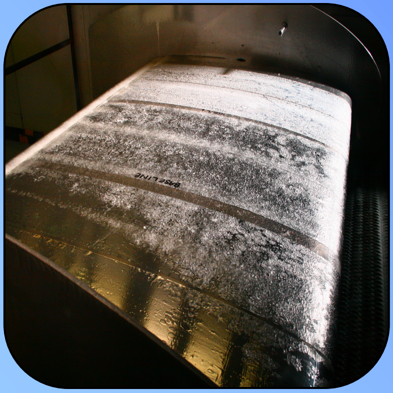
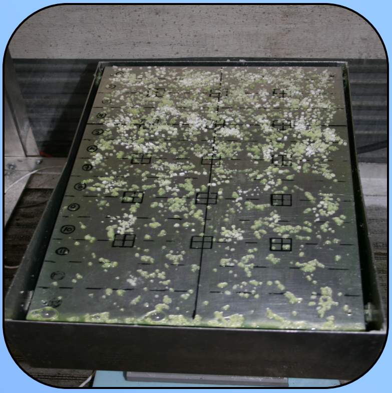
TP 15053E

Aircraft Ground Icing General Research Activities During the 2009-10 Winter





Prepared for:

Transportation Development Centre

In cooperation with:

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

APS Aviation Inc.

March 2011
Final Version 1.0

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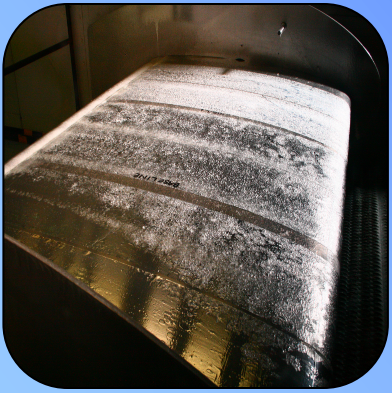

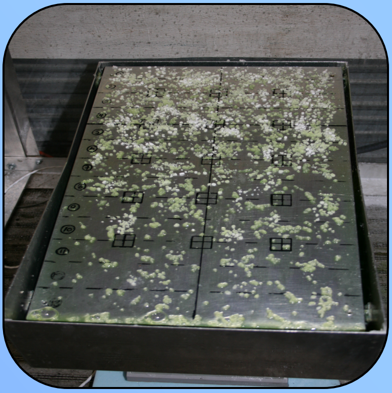

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The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

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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Reviewed by:

Feb 27, 2026

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Approved by: **

Feb 27, 2026

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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; and update and maintain the website for the holdover time guidelines;
- To evaluate weather data from previous winters that can have an impact on the format of the holdover time guidelines;
- To develop Type I holdover times for composite surfaces; and evaluate first-step rule for use with composite surfaces;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests simulating vertical stabilizer anti-icing;
- To conduct endurance time tests in simulated snow pellet conditions;
- To conduct endurance time tests with a snow machine in an attempt to refine the current test protocol;
- To conduct endurance time tests in heavy snow conditions;
- To support Federal Aviation Administration and Transport Canada in the development of an advisory circular for the implementation of a holdover time determination system;
- To evaluate the use of sensors in determining active frost conditions;
- To initiate research for development of ice detection capabilities for departing aircraft at the runway threshold;
- To evaluate frost holdover times for use during cold-soaked wing frost conditions;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids;
- To conduct endurance time tests on surfaces treated with ice phobic products;
- To evaluate holdover times for anti-icing in a hangar;
- To conduct research at the National Research Council Canada wind tunnel to further develop and expand ice pellet allowance times; and
- To conduct various aerodynamic research activities at the National Research Council Canada wind tunnel.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2009-10 are documented in eight reports. The titles of the reports are as follows:

- TP 15050E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2009-10 Winter;
- TP 15051E Winter Weather Impact on Holdover Time Table Format (1995-2010);
- TP 15052E Development of Type I Fluid Holdover Times for Use on Aircraft with Composite Surfaces;

- TP 15053E Aircraft Ground Icing General Research Activities During the 2009-10 Winter;
- TP 15054E Regression Coefficients and Equations Used to Develop the Winter 2010-11 Aircraft Ground Deicing Holdover Time Tables;
- TP 15055E Emerging De/Anti-Icing Technology: Evaluation of Ice Phobic Products for Potential Use in Aircraft Operations;
- TP 15056E Holdover Times Related to Aircraft Hangar Operations; and
- TP 15057E Exploratory Wind Tunnel Aerodynamic Research Examination of Contaminated Anti-Icing Fluid Flow-Off Characteristics Winter 2009-10.

In addition, the following interim report is being prepared:

- *Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables, Winter 2009-10.*

This report, TP 15053E, has the following objective:

- To document the exploratory research and general activities carried out during the winter of 2009-10.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Civil Aviation Group, Transport Canada with support from the Federal Aviation Administration, William J. Hughes Technical Center, Atlantic City, NJ. This program could not have been accomplished without the participation of many organizations. APS Aviation Inc. would therefore like to thank the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, National Research Council Canada, the Meteorological Service of Canada, and several fluid manufacturers.

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Stephanie Bendickson, Michael Chaput, John D’Avirro, Peter Dawson, Jesse Dybka, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Michelle Pineau, Marco Ruggi, David Smith, James Smyth, Robert ter Beek, Joey Tiano, David Youssef and Victoria Zoitakis.

Special thanks are extended to Howard Posluns, Angelo Boccanfuso, Yagusha Bodnar, Doug Ingold and Warren Underwood, who on behalf of the Transportation Development Centre and the Federal Aviation Administration, have participated, contributed and provided guidance in the preparation of these documents.

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

16. Abstract
This report documents the general activities completed by APS Aviation Inc. (APS) related to aircraft ground deicing research in the winter of 2009-10. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2009-10, which are documented in separate reports. The twelve activities included in this report are described below.

1. Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces: APS conducted a series of tests to evaluate the endurance time performance of de/anti-icing fluid applied to vertical surfaces and potentially develop guidance material for anti-icing aircraft vertical stabilizers. The results are provided in this report.
2. Evaluation of Sensor for NowCasting Active Frost: A sensor was tested that can nowcast frost, and the preliminary results indicate that there could be potential for using this type of technology in operations.
3. Evaluation of Holdover Time Guidelines for Cold-Soak Wing during Natural Frost Conditions: When a cold-soaked wing is subject to natural frost conditions, current holdover times (HOTs) are not appropriate. Guidance was added within the HOT Guidelines to account for this.
4. Holdover Times in Conditions of Heavy Snow: Due to extensive heavy snow conditions present during deicing operations, research is ongoing in an attempt to develop holdover times using snow machines.
5. Development and Evaluation of New Protocol Using Snow Machine: A new protocol for snow machines to better simulate natural snow conditions is being considered, and tests have been conducted that indicate that the new protocol may be appropriate. Preliminary results based on limited testing indicate that this new protocol provided endurance times that closely matched those of natural snow.
6. Support for the Development of Use of Ice Detection Cameras at End-of-Runway: The development of ice detection technology has been ongoing for a number of years. This work has been supported by Transport Canada (TC) and the Federal Aviation Administration (FAA). In 2009-10, meetings were held that focused on a flight crew survey, accident/incident reports, and the development of a project timeline, action plan, and problem definition.
7. Fluid Endurance Time Testing in Snow Pellet Conditions. Research was conducted that leads to the integration of the snow pellet condition within the snow column of the HOT tables.
8. Development of LOUT Table for Holdover Time Guidelines: Based on industry requests, the regulators have developed and published a lowest operational use temperature (LOUT) table as part of the HOT Guidelines; a revised version is in development.
9. Differences in HOT Guidelines (TC, FAA, and AEA): Formatting discrepancies existed between the TC, the FAA, and the Association of European Airlines (AEA) HOT Guidelines. Industry members were informed of the differences that exist between the TC/FAA/AEA guidelines and proposed remedies were implemented.
10. Provisions of Support for the Development of the FAA Advisory Circular on Liquid Water Equivalent Systems: APS was contracted by the FAA to provide support in the development and implementation of an advisory circular on liquid water equivalent systems (LWES) for US operations.
11. Holdover Time Guidelines Website: APS developed and implemented a website for the official TC 2010-11 HOT Guidelines.
12. Test Procedures, Presentations, and Fluid Manufacturer Reports: An account of the test procedures, presentations, and fluid manufacturer reports that were produced for the 2009-10 test program is included in this report.

17. Key Words
Deicing, hangar, end-of-runway, sensor, nowcasting, cold-soak wing, heavy snow, snow machine, ROGIDS, snow pellet, HOT guidelines, frost, ice detection, vertical stabilizer

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Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada. 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.

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 2009-2010. Les activités dont fait état ce rapport ont été effectuées en plus des projets de recherche principaux menés pendant l'hiver 2009-2010, qui sont documentés dans des rapports distincts. Les douze activités qui font l'objet du présent rapport sont énumérées ci-dessous.

1. Évaluation préliminaire des durées d'endurance sur les surfaces verticales : APS a mené une série d'essais pour évaluer les durées d'endurance des liquides de dégivrage et d'antigivrage appliqués à des surfaces verticales et potentiellement mettre au point des lignes directrices relatives à l'antigivrage des stabilisateurs verticaux. Les résultats sont présentés dans le présent rapport.
2. Évaluation des détecteurs pour les prévisions immédiates de givre actif : On a testé un détecteur pouvant fournir des prévisions immédiates de givre, et les résultats préliminaires indiquent qu'on pourrait potentiellement utiliser ce type de technologie dans le cadre d'opérations.
3. Évaluation des lignes directrices sur les durées d'efficacité sur une aile imprégnée de froid dans des conditions de givre naturel : Quand une aile imprégnée de froid est soumise à des conditions naturelles de givre, les durées d'efficacité actuelles sont inadéquates. Des directives ont été ajoutées aux lignes directrices sur les durées d'efficacité afin de prendre en compte ce phénomène.
4. Durées d'efficacité dans des conditions de neige forte : En raison des intenses conditions de neige forte présentes durant les opérations de dégivrage, des activités de recherche sont en cours pour définir des durées d'efficacité à l'aide de canons à neige.
5. Mise au point et évaluation d'un nouveau protocole sur l'utilisation de canons à neige : Un nouveau protocole encadrant l'utilisation de canons à neige a été mis au point pour mieux simuler les conditions de neige, et est actuellement à l'étude. Des essais menés à cet effet indiquent que ce nouveau protocole peut être adéquat. Les résultats préliminaires basés sur des tests limités laissent croire que ce dernier permet d'établir des durées d'endurance concordant étroitement à celles relevées dans des conditions de neige naturelle.
6. Soutien à l'accroissement de l'utilisation de caméras de détection de givre en bout de piste : Le développement des technologies de détection du givre est un phénomène en cours depuis plusieurs années. Ces travaux ont été appuyés par Transports Canada (TC) et la Federal Aviation Administration (FAA). En 2009-2010, des réunions ont porté sur un sondage auprès des membres d'équipage, des rapports d'accident/d'incident et l'élaboration d'un calendrier de projet, d'un plan d'action et d'un cadre de définition des problèmes.
7. Essais sur les durées d'endurance des liquides dans des conditions de neige roulée : Des recherches ont mené à l'inclusion des conditions de neige roulée dans la colonne des tableaux de durées d'efficacité relatives à la neige.
8. Mise au point du tableau de la LOUT pour les lignes directrices sur les durées d'efficacité : À la demande de membres du secteur, les organismes de réglementation ont mis au point et publié un tableau de la température minimale d'utilisation opérationnelle (LOUT) dans le cadre des lignes directrices sur les durées d'efficacité; une version révisée est en cours d'élaboration.
9. Différences entre les lignes directrices sur les durées d'efficacité (TC, FAA, et AEA) : Il existe plusieurs écarts entre les lignes directrices sur les durées d'efficacité de TC, de la FAA et de l'Association of European Airlines (AEA). Les membres du secteur ont été avisés de l'existence de certaines divergences entre les lignes directrices de TC, de la FAA et de l'AEA, et les solutions proposées ont été mises en œuvre.
10. Dispositions d'appui à l'élaboration de la circulaire consultative de la FAA sur les systèmes de taux d'équivalence en eau liquide : La FAA a recouru aux services d'APS en soutien à la mise au point et à la mise en œuvre d'une circulaire consultative sur les systèmes de taux d'équivalence en eau liquide pour les opérations américaines.
11. 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 (2010-2011) officielles de TC.
12. 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 2009-2010 figure dans le présent rapport.

17. Mots clés
Dégivrage, hangar, bout de piste, détecteur, prévisions immédiates, aile imprégnée de froid, neige forte, canon à neige, ROGIDS, neige roulée, lignes directrices sur les durées d'efficacité, givre, détection du givre, stabilisateur vertical

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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 2009-10 on behalf of the Transportation Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA). The twelve activities documented in this report are described below and were carried out in addition to the main research projects completed in the winter of 2009-10, which are documented in separate reports.

Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces (Section 2)

Typically, the vertical surfaces of an aircraft are de-iced to prevent loss of directional control; however, the requirement to anti-ice varies among operators. APS conducted a series of tests to evaluate the endurance time performance of de/anti-icing fluid applied to vertical surfaces and potentially develop guidance material for anti-icing aircraft vertical stabilizers. Preliminary plate test results indicate that both Type I and Type II/IV fluids applied on vertical surfaces show large reductions in endurance times as compared to horizontal surfaces.

Evaluation of Sensor for NowCasting Active Frost (Section 3)

A series of frost tests were conducted in 2009-10 to investigate the accuracy of predicting frost using a simple frosticator plate that is used for standard frost endurance time tests. Results indicated that this type of technology is feasible, but more data should be collected for further development.

Evaluation of Holdover Time Guidelines for Cold-Soaked Wing During Natural Frost Conditions (Section 4)

Industry has indicated that holdover times (HOTs) could be shorter when frost conditions and cold-soaked wing (CSW) conditions are combined. Therefore, preliminary tests were conducted to examine the condition of frost coupled with CSWs. Testing with Type I fluid indicated that the holdover times could be much shorter than the current forty-five minutes. Based on this, general guidance was provided by TC for Winter 2010-11 to alert operators of this issue.

Holdover Times in Conditions of Heavy Snow (Section 5)

Heavy snow occurrences account for a significant number of deicing operations. Currently, holdover times for heavy snow do not exist. APS has conducted preliminary tests over several years; however, these tests were not extensive. This report summarizes those tests. The research to date shows that endurance times for simulated heavy snow are approximately half that of the moderate snow endurance times. Work is ongoing in an attempt to develop a correlation method with snow machines to measure endurance times in heavy snow.

Development and Evaluation of New Protocol Using Snow Machine (Section 6)

A protocol was developed several years ago for testing with snow machines. This current protocol generates endurance times by conducting simulated snow tests at the most restrictive temperatures and precipitation rates set forth in the current HOT Guidelines. It was found that the snow machine could not reproduce the same results as the outdoor tests at colder temperatures and high rates.

A new proposed protocol was developed by which to best simulate natural snow conditions using the snow machine. A preliminary set of flat plate tests were conducted to evaluate the effectiveness of this new protocol. It has been observed that using this new proposed protocol could provide improved results; however, this observation is based on limited tests.

Support for the Development of Use of Ice Detection Cameras at End-of-Runway (Section 7)

The development of ice detection technology has been ongoing for a number of years. While there has been advancement in post-deicing application, recent focus has been on the end-of-runway application to perform pre-takeoff contamination checks at the end of the runway just prior to takeoff.

In 2009-10, meetings were held that focused on a flight crew survey, accident/incident reports, and the development of a project timeline, action plan, and problem definition.

Due to the end-of-runway application likely requiring longer introduction within operations, it was concluded that short-term efforts would focus on engine icing and pre-deicing.

Fluid Endurance Time Testing in Snow Pellet Conditions (Section 8)

APS conducted a series of tests to identify if the current guidelines can be expanded to include snow pellets in the current snow holdover time column. In Winter 2007-08, preliminary testing conducted by APS indicated that simulated snow pellets and the simulated snow had equivalent endurance times. Further testing was conducted in Winter 2009-10 by APS and another laboratory, with different fluids and dilutions to substantiate the results obtained. Results supported the expansion of the current snow HOT column to include snow pellets.

Development of LOUT Table for Holdover Time Guidelines (Section 9)

At the request of users, lowest operational use temperature (LOUT) information for Type I, II, III, and IV fluids was added to the 2010-11 HOT Guidelines issued by TC in July 2010, and also by the FAA in the fall of 2010. This information was provided by the fluid manufacturers. Because the timing for the development of the LOUT table was short, the information published was not complete, with some discrepancies in some cases. Changes are anticipated to be made during the winter of 2010-11.

Differences in HOT Guidelines (TC, FAA, and AEA) (Section 10)

Several discrepancies existed between the TC, the FAA, and the Association of European Airlines (AEA) HOT Guidelines. Industry members were informed of some differences that exist between the TC/FAA/AEA guidelines and were given proposed remedies. In general, it was decided by the members that the proposed changes were acceptable, and most were implemented.

Provisions of Support for the Development of the FAA Advisory Circular on Liquid Water Equivalent Systems (Section 11)

APS provided support to the FAA in the development and implementation of an advisory circular on liquid water equivalent systems (LWES) for US operations.

Holdover Time Guidelines Website (Section 12)

APS developed and implemented a website for the official TC HOT Guidelines in 2003 to eliminate the safety risks associated with discrepancies occurring as a result of holdover time information being published in multiple locations. Since then, APS has updated the website annually to reflect changes made to the guidelines. The website was updated with the 2010-11 HOT Guidelines in July 2010.

Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 13)

A number of test procedures, presentations, and fluid manufacturer reports were produced by APS for the 2009-10 test program. An account of these activities is included in this report.

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SOMMAIRE

Ce rapport fait état des activités générales se rapportant à la recherche sur le dégivrage d'aéronefs au sol menée par APS Aviation Inc. (APS), au cours de l'hiver 2009-2010, pour le compte du Centre de développement des transports (CDT) de Transports Canada (TC) et de la Federal Aviation Administration (FAA). Les douze activités dont fait état ce rapport sont décrites ci-dessous et ont été effectuées en plus des projets de recherche principaux menés pendant l'hiver 2009-2010, qui sont documentés dans des rapports distincts.

Évaluation préliminaire des durées d'endurance sur les surfaces verticales (Section 2)

En général, les surfaces verticales d'un aéronef sont dégivrées pour prévenir la perte de contrôle directionnel; toutefois, les exigences encadrant les opérations d'antigivrage varient d'un exploitant à l'autre. APS a mené une série d'essais pour évaluer les durées d'endurance des liquides de dégivrage et d'antigivrage appliqués à des surfaces verticales et potentiellement mettre au point des lignes directrices relatives à l'antigivrage des stabilisateurs verticaux. Les résultats préliminaires d'essais sur plaque plane indiquent que les liquides de type I, II et IV ont des durées d'endurance considérablement réduites sur des surfaces verticales comparativement à lorsqu'ils sont appliqués sur des surfaces horizontales.

Évaluation de détecteurs pour les prévisions immédiates de givre actif (Section 3)

Une série de tests sur le givrage a été menée en 2009-2010 afin d'étudier l'exactitude des prévisions de givre obtenues à l'aide d'une plaque à générateur d'humidité unique utilisée pour les essais d'endurance standard dans des conditions de givre. Les résultats de ces tests ont indiqué que ce type de technologie est possible, mais que plus de données doivent être recueillies pour la développer davantage.

Évaluation des lignes directrices sur les durées d'efficacité sur une aile imprégnée de froid dans des conditions de givre naturel (Section 4)

Selon le secteur, les durées d'efficacité pourraient être réduites lorsque des conditions de givre sont combinées à celles d'une aile imprégnée de froid (CSW). Par conséquent, des essais préliminaires ont été menés pour examiner cette association. Les tests effectués à l'aide de liquide de type I ont indiqué que les durées d'efficacité pouvaient être considérablement inférieures à celles de quarante-cinq minutes actuellement appliquées. Sur la base de cette information, Transports Canada a émis des directives générales pour l'hiver 2010-2011 afin d'alerter les exploitants à cet enjeu.

Durées d'efficacité dans des conditions de neige forte (Section 5)

Les fortes chutes de neige sont à la base d'un nombre important d'opérations de dégivrage. À l'heure actuelle, il n'existe pas de durées d'efficacité pour de telles conditions. APS a mené des essais préliminaires sur plusieurs années; toutefois, ces tests n'étaient pas détaillés. Le présent rapport résume ces travaux. La recherche effectuée à ce jour démontre que les durées d'endurance dans des conditions simulées de neige forte sont d'environ la moitié de celles sous neige modérée. Des travaux sont en cours pour tenter de mettre au point, à l'aide de canons à neige, une méthode de corrélation en vue de mesurer les durées d'endurance dans des conditions de neige forte.

