exist
to -14	to 7	75/25	0:20 - 0:55	0:10 - 0:20	0:15 - 0:30 <sup>2</sup>	0:05 - 0:15 <sup>2</sup>		
below -14	below 7	1000	0:15 - 0:20 <sup>2</sup>	0:15 - 0:30 <sup>2</sup>				
to -25	to -13	1000						

Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 1°C (1.8°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

- Based on the lowest holdover times of the Type II fluids listed in Table 3-2.
- Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10°C (18°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-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOLD GUIDELINES

TABLE 2- Generic

SAE TYPE II FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>

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

Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration (Neat Fluid/Water) (Volume/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
			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>
-3 and above	27 and above	1000	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	
		75/25	5:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:40	0:10 - 0:25	0:05 - 0:25	
		50/50	3:00 <sup>2</sup>	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10		
below -3	below 27	1000	8:00 <sup>2</sup>	0:20 - 1:05	0:15 - 0:30	0:15 - 0:45 <sup>2</sup>	0:10 - 0:20 <sup>2</sup>		CAUTION: No holdover time guidelines exist
to -14	to 7	75/25	5:00 <sup>2</sup>	0:20 - 0:55	0:10 - 0:20	0:15 - 0:30 <sup>2</sup>	0:05 - 0:15 <sup>2</sup>		
below -14	below 7	1000	3:00 <sup>2</sup>	0:15 - 0:20 <sup>2</sup>	0:15 - 0:30 <sup>2</sup>				
to -25	to -13	1000							

Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 1°C (1.8°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

- Based on the lowest holdover times of the Type II fluids listed in Table 3-2.
- Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10°C (18°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Substantive icing during active frost conditions may reduce holdover times when operating close to the lower end of the outside air temperature range.
- Ensure that the lowest operational use temperature (LOUT) is respected.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 4-Generic:  
SAE TYPE IV FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<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 (lower limits only)					Other <sup>2</sup>
Degrees Celsius	Degrees Fahrenheit	Heat Fluid/Water (wt/wt %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100G	12:00	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50
		75/25	5:00	1:15 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35
below -3 to -14	below 27 to 7	50/50	3:00 <sup>4</sup>	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10	CAUTION: No holdover time guidelines exist
		100G	12:00 <sup>4</sup>	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 <sup>5</sup>	0:10 - 0:25 <sup>5</sup>	
below -14 to -25	below 7 to -13	75/25	5:00 <sup>4</sup>	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>5</sup>	0:10 - 0:20 <sup>5</sup>	CAUTION: No holdover time guidelines exist
below -25	below -13	100G	12:00 <sup>4</sup>	0:15 - 0:40 <sup>5</sup>	0:15 - 0:30 <sup>5</sup>	0:15 - 0:30 <sup>5</sup>	0:10 - 0:20 <sup>5</sup>	

NOTE: 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 4.  
2. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.  
3. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.  
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.  
5. Reusable coating during active frost operations may reduce holdover times when operating close to the lower end of the outside air temperature range.  
6. Ensure that the lowest operational use temperature (LOUT) is respected.

CAUTIONS:  
1. The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.  
2. The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.  
3. High wind velocity or jet blast may reduce holdover time.  
4. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.  
5. Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ PREVIOUS WORK
- ➔ FLUID FREEZE POINT FAILURE
- ➔ ALTERNATIVES FOR CHANGES
  - ➔ Option 3
  - ➔ Option 4
  - ➔ Option 1
  - ➔ Option 2
- ➔ POTENTIAL FUTURE WORK
- ➔ OPEN DISCUSSION

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## OPTION 1 CURRENT FORMAT / REDUCED HOT'S

- ➔ Use current temperature breakdowns for Frost HOT's
- ➔ Issue reduced HOT changes in current HOT table format

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PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 2-Generic:  
SAE TYPE II FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<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 (lower limits only)					Other <sup>2</sup>
Degrees Celsius	Degrees Fahrenheit	Heat Fluid/Water (wt/wt %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100G	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40
		75/25	5:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:45	0:10 - 0:25	0:05 - 0:25
below -3 to -14	below 27 to 7	50/50	3:30	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10	CAUTION: No holdover time guidelines exist
		100G	8:00	0:20 - 1:05	0:15 - 0:30	0:15 - 0:45 <sup>4</sup>	0:10 - 0:20 <sup>4</sup>	
below -14 to -25	below 7 to -13	75/25	5:00	0:20 - 0:55	0:10 - 0:20	0:15 - 0:30 <sup>5</sup>	0:05 - 0:15 <sup>5</sup>	CAUTION: No holdover time guidelines exist
below -25	below -13	100G	8:00	0:15 - 0:20 <sup>5</sup>	0:15 - 0:30 <sup>5</sup>	0:15 - 0:30 <sup>5</sup>	0:05 - 0:15 <sup>5</sup>	

NOTE: 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 2-2.  
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:  
1. The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.  
2. The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.  
3. High wind velocity or jet blast may reduce holdover time.  
4. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.  
5. Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ PREVIOUS WORK
- ➔ FLUID FREEZE POINT FAILURE
- ➔ ALTERNATIVES FOR CHANGES
  - ➔ Option 3
  - ➔ Option 4
  - ➔ Option 1
  - ➔ Option 2
- ➔ POTENTIAL FUTURE WORK
- ➔ OPEN DISCUSSION

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## OPTION 2 CURRENT FORMAT / OAT FOOTNOTES FOR DILUTED FLUIDS

- ➔ Issue changes in the current HOT tables
- ➔ Restrict use of DILUTED fluids to reflect skin temp. differential experienced during frost conditions
- ➔ Include notes in tables to describe temperature restrictions

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PROPOSED OPTIONS FOR CHANGES TO FROST HOT GUIDELINES

TABLE 2 Generic  
SAE TYPE II FLUID HOLOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>  
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration Fluid/Water parts by mass	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							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	27 and above	75/25	8:00	0:35 - 1:30	0:25 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	0:05 - 0:25	
		50/50	3:00 <sup>4</sup>	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10			
below -3 to -14	below 27 to 7	100/0	2:00	0:20 - 0:05	0:15 - 0:30	0:15 - 0:45 <sup>5</sup>	0:10 - 0:20 <sup>6</sup>			CAUTION: No holdover time guidelines exist
		75/25	5:00	0:20 - 0:05	0:10 - 0:20	0:15 - 0:30 <sup>5</sup>	0:05 - 0:15 <sup>6</sup>			
below -14 to -25	below 7 to -13	100/0	2:00	0:15 - 0:20 <sup>7</sup>	0:15 - 0:30 <sup>7</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 2-2.  
2 Heavy snow, snow pellets, ice pellets, moisture and heavy freezing rain, and hail.  
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.  
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.  
5 Ensure that the lowest operational use temperature (LOUT) is respected.  
6 These holdover times only apply to outside air temperatures to -10°C (14°F) under active frost.  
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under active frost.

CAUTIONS  
1 The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.  
2 The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.  
3 High wind velocity or jet blast may reduce holdover time.  
4 Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.  
5 Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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## PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

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## POTENTIAL FUTURE WORK

- Full-scale HOT validation with Type II and Type IV fluids on TC Jetstar Wing in natural frost conditions
- Additional endurance time testing with Type II/III/IV fluids
  - Priority given to testing at above -3°C conditions and at the lower end of the temperature ranges for each fluid dilution.
- Hot vs. Cold endurance time testing with Type II/III/IV fluids
- Composite endurance time testing with Type II/III/IV fluids

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## WORKING GROUP

- APS has had discussions with industry operators and regulators
- It is anticipated that this working group approach will be continued during the coming year

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## PRESENTATION OUTLINE

- BACKGROUND
- PREVIOUS WORK
- FLUID FREEZE POINT FAILURE
- ALTERNATIVES FOR CHANGES
  - Option 3
  - Option 4
  - Option 1
  - Option 2
- POTENTIAL FUTURE WORK
- OPEN DISCUSSION

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SAE TYPE II FLUID HOLOVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>

TABLE 2 Generic

Outside Air Temperature Degrees Celsius	Degrees Fahrenheit	Type II Fluid Concentration Fluid/Water parts by mass	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							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	27 and above	75/25	8:00	0:35 - 1:30	0:25 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	0:05 - 0:25	
		50/50	3:00 <sup>4</sup>	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10			
below -3 to -14	below 27 to 7	100/0	2:00	0:20 - 0:05	0:15 - 0:30	0:15 - 0:45 <sup>5</sup>	0:10 - 0:20 <sup>6</sup>			CAUTION: No holdover time guidelines exist
		75/25	5:00	0:20 - 0:05	0:10 - 0:20	0:15 - 0:30 <sup>5</sup>	0:05 - 0:15 <sup>6</sup>			
below -14 to -25	below 7 to -13	100/0	2:00	0:15 - 0:20 <sup>7</sup>	0:15 - 0:30 <sup>7</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 2-2.  
2 Heavy snow, snow pellets, ice pellets, moisture and heavy freezing rain, and hail.  
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.  
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.  
5 Ensure that the lowest operational use temperature (LOUT) is respected.  
6 These holdover times only apply to outside air temperatures to -10°C (14°F) under active frost.  
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under active frost.

CAUTIONS  
1 The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.  
2 The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.  
3 High wind velocity or jet blast may reduce holdover time.  
4 Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.  
5 Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

Option 1

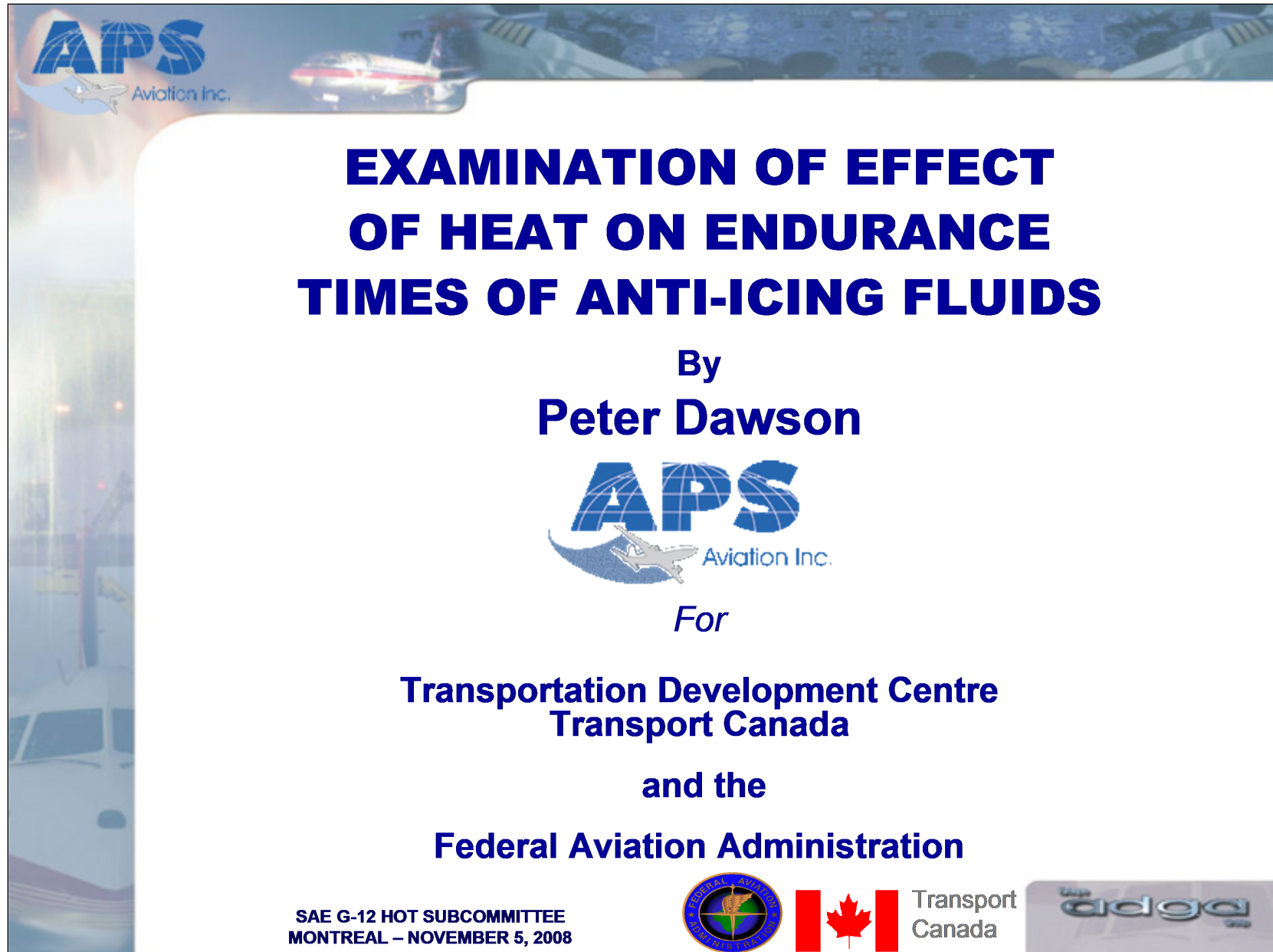
Option 2

Option 3

Option 4



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**APS**  
Aviation Inc.

# **EXAMINATION OF EFFECT OF HEAT ON ENDURANCE TIMES OF ANTI-ICING FLUIDS**

By  
**Peter Dawson**

**APS**  
Aviation Inc.



*For*

**Transportation Development Centre  
Transport Canada**


and the

**Federal Aviation Administration**

SAE G-12 HOT SUBCOMMITTEE  
MONTREAL – NOVEMBER 5, 2008



Transport  
Canada



**APS**  
AIRCRAFT

### EXAMINATION OF EFFECT OF HEAT ON ENDURANCE TIMES OF ANTI-ICING FLUIDS

Background

- Following the implementation of the Type I Fluid endurance test protocol based on application of heated fluid, questions arose about the use of heated Type II and IV.
- Some operators use heated Type II and Type IV fluids in 50/50 and 75/25 concentrations in one-step deicing.
- A field survey found that the applied temperature of Type II and Type IV fluids was often well above OAT, due to heat transfer between truck tanks.
  - Overall sample: fluid temp averaged 14°C above OAT
  - Lowest 60% ranged from 0 to 17°C and averaged 9°C above OAT
  - Highest 20% ranged from 25 to 69°C and averaged 40°C above OAT
- Type III fluid was introduced as a replacement for Type I, and applied heated as a one-step procedure, or potentially, as unheated fluid for second step, but was tested with fluid at OAT.

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### EXAMINATION OF EFFECT OF HEAT ON ENDURANCE TIMES OF ANTI-ICING FLUIDS

Background

- Guidance material for heated fluids was provided in FAA Approved Deicing Program Updates:
  - no basis for reducing the current MOT guideline values for Types II and IV fluids or using the Type I fluid MOT guidelines when heated Type II and IV fluids are properly applied.
  - anti-icing applications of Type III fluid may be heated or unheated.

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### EXAMINATION OF EFFECT OF HEAT ON ENDURANCE TIMES OF ANTI-ICING FLUIDS

Objective:

To compare endurance time tests obtained from heated Type II, III and IV fluids to times produced by the standard test protocol.

- Tests were conducted in pairs to compare ET from heated fluid to OAT fluid
- Tests in natural snow at the APS test site at the Montreal-Trudeau Airport
- Tests in freezing precipitation at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa
- Tests on eleven fluid brands and three fluid types.