Mise au point et évaluation d'un nouveau protocole sur l'utilisation de canons à neige (Section 6)

Il y a plusieurs années, un protocole encadrant les essais réalisés à l'aide de canons à neige a été élaboré. Il permet aujourd'hui d'établir les durées d'endurance lors d'essais menés à l'aide de neige simulée dans les températures et les taux de précipitation les plus limitants qui figurent dans les lignes directrices actuelles. On a constaté qu'un canon à neige ne pouvait reproduire les résultats d'essais menés en plein air à des températures inférieures et des taux de précipitations supérieurs.

Un nouveau protocole proposé a été mis au point pour mieux simuler les conditions naturelles à l'aide d'un canon à neige. Une série préliminaire d'essais sur plaque plane a été réalisée pour évaluer l'efficacité de ce nouveau protocole. On a observé que l'application de ce nouveau protocole proposé pourrait entraîner des résultats améliorés; toutefois, ces conclusions sont fondées sur des tests restreints.

Soutien à l'utilisation accrue de caméras de détection de givre en bout de piste (Section 7)

Le développement des technologies de détection du givre est un phénomène en cours depuis plusieurs années. Leur application en post-dégivrage a connu des avancées; toutefois, c'est sur leur utilisation en bout de piste pour procéder à l'inspection de contamination avant le décollage, juste avant le décollage, que se sont concentrés les efforts dernièrement.

En 2009-2010, des réunions ont porté sur un sondage auprès des membres d'équipage, des rapports d'accident/d'incident et l'élaboration d'un calendrier de projet, d'un plan d'action et d'un cadre de définition des problèmes.

Puisque l'introduction de ces technologies dans les opérations en bout de piste prendra probablement plus de temps, il a été décidé que les efforts à court terme seront axés sur leur application pour le givrage sur moteur et en contexte de prédégivrage.

Essais sur les durées d'endurance des liquides dans des conditions de neige roulée (Section 8)

APS a mené une série d'essais pour déterminer si les lignes directrices actuelles peuvent être élargies pour inclure les conditions de neige roulée dans la colonne des durées d'efficacité relatives à la neige. Au cours de l'hiver 2007-2008, des essais préliminaires effectués par APS ont indiqué que les conditions simulées de neige et de neige roulée étaient associées à des durées d'endurance équivalentes. D'autres tests ont été réalisés à l'hiver 2009-2010 par APS et un autre laboratoire, avec différents liquides et dans diverses dilutions, en vue d'étayer les efforts préliminaires. Les résultats ont appuyé l'élargissement de la colonne des durées d'efficacité relatives à la neige pour y inclure les conditions de neige roulée.

Mise au point du tableau de la LOUT pour les lignes directrices sur les durées d'efficacité (Section 9)

À la demande des utilisateurs, des renseignements sur la température minimale d'utilisation opérationnelle (LOUT) pour les liquides de type I, II, III et IV ont été ajoutés aux lignes directrices sur les durées d'efficacité de 2010-2011 publiées par TC en juillet 2010 et par la FAA à l'automne 2010. Cette information a été fournie par les fabricants de liquides. En raison du délai restreint pour l'élaboration du tableau de la LOUT, l'information publiée était incomplète et comprenait dans certains cas quelques écarts. Des changements devraient être apportés au cours de l'hiver 2010-2011.

Différences entre les lignes directrices sur les durées d'efficacité (TC, FAA, et AEA) (Section 10)

Il existe plusieurs écarts entre les lignes directrices sur les durées d'efficacité de Transports Canada (TC), celles de la Federal Aviation Administration (FAA) et celles de l'Association of European Airlines (AEA). Les membres du secteur ont été avisés de l'existence de certaines divergences entre les lignes directrices de TC, de la FAA et de l'AEA, et ont reçu des solutions proposées. En général, les membres ont convenu que les changements proposés étaient acceptables, et la plupart des solutions ont été mises en œuvre.

Dispositions d'appui à l'élaboration de la circulaire consultative de la FAA sur les systèmes de taux d'équivalence en eau liquide (Section 11)

APS a épaulé la FAA dans la mise au point et la mise en œuvre d'une circulaire consultative sur les systèmes de taux d'équivalence en eau liquide pour les opérations américaines.

Site Web des lignes directrices sur les durées d'efficacité (Section 12)

En 2003, APS a conçu et mis en place un site Web présentant les lignes directrices officielles de TC sur les durées d'efficacité, afin d'éliminer les risques pour la sécurité associés à la possibilité de divergences lorsque l'information sur les durées d'efficacité est publiée à plusieurs endroits. Depuis, APS a mis à jour le site Web chaque année pour refléter les changements apportés aux lignes directrices. Les lignes directrices sur les durées d'efficacité de 2010-2011 y ont été ajoutées en juillet 2010.

Procédures d'essai, présentations, et rapports des fabricants de liquides (Section 13)

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 2009-2010. Le présent rapport contient une description de ces activités.

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GLOSSARY

AEA	Association of European Airlines
AMIL	Anti-Icing Materials International Laboratory
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
ASRS	Aviation Safety Reporting System (United States)
ATAC	Air Transport Association of Canada
CAA	Civil Aviation Authorities
CADORS	Civil Aviation Daily Occurrences Reporting System (Canada)
CBAA	Canadian Business Aviation Administration
CBAAC	Commercial and Business Aviation Advisory Circular
CSW	Cold-Soaked Wing
ET	Endurance Time
FAA	Federal Aviation Administration
HOT	Holdover Time
HOTDS	Holdover Time Determination System
LOUT	Lowest Operational Use Temperature
LWE	Liquid Water Equivalent
LWES	Liquid Water Equivalent System
MSC	Meteorological Service of Canada
NCAR	National Center for Atmospheric Research

NRC	National Research Council Canada
OAT	Outside Air Temperature
RH	Relative Humidity
ROCSW	Rain on Cold-Soaked Wing
ROGIDS	Remote On-Ground Ice Detection Systems
SAE	SAE International
SAS	Scandinavian Airlines
TC	Transport Canada
TCCA	Transport Canada Civil Aviation
TDC	Transportation Development Centre

1. INTRODUCTION

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

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

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

1.1 General Activities Completed in 2009-10

The general activities completed in 2009-10 are listed below. Each activity is described in a separate section of this report (shown in parentheses):

a) Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces (Section 2);

b) Evaluation of Sensor for NowCasting Active Frost (Section 3);

c) Evaluation of Holdover Time Guidelines for Cold-Soaked Wing During Natural Frost Conditions (Section 4);

d) Holdover Times in Conditions of Heavy Snow (Section 5);

e) Development and Evaluation of New Protocol Using Snow Machine (Section 6);

f) Support for the Development of Use of Ice Detection Cameras at End-of-Runway (Section 7);

g) Fluid Endurance Time Testing in Snow Pellet Conditions (Section 8);

h) Development of LOUT Table for Holdover Time Guidelines (Section 9);

i) Differences in HOT Guidelines (TC, FAA, and AEA) (Section 10);

j) Provisions of Support for the Development of the FAA Advisory Circular on Liquid Water Equivalent Systems (Section 11);

k) Holdover Time Guidelines Website (Section 12); and

l) Test Procedures, Presentations, and Fluid Manufacturer Reports (Section 13).

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

2. PRELIMINARY EVALUATION OF ENDURANCE TIME PERFORMANCE ON VERTICAL SURFACES

2.1 Background

Aircraft deicing fluid is typically used to clean frozen contamination from all aircraft surfaces, and aircraft anti-icing fluid is used to protect critical aircraft surfaces from icing conditions within a specified holdover time (HOT). Critical aircraft surfaces include aircraft wings and horizontal stabilizers, which are typically deiced and anti-iced during winter icing conditions; however, the aircraft vertical stabilizer is also considered a critical surface. Contaminated wings can cause a loss of lift, whereas a contaminated vertical stabilizer can cause a loss of directional control. Typically, the vertical stabilizer is deiced in icing conditions; however, the requirement to anti-ice varies among operators and regulators. When applying anti-icing fluid to vertical surfaces, it quickly flows off and results in a reduced fluid thickness layer and consequently shortened endurance times. Due to the lack of data to quantify actual endurance times on vertical surfaces, the industry has requested that testing be conducted to evaluate and potentially develop guidance material for operating with anti-iced vertical stabilizer surfaces.

Preliminary work was conducted during the winter of 1999-2000 and is documented in the Transport Canada (TC) report, TP 13659E, *Aircraft Ground De/Anti-icing Fluid Holdover Time and Endurance Time Testing Program for the 1999-2000 Winter* (1). In total, eight preliminary tests were conducted with Type I, II, and IV fluids. In each test, the standard 10-degree-oriented plate outperformed the vertical plate. For the Type I tests, the vertical endurance times recorded were 49 percent of standard endurance times. For the Type II and IV tests, the vertical endurance times recorded were 31 percent of standard endurance times. The horizontal air component was found to be an important factor for the reduced endurance times as it increased the catch rate on vertical surfaces and greatly reduced the endurance time.

It was recommended that additional testing be conducted to substantiate the results observed and to potentially develop guidance material for anti-icing aircraft vertical stabilizers. More specifically, testing would investigate the added protection from Type II/IV fluid versus a Type I fluid on a vertical surface.

2.2 Objectives

The objectives were to evaluate the endurance time performance of de/anti-icing fluid applied to vertical surfaces and to potentially develop guidance material for de/anti-icing aircraft vertical stabilizers. Testing will investigate the added protection from Type II/IV fluid versus a Type I fluid on a vertical surface.

2.3 Test Methodology

The detailed procedure used for this testing is included in Appendix B. The following is a brief description of the methodology used.

Endurance time tests were conducted with various Type I and Type II/IV fluids at the Montreal–Trudeau Airport test site. Table 2.1 lists the fluids tested.

Table 2.1: Fluid Tested

Fluid Type	Fluid Name
I	Octagon Octaflo
II	Kilfrost ABC-2000
IV	Kilfrost ABC-S
IV	Clariant MPIV Launch

Standard fluid endurance time test procedures were used. During each test run, four tests were conducted simultaneously, comprising the baseline conducted at 10 degrees from the horizontal and three tests conducted at 80 degrees from the horizontal (see Figure 2.1). The following describes the configuration for the four test surfaces:

- Plate 1: 10° plate with Type II/IV fluid (baseline test):
  - To simulate the standard holdover time test representing aircraft wings and horizontal surfaces.
- Plate 2: 80° plate with Type I fluid:
  - To simulate a vertical stabilizer that has only been deiced and not anti-iced.
- Plate 3: 80° plate with Type II/IV fluid:
  - To simulate a vertical stabilizer that has been anti-iced and to compare the effects of the angle of the plate on fluid endurance time.
- Plate 4: 80° plate with Type I and Type II/IV fluids (two-step application):
  - To simulate a vertical stabilizer that has been both deiced and anti-iced using a two-step procedure.

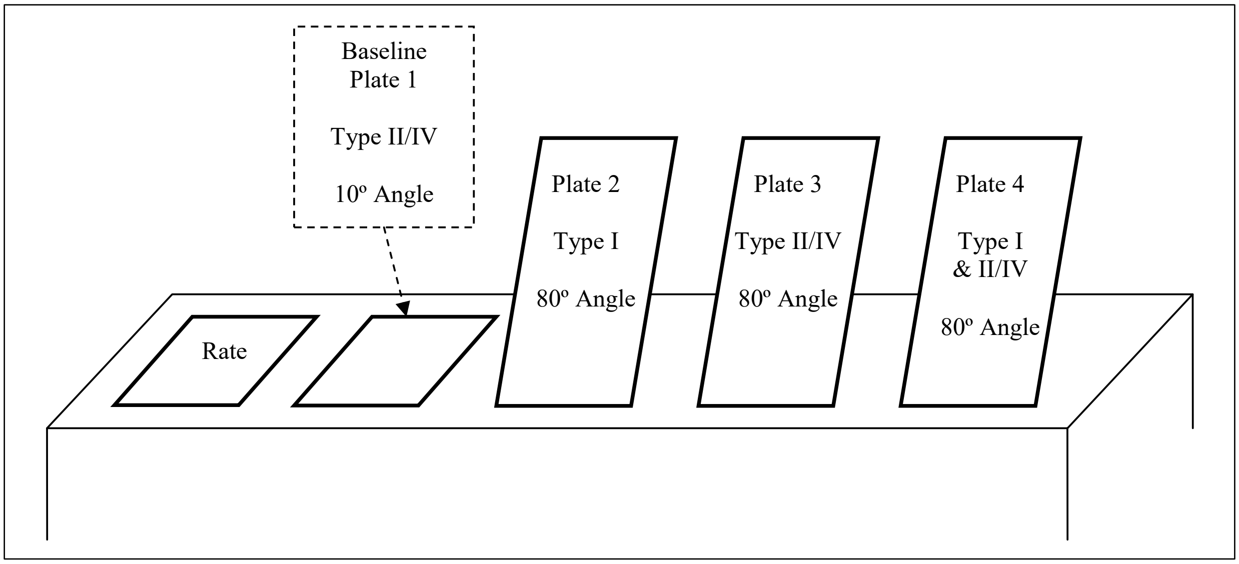
Baseline
Plate 1
Type II/IV
10º Angle
Rate
Plate 2
Type I
80º Angle
Plate 3
Type II/IV
80º Angle
Plate 4
Type I
& II/IV
80º Angle

Figure 2.1: General Setup

2.4 Test Results

A total of 12 comparative test runs were conducted during the winter of 2009-10. A log summarizing the data collected has been compiled and is included as Table 2.2. For each of the 12 test runs, a bar chart has been compiled demonstrating the comparison in endurance times (see Figure 2.2 to Figure 2.13).

Table 2.2: Test Log

Run (#)	Fluid	Precip. Rate (g/dm²/h)	Avg. OAT (°C)	Avg. Wind Speed (km/h)	Plate Inclination (°)	Brix @ 5 Min. (°)	Brix @ Fail (°)	Brix @ Baseline Fail (°)	Thick. @ 5 Min. (mm)	Thick. @ Fail (mm)	Thick. @ Baseline Fail (mm)	Fail Time (min.)	Fail time % of Baseline
1	Type IV PG – L	8	-3.0	25	10 (Baseline)	36	N/A	N/A	1.5	N/A		172	-
1	Type I PG – O	1	-2.7	26	80	N/A	8	N/A	0	0	N/A	22	13%
1	Type IV PG – L	2	-2.8	25	80	35	10	N/A	0.3	0.4	N/A	50	29%
1	Type I PG – O & Type IV PG – L	2	-2.8	25	80	32.25	9.5	N/A	0.2	0.4	N/A	47	28%
2	Type IV EG	18	-3.4	28	10 (Baseline)	23	13.25		2.5	0.7		32	-
2	Type I PG – O	17	-3.4	28	80	0	N/A	N/A	N/A	N/A	N/A	3	10%
2	Type IV EG	15	-3.4	28	80	21	N/A	12	0.6	0.2	N/A	9	29%
2	Type I PG – O & Type IV EG	15	-3.4	28	80	18	N/A	9.5	1.6	0.5	N/A	9	27%
3	Type II PG – F	9	-5.0	24	10 (Baseline)	N/A	N/A		N/A	N/A		66	-
3	Type II PG – F	12	-5.0	24	80	N/A	N/A	N/A	N/A	N/A	N/A	7	10%
4	Type IV EG	6	0.2	16.5	10 (Baseline)	27.5	0.25		2.2	0.1		153	-
4	Type I PG – O	8	-0.1	15	80	N/A	2	0	0	0	N/A	23	15%
4	Type IV EG	7	-0.1	15	80	30	1.5	0	0.4	0	N/A	55	36%
4	Type I PG – O & Type IV EG	7	-0.1	15	80	30.5	3	0	0.4	0	N/A	63	41%
5	Type II PG – A	3	0.5	16	10 (Baseline)	30	0.5		N/A	N/A		73	-
5	Type I PG – O	4	0.5	16	80	N/A	0	N/A	N/A	N/A	N/A	86	118%
5	Type II PG – A	4	0.5	16	80	29.25	0	N/A	N/A	N/A	N/A	86	118%
5	Type I PG – O & Type II PG – A	4	0.5	16	80	29.25	0	N/A	N/A	N/A	N/A	86	119%
6	Type IV PG – A	7	0.5	14	10 (Baseline)	N/A	2		N/A	0.1		202	-
6	Type I PG – O	15	0.4	13	80	N/A	0	0	N/A	0	N/A	15	7%
6	Type IV PG – A	6	0.5	13	80	N/A	1.25	1.25	N/A	0	N/A	161	79%
6	Type I PG – O & Type IV PG – A	6	0.5	13	80	N/A	1.25	1.25	N/A	0	N/A	163	81%

Table 2.2: Test Log (cont'd)

Run (#)	Fluid	Precip. Rate (g/dm²/h)	Avg. OAT (°C)	Avg. Wind Speed (km/h)	Plate Inclination (°)	Brix @ 5 Min. (°)	Brix @ Fail (°)	Brix @ Baseline Fail (°)	Thick. @ 5 Min. (mm)	Thick. @ Fail (mm)	Thick. @ Baseline Fail (mm)	Fail Time (min.)	Fail time % of Baseline
7	Type IV PG – A	8	0.7	19	10 (Baseline)	N/A	1.5		N/A	0.2		237	-
7	Type I PG – O	8	0.6	17	80	N/A	0	0	N/A	0	N/A	18	8%
7	Type IV PG – A	10	0.6	17	80	N/A	4.5	0	N/A	0	N/A	28	12%
7	Type I PG – O & Type IV PG – A	10	0.6	17	80	N/A	3.5	0	N/A	0	N/A	26	11%
8	Type II PG – A	11	0.9	20	10 (Baseline)	26.5	0.5		0.2	0.1		17	-
8	Type I PG – O	11	0.9	20	80	2	0.25	0	0	N/A	0	14	82%
8	Type II PG – A	11	0.9	20	80	3	0.5	0	0	0	0	10	59%
8	Type I PG – O & Type II PG – A	11	0.9	20	80	4	0.25	0	0	N/A	0	15	89%
9	Type IV PG – L	4	1.0	27	10 (Baseline)	33.5	N/A		2.7	N/A		295	-
9	Type I PG – O	7	0.8	22	80	N/A	1	N/A	0	0	N/A	17	6%
9	Type IV PG – L	12	0.8	22	80	32.75	3.25	N/A	0.6	0.1	N/A	28	9%
9	Type I PG – O & Type IV PG – L	12	0.8	22	80	33.5	9	N/A	0.6	0.1	N/A	27	9%
10	Type II PG – A	31	1.1	30	10 (Baseline)	N/A	3		N/A	0.1		8	-
10	Type I PG – O	33	1.1	30	80	N/A	N/A	1	N/A	N/A	0.1	7	84%
10	Type II PG – A	35	1.1	30	80	N/A	1.75	1	N/A	N/A	0.1	4	52%
10	Type I PG – O & Type II PG – A	35	1.1	30	80	N/A	1.75	1	N/A	N/A	0.1	4	56%
11	Type II PG – A	4	1.2	37	10 (Baseline)	32.5	1		0.2	0.2		53	-
11	Type I PG – O	3	1.2	37	80	N/A	0	0	0	N/A	N/A	43	80%
11	Type II PG – A	3	1.2	37	80	21	1	0	0.1	N/A	N/A	43	81%
11	Type I PG – O & Type II PG – A	3	1.2	37	80	19	0.75	0	0.1	N/A	N/A	44	82%
12	Type IV PG – A	9	0.8	34	10 (Baseline)	36.5	15.5		2.2	0.3		146	-
12	Type I PG – O	7	0.8	34	80	N/A	1	0	0	0	0	34	23%
12	Type IV PG – A	8	0.8	34	80	36	2	0	0.5	0	0	36	24%
12	Type I PG – O & Type IV PG – A	8	0.8	34	80	35	2	0	0.4	0	0	36	25%