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### Fluids Tested

Fluid Brand	Fluid Type	Dilution/Treatment	Commercial or Experimental Fluid
Fluid A	II	50% 75%, 100%	Commercial
Fluid B	III	50% 75%, 100%	Commercial
Fluid C1	IV	75% 100%	Experimental
Fluid C2	II	50% 75%, 100%	Commercial
Fluid D	IV	50% 75%, 100%	Commercial
Fluid E	IV	100%	Commercial
Fluid F	II	50% 75%	Commercial
Fluid G	IV	75%	Commercial
Fluid H	IV	50% 75%	Experimental
Fluid I	II	50% 75%	Experimental
Fluid J	III	50% 75%, 100%	Experimental

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### Test Method - Outdoor tests in natural snow

- Cold fluid test was conducted according to current Type II/III/IV fluid endurance protocol (1.0 L of fluid at OAT on standard aluminum plate).
- Heated fluid test was conducted with the current Type I protocol for outdoor tests (0.5 L of fluid at 60°C on empty 7.5 cm box).
- The Type I protocol for outdoor tests was examined and confirmed to be a valid method for testing heated Type II, III and IV fluids outdoors;
  - Heated Type IV on a box produced a temperature profile similar to that of heated Type IV on a wing. Both temperature profiles (box and wing) fit within the scatter of the Type I data previously collected.

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### Test Method - Indoor tests in artificial precipitation

- Cold fluid test conducted according to current Type II/III/IV fluid endurance protocol (1.0 L of fluid at OAT on standard aluminum plate).
- Initial heated fluid tests were conducted with 1.0L of fluid at 60°C on flat plate. This differs from the Type I indoor test protocol, which is based on fluid applied at 20°C.
- Later in the test series, after reviewing some indoor test data, it was suspected that the 60°C temperature might have had too much influence on endurance times for some tests, particularly short duration tests.
- Before further lab tests in 2007, the test procedure was reviewed. Duplicate tests were run with Type III Fluid at 20°C and 60°C temperatures.

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Test Method - Indoor tests in artificial precipitation

- Results led to the conclusion that indoor laboratory testing for heated Type III fluid should be conducted with fluid applied at 20°C.
- For Type II, and IV fluids, the test data collected with fluid at 60°C was found to be valid for the purpose of the study.

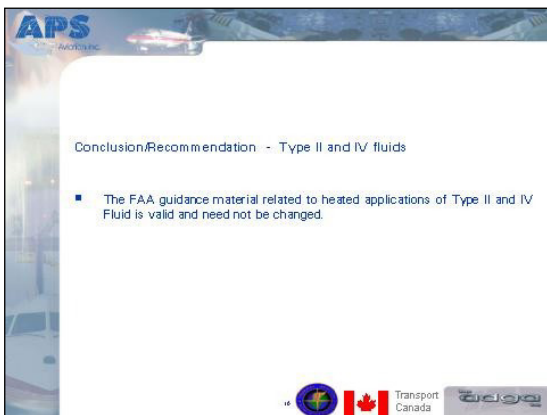
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Findings - Type II and IV fluids

- With the exception of one specific Type II fluid brand, the initial data was sufficient to conclude that endurance times from heated applications of Type II and IV fluids was equal to or better than that from cold fluid applications.
- The Type II Fluid exception (Fluid A):
  - is being withdrawn from production.
  - Showed some endurance time reduction for heated fluid in freezing drizzle and freezing rain, at high precipitation rates and cold temperatures.
  - Showed little difference in snow tests between heated and cold fluid applications.

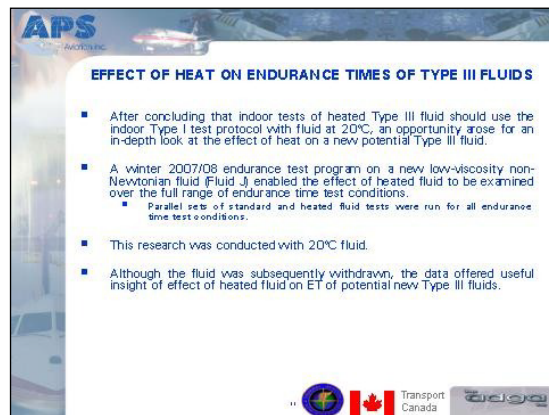
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Conclusion/Recommendation - Type II and IV fluids

- The FAA guidance material related to heated applications of Type II and IV Fluid is valid and need not be changed.

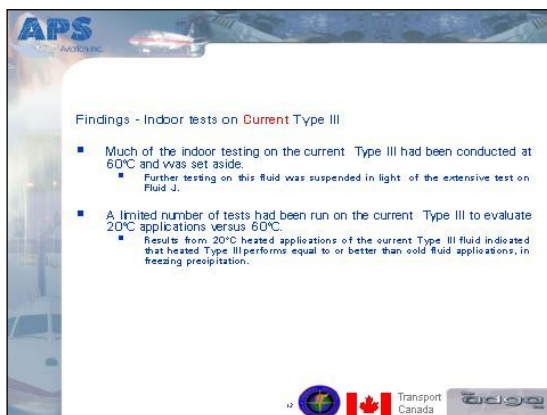
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EFFECT OF HEAT ON ENDURANCE TIMES OF TYPE III FLUIDS

- After concluding that indoor tests of heated Type III fluid should use the indoor Type I test protocol with fluid at 20°C, an opportunity arose for an in-depth look at the effect of heat on a new potential Type III fluid.
- A winter 2007/08 endurance test program on a new low-viscosity non-Newtonian fluid (Fluid J) enabled the effect of heated fluid to be examined over the full range of endurance time test conditions.
  - Parallel sets of standard and heated fluid tests were run for all endurance time test conditions.
- This research was conducted with 20°C fluid.
- Although the fluid was subsequently withdrawn, the data offered useful insight of effect of heated fluid on ET of potential new Type III fluids.

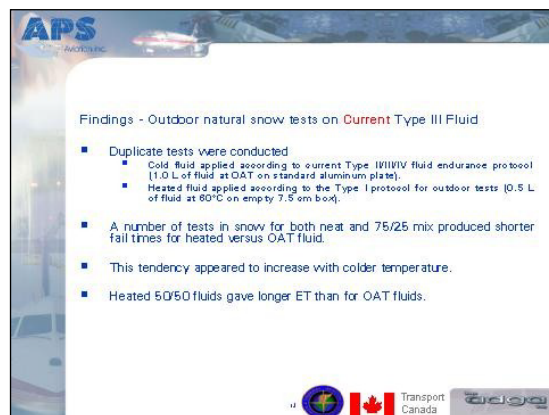
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Findings - Indoor tests on Current Type III

- Much of the indoor testing on the current Type III had been conducted at 60°C and was set aside.
  - Further testing on this fluid was suspended in light of the extensive test on Fluid J.
- A limited number of tests had been run on the current Type III to evaluate 20°C applications versus 60°C.
  - Results from 20°C heated applications of the current Type III fluid indicated that heated Type III performs equal to or better than cold fluid applications, in freezing precipitation.

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Findings - Outdoor natural snow tests on Current Type III Fluid

- Duplicate tests were conducted.
  - Cold fluid applied according to current Type III/IV fluid endurance protocol (1.0 L of fluid at OAT on standard aluminum plate).
  - Heated fluid applied according to the Type I protocol for outdoor tests (0.5 L of fluid at 60°C on empty 7.5 cm box).
- A number of tests in snow for both neat and 75/25 mix produced shorter fail times for heated versus OAT fluid.
- This tendency appeared to increase with colder temperature.
- Heated 50/50 fluids gave longer ET than for OAT fluids.