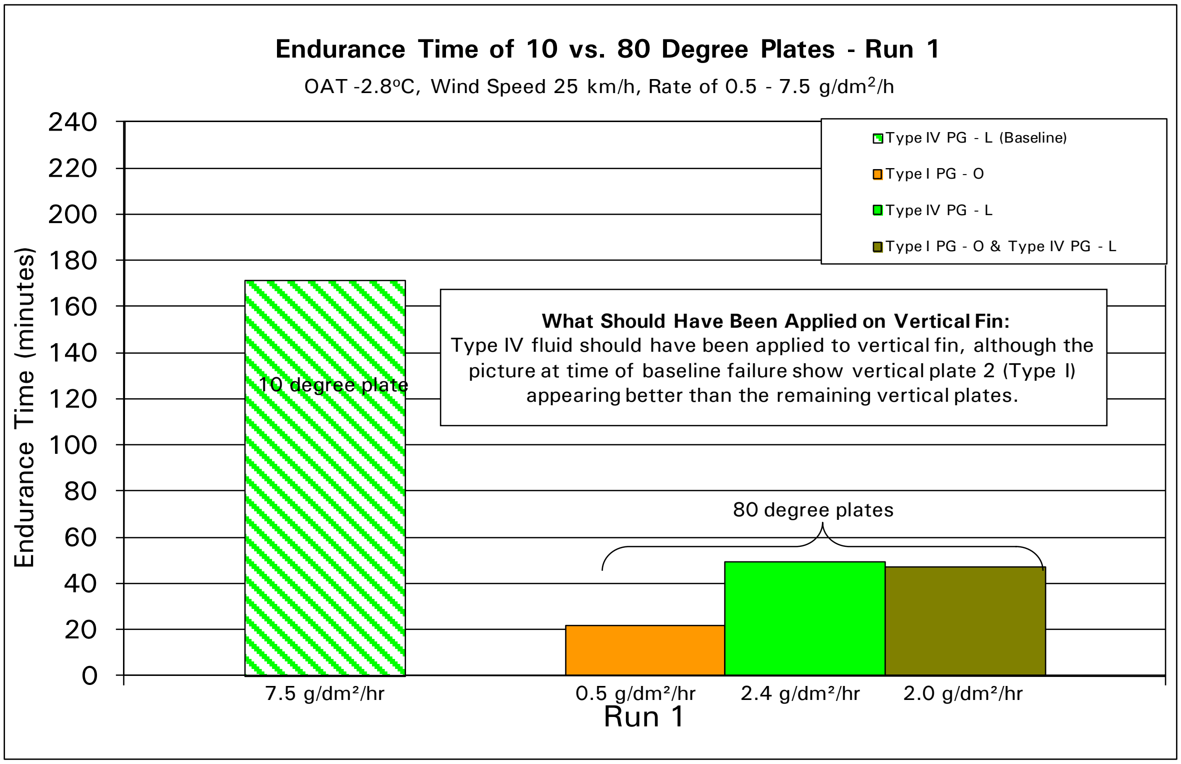

Figure 2.2: Endurance Time Comparison – Run #1

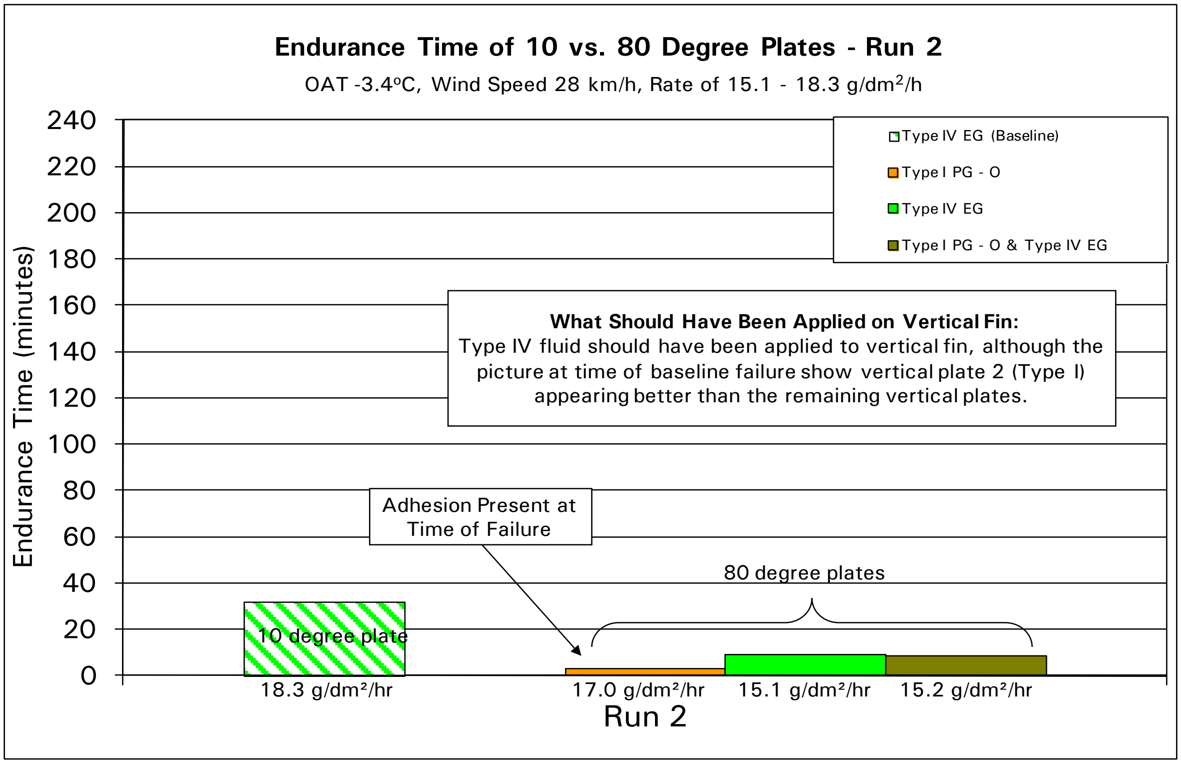

Figure 2.3: Endurance Time Comparison – Run #2

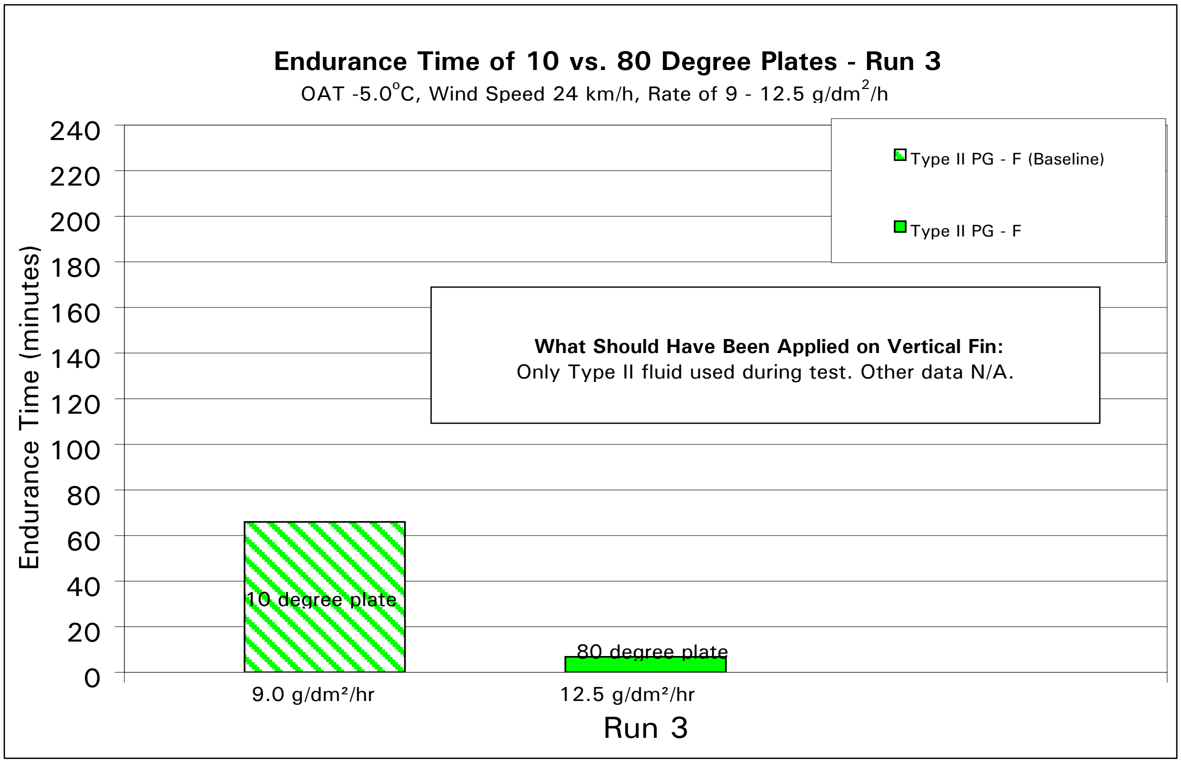

Figure 2.4: Endurance Time Comparison – Run #3

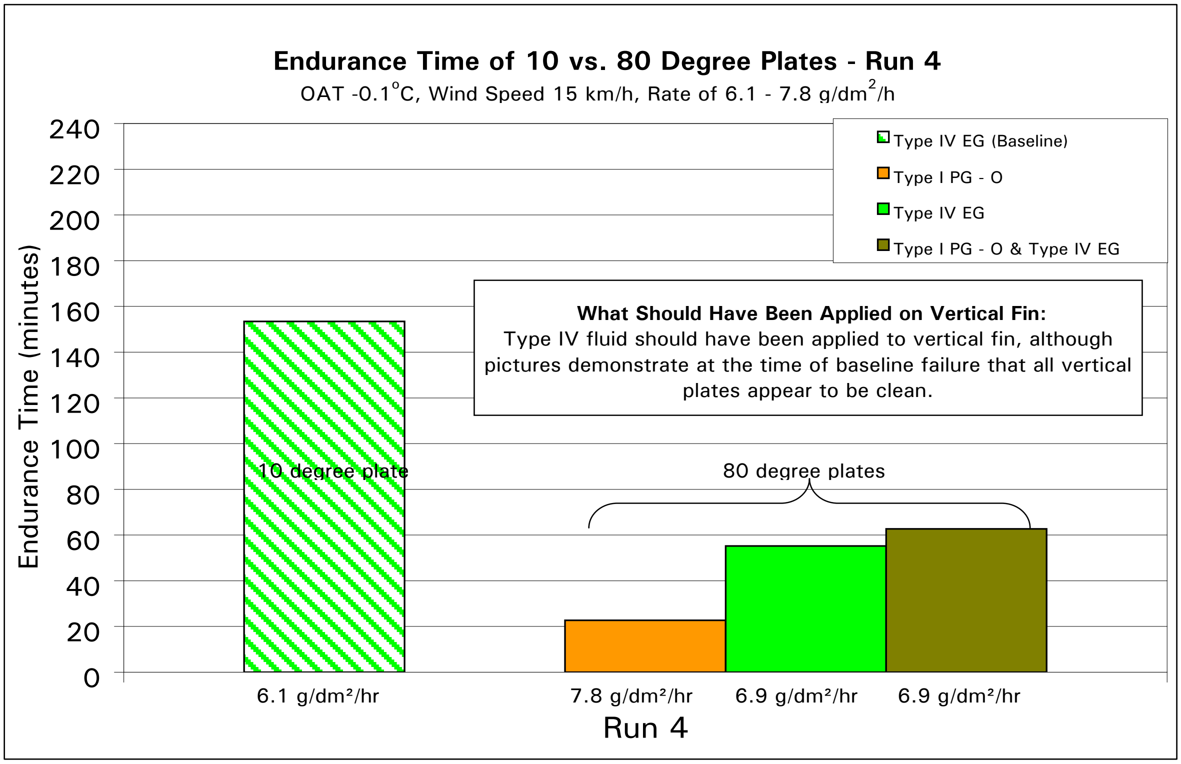

Figure 2.5: Endurance Time Comparison – Run #4

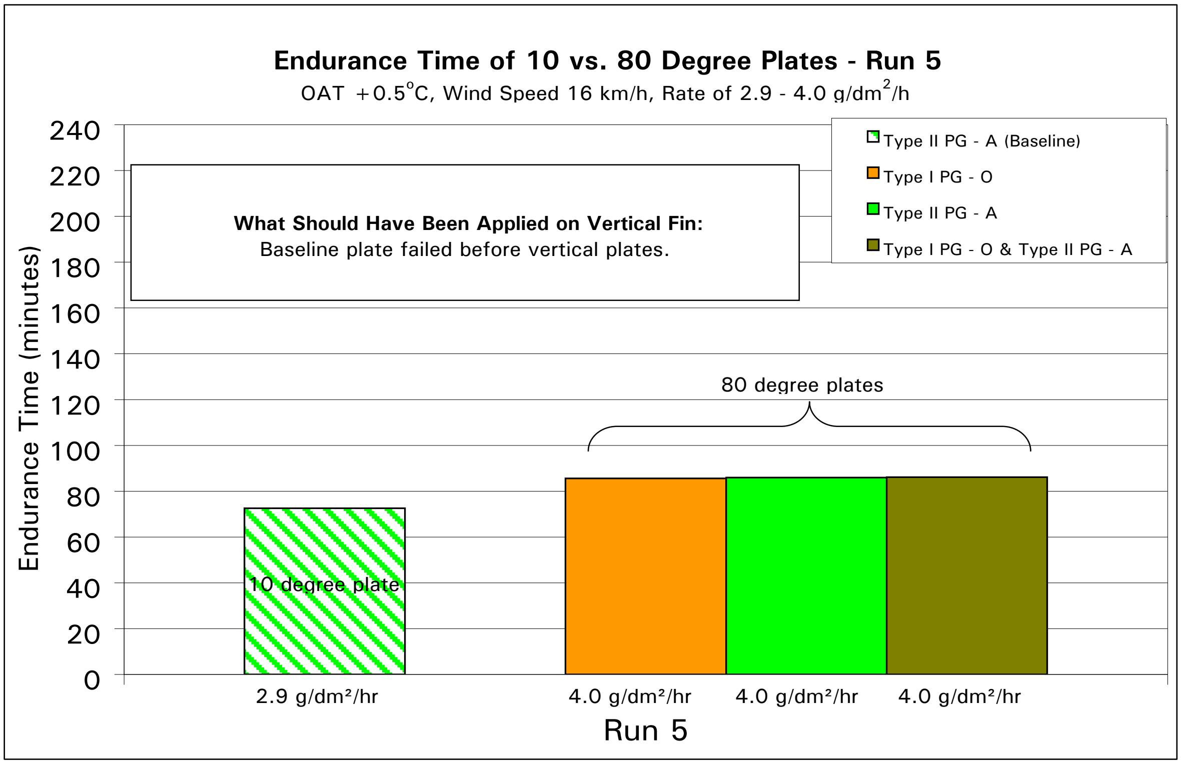

Figure 2.6: Endurance Time Comparison – Run #5

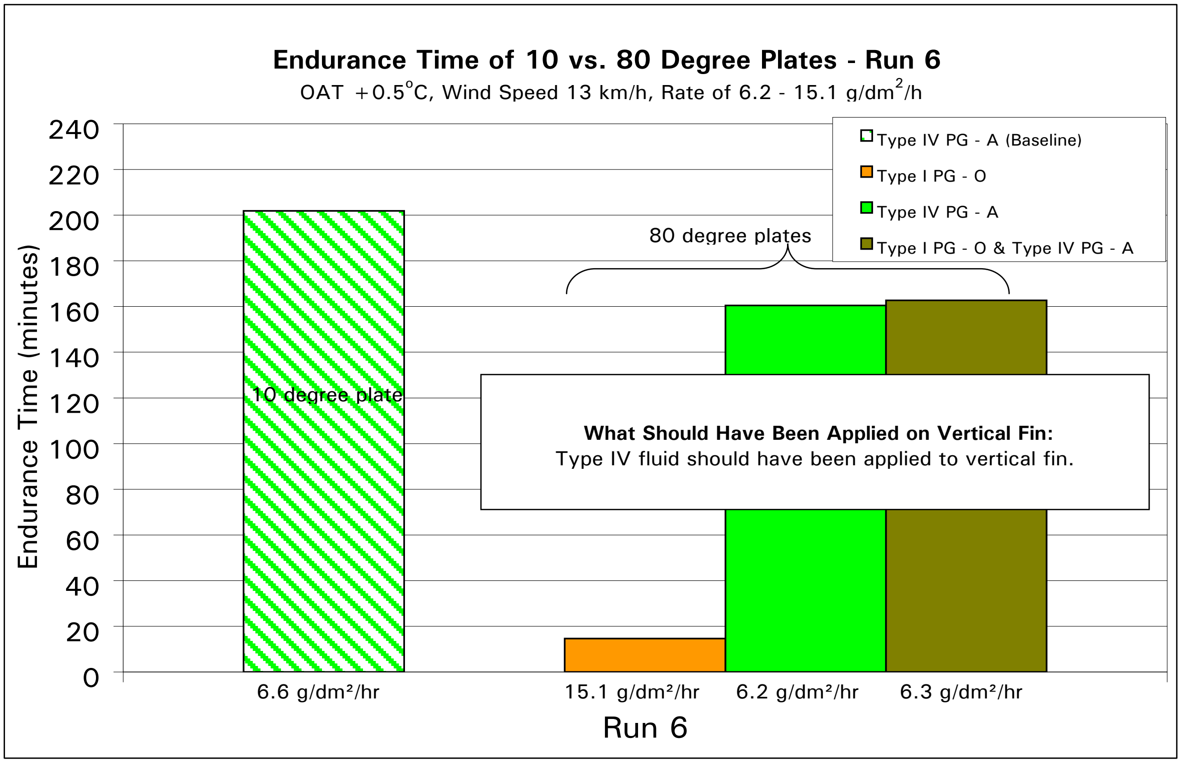

Figure 2.7: Endurance Time Comparison – Run #6

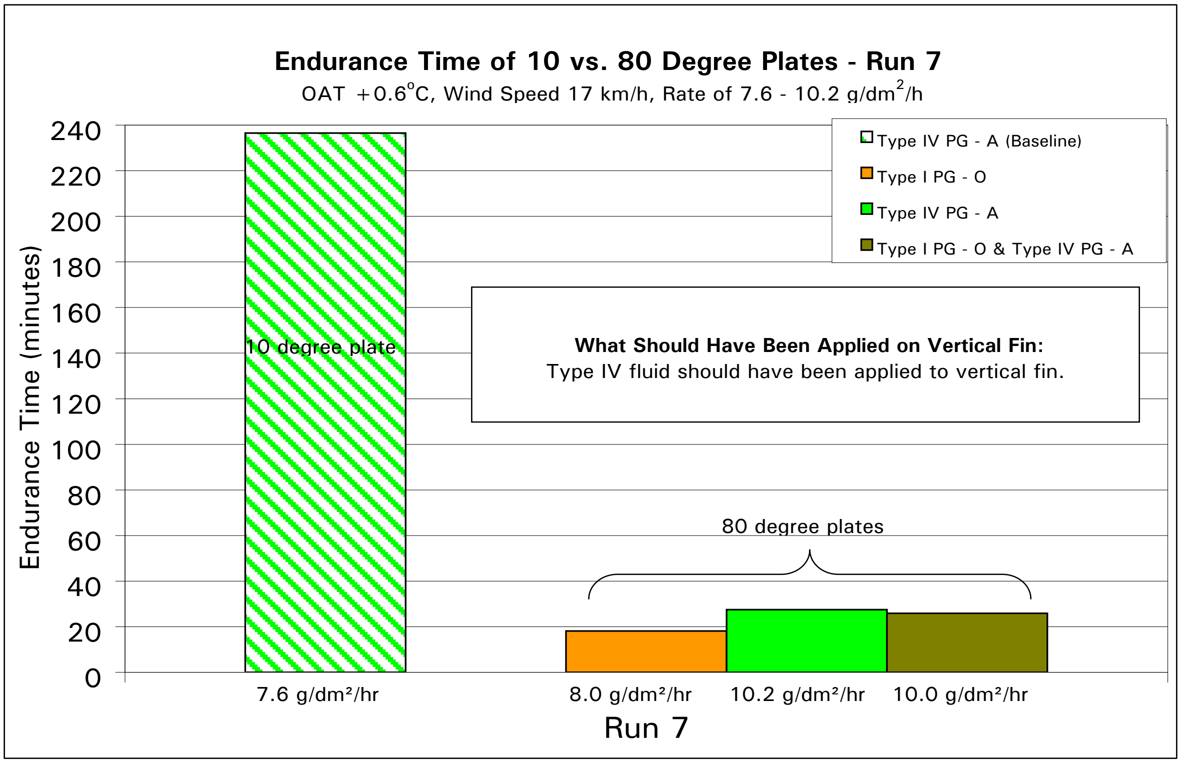

Figure 2.8: Endurance Time Comparison – Run #7

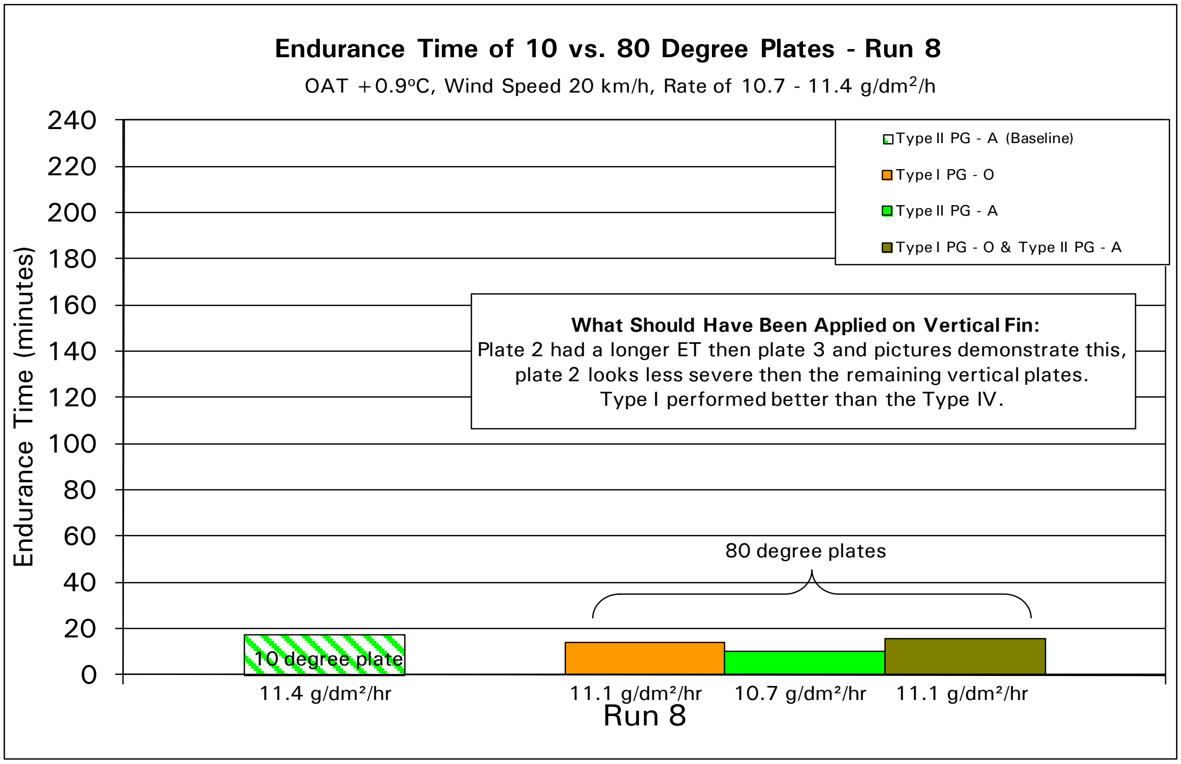

Figure 2.9: Endurance Time Comparison – Run #8

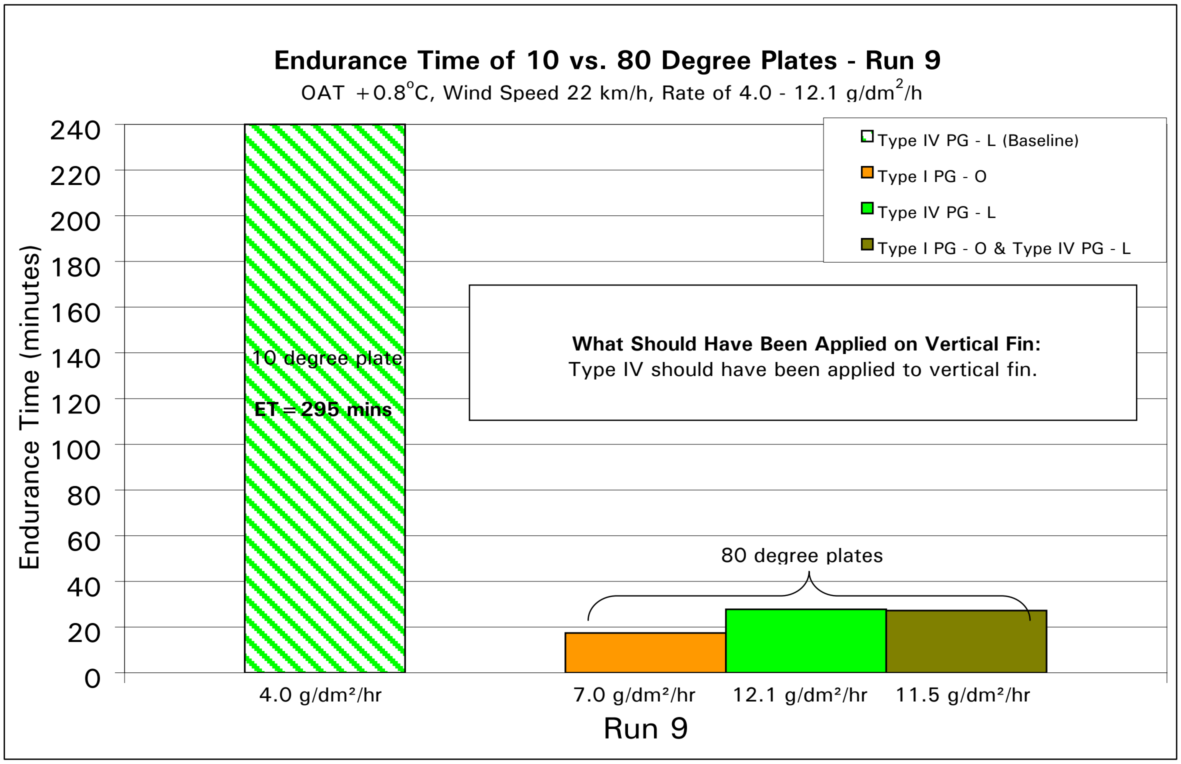

Figure 2.10: Endurance Time Comparison – Run #9

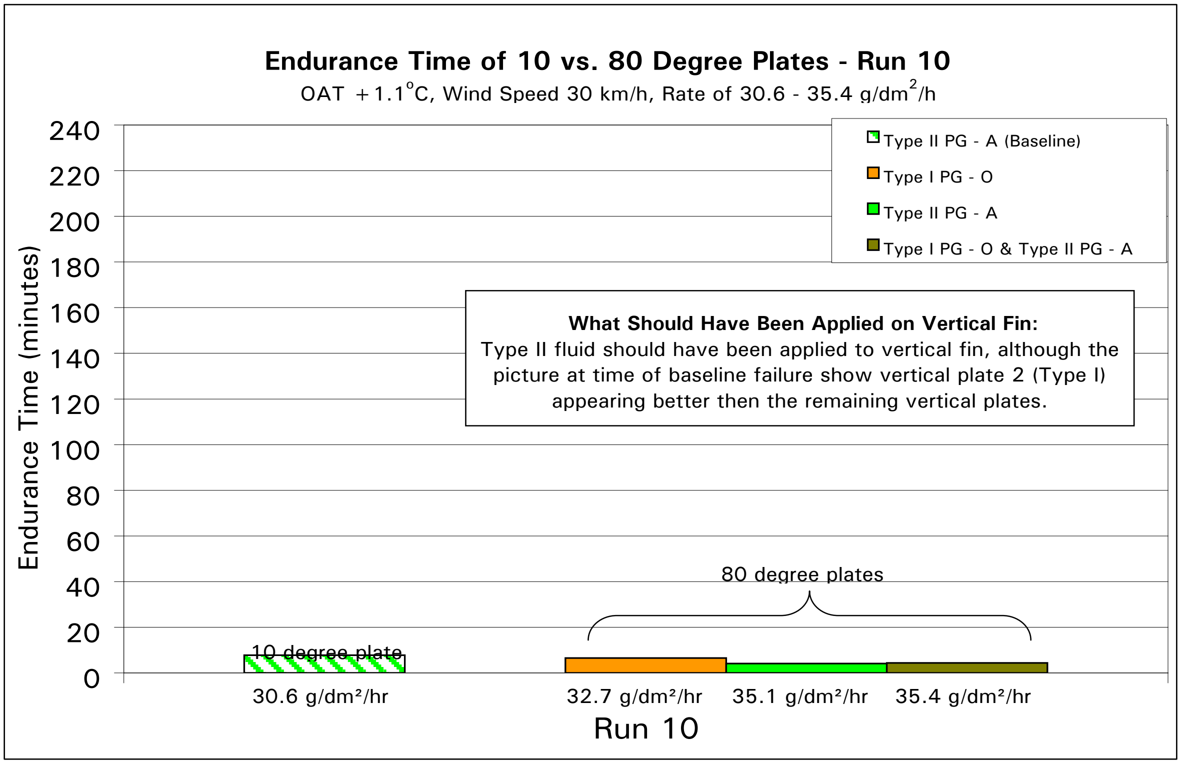

Figure 2.11: Endurance Time Comparison – Run #10

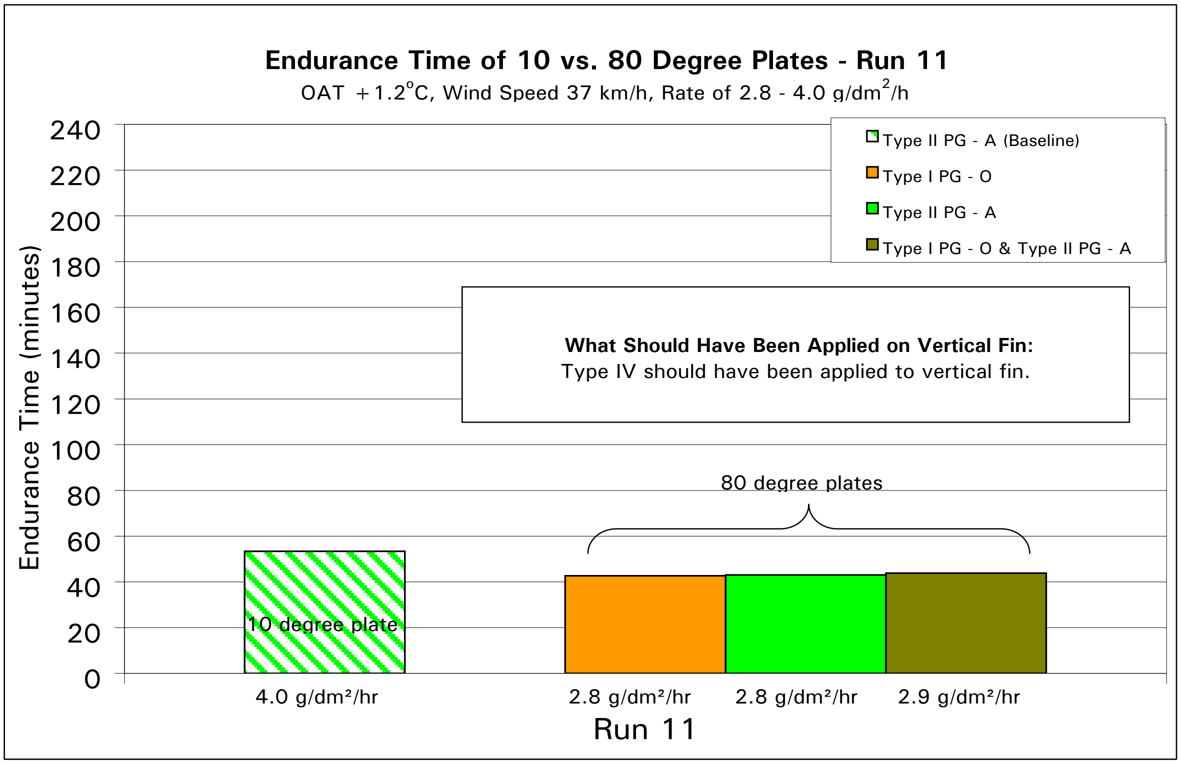

Figure 2.12: Endurance Time Comparison – Run #11

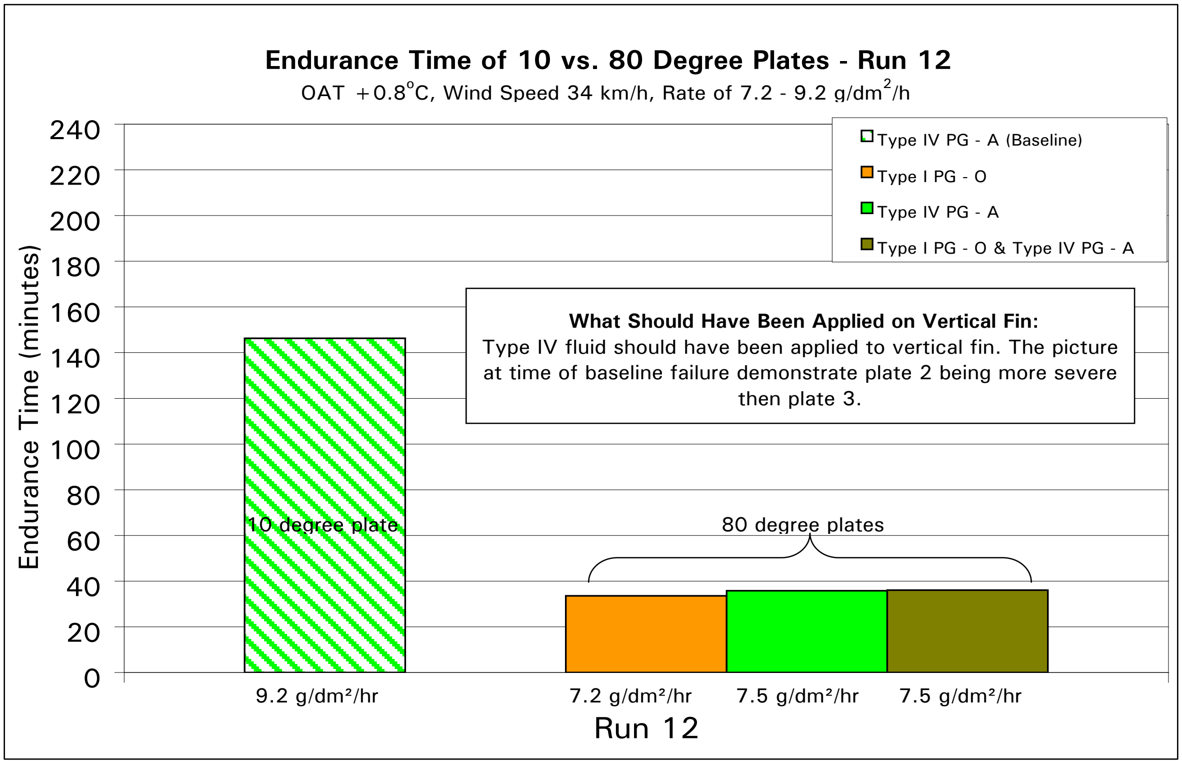

Figure 2.13: Endurance Time Comparison – Run #12

The results of the 12 tests are summarized in Table 2.3. The results indicate that vertical plate endurance times with Type II/IV fluid only were 45 percent of the standard 10-degree plate times; these results are in line with the 7 preliminary tests conducted in Winter 1999-2000, which demonstrated 31 percent of standard endurance times. Vertical plates to which Type II/IV fluids were applied in a one-step process performed in general equally well compared to the vertical plates treated with Type I followed by Type II/IV fluids (two-step), which had an average of 52 percent of standard endurance times. For those tests conducted with the vertical plates treated with Type I fluid only, the endurance times were 40 percent of standard endurance times. It should be noted that the majority of the testing was conducted at warmer temperatures (close to 0°C). Additional testing should be conducted at colder temperatures to substantiate the results observed.

Table 2.3: Summary of 2009-10 Endurance Time Results

Percentage of Baseline Endurance Time	
Type I (80° Plate)	40%
Type II/IV (80° Plate)	45%
Type I & Type II/IV (80° Plate)	52%

From a visual perspective, there were no large differences between Type I and Type II/IV vertical plates at the time of baseline failure (they were generally completely failed). However, differences did exist in the physical properties of the heavy contamination present; Photo 2.1 to Photo 2.20 demonstrate the different failure mechanisms observed during the tests. The tests conducted with Type I fluid on vertical plates can result in adhered, drier contamination as a result of the heat applied, whereas Type II/IV fluid on vertical plates can result in a stickier, thick slush due to the higher viscosity of the fluid.

Test #2 clearly demonstrates the difference in failure mechanisms. Photo 2.3 shows the Type I failure on the vertical plate; adherence of contamination was observed. In the same photo, however, the vertical plates protected with Type IV fluid demonstrated minimal failure. Although, at the time of the baseline plate failure (representing the typical fluid HOT), the plate protected with Type I fluid had a lesser degree of contamination (some of the dry contamination blew off in the wind), whereas both vertical plates protected with Type IV fluid showed severe levels of contamination (the contamination is a thick slush).

Based on these preliminary tests, it is not feasible to make conclusions regarding operational best practices. Aerodynamic testing is recommended to verify the severity of the two different types of contamination observed: dry, adhered contamination associated with Type I fluids versus thick, slushy contamination found with Type II/IV fluids.

2.5 Analysis Excluding Data with Large Rate Differences

Testing was conducted during natural snow conditions, and as a result, variations in precipitation intensity were inevitable. Due to differences in fluid endurance times, some tests may have lasted longer or shorter, and therefore may have experienced a different average rate of precipitation compared to other tests during the same run. Due to the limited data that was collected, all the data was included in this report; however, the following sensitivity analysis aims at identifying possible discrepancies that may have resulted due to the variation in precipitation rate.

Table 2.4 displays the data used for the sensitivity analysis; tests with precipitation rates that were different by more than 20 percent compared to the baseline were removed.

Table 2.5 demonstrates the results of the sensitivity analysis compared to the full 2009-10 data set and the previous data collected in 1999-2000. The results of the sensitivity analysis indicate that the conclusions do not change significantly when tests with precipitation rates differing by more than 20 percent compared to the baseline are removed.

2.6 SAE G-12 Discussion of Results

The work conducted was presented at both the SAE International (SAE) G-12 Aerodynamics Working Group meeting and the HOT Committee meeting in Berlin in May 2010. The feedback indicated a concern regarding the reduced protection time on vertical surfaces. It was suggested that a note be added in the HOT Guidelines (as an interim solution to reducing the HOTs) regarding the data collected and the reduced endurance times observed; however, following some discussion, it was determined that the data is still preliminary and that additional testing would be required before specific guidance can be issued.

In addition, a presentation was made by Austrian Airlines (with support from Finnair and Clariant) describing some preliminary testing that was conducted. The testing indicated results similar to those presented by APS Aviation Inc. (APS); reduced protection times were observed on the simulated vertical surfaces.

Table 2.4: Test Log – Data Used for Sensitivity Analysis

Run (#)	Fluid	Precip. Rate (g/dm²/h)	% Diff. in Precip. Rate (x/baseline)	Avg. OAT (°C)	Avg. Wind Speed (km/h)	Plate Inclination (°)	Fail Time (min.)	Fail time % of Baseline
2	Type IV EG	18	-	-3.4	28	10 (Baseline)	32	-
2	Type I PG – O	17	93%	-3.4	28	80	3	10%
2	Type IV EG	15	83%	-3.4	28	80	9	29%
2	Type I PG – O & Type IV EG	15	83%	-3.4	28	80	9	27%
4	Type IV EG	6	-	0.2	16.5	10 (Baseline)	153	-
4	Type I PG – O	8	128%	-0.1	15	80	23	15%
4	Type IV EG	7	113%	-0.1	15	80	55	36%
4	Type I PG – O & Type IV EG	7	113%	-0.1	15	80	63	41%
6	Type IV PG – A	7	-	0.5	14	10 (Baseline)	202	-
6	Type IV PG – A	6	95%	0.5	13	80	161	79%
6	Type I PG – O & Type IV PG – A	6	95%	0.5	13	80	163	81%
7	Type IV PG – A	8	-	0.7	19	10 (Baseline)	237	-
7	Type I PG – O	8	105%	0.6	17	80	18	8%
8	Type II PG – A	11	-	0.9	20	10 (Baseline)	17	-
8	Type I PG – O	11	97%	0.9	20	80	14	82%
8	Type II PG – A	11	94%	0.9	20	80	10	59%
8	Type I PG – O & Type II PG – A	11	97%	0.9	20	80	15	89%
10	Type II PG – A	31	-	1.1	30	10 (Baseline)	8	-
10	Type I PG – O	33	107%	1.1	30	80	7	84%
10	Type II PG – A	35	115%	1.1	30	80	4	52%
10	Type I PG – O & Type II PG – A	35	116%	1.1	30	80	4	56%
12	Type IV PG – A	9	-	0.8	34	10 (Baseline)	146	-
12	Type I PG – O	7	79%	0.8	34	80	34	23%
12	Type IV PG – A	8	82%	0.8	34	80	36	24%
12	Type I PG – O & Type IV PG – A	8	82%	0.8	34	80	36	25%

NOTE: Tests with precipitation rates that were different by more than 20% compared to the baseline were removed.

Table 2.5: Results of Sensitivity Analysis

Percentage of Baseline Endurance Time			
	1999-2000	**2009-10 (All Data)**	**2009-10 (Sensitivity Analysis)**
Type I (80° Plate)	N/A	40%	37%
Type II/IV (80° Plate)	39%	45%	47%
Type I & Type II/IV (80° Plate)	N/A	52%	53%

2.7 Conclusions and Recommendations

The 2009-10 results indicate that both Type I (40 percent) and Type II/IV (45 percent) fluid endurance times on vertical surfaces show large reductions in endurance times compared to the baseline test; additional testing is recommended at colder temperatures to substantiate the results observed. In addition, it is recommended to validate the flat plate results with visual observations during live aircraft testing (with the TC Citation aircraft) using Type I and Type IV fluids.