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### POTENTIAL FLUID J HOLDOVER GUIDELINES

Deck or Cabin Temperature	Deck or Cabin Fahrenheit	Type III Fluid Category	Endurance Times and Release Weather Conditions (Minutes)							Other
			Freezing Fog	Snow or Snow Drizzle			Freezing Drizzle	Light Freezing Rain	Wet on Cold Deck or Wing	
			Very Light	Light	Medium	Heavy	Light			
3 and above	21 and above	1000	PLU J Cold	60-100	25	40	20	20-40	14-21	0-20
			PLU J Heated	80-100	40	20	10	10-20	4-20	
			PLU J Cold	80-100	20	10	10	10-20	4-20	
			PLU J Heated	80-100	20	10	10	10-20	4-20	
below 3 to 10	below 27 to 64	1000	PLU J Cold	35-77	10	10	10	20-30	13-20	
			PLU J Heated	35-77	10	10	10	20-30	13-20	
			PLU J Cold	35-40	10	10	10	10-20	6-14	
			PLU J Heated	35-40	10	10	10	10-20	6-14	
below 10	below 14	1000	PLU J Cold	25-43	10	10	10	10-20	6-14	
			PLU J Heated	25-43	10	10	10	10-20	6-14	

**CAUTION:** No holdover time guidelines exist

### FLUID J ENDURANCE TIMES COMPARED TO TYPE III HOT

- ET for Fluid J are notably longer than Type III HOT, both for heated and OAT fluid temperature applications

### POTENTIAL FLUID J HOLDOVER GUIDELINES COMPARED TO TYPE III

Deck or Cabin Temperature	Deck or Cabin Fahrenheit	Type III Fluid Category	Endurance Times and Release Weather Conditions (Minutes)							Other
			Freezing Fog	Snow or Snow Drizzle			Freezing Drizzle	Light Freezing Rain	Wet on Cold Deck or Wing	
			Very Light	Light	Medium	Heavy	Light			
3 and above	21 and above	1000	Type III HOT	20-40	10	10	10	10-20	6-10	0-20
			PLU J Cold	60-100	25	40	20	20-40	14-21	0-20
			PLU J Heated	80-100	40	20	10	10-20	4-20	
			Type III HOT	20-40	10	10	10	10-20	6-10	0-20
below 3 to 10	below 27 to 64	1000	Type III HOT	10-20	10	10	10	10-20	6-10	0-20
			PLU J Cold	35-77	10	10	10	20-30	13-20	
			PLU J Heated	35-40	10	10	10	10-20	6-14	
			Type III HOT	10-20	10	10	10	10-20	6-10	0-20
below 10	below 14	1000	Type III HOT	20-40	10	10	10	10-20	6-10	0-20
			PLU J Cold	25-43	10	10	10	10-20	6-14	

**CAUTION:** No holdover time guidelines exist

### EFFECT OF HEAT ON TYPE III ENDURANCE TIMES

Summary

- Effect of heat on endurance times is not constant for all conditions or for all potential Type III fluids
- In snow
  - Heated 75/25 and neat sometimes produce shorter times. The gap increases with colder OAT.
- Fluid J
  - Heated 75/25 and 50/50 give longer times.
  - Heated neat matches OAT fluid at mild OAT, but lags at colder OAT
- In freezing precipitation (heated fluid at 20°C)
  - 2031 Fluid
    - Heated gives longer times for 50/50 mix and some 75/25 conditions
    - Heated neat fluid produces no change.
  - Fluid J
    - Heated gives much longer times for both 50/50 and 75/25 mixes.
    - Heated neat gives slightly longer times.
- Fluid J ET is notably longer than Type III HOT both for heated and OAT applications.

### FUTURE OF HEATED TYPE III

This examination raised some fundamental questions:

- Should Type III fluids be tested heated or cold, or both?
- What laboratory test protocol should be used?
- Should a separate HOT guideline be published for heated and cold times?
- Would it be feasible and advantageous to measure and produce Type III HOTs using buffered fluid instead of the three levels of 100, 75 and 50%?
  - Type III is moving closer to being viewed in the same way as Type I.
  - More and more deicers have fluid blenders.

### FUTURE OF HEATED TYPE III

Considerations:


- Heated Type III fluid endurance times differ from cold fluid applications; most are longer and some shorter.
- The effect of heat is not the same for all conditions:
  - Future Type III fluids may respond differently to heated application
  - Differences can be derived only through testing.
- Type III fluid was originally developed as a replacement for Type I fluid:
  - Used in the same manner as Type I fluid; i.e. heated, full strength, as a one-step operation.
  - Used primarily at regional airports where it is a drop-in replacement for Type I fluid, using the same unmodified deicing vehicles.
  - No known practical scenario where the fluid would be used in a cold application.
- A new Type III fluid may be introduced as a replacement for the current fluid during the next two seasons.

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**FUTURE OF HEATED TYPE III**

Recommendations:

- 1) The test method for Type III Fluid in SAE ARP5466 should be changed to reflect that tests be conducted with heated fluid, to accord with the actual mode of use in the field, and with the Type I fluid test protocol.
- 2) Review of the test method for Type III Fluid should consider whether it would be feasible and advantageous to test and develop HOTs based on buffered fluid rather than the current 100, 75 and 50% mixes.
- 3) Heated fluid applications should be the only approved method of use for Type III fluid when HOT times are required.
- 4) Fluid application guidelines should be modified to state that HOT times are applicable only when heated fluid is applied, as is the case for Type I fluid.




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**FUTURE OF HEATED TYPE III**

Recommendations Cont'd:

- 4) Holdover times for new Type III fluids should be published in fluid specific tables
  - Remove limitation of one generic table for all Type III Fluids.
  - Enable field operations to take advantage of the longer times from new Fluids.
  - Provide an incentive to fluid manufacturers to develop improved Type III Fluids.
- 5) The current SAE AMS1428 should be reviewed to better reflect the unique characteristics of SAE Type III Fluid.
- 6) It is not necessary nor practical to retest the current Type III fluid in accordance with Type I test protocol, in view of:
  - Its limited remaining life.
  - The long time associated with gaining approval, conducting the tests, presenting the results and publishing new holdover times.
  - The considerable safety buffer integrated into the current generic times.



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# **HOLDOVER TIMES BELOW -25°C FOR ANTI-ICING FLUIDS**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

For

**Transportation Development Centre  
Transport Canada**

and the

**Federal Aviation Administration**

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE  
MONTREAL – NOVEMBER 5, 2008

adga

## PRESENTATION OUTLINE

- ➔ BACKGROUND
- ➔ ENDURANCE TIME TESTING CONDUCTED
- ➔ OBSERVATIONS AND RECOMMENDATIONS

## BACKGROUND

- ➔ Lowest operational use temperature (LOUT) of thickened Type II and Type IV fluids is generally a few degrees below -25°C
  - ➔ Type II/IV LOUT is generally -28 or -29°C
- ➔ Holdover time (HOT) guidelines below -25°C do not exist for these fluids

**Transport Canada Holdover Time Guidelines Winter 2007-2008**

**TABLE 4-Generic**

**SAE TYPE IV FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**

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

Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Type IV Fluid Concentration Heat Fluid/Water (volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					Other <sup>2</sup>
			Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	
-3 and above	27 and above	1000	12:00	1:15 - 2:30	1:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50
		75/25	5:00	1:05 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10	
below -3 to -14	below 27 to 7	1000	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 <sup>4</sup>	0:10 - 0:25 <sup>5</sup>	CAUTION: No holdover time guidelines exist
75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>6</sup>	0:10 - 0:20 <sup>6</sup>			
50/50	3:00	0:15 - 0:40 <sup>7</sup>	0:15 - 0:30 <sup>7</sup>	0:10 - 0:20 <sup>7</sup>				
below -14 to -25	below 7 to -13	1000	12:00 <sup>8</sup>	0:15 - 0:40 <sup>8</sup>	0:15 - 0:30 <sup>8</sup>	0:15 - 0:30 <sup>8</sup>	0:10 - 0:20 <sup>8</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) 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						

**NOTES**

- Based on the lowest holdover times of the Type IV fluids listed in Table 5.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover time if precise identification of freezing drizzle is not possible.
- Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground de-icing/anti-icing do not provide inflight icing protection.