Differences in the physical properties of the heavy contamination present were observed between Type I and Type II/IV fluids on vertical plates at the time of baseline failure. Aerodynamic testing is recommended to verify the severity of the two different types of contamination observed: dry, adhered contamination associated with Type I fluids versus thick, slushy contamination observed with Type II/IV fluids.

Potential testing could be conducted using ice phobic treated surfaces to investigate potential benefits of using the ice phobic products on surfaces prone to early fluid failure.

A cooperative effort could be coordinated with Austrian Airlines to collect operational data regarding early fluid failure on vertical surfaces. This data could be used to validate the test methodology currently being used by APS for evaluating fluid endurance times on vertical surfaces.

2.8 Operational Considerations

The testing conducted in natural snow conditions simulating aircraft vertical surfaces (vertical tails and winglets) has indicated a potential significant reduction in fluid endurance times. Preliminary results have indicated that applying Type II/IV fluid on the vertical surfaces (versus only applying Type I fluid) can provide some additional protection; however, the aerodynamic severity of heavily contaminated Type I versus Type II/IV fluid on vertical surfaces has yet to be investigated.

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Photo 2.1: Vertical Stabilizer Run #1 – At Vertical Plate Failure
February 18, 2010

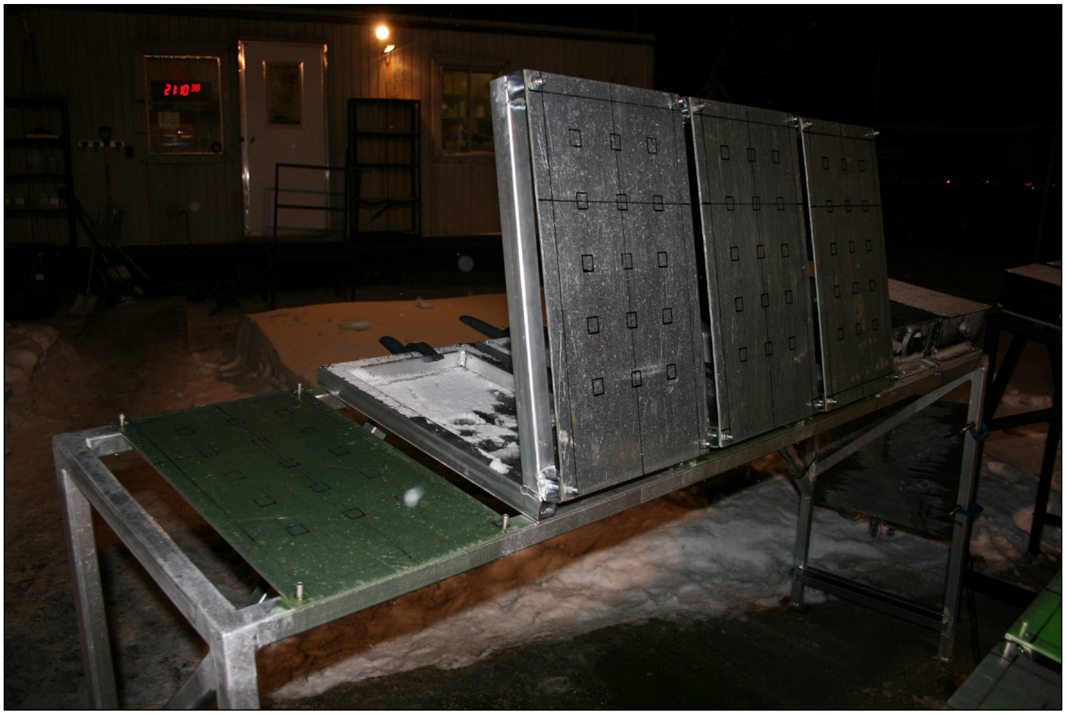


Photo 2.2: Vertical Stabilizer Run #1 – At Baseline Plate Failure
February 18, 2010

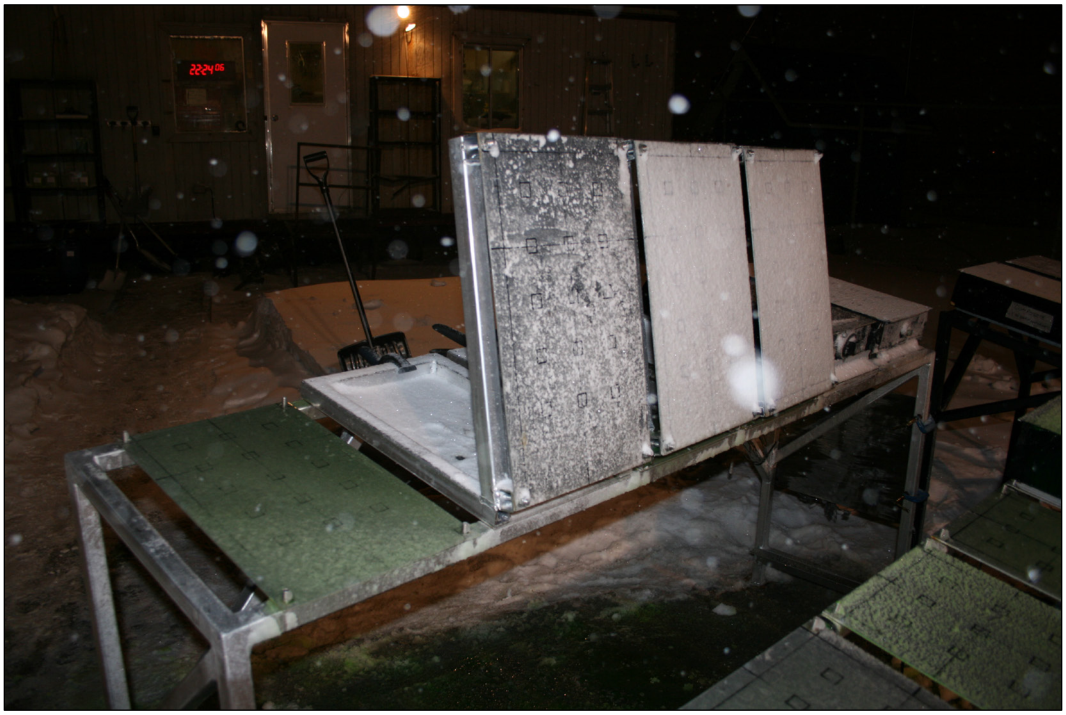


Photo 2.3: Vertical Stabilizer Run #2 – At Vertical Plate Failure
February 18/19, 2010

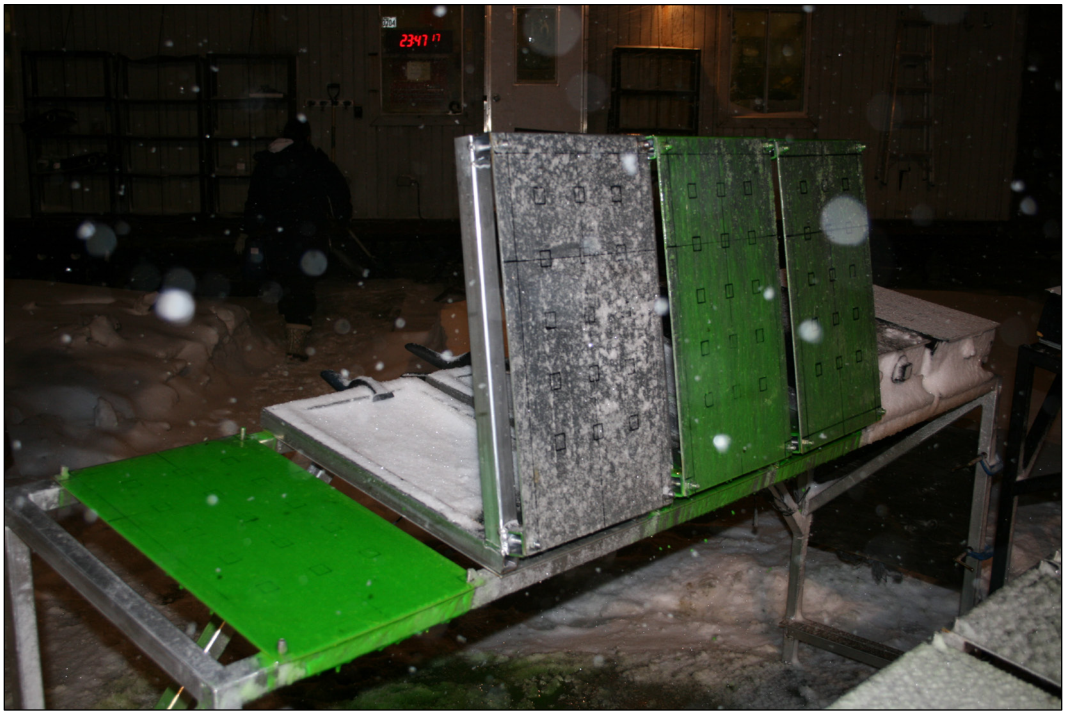


Photo 2.4: Vertical Stabilizer Run #2 – At Baseline Plate Failure
February 18/19, 2010

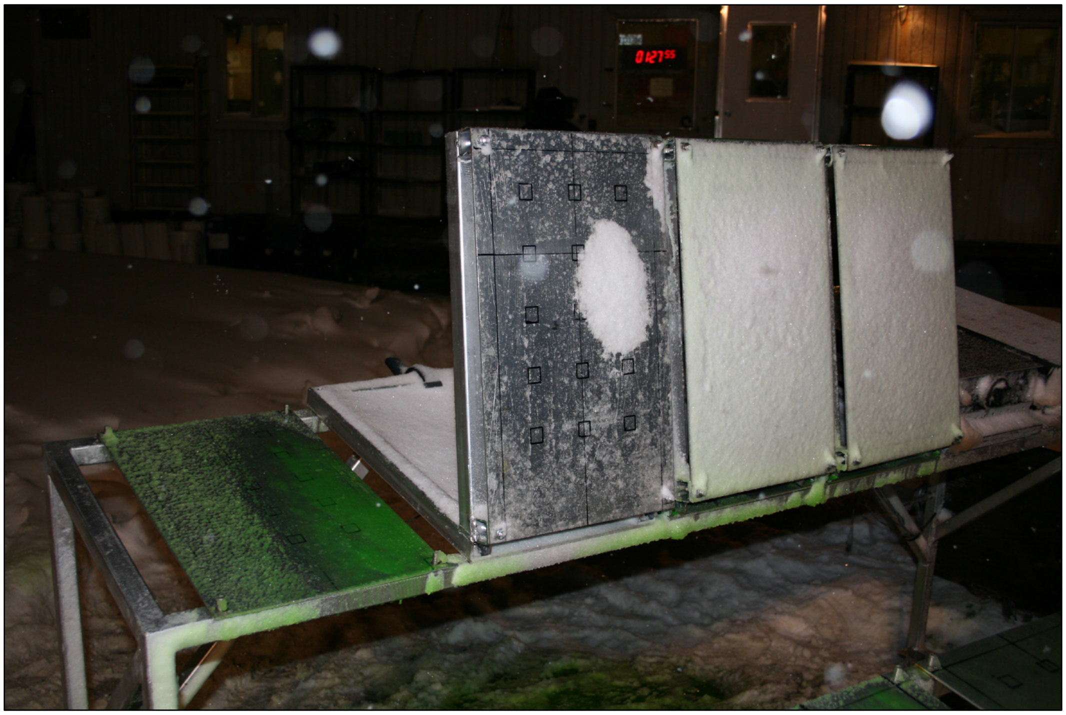


Photo 2.5: Vertical Stabilizer Run #3 – At Vertical Plate Failure
February 19, 2010

Photo not Available

Photo 2.6: Vertical Stabilizer Run #3 – At Baseline Plate Failure
February 19, 2010

Photo not Available

Photo 2.7: Vertical Stabilizer Run #4 – At Vertical Plate Failure
February 23, 2010

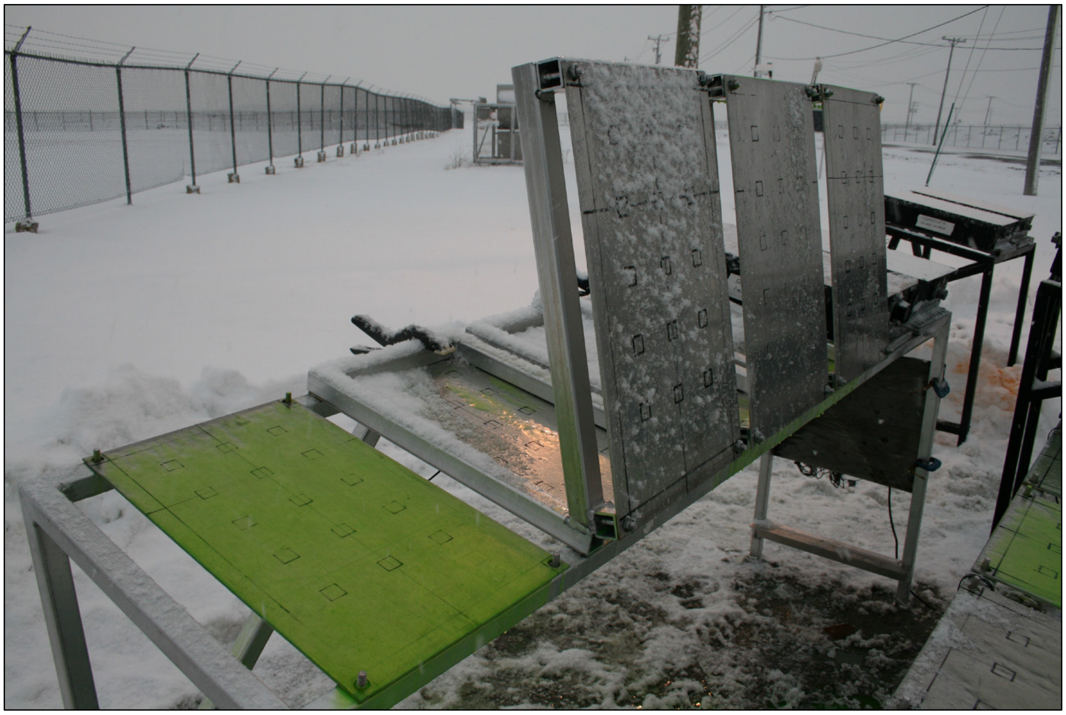


Photo 2.8: Vertical Stabilizer Run #4 – At Baseline Plate Failure
February 23, 2010

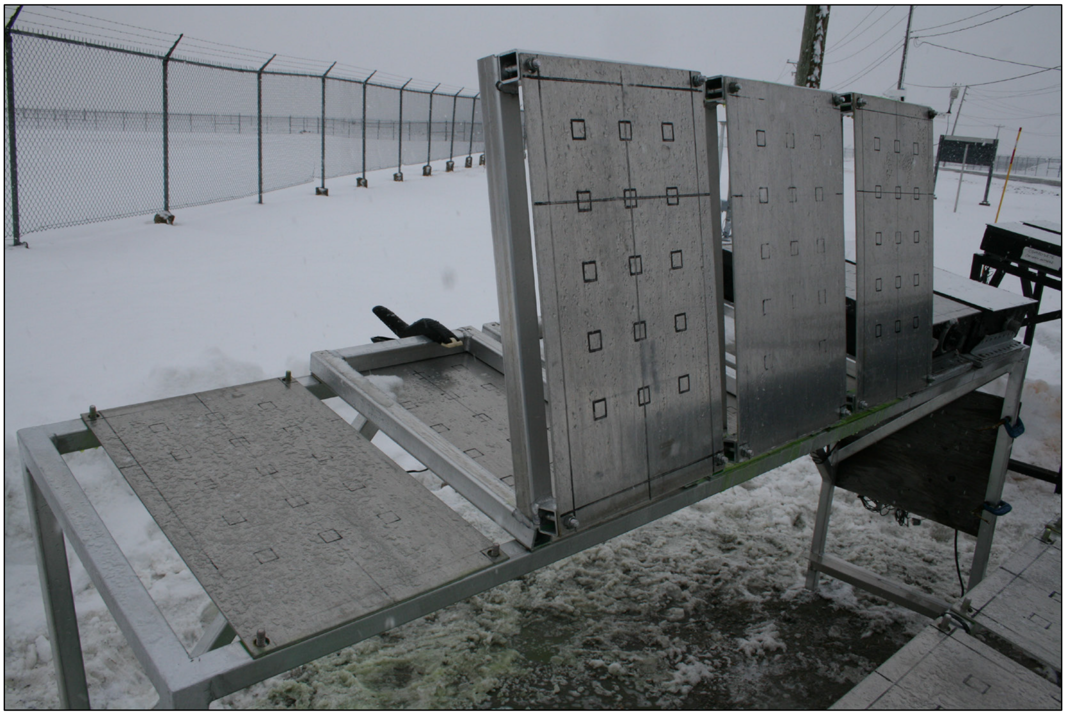


Photo 2.9: Vertical Stabilizer Run #5 – At Vertical and Baseline Plate Failure
February 24, 2010

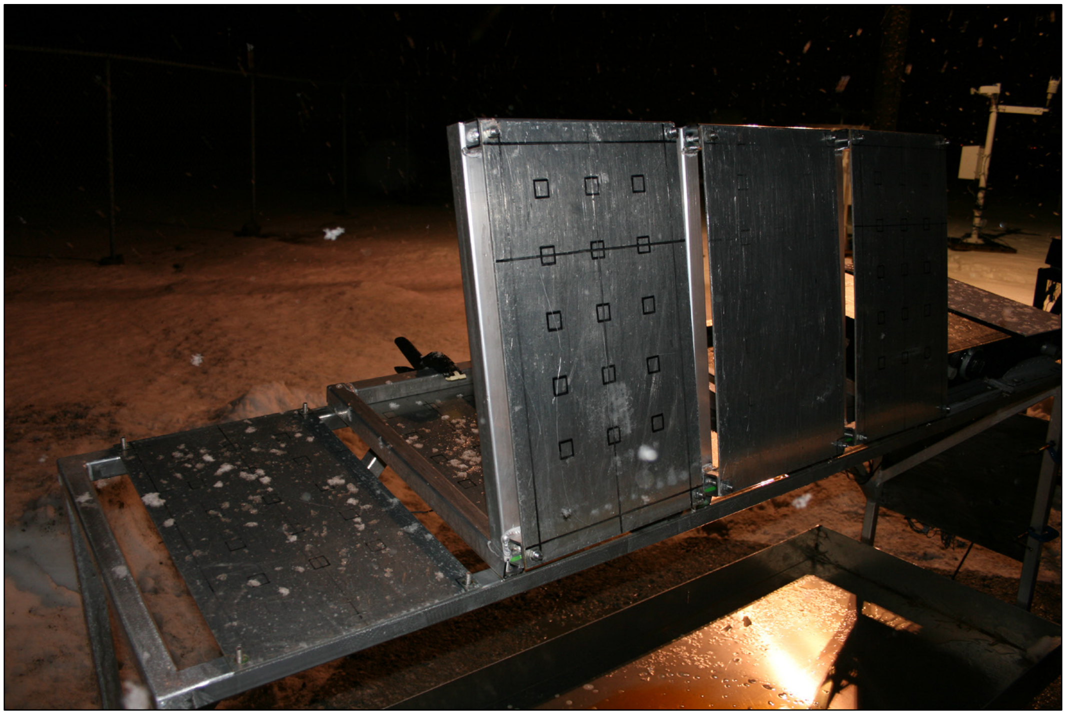


Photo 2.10: Vertical Stabilizer Run #6 – At Vertical Plate Failure
February 24, 2010

Photo not Available

Photo 2.11: Vertical Stabilizer Run #6 – At Baseline Plate Failure
February 24, 2010

Photo not Available

Photo 2.12: Vertical Stabilizer Run #7 – At Vertical Plate Failure
February 24, 2010