Page 17 of 40 October 2007

## BACKGROUND

- ➔ Testing is conducted for each qualified fluid in simulated freezing fog conditions at -25°C, however
- ➔ Natural snow data collected as part of the standard HOT testing protocol contains limited data at these colder temperatures.
- ➔ Generic HOT values are assigned for Type II and Type IV fluids below -14°C to -25°C in snow conditions.

**Transport Canada Holdover Time Guidelines Winter 2007-2008**

**TABLE 4-Generic**

**SAE TYPE IV FLUID HOLD-OVER GUIDELINES FOR WINTER 2007-2008<sup>1</sup>**

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

Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Type IV Fluid Concentration Heat Fluid/Water (volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					Other <sup>2</sup>
			Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle <sup>3</sup>	Light Freezing Rain	
-3 and above	27 and above	1000	12:00	1:15 - 2:30	1:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 0:50
		75/25	5:00	1:05 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:35
		50/50	3:00	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10	
below -3 to -14	below 27 to 7	1000	12:00	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45 <sup>4</sup>	0:10 - 0:25 <sup>5</sup>	CAUTION: No holdover time guidelines exist
75/25	5:00	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30 <sup>6</sup>	0:10 - 0:20 <sup>6</sup>			
50/50	3:00	0:15 - 0:40 <sup>7</sup>	0:15 - 0:30 <sup>7</sup>	0:10 - 0:20 <sup>7</sup>				
below -14 to -25	below 7 to -13	1000	12:00 <sup>8</sup>	0:15 - 0:40 <sup>8</sup>	0:15 - 0:30 <sup>8</sup>	0:15 - 0:30 <sup>8</sup>	0:10 - 0:20 <sup>8</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) 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						

**NOTES**

- Based on the lowest holdover times of the Type IV fluids listed in Table 5.
- Heavy snow, sleet pellets, ice pellets, moderate and heavy freezing rain, and hail.
- These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover time if precise identification of freezing drizzle is not possible.
- Ensure that the lowest operational use temperature (LOUT) is respected.

**CAUTIONS**

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground de-icing/anti-icing do not provide inflight icing protection.

Page 17 of 40 October 2007

## BACKGROUND

- ➔ Recent industry need to provide guidance material for operations with thickened fluids below -25°C
- ➔ Testing was required to investigate if the current holdover times in the cells "below -14°C to -25°C" could be extended to the fluid LOUT for Type II and Type IV fluids

**PRESENTATION OUTLINE**

- BACKGROUND
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS

**OBJECTIVE**

- To determine the differences in endurance time of Type II/IV fluid at -25°C in comparison to testing conducted at the fluid LOUT.

**METHODOLOGY**

- Standard indoor endurance time testing procedure and methodology was followed
- Preliminary testing was conducted with only three fluids in conjunction with standard HOT testing
- Comparative endurance time testing was conducted using the same fluids and dilution at both -25°C and -28.5°C in freezing fog conditions
- Visual fluid failure was used as the comparative measure, however the failure call was difficult

**ENDURANCE TIME TESTING**

- 3 preliminary comparative sets of tests were conducted

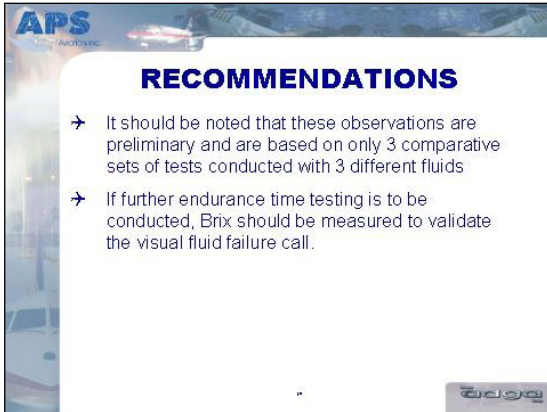
Test #	Fluid	Average Fail Time (min)	Average Rate of Precip (g/m <sup>2</sup> /hr)	Ambient Temp (°C)	Precipitation (Type)
LOUT1 / LOU1A	Type IV EG	37	4.4	-28.5	Freezing Fog
LOUT4 / LOU4A	Type IV EG	38	5.4	-25	Freezing Fog
LOUT2 / LOU2A	Type IV PG	40	4.7	-28.5	Freezing Fog
LOUT5 / LOU5A	Type IV PG	43	5.4	-25	Freezing Fog
LOUT3 / LOU3A	Type II PG	29	4.8	-28.5	Freezing Fog
LOUT6 / LOU6A	Type II PG	29	5.2	-25	Freezing Fog

**PRESENTATION OUTLINE**

- BACKGROUND
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS

**OBSERVATIONS**

- Results did not demonstrate significant differences in endurance times for -25°C vs. -28.5°C tests
- Based on the current generation of fluids (LOUT of approx -28.5°C), the current -25°C HOT's could potentially be expanded to apply to the fluid LOUT
  - Additional testing would be required to substantiate the results
- If fluid manufacturers begin to develop fluids with lower LOUT's, further testing will be required to substantiate the new LOUT HOT's.




Slide 1: Recommendations

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## RECOMMENDATIONS

- It should be noted that these observations are preliminary and are based on only 3 comparative sets of tests conducted with 3 different fluids
- If further endurance time testing is to be conducted, Brix should be measured to validate the visual fluid failure call.

“ 



Slide 2: Contact Information

**APS**  
Aviation Inc.

**Marco Ruggi**  
[mruggi@adga.ca](mailto:mruggi@adga.ca)

“ 

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# **HOLDOVER TIMES IN CONDITIONS OF RAIN MIXED WITH SNOW**

By  
**Marco Ruggi**

**APS**  
Aviation Inc.

*For*

**Transportation Development Centre  
Transport Canada**

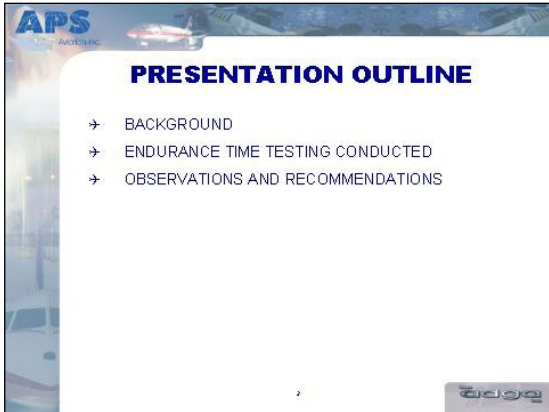
**and the**

**Federal Aviation Administration**

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE  
MONTREAL – NOVEMBER 5, 2008

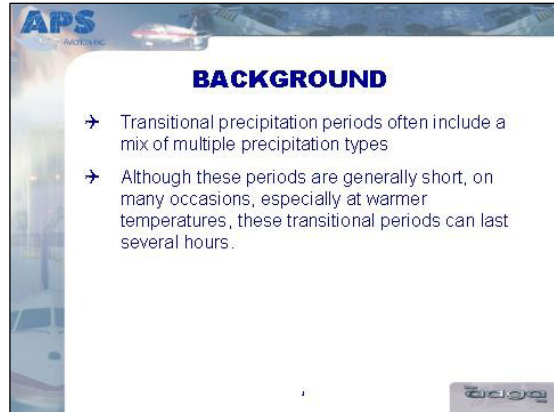
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## PRESENTATION OUTLINE

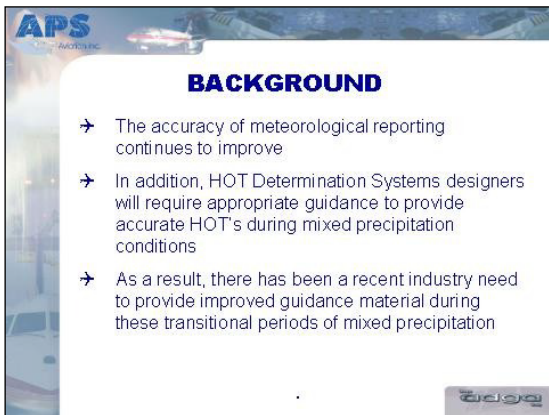
- BACKGROUND
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS



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## BACKGROUND

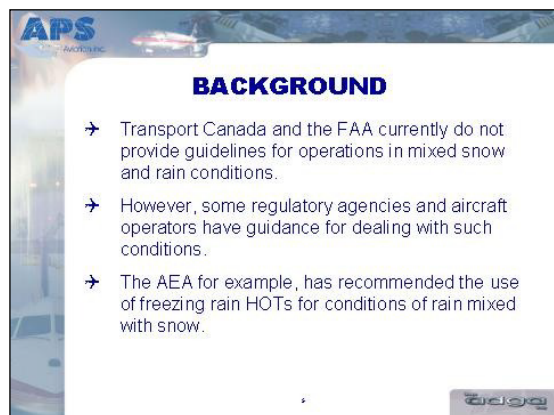
- Transitional precipitation periods often include a mix of multiple precipitation types
- Although these periods are generally short, on many occasions, especially at warmer temperatures, these transitional periods can last several hours.