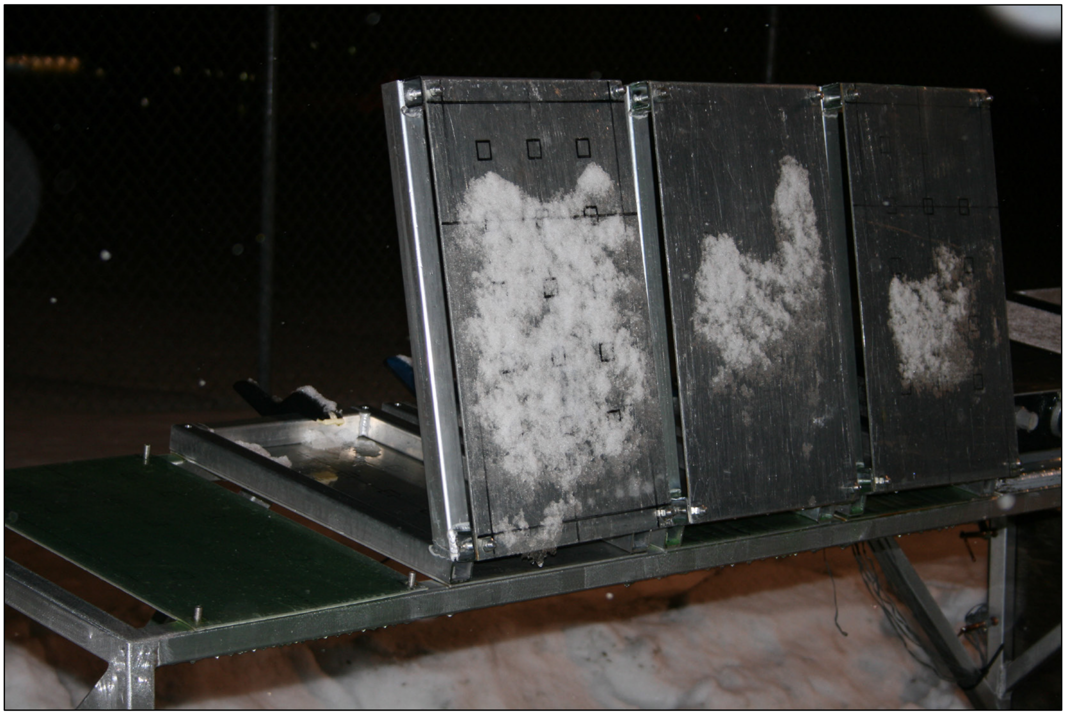


Photo 2.13: Vertical Stabilizer Run #8 – At Vertical and Baseline Plate Failure
February 24, 2010

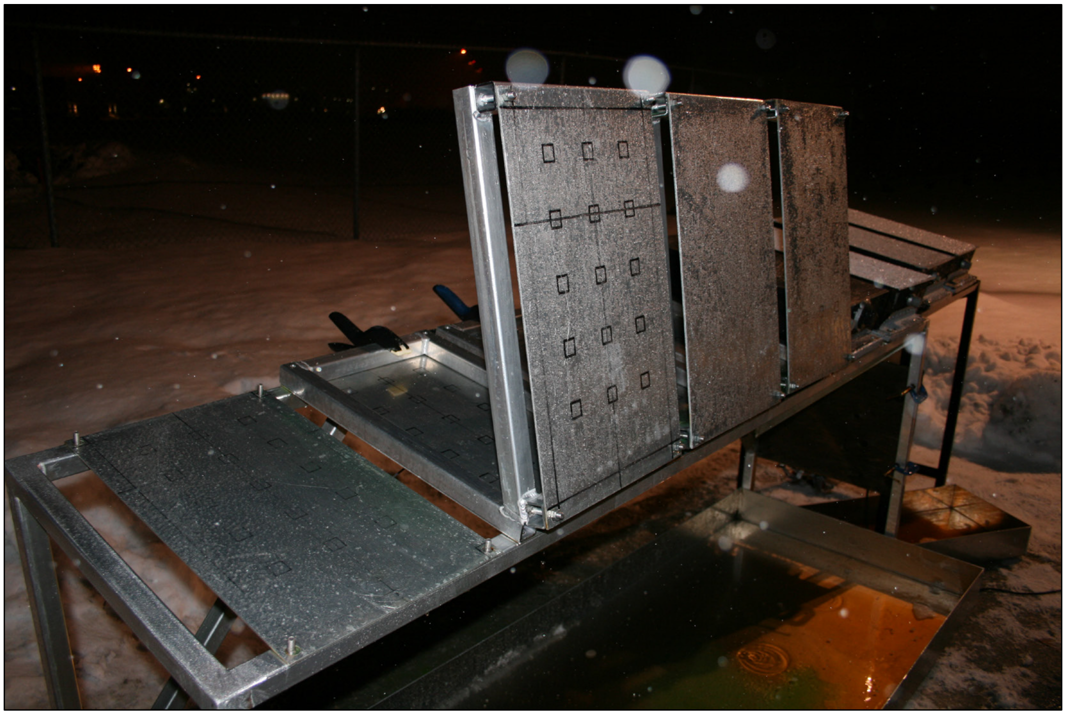


Photo 2.14: Vertical Stabilizer Run #9 – At Vertical Plate Failure
February 24, 2010

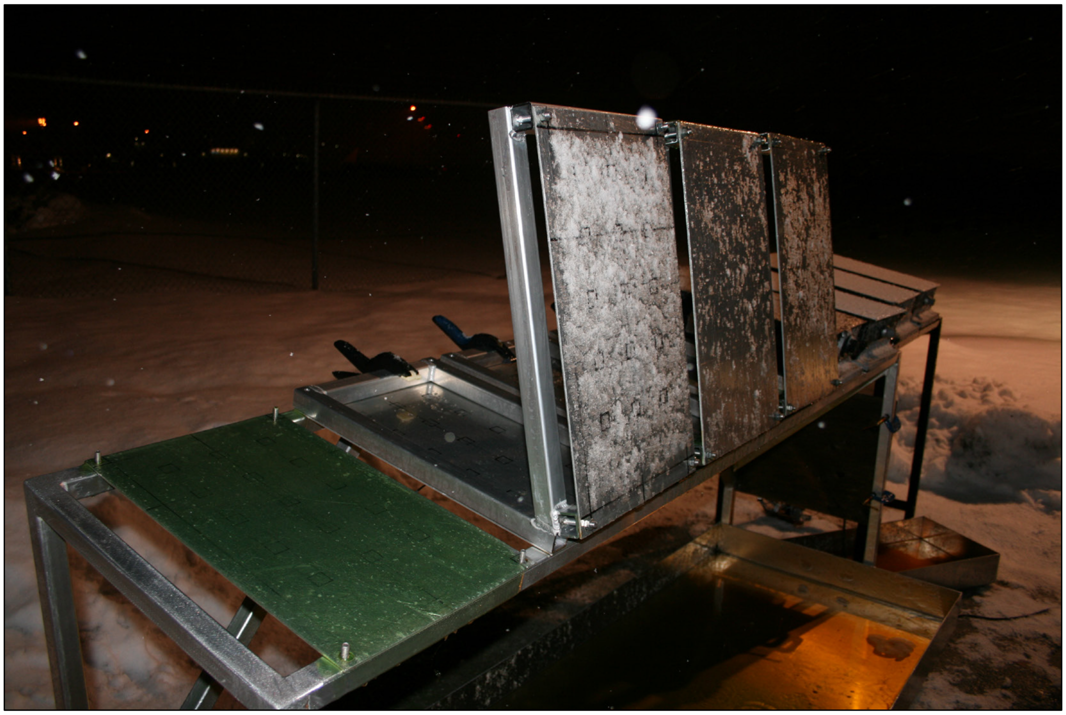


Photo 2.15: Vertical Stabilizer Run #10 – At Vertical Plate Failure
February 25, 2010

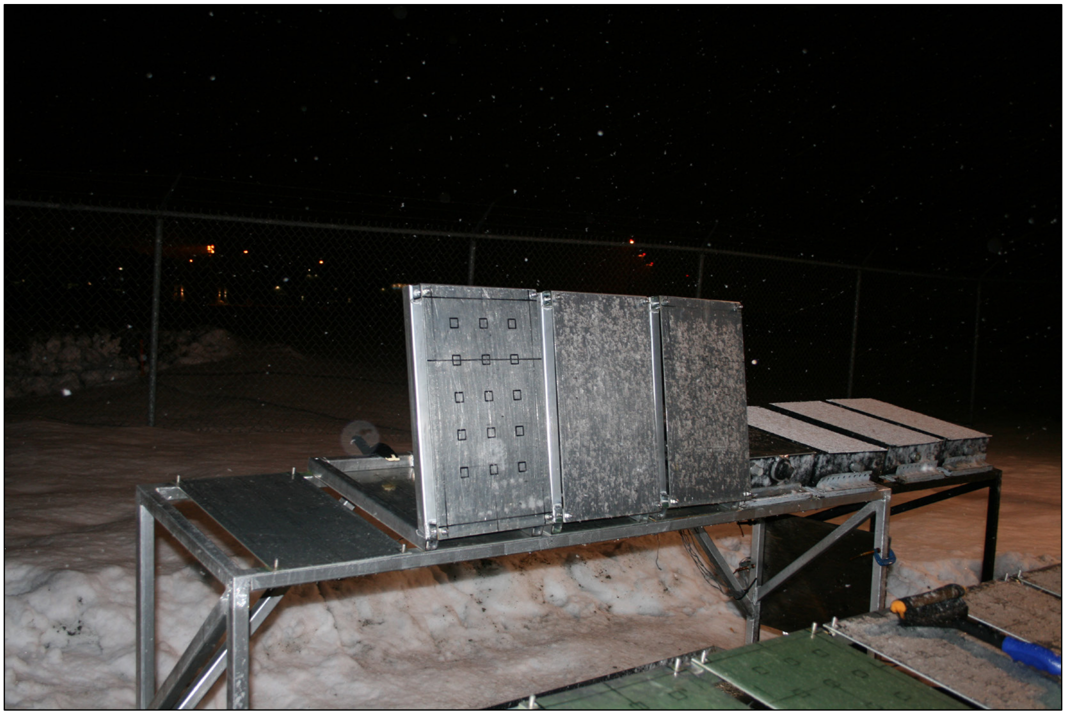


Photo 2.16: Vertical Stabilizer Run #10 – At Baseline Plate Failure
February 25, 2010

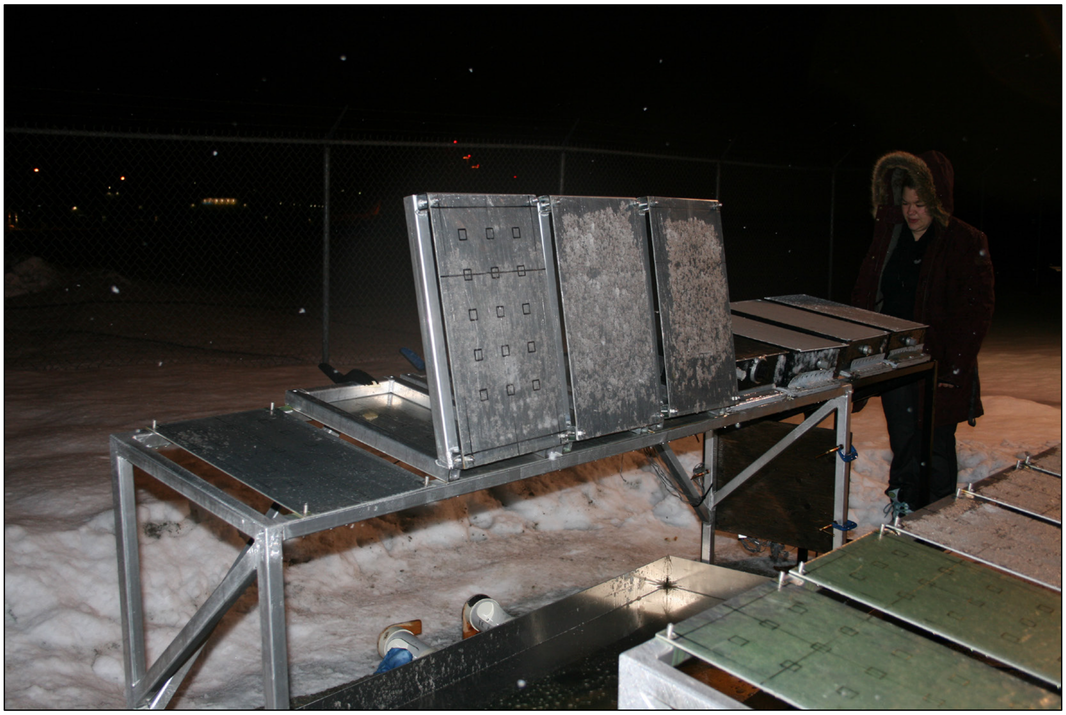


Photo 2.17: Vertical Stabilizer Run #11 – At Vertical Plate Failure
February 27, 2010

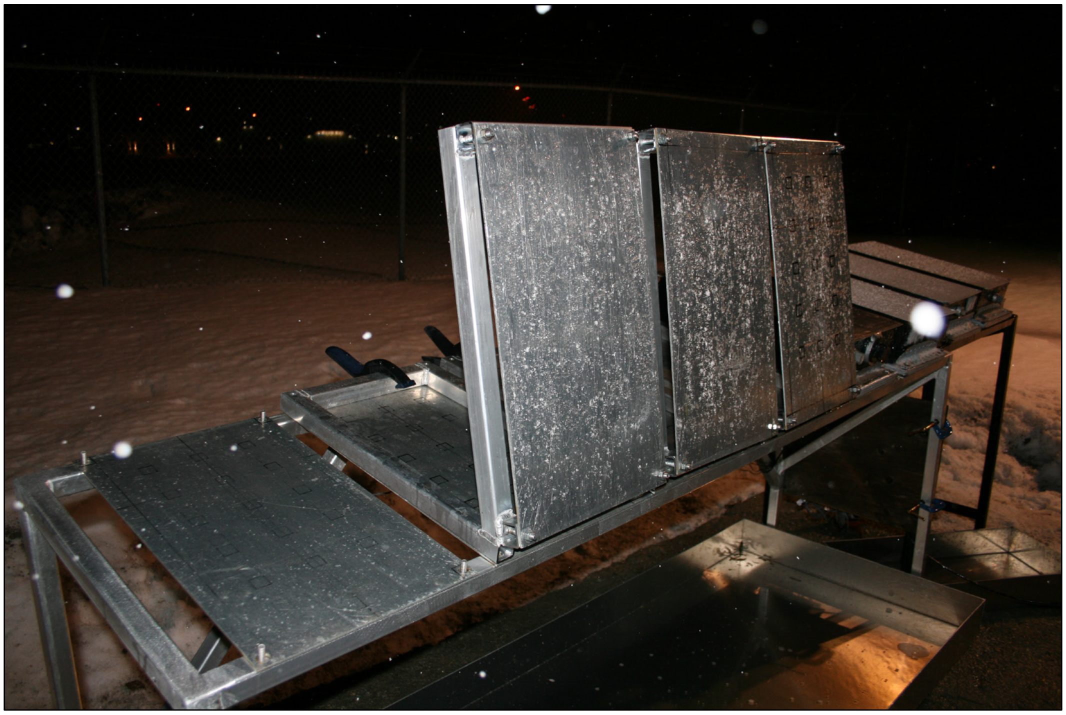


Photo 2.18: Vertical Stabilizer Run #11 – At Baseline Plate Failure
February 27, 2010

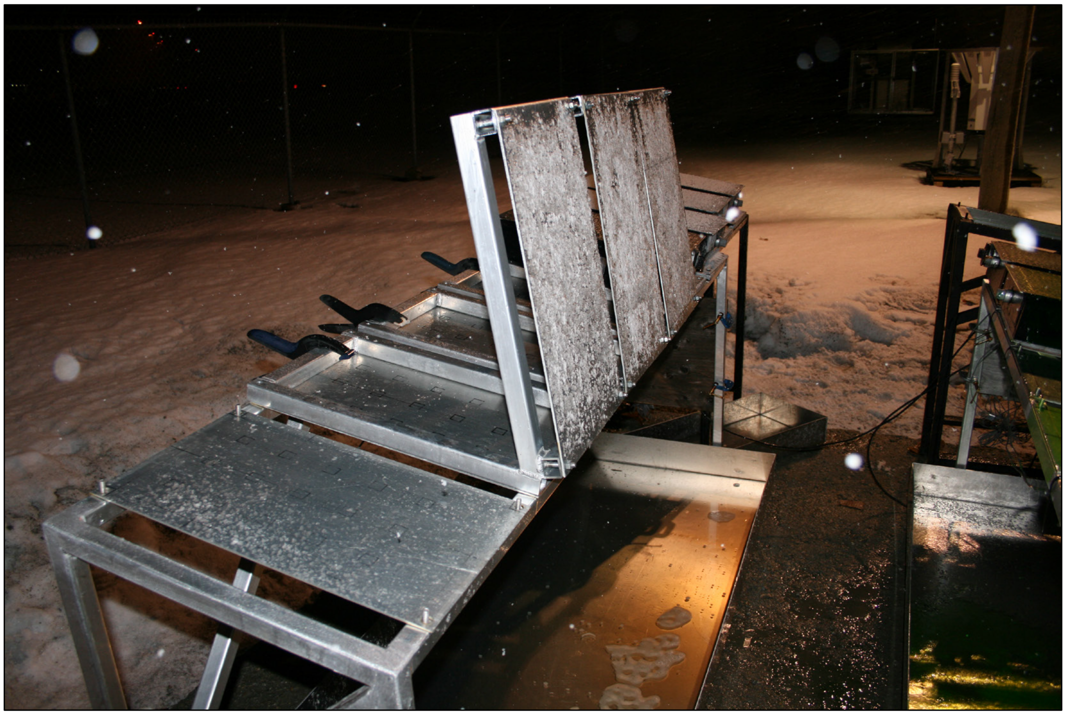


Photo 2.19: Vertical Stabilizer Run #12 – At Vertical Plate Failure
February 27, 2010

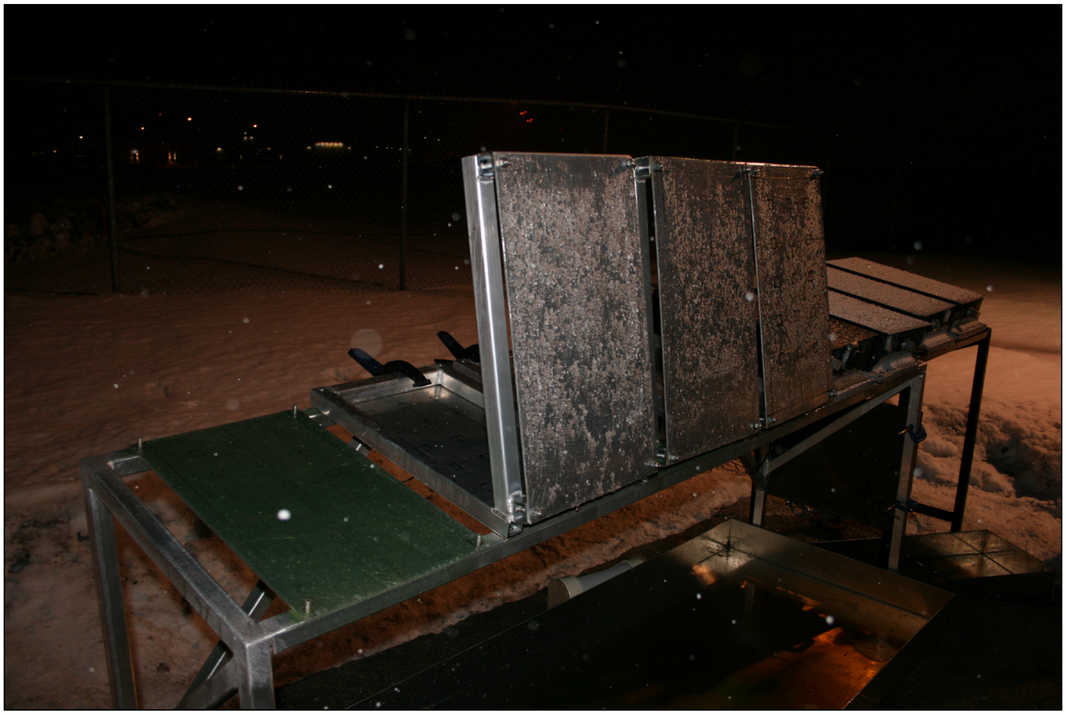
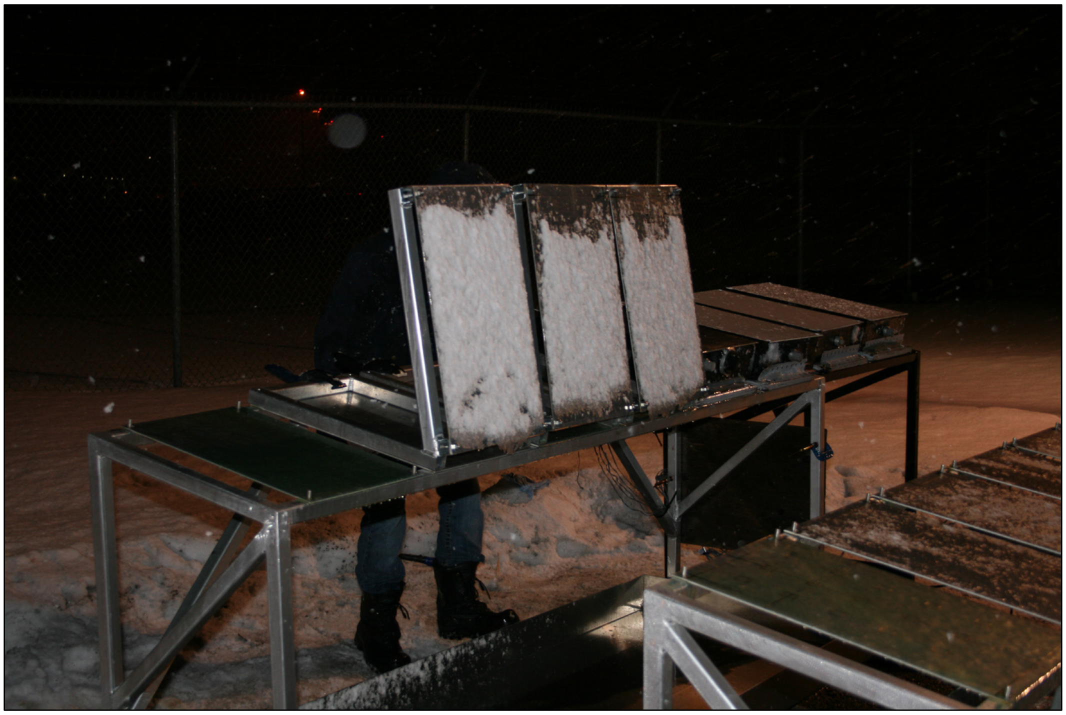


Photo 2.20: Vertical Stabilizer Run #12 – At Baseline Plate Failure
February 27, 2010



3. EVALUATION OF A SENSOR FOR NOWCASTING ACTIVE FROST

3.1 Background

Frost is an important consideration in aircraft deicing. Irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. This potential hazard is amplified by the frequent occurrence of frost accretion in winter operations.