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## BACKGROUND

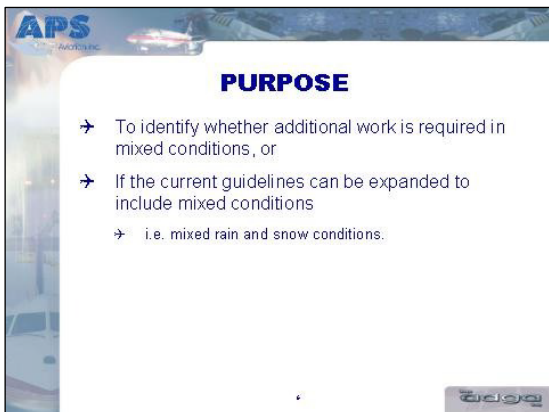
- The accuracy of meteorological reporting continues to improve
- In addition, HOT Determination Systems designers will require appropriate guidance to provide accurate HOT's during mixed precipitation conditions
- As a result, there has been a recent industry need to provide improved guidance material during these transitional periods of mixed precipitation



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## BACKGROUND

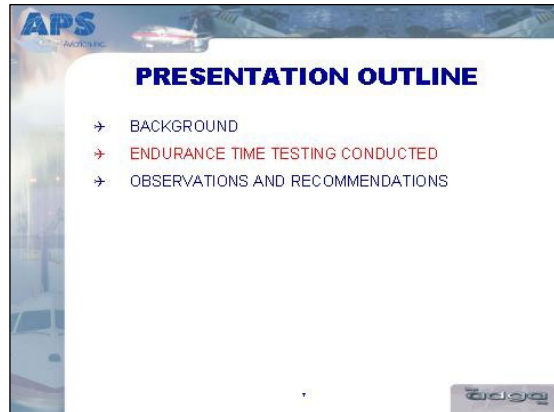
- Transport Canada and the FAA currently do not provide guidelines for operations in mixed snow and rain conditions.
- However, some regulatory agencies and aircraft operators have guidance for dealing with such conditions.
- The AEA for example, has recommended the use of freezing rain HOTs for conditions of rain mixed with snow.



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## PURPOSE

- To identify whether additional work is required in mixed conditions, or
- If the current guidelines can be expanded to include mixed conditions
  - i.e. mixed rain and snow conditions.



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## PRESENTATION OUTLINE

- BACKGROUND
- **ENDURANCE TIME TESTING CONDUCTED**
- OBSERVATIONS AND RECOMMENDATIONS

### METHODOLOGY

- Comparative endurance time testing was conducted using the same fluids and dilution at
  - -3°C (LZR)
  - +1°C (R/SN)
- Baseline light freezing rain tests (at 25 g/dm<sup>2</sup>/h) were conducted using standard indoor endurance time testing methodology
- Mixed Rain and Snow conditions generated by
  - Simulated Snow (Rate of 12 g/dm<sup>2</sup>/h)
  - Simulated Rain (Rate of 13 g/dm<sup>2</sup>/h)

### ENDURANCE TIME TESTING

→ 2 preliminary comparative sets of tests were conducted

Test #	Fluid	Endurance Time [min]	Approx. Rate of Precip (g/dm <sup>2</sup> /hr)	Ambient Temp (°C)	Final Brinx (°)	Precipitation (Type)
RS1	Type IV EG	59	25	1	8.00	Rain / Snow
RS1-1	Type IV EG	51	24	-3	5.50	Light Freezing Rain
RS2	Type IV PG	69	25	1	5.50	Rain / Snow
RS2-2	Type IV PG	61	24	-3	6.50	Light Freezing Rain

### FAILURE COMPARISON TYPE IV PG

### PRESENTATION OUTLINE

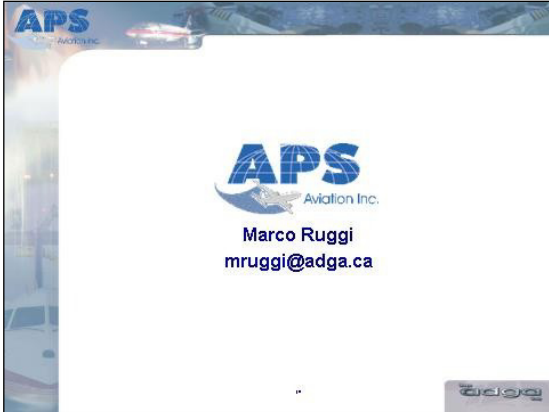
- BACKGROUND
- ENDURANCE TIME TESTING CONDUCTED
- OBSERVATIONS AND RECOMMENDATIONS

### OBSERVATIONS

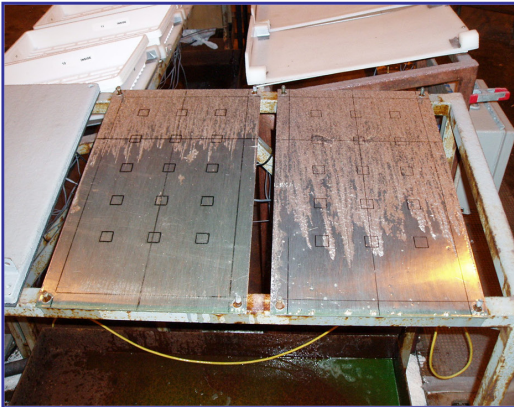
- The estimated endurance time in rain and snow was on average 10-15% longer as compared to the light freezing rain only test.
- At the estimated time of failure, adherence was present on the plate for both conditions.
- The condition of the fluid during the rain and snow test showed characteristics similar to light freezing rain conditions
  - i.e. presence of adherence and erosion of the fluid layer.

### RECOMMENDATIONS

- Light freezing rain holdover times seem a good conservative approach for mixed rain and snow conditions
  - This is in accordance with the Association of European Airlines (AEA) recommendation.
- These observations are based on only two comparative tests.
- Additional tests would be required to substantiate the conclusion.



# PREPARATION OF HOLDOVER TIME GUIDELINES REGRESSION COEFFICIENT DATA




**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
MONTREAL – NOV 5, 2008**

*Presented by Stephanie Bendickson*



**PREPARED AND PRESENTED ON BEHALF OF:**

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA

 Transport Canada



AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE



## OBJECTIVE

- To produce a table of regression coefficients for each holdover time table in the holdover time guidelines
- This enables users to calculate a precise holdover time for a given temperature and precipitation rate

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## BACKGROUND

- Over the past several years, several companies have been developing holdover time determination systems (HOTDS)
- HOTDS use real-time meteorological measurements in conjunction with the regression coefficients underlying the holdover time tables to provide precise holdover times for specific precipitation rates and temperatures
- The development of HOTDS has required Transport Canada and the FAA publish regression coefficient and equation information for all fluids

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## WHAT DATA IS REQUIRED?