Frost occurs when the surface temperature of an object is below the frost point; the frost point is determined by outside air temperature (OAT) and relative humidity (RH). The ideal conditions for frost accretion are the following:

- Outside Ambient Temperature: Below 3ºC
- Relative Humidity: Above 60 percent
- Wind Speed: Less than 5 km/h
- Sky Condition: Clear or mostly unobstructed

Frost contamination represents a significant portion of deicing operations, on average 33 percent in Europe, North America, and Asia.

Currently, no standardized technology or manual approach is being used in aircraft operations to determine active frost conditions. Typically, visual inspections of aircraft surfaces and surroundings are performed to determine if frost conditions are active.

3.2 Objective

The objective of this research was to investigate the accuracy of predicting frost using data obtained from Environment Canada and the data acquired from APS Aviation Inc. (APS) frost equipment. To achieve this objective, a series of preliminary frost tests were conducted in natural frost conditions during the 2009-10 testing season. Very limited testing was conducted due to funding limitations and questions on feasibility.

3.3 Test Methodology

Details of the procedure used for testing can be found in Appendix C. The following is a brief description of the test parameters monitored and measured as well as a general summary of the methodology used.

3.3.1 OAT and RH Data

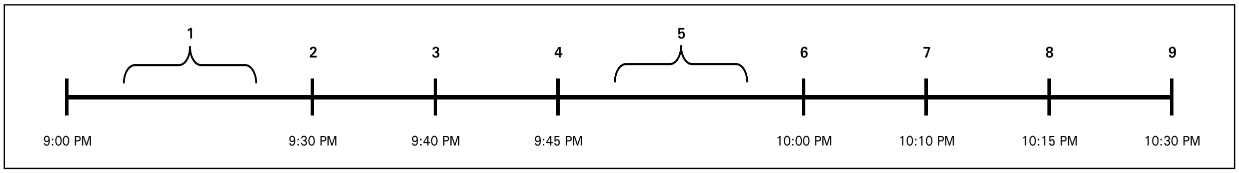
OAT and RH data was obtained online from the Environment Canada website. Data was updated hourly (on the hour mark). The Environment Canada weather station is located adjacent to the APS Montreal–Trudeau Airport test site.

3.3.2 "Frosticator" Plate Surface Temperature Data

Two standard aluminum test plates were used for testing. The plates were configured as "frosticator" plates, historically used for natural frost endurance time testing; the aluminum plates were painted white using aircraft-grade paint, an insulation backing was adhered, and a thermistor probe was positioned on the top surface at the 15 cm line (from the top of the plate). The plate surface temperature was monitored, and it was visually inspected during each test for frost accretion. In addition, the rate of frost accretion was measured by weighing the frosticator plates before and after exposure (see Photo 3.1, Photo 3.2, and Photo 3.3).

3.3.3 Methodology Used to Collect Data Points

Figure 3.1 provides a schematic of a sample test run. Test points were determined from observations specific to the "hour." For example, Run 3 on January 21, 2010 (morning of January 22) had a RH of 87 percent and an OAT of -9.0°C, measured by Environment Canada at exactly 3:00 AM. This resulted in a frost point calculation of -9.7°C. The test plate temperature, measured using the APS thermistor logger, was -12.8°C at 3:00 AM. The analytical results of this event indicated that frost was active. Simultaneously, a plate was placed outside over a 30-minute period (from 2:45 to 3:15 AM) to accumulate frost. In this example, this plate provided positive indication of active frost.



*Example of Test Run Performed from 9:00 PM to 10:30 PM

Figure 3.1: Sample Test Run

1.	9:00-9:30 PM:	Site/Plate Setup
2.	9:30 PM:	Plate Positioning (Outdoors, Upside Down)
3.	9:40 PM:	Test Run Preparation
4.	9:45 PM:	Start of Test Run
5.	9:45-10:00 PM:	Visual Verification of Frost (Visual)
6.	10:00 PM:	Plate Temperature Data Collection
7.	10:10 PM:	Environment Canada Data (DetermineFrost Point)
8.	10:15 PM:	Plate Measurement of Weight; Visual Observation of Frost (Observe Environment, i.e., Cars)
9.	10:30 PM:	Determination of Frost Occurrence (Analytical)

3.3.4 General Test Methodology

Using the hourly RH and OAT data from Environment Canada, the frost point was calculated using a frost point chart (see Table 3.1). The calculated frost point was then compared to the measured plate surface temperature at the hour mark. Based on these parameters, if the measured plate surface temperature was below the calculated frost point, this indicated active frost conditions; if the measured plate surface temperature was above the calculated frost point, this indicated non-active frost conditions.

Table 3.1: Frost Point Calculation

OAT °C	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30
RH%																																				
50	-3.2	-4.0	-4.9	-5.7	-6.6	-7.4	-8.3	-9.1	-10.0	-10.9	-11.7	-12.6	-13.4	-14.3	-15.1	-16.0	-16.9	-17.7	-18.6	-19.4	-20.3	-21.2	-22.0	-22.9	-23.7	-24.6	-25.5	-26.3	-27.2	-28.0	-28.9	-29.8	-30.6	-31.5	-32.4	-33.2
51	-2.9	-3.8	-4.7	-5.5	-6.4	-7.2	-8.1	-8.9	-9.8	-10.7	-11.5	-12.4	-13.2	-14.1	-15.0	-15.8	-16.7	-17.5	-18.4	-19.3	-20.1	-21.0	-21.8	-22.7	-23.6	-24.4	-25.3	-26.1	-27.0	-27.9	-28.7	-29.6	-30.5	-31.3	-32.2	-33.1
52	-2.7	-3.6	-4.4	-5.3	-6.2	-7.0	-7.9	-8.7	-9.6	-10.5	-11.3	-12.2	-13.0	-13.9	-14.8	-15.6	-16.5	-17.4	-18.2	-19.1	-19.9	-20.8	-21.7	-22.5	-23.4	-24.2	-25.1	-26.0	-26.8	-27.7	-28.6	-29.4	-30.3	-31.2	-32.0	-32.9
53	-2.5	-3.4	-4.2	-5.1	-6.0	-6.8	-7.7	-8.5	-9.4	-10.3	-11.1	-12.0	-12.9	-13.7	-14.6	-15.4	-16.3	-17.2	-18.0	-18.9	-19.8	-20.6	-21.5	-22.3	-23.2	-24.1	-24.9	-25.8	-26.7	-27.5	-28.4	-29.3	-30.1	-31.0	-31.9	-32.7
54	-2.3	-3.2	-4.0	-4.9	-5.8	-6.6	-7.5	-8.4	-9.2	-10.1	-10.9	-11.8	-12.7	-13.5	-14.4	-15.3	-16.1	-17.0	-17.9	-18.7	-19.6	-20.4	-21.3	-22.2	-23.0	-23.9	-24.8	-25.6	-26.5	-27.4	-28.2	-29.1	-30.0	-30.8	-31.7	-32.6
55	-2.1	-3.0	-3.8	-4.7	-5.6	-6.4	-7.3	-8.2	-9.0	-9.9	-10.8	-11.6	-12.5	-13.4	-14.2	-15.1	-15.9	-16.8	-17.7	-18.5	-19.4	-20.3	-21.1	-22.0	-22.9	-23.7	-24.6	-25.5	-26.3	-27.2	-28.1	-29.0	-29.8	-30.7	-31.6	-32.4
56	-1.9	-2.8	-3.7	-4.5	-5.4	-6.2	-7.1	-8.0	-8.8	-9.7	-10.6	-11.4	-12.3	-13.2	-14.0	-14.9	-15.8	-16.6	-17.5	-18.4	-19.2	-20.1	-21.0	-21.8	-22.7	-23.6	-24.5	-25.3	-26.2	-27.1	-27.9	-28.8	-29.7	-30.5	-31.4	-32.3
57	-1.7	-2.6	-3.5	-4.3	-5.2	-6.1	-6.9	-7.8	-8.7	-9.5	-10.4	-11.3	-12.1	-13.0	-13.9	-14.7	-15.6	-16.5	-17.3	-18.2	-19.1	-19.9	-20.8	-21.7	-22.6	-23.4	-24.3	-25.2	-26.0	-26.9	-27.8	-28.6	-29.5	-30.4	-31.3	-32.1
58	-1.5	-2.4	-3.3	-4.1	-5.0	-5.9	-6.7	-7.6	-8.5	-9.4	-10.2	-11.1	-12.0	-12.8	-13.7	-14.6	-15.4	-16.3	-17.2	-18.0	-18.9	-19.8	-20.7	-21.5	-22.4	-23.3	-24.1	-25.0	-25.9	-26.8	-27.6	-28.5	-29.4	-30.2	-31.1	-32.0
59	-1.4	-2.2	-3.1	-4.0	-4.8	-5.7	-6.6	-7.4	-8.3	-9.2	-10.0	-10.9	-11.8	-12.7	-13.5	-14.4	-15.3	-16.1	-17.0	-17.9	-18.8	-19.6	-20.5	-21.4	-22.2	-23.1	-24.0	-24.9	-25.7	-26.6	-27.5	-28.3	-29.2	-30.1	-31.0	-31.8
60	-1.2	-2.0	-2.9	-3.8	-4.7	-5.5	-6.4	-7.3	-8.1	-9.0	-9.9	-10.7	-11.6	-12.5	-13.4	-14.2	-15.1	-16.0	-16.8	-17.7	-18.6	-19.5	-20.3	-21.2	-22.1	-23.0	-23.8	-24.7	-25.6	-26.5	-27.3	-28.2	-29.1	-30.0	-30.8	-31.7
61	-1.0	-1.9	-2.7	-3.6	-4.5	-5.3	-6.2	-7.1	-8.0	-8.8	-9.7	-10.6	-11.5	-12.3	-13.2	-14.1	-14.9	-15.8	-16.7	-17.6	-18.4	-19.3	-20.2	-21.1	-21.9	-22.8	-23.7	-24.6	-25.4	-26.3	-27.2	-28.1	-28.9	-29.8	-30.7	-31.6
62	-0.8	-1.7	-2.6	-3.4	-4.3	-5.2	-6.0	-6.9	-7.8	-8.7	-9.5	-10.4	-11.3	-12.2	-13.0	-13.9	-14.8	-15.7	-16.5	-17.4	-18.3	-19.2	-20.0	-20.9	-21.8	-22.7	-23.5	-24.4	-25.3	-26.2	-27.0	-27.9	-28.8	-29.7	-30.5	-31.4
63	-0.6	-1.5	-2.4	-3.3	-4.1	-5.0	-5.9	-6.8	-7.6	-8.5	-9.4	-10.3	-11.1	-12.0	-12.9	-13.8	-14.6	-15.5	-16.4	-17.3	-18.1	-19.0	-19.9	-20.8	-21.6	-22.5	-23.4	-24.3	-25.1	-26.0	-26.9	-27.8	-28.7	-29.5	-30.4	-31.3
64	-0.5	-1.3	-2.2	-3.1	-4.0	-4.8	-5.7	-6.6	-7.5	-8.3	-9.2	-10.1	-11.0	-11.8	-12.7	-13.6	-14.5	-15.4	-16.2	-17.1	-18.0	-18.9	-19.7	-20.6	-21.5	-22.4	-23.3	-24.1	-25.0	-25.9	-26.8	-27.6	-28.5	-29.4	-30.3	-31.2
65	-0.3	-1.2	-2.0	-2.9	-3.8	-4.7	-5.6	-6.4	-7.3	-8.2	-9.1	-9.9	-10.8	-11.7	-12.6	-13.4	-14.3	-15.2	-16.1	-17.0	-17.8	-18.7	-19.6	-20.5	-21.4	-22.2	-23.1	-24.0	-24.9	-25.7	-26.6	-27.5	-28.4	-29.3	-30.1	-31.0
66	-0.1	-1.0	-1.9	-2.8	-3.6	-4.5	-5.4	-6.3	-7.1	-8.0	-8.9	-9.8	-10.7	-11.5	-12.4	-13.3	-14.2	-15.1	-15.9	-16.8	-17.7	-18.6	-19.5	-20.3	-21.2	-22.1	-23.0	-23.9	-24.7	-25.6	-26.5	-27.4	-28.3	-29.1	-30.0	-30.9
67	0.0	-0.8	-1.7	-2.6	-3.5	-4.4	-5.2	-6.1	-7.0	-7.9	-8.7	-9.6	-10.5	-11.4	-12.3	-13.1	-14.0	-14.9	-15.8	-16.7	-17.5	-18.4	-19.3	-20.2	-21.1	-22.0	-22.8	-23.7	-24.6	-25.5	-26.4	-27.2	-28.1	-29.0	-29.9	-30.8
68	0.2	-0.7	-1.6	-2.4	-3.3	-4.2	-5.1	-6.0	-6.8	-7.7	-8.6	-9.5	-10.4	-11.2	-12.1	-13.0	-13.9	-14.8	-15.6	-16.5	-17.4	-18.3	-19.2	-20.1	-20.9	-21.8	-22.7	-23.6	-24.5	-25.4	-26.2	-27.1	-28.0	-28.9	-29.8	-30.7
69	0.4	-0.5	-1.4	-2.3	-3.2	-4.0	-4.9	-5.8	-6.7	-7.6	-8.4	-9.3	-10.2	-11.1	-12.0	-12.9	-13.7	-14.6	-15.5	-16.4	-17.3	-18.2	-19.0	-19.9	-20.8	-21.7	-22.6	-23.5	-24.3	-25.2	-26.1	-27.0	-27.9	-28.8	-29.6	-30.5
70	0.5	-0.4	-1.2	-2.1	-3.0	-3.9	-4.8	-5.6	-6.5	-7.4	-8.3	-9.2	-10.1	-10.9	-11.8	-12.7	-13.6	-14.5	-15.4	-16.2	-17.1	-18.0	-18.9	-19.8	-20.7	-21.6	-22.4	-23.3	-24.2	-25.1	-26.0	-26.9	-27.7	-28.6	-29.5	-30.4
71	0.7	-0.2	-1.1	-2.0	-2.8	-3.7	-4.6	-5.5	-6.4	-7.3	-8.1	-9.0	-9.9	-10.8	-11.7	-12.6	-13.5	-14.3	-15.2	-16.1	-17.0	-17.9	-18.8	-19.7	-20.5	-21.4	-22.3	-23.2	-24.1	-25.0	-25.9	-26.7	-27.6	-28.5	-29.4	-30.3
72	0.8	0.0	-0.9	-1.8	-2.7	-3.6	-4.5	-5.4	-6.2	-7.1	-8.0	-8.9	-9.8	-10.7	-11.5	-12.4	-13.3	-14.2	-15.1	-16.0	-16.9	-17.7	-18.6	-19.5	-20.4	-21.3	-22.2	-23.1	-24.0	-24.8	-25.7	-26.6	-27.5	-28.4	-29.3	-30.2
73	1.0	0.1	-0.8	-1.7	-2.5	-3.4	-4.3	-5.2	-6.1	-7.0	-7.9	-8.7	-9.6	-10.5	-11.4	-12.3	-13.2	-14.1	-15.0	-15.8	-16.7	-17.6	-18.5	-19.4	-20.3	-21.2	-22.1	-22.9	-23.8	-24.7	-25.6	-26.5	-27.4	-28.3	-29.2	-30.0
74	1.1	0.3	-0.6	-1.5	-2.4	-3.3	-4.2	-5.1	-5.9	-6.8	-7.7	-8.6	-9.5	-10.4	-11.3	-12.2	-13.0	-13.9	-14.8	-15.7	-16.6	-17.5	-18.4	-19.3	-20.2	-21.0	-21.9	-22.8	-23.7	-24.6	-25.5	-26.4	-27.3	-28.2	-29.0	-29.9
75	1.3	0.4	-0.5	-1.4	-2.3	-3.1	-4.0	-4.9	-5.8	-6.7	-7.6	-8.5	-9.4	-10.2	-11.1	-12.0	-12.9	-13.8	-14.7	-15.6	-16.5	-17.4	-18.2	-19.1	-20.0	-20.9	-21.8	-22.7	-23.6	-24.5	-25.4	-26.3	-27.1	-28.0	-28.9	-29.8
76	1.4	0.6	-0.3	-1.2	-2.1	-3.0	-3.9	-4.8	-5.7	-6.6	-7.4	-8.3	-9.2	-10.1	-11.0	-11.9	-12.8	-13.7	-14.6	-15.5	-16.3	-17.2	-18.1	-19.0	-19.9	-20.8	-21.7	-22.6	-23.5	-24.4	-25.3	-26.1	-27.0	-27.9	-28.8	-29.7
77	1.6	0.7	-0.2	-1.1	-2.0	-2.9	-3.7	-4.6	-5.5	-6.4	-7.3	-8.2	-9.1	-10.0	-10.9	-11.8	-12.7	-13.5	-14.4	-15.3	-16.2	-17.1	-18.0	-18.9	-19.8	-20.7	-21.6	-22.5	-23.4	-24.2	-25.1	-26.0	-26.9	-27.8	-28.7	-29.6
78	1.7	0.8	0.0	-0.9	-1.8	-2.7	-3.6	-4.5	-5.4	-6.3	-7.2	-8.1	-9.0	-9.8	-10.7	-11.6	-12.5	-13.4	-14.3	-15.2	-16.1	-17.0	-17.9	-18.8	-19.7	-20.6	-21.4	-22.3	-23.2	-24.1	-25.0	-25.9	-26.8	-27.7	-28.6	-29.5
79	1.9	1.0	0.1	-0.8	-1.7	-2.6	-3.5	-4.4	-5.3	-6.1	-7.0	-7.9	-8.8	-9.7	-10.6	-11.5	-12.4	-13.3	-14.2	-15.1	-16.0	-16.9	-17.8	-18.7	-19.5	-20.4	-21.3	-22.2	-23.1	-24.0	-24.9	-25.8	-26.7	-27.6	-28.5	-29.4
80	2.0	1.1	0.2	-0.7	-1.6	-2.4	-3.3	-4.2	-5.1	-6.0	-6.9	-7.8	-8.7	-9.6	-10.5	-11.4	-12.3	-13.2	-14.1	-15.0	-15.8	-16.7	-17.6	-18.5	-19.4	-20.3	-21.2	-22.1	-23.0	-23.9	-24.8	-25.7	-26.6	-27.5	-28.4	-29.3
81	2.2	1.3	0.4	-0.5	-1.4	-2.3	-3.2	-4.1	-5.0	-5.9	-6.8	-7.7	-8.6	-9.5	-10.4	-11.3	-12.1	-13.0	-13.9	-14.8	-15.7	-16.6	-17.5	-18.4	-19.3	-20.2	-21.1	-22.0	-22.9	-23.8	-24.7	-25.6	-26.5	-27.4	-28.3	-29.2
82	2.3	1.4	0.5	-0.4	-1.3	-2.2	-3.1	-4.0	-4.9	-5.8	-6.7	-7.5	-8.4	-9.3	-10.2	-11.1	-12.0	-12.9	-13.8	-14.7	-15.6	-16.5	-17.4	-18.3	-19.2	-20.1	-21.0	-21.9	-22.8	-23.7	-24.6	-25.5	-26.4	-27.3	-28.2	-29.1
83	2.4	1.5	0.6	-0.3	-1.1	-2.0	-2.9	-3.8	-4.7	-5.6	-6.5	-7.4	-8.3	-9.2	-10.1	-11.0	-11.9	-12.8	-13.7	-14.6	-15.5	-16.4	-17.3	-18.2	-19.1	-20.0	-20.9	-21.8	-22.7	-23.6	-24.5	-25.4	-26.3	-27.2	-28.1	-29.0
84	2.6	1.7	0.8	-0.1	-1.0	-1.9	-2.8	-3.7	-4.6	-5.5	-6.4	-7.3	-8.2	-9.1	-10.0	-10.9	-11.8	-12.7	-13.6	-14.5	-15.4	-16.3	-17.2	-18.1	-19.0	-19.9	-20.8	-21.7	-22.6	-23.5	-24.4	-25.3	-26.2	-27.1	-28.0	-28.9
85	2.7	1.8	0.9	0.0	-0.9	-1.8	-2.7	-3.6	-4.5	-5.4	-6.3	-7.2	-8.1	-9.0	-9.9	-10.8	-11.7	-12.6	-13.5	-14.4	-15.3	-16.2	-17.1	-18.0	-18.9	-19.8	-20.7	-21.6	-22.5	-23.4	-24.3	-25.2	-26.1	-27.0	-27.9	-28.8
86	2.8	1.9	1.0	0.1	-0.8	-1.7	-2.6	-3.5	-4.4	-5.3	-6.2	-7.1	-8.0	-8.9	-9.8	-10.7	-11.5	-12.4	-13.3	-14.2	-15.1	-16.0	-16.9	-17.8	-18.7	-19.6	-20.5	-21.4	-22.3	-23.2	-24.1	-25.0	-25.9	-26.8	-27.7	-28.6
87	3.0	2.1	1.2	0.3	-0.6	-1.5	-2.4	-3.3	-4.2	-5.1	-6.0	-6.9	-7.8	-8.7	-9.6	-10.5	-11.4	-12.3	-13.2	-14.1	-15.0	-15.9	-16.8	-17.7	-18.6	-19.5	-20.4	-21.3	-22.2	-23.1	-24.0	-24.9	-25.8	-26.7	-27.6	-28.6
88	3.1	2.2	1.3	0.4	-0.5	-1.4	-2.3	-3.2	-4.1	-5.0	-5.9	-6.8	-7.7	-8.6	-9.5	-10.4	-11.3	-12.2	-13.1	-14.0	-14.9	-15.8	-16.7	-17.6	-18.5	-19.4	-20.3	-21.2	-22.1	-23.0	-23.9	-24.8	-25.7	-26.6	-27.5	-28.5
89	3.2	2.3	1.4	0.5	-0.4	-1.3	-2.2	-3.1	-4.0	-4.9	-5.8	-6.7	-7.6	-8.5	-9.4	-10.3	-11.2	-12.1	-13.0	-13.9	-14.8	-15.7	-16.6	-17.5	-18.4	-19.3	-20.2	-21.1	-22.0	-22.9	-23.8	-24.7	-25.6	-26.5	-27.5	-28.4
90	3.4	2.5	1.5	0.6	-0.3	-1.2	-2.1	-3.0	-3.9	-4.8	-5.7	-6.6	-7.5	-8.4	-9.3	-10.2	-11.1	-12.0	-12.9	-13.8	-14.7	-15.6	-16.5	-17.4	-18.3	-19.2	-20.1	-21.0	-21.9	-22.8	-23.7	-24.6	-25.5	-26.5	-27.4	-28.3
91	3.5	2.6	1.7	0.8	-0.1	-1.0	-1.9	-2.8	-3.8	-4.7	-5.6	-6.5	-7.4	-8.3	-9.2	-10.1	-11.0	-11.9	-12.8	-13.7	-14.6	-15.5	-16.4	-17.3	-18.2	-19.1	-20.0	-20.9	-21.8	-22.7	-23.6	-24.5	-25.4	-26.4	-27.3	-28.2
92	3.6	2.7	1.8	0.9	0.0	-0.9	-1.8	-2.7	-3.6	-4.5	-5.4	-6.3	-7.3	-8.2	-9.1	-10.0	-10.9	-11.8	-12.7	-13.6	-14.5	-15.4	-16.3	-17.2	-18.1	-19.0	-19.9	-20.8	-21.7	-22.6	-23.5	-24.4	-25.4	-26.3	-27.2	-28.1
93	3.7	2.8	1.9	1.0	0.1	-0.8	-1.7	-2.6	-3.5	-4.4	-5.3	-6.2	-7.1	-8.0	-9.0	-9.9	-10.8	-11.7	-12.6	-13.5	-14.4	-15.3	-16.2	-17.1	-18.0	-18.9	-19.8	-20.7	-21.6	-22.5	-23.4	-24.4	-25.3	-26.2	-27.1	-28.0
94	3.8	2.9	2.0	1.1	0.2	-0.7	-1.6	-2.5	-3.4	-4.3	-5.2	-6.1	-7.0	-7.9	-8.8	-9.7	-10.7	-11.6	-12.5	-13.4	-14.3	-15.2	-16.1	-17.0	-17.9	-18.8	-19.7	-20.6	-21.5	-22.4	-23.3	-24.3	-25.2	-26.1	-27.0	-27.9
95	4.0	3.1	2.2	1.2	0.3	-0.6	-1.5	-2.4	-3.3	-4.2	-5.1	-6.0	-6.9	-7.8	-8.7	-9.6	-10.5	-11.5	-12.4	-13.3	-14.2	-15.1	-16.0	-16.9	-17.8	-18.7	-19.6	-20.5	-21.4	-22.3	-23.3	-24.2	-25.1	-26.0	-26.9	-27.8
96	4.1	3.2	2.3	1.4	0.5	-0.5	-1.4	-2.3	-3.2	-4.1	-5.0	-5.9	-6.8	-7.7	-8.6	-9.5	-10.4	-11.3	-12.3	-13.2	-14.1	-15.0	-15.9	-16.8	-17.7	-18.6	-19.5	-20.4	-21.3	-22.2	-23.2	-24.1	-25.0	-25.9	-26.8	-27.7
97	4.2	3.3	2.4	1.5	0.6	-0.3	-1.2	-2.2	-3.1	-4.0	-4.9	-5.8	-6.7	-7.6	-8.5	-9.4	-10.3	-11.2	-12.2	-13.1	-14.0	-14.9	-15.8	-16.7	-17.6	-18.5	-19.4	-20.3	-21.2	-22.2	-23.1	-24.0	-24.9	-25.8	-26.7	-27.6
98	4.3	3.4	2.5	1.6	0.7	-0.2	-1.1	-2.0	-3.0	-3.9	-4.8	-5.7	-6.6	-7.5	-8.4	-9.3	-10.2	-11.1	-12.1	-13.0	-13.9	-14.8	-15.7	-16.6	-17.5	-18.4	-19.3	-20.2	-21.2	-22.1	-23.0	-23.9	-24.8	-25.7	-26.6	-27.5
99	4.4	3.5	2.6	1.7	0.8	-0.1	-1.0	-1.9	-2.8	-3.8	-4.7	-5.6	-6.5	-7.4	-8.3	-9.2	-10.1	-11.0	-12.0	-12.9	-13.8	-14.7	-15.6	-16.5	-17.4	-18.3	-19.2	-20.1	-21.1	-22.0	-22.9	-23.8	-24.7	-25.6	-26.5	-27.4
100	4.6	3.6	2.7	1.8	0.9	0.0	-0.9	-1.8	-2.7	-3.6	-4.6	-5.5	-6.4	-7.3	-8.2	-9.1	-10.0	-10.9	-11.8	-12.8	-13.7	-14.6	-15.5	-16.4	-17.3	-18.2	-19.1	-20.1	-21.0	-21.9	-22.8	-23.7	-24.6	-25.5	-26.4	-27.3