- Data is required for each holdover time table included in the current holdover time guidelines
  - Generic Tables (4): Type I, Type II, Type III, Type IV
  - Fluid Specific Tables (22): Type II (9), Type IV (13)
- For each holdover time table, a table of regression coefficients is required
- Regression coefficients are required for each cell in each table (some exceptions, some additions)

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### SAMPLE HOLDOVER TIME TABLE

Outside Air Temperature		Wind Direction	Approximate Holdover Times Under Various Weather Conditions (See Table 10)						
Degrees Celsius	Degrees Fahrenheit		Active Precip	Freezing Fog	Over or Near Ceiling	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	1000	8:00	1:15 - 2:15	0:45 - 1:20	0:50 - 1:30	0:30 - 0:45	0:10 - 1:15	
		75/25	5:00	0:45 - 1:00	0:25 - 0:40	0:25 - 0:45	0:15 - 0:25	0:05 - 0:15	
		50/30	3:00	0:20 - 0:30	0:15 - 0:25	0:10 - 0:15	0:05 - 0:10		
below -3 to -14	below 27 to 1	1000	8:00	1:10 - 2:40	0:35 - 1:00	0:20 - 1:35	0:25 - 0:40		CAUTION: Holdover times are guidelines only!
		75/25	5:00	0:45 - 1:20	0:15 - 0:30	0:20 - 0:45	0:15 - 0:20		
below -14 to -25	below 7 to -10	1000	8:00	0:35 - 0:50	0:15 - 0:30				

### SAMPLE REGRESSION DATA TABLE

Outside Air Temperature		Wind Direction	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit		Active Precip	Freezing Fog	Over or Near Ceiling	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	1000	$I = 2.3076$ $A = -0.5804$	$I = 2.6239$ $A = -0.5936$ $B = -0.1965$	$I = 2.3723$ $A = -0.5075$	$I = 2.2358$ $A = -0.5338$	$I = 2.3521$ $A = -0.6723$	
		75/25	$I = 1.8926$ $A = -0.3695$	$I = 2.3890$ $A = -0.5522$ $B = -0.3127$	$I = 2.0098$ $A = -0.5277$	$I = 2.4102$ $A = -0.9057$	$I = 2.1732$ $A = -0.7748$	
		50/30	$I = 1.6153$ $A = -0.4676$	$I = 2.0865$ $A = -0.6802$ $B = -0.0385$	$I = 1.5310$ $A = -0.4446$	$I = 2.0917$ $A = -0.9811$		
below -3 to -14	below 27 to 1	1000	$I = 2.4847$ $A = -0.8764$	$I = 2.6239$ $A = -0.5936$ $B = -0.1965$	$I = 3.0544$ $A = -1.5316$	$I = 2.2370$ $A = -0.5743$	CAUTION: Holdover times are guidelines only!	
		75/25	$I = 2.0865$ $A = -0.6423$	$I = 2.3890$ $A = -0.5522$ $B = -0.3127$	$I = 2.2656$ $A = -0.8827$	$I = 2.0691$ $A = -0.6835$		
below -14 to -25	below 7 to -10	1000	$I = 1.6204$ $A = -0.4264$	$I = 2.2336$ $A = -0.7565$ $B = 0.0000$				

### WHERE IS THE DATA?

- Holdover time test data and analysis, including the regression coefficients, is published in the annual Transport Canada report on holdover time testing; it also exists electronically
- The information is archived each year



### DATA COLLECTION

- Data collection was somewhat complex due to:
  - the number of fluids involved
  - the existence of multiple data sets for several fluids
  - the data being archived up to 13 years ago
  - some values in the holdover time tables not being derived directly from regression analysis



### DATA COLLECTION PROCESS

- 1) The relevant data set(s) for each fluid were collected from the archives
- 2) The data sets of fluids tested in multiple years were compared to determine which data set was responsible for each specific value in the fluid's fluid-specific HOT table



### DATA COLLECTION PROCESS

- 3) Regression coefficients were created for cell values which were not derived directly from regression analysis
  - Type I generic table values
  - Type II grandfathered data
- 4) The data was amalgamated into a complete set of regressions coefficients tables: one table to correspond with each holdover time table (several exceptions)

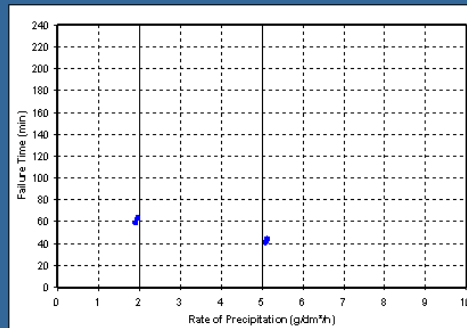


### HOW ARE COEFFICIENTS DERIVED?

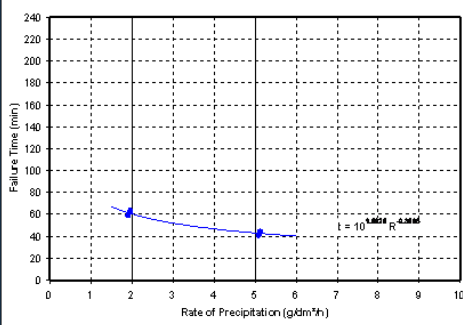
- Endurance time tests are conducted
- Power-law regression is performed on the test data
- The forms of the regression equation are:
  - $t = 10^l R^A$  (freezing precipitation)
  - $t = 10^l R^A (2-T)^B$  (snow)
- $t$  = failure time  $R$  = rate  $A, B, l$  = regression coefficients
- The regression produces the regression coefficients



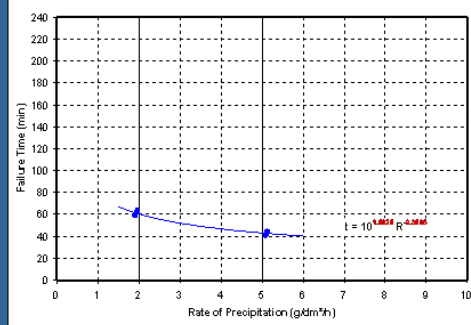
### HOW ARE COEFFICIENTS DERIVED?



### HOW ARE COEFFICIENTS DERIVED?



### HOW ARE COEFFICIENTS DERIVED?



### SAMPLE REGRESSION DATA TABLE

Outside Air Temperature		Road Condition	Regression Coefficients for Calculating HOTS at Various Times under Various Weather Conditions						
Degree Celsius	Degree Fahrenheit		Active Road	Freezing Fog	Snow or Snow-Crains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Paving	Other
-3 and above	27 and above	000	8.104 E	I = 2.3076 A = -0.6904	I = 2.6239 A = -0.3936	I = 2.3723 A = -0.6076	I = 2.3369 A = -0.3338	I = 2.3521 A = -0.6723	
			752E	I = 1.8326 A = -0.3385	I = 2.3890 A = -0.5522	I = 2.0098 A = -0.5277	I = 2.4102 A = -0.3007	I = 2.1732 A = -0.7748	
			000D	I = 1.6163 A = -0.4676	I = 2.0985 A = -0.6802	I = 1.5310 A = -0.4446	I = 2.0917 A = -0.5611		
below -3 to -14	below 27 to 7	000	8.104 E	I = 2.4647 A = -0.6764	I = 2.6239 A = -0.3936	I = 3.0544 A = -1.5316	I = 2.2370 A = -0.5743		CAUTION: No HOTS for galeries exist
			752E	I = 2.0965 A = -0.6423	I = 2.3890 A = -0.5522	I = 2.2656 A = -0.8827	I = 2.0961 A = -0.6835		
below -14 to -25	below 7 to 0	000	8.104 E	I = 1.8204 A = -0.4264	I = 2.2336 A = -0.3365				
					I = 0.0000				

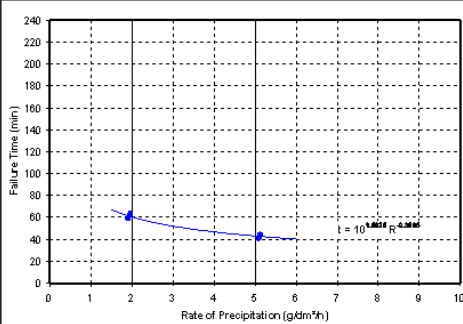
1 Regression Equation:  $t = 10 \cdot R^2$ , where R = rate (g/dm<sup>2</sup>/h)  
 2 Regression Equation:  $t = 10 \cdot R^2 \cdot (2.7)^T$ , where R = rate (g/dm<sup>2</sup>/h) and T = temperature (in °C)

### HOW TO USE COEFFICIENTS

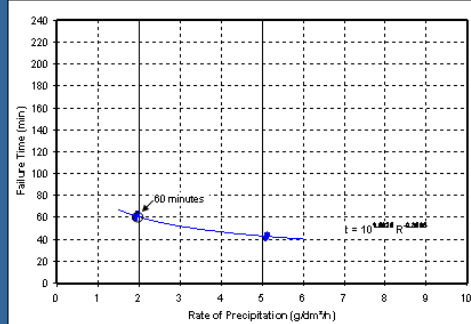
- The regression coefficients/equations are used to calculate values for the HOTS tables at predetermined precipitation rates and temperatures
- HOTS can use the same regression coefficients/equations to calculate HOTS at many precipitation rates and temperatures

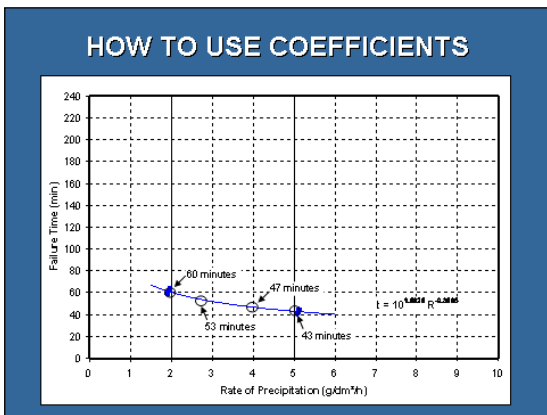
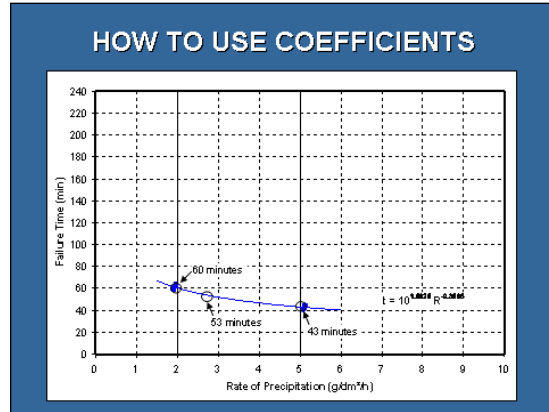
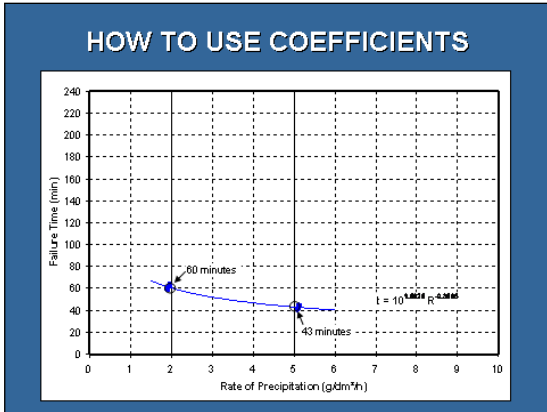


### HOW TO USE COEFFICIENTS



### HOW TO USE COEFFICIENTS





### CONCLUSIONS

- ➔ Transport Canada will publish a draft report containing the regression data for the 2008-09 HOT guidelines in December 2008
- ➔ The information will need to be updated on an annual basis to reflect the annual changes made to the holdover time guidelines

Transport Canada

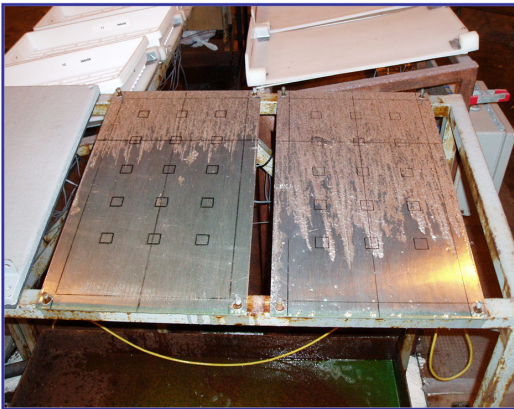
### FOR MORE INFORMATION

- ➔ Contact Stephanie Bendickson: sbendickson@telus.net
- ➔ For a copy of the draft report: contact the Transportation Development Centre (Yagusha Bodnar)

Transport Canada

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# HOLDOVER TIME GUIDELINES UPDATE FALL 2008




**SAE G-12 HOLDOVER TIME SUBCOMMITTEE  
MONTREAL – NOV 5, 2008**

*Presented by Stephanie Bendickson*



PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE  
TRANSPORT CANADA







AND

FEDERAL AVIATION ADMINISTRATION  
WILLIAM J. HUGHES TECHNICAL CENTRE





### PRESENTATION OUTLINE

- Publication of Winter 2008-09 Holdover Time Guidelines
- Summary of Changes to Guidelines for Winter 2008-09 (presented in Warsaw, May 2008)
- Summary of Changes to Guidelines for Winter 2008-09 (changes made after Warsaw presentation)
- Future Changes

### PUBLICATION OF WINTER 2008-09 HOLDOVER TIME GUIDELINES

- Transport Canada guidelines published July 28, 2008
  - [www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm](http://www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm) (English)
  - [www.tc.gc.ca/AviationCivile/commerce/DelaissEfficacite/menu.htm](http://www.tc.gc.ca/AviationCivile/commerce/DelaissEfficacite/menu.htm) (French)
- FAA guidelines published August 1, 2008
  - [www.faa.gov/about/office\\_org/headquarters\\_offices/avs/offices/ats/ats200/](http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/ats/ats200/)





### SUMMARY OF HOT GUIDELINE CHANGES (PRESENTED IN WARSAW)

**TYPE I** → No changes

**TYPE II** → Fluid-specific table added for Kilfrost ABC-K PLUS  
→ No changes to Type II generic table





**TYPE III** → No changes

**TYPE IV** → Increases to cold soaked wing HOTs in Type IV generic table





### SUMMARY OF HOT GUIDELINE CHANGES (MADE AFTER WARSAW)

- Note added to Type II / IV tables advising users radiational cooling during active frost may reduce HOT when operating at the lower end of the temperature range
- Transport Canada added a fluid-specific table for Dow Chemical UCAR™ FlightGuard AD-480
  - Already exists in FAA guidelines
  - Identical to ABA X AD-480 fluid-specific table
- Aviation Xi'an KHF-II Type II fluid-specific table removed from FAA guidelines due to ongoing certification testing
  - Transport Canada currently considering table status

### FUTURE CHANGES

- Minor error discovered in Type II generic table
- Freezing Fog, 75/25, below -3°C to -14°C
  - Current Type II Generic HOT: 0:20 – 0:55
  - Shortest HOT, all Type II fluids: 0:20 – 0:55
  - Shortest HOT, all Type IV fluids: 0:25 – **0:50**
- ARP 5718 55.11: Type IV fluids also qualify as Type II fluids
  - Type II Generic is shortest HOT of all Type II and Type IV fluids
  - Type II Generic HOT (2009-10): 0:20 – **0:50**



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