The "active" or "non-active" frost predictions were validated by weighing the frosticator plates before and after each test and by visually inspecting their surfaces for frost accretion. More specifically, the plate was weighed 15 minutes before and after the hour mark; an increase in weight indicated frost accretion, and the frosticator plate was visually inspected at the hour mark for signs of frost accretion.

3.4 Test Results

Testing was conducted during four overnight test sessions. Active frost conditions were expected during each of these nights; however, some tests were conducted during non-active frost conditions, typically at the beginning or end of the test session. Non-active frost test data is also important for this research; however, due to funding limitations, limited data was collected, and data was primarily collected in active frost. A total of 17 test runs were completed during the four sessions; the OAT ranged from -2°C to -13°C. A log summarizing the data collected has been compiled and is included as Table 3.2.

The results in Table 3.2 indicate the following:

- 15 of the 17 test runs were accurately predicted; and
- 2 of 17 test runs were not accurately predicted, and one of the two events would not have been safe (i.e., frost was present, but it was not predicted).

Table 3.2: Frost Sensor Log of Tests

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Frost Point - Plate Temp (°C)	Active Frost Nowcast	Active Frost Truthing	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	active frost	*no active frost	**no**
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost	yes
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	no active frost	active frost	**no**
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	no active frost	yes
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost	yes
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost	yes

*Some frost was seen on plate.

3.5 Interpretation of Data for Aircraft Operations

The data collected indicated a promising potential for this technology to be used in the field; however, the output of such a system would need to be modified so that it could be interpreted and be useful to aircraft operators. One potential way to do this would be to use a messaging system as follows:

- "Frost":
  - When plate temperature is below the frost point;
- "No Frost":
  - When plate temperature is above the frost point; and
- "Frost Advisory":
  - When frost point and plate temperature are close to one another (exact amount to be determined).

The purpose of the "Frost Advisory" warning is to provide a level of conservatism and safety into the system for cases where the data may be indicating marginal differences in frost point and plate surface temperature. The data collected was re-analysed using the above-mentioned warning system with both ±1°C and ±0.5°C used as the frost advisory band (see Figure 3.2 and Figure 3.3). Table 3.3 and Table 3.4 contain the re-analysed data using the ±1°C and ±0.5°C frost advisory bands.

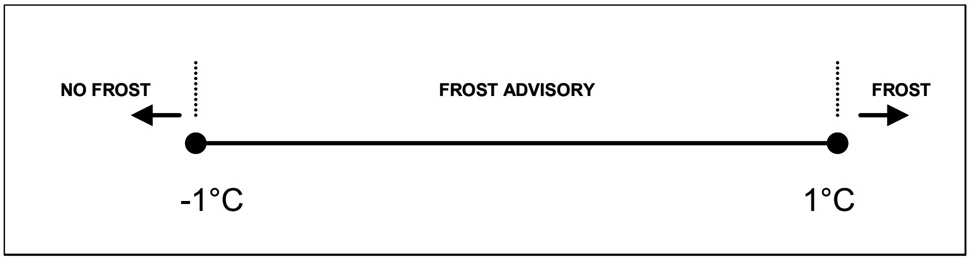


Figure 3.2: Frost Warning Bands Using ±1°C as the Frost Advisory Band

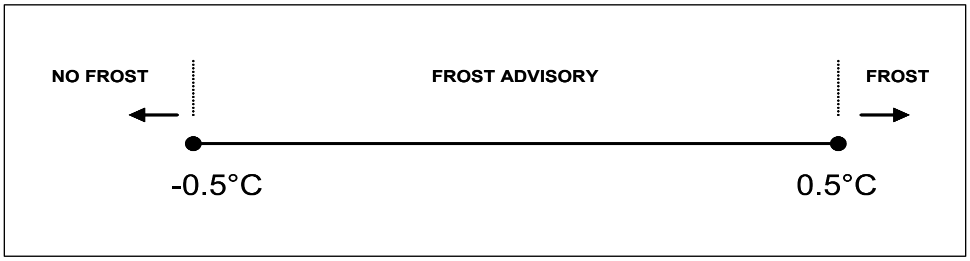


Figure 3.3: Frost Warning Bands Using ±0.5°C as the Frost Advisory Band

Table 3.3: Data Re-Analysed Using ±1ºC as the Frost Advisory Band

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Frost Point - Plate Temp (°C)	Active Frost Truthing	Message Advisory Band -1 to 1°C	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	no active frost	active frost advisory	**advisory**
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost advisory	**advisory**
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	active frost	active frost advisory	**advisory**
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	active frost advisory	**advisory**
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost advisory	**advisory**
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost advisory	**advisory**

Table 3.4: Data Re-Analysed Using ±0.5ºC as the Frost Advisory Band

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Frost Point - Plate Temp (°C)	Active Frost Truthing	Message Advisory Band -0.5 to 0.5°C	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	no active frost	active frost	**no**
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost	yes
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	active frost	active frost advisory	**advisory**
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	no active frost	yes
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost	yes
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost	yes

The re-analysed data with the frost advisory band set at ±1°C resulted in the following indications:

- 11 predicted "Frost" events:
  - All predictions were accurate.
- 6 predicted "Frost Advisory" events:
  - 4 predictions had frost; and
  - 2 predictions had no frost.
- 0 predicted "No Frost" event:
  - Prediction was accurate.

The re-analysed data with the frost advisory band set at ±0.5°C resulted in the following indications:

- 15 predicted "Frost" events:
  - 14 predictions were accurate; and
  - 1 prediction was not accurate.
- 1 predicted "Frost Advisory" event:
  - Prediction had frost.
- 1 predicted "No Frost" event:
  - Prediction was accurate.

3.5.1 Summary of Results

Table 3.5 provides a summary of the overall results related to prediction accuracy for each of the frost advisory bands that were evaluated.

Table 3.5: Prediction Accuracy

No band for advisory	• 15 runs accurate • 2 runs not accurate (1 with safety implications)
±1°C band for advisory	• 17 runs accurate (6 were frost advisories)
±0.5°C band for advisory	• 16 runs accurate (1 was frost advisory) • 1 run not accurate

The re-analysed data indicated that using the frost advisory band would help eliminate potential safety issues by minimizing the cases where a false “No Frost” prediction is made by the system. However, large bands will tend to reduce safety issues, but will generate more frost advisories, which can be considered a nuisance. It is recommended that additional testing be conducted in both active and non-active frost conditions to help determine the ideal frost advisory bandwidth that will minimize safety issues while not being overly conservative.

3.6 Conclusion and Recommendations

It seems feasible at this point to further develop this type of technology. Much more data should be collected, as this is necessary to further develop and determine the appropriate frost advisory band, and to obtain data during non-active frost conditions to ensure false positive predictions are unlikely. An accuracy target for the technology should be set in conjunction with regulators.

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Photo 3.1: Frosticator Plate During Exposure to Frost

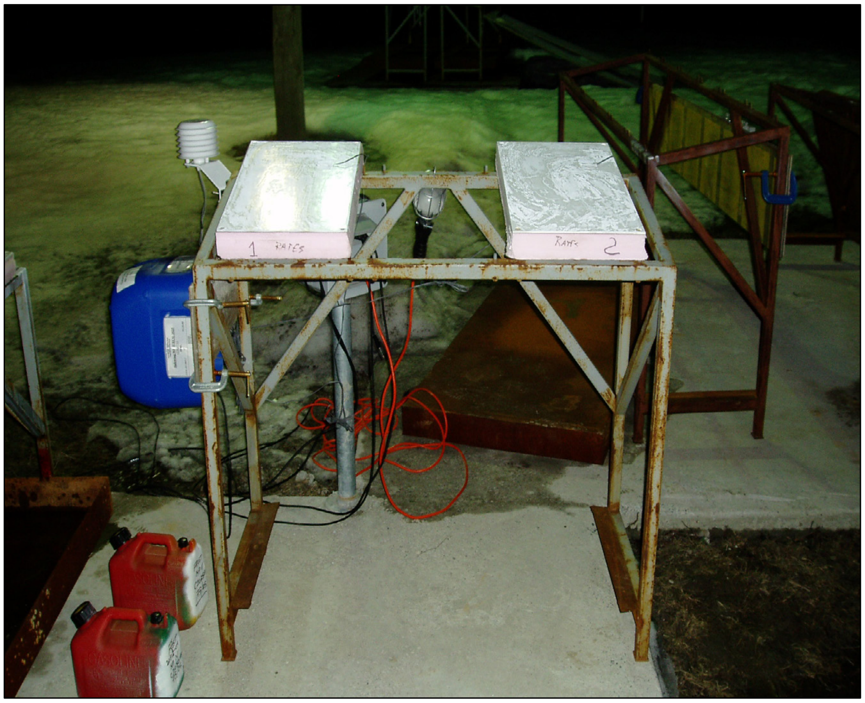

Photo 3.2: Frost Accretion of Frosticator Plate

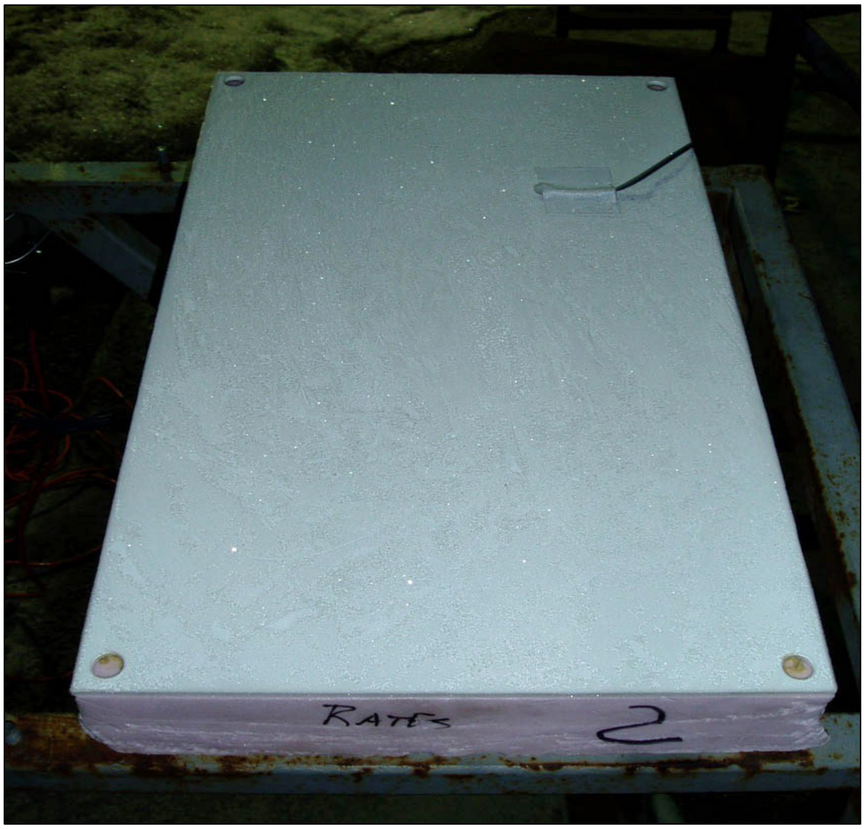

Photo 3.3: Weighing Frosticator Plate to Determine Rate of Accretion

Denver Instrument Company
TR-12001
16885 g
WEIGH
ZERO

4. EVALUATION OF HOLDOVER TIME GUIDELINES FOR COLD-SOAKED WING DURING NATURAL FROST CONDITIONS

4.1 Background

Frost is an important consideration in aircraft deicing. Irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. Frost can be an insidious type of threat to the safety of aircraft operations. Because it often has the appearance of being a minor degree of contamination, it does not offer the same obvious signal of danger as other types of contamination, such as snow or ice. However, certain characteristics of frost cause it to be of genuine concern: it is always adhered to the aircraft surface, and it is always rough.

The current frost holdover times (HOTs) for Type I, II, III, and IV fluids have been evaluated and substantiated for use during natural active frost conditions; however, it is not known if these holdover times can also be applied to cold-soaked wing (CSW) frost. The fundamental difference between the two types of frost is how the wing skin temperature is cooled below outside air temperature (OAT): radiation cooling versus conduction cooling. During natural active frost, the wing skin temperature will be cooled below ambient temperature as a result of radiation cooling from the cold clear sky (see Figure 4.1). The condition of CSW is typically experienced by aircraft that land with fuel in wing tanks that has been chilled to very low temperatures at flight altitudes. Aircraft with integral wing tanks, which allow the fuel to wet the wing skin inner surface, are particularly susceptible to the condition (see Figure 4.2). Refuelling with cold fuel can also cause the condition. If the aircraft has completed the last flight of the day, it may then sit overnight before being refuelled. Natural frost typically occurs from sundown to sunrise, during typical aircraft operating hours; thus, a combination of natural frost and CSW conditions is possible (see Figure 4.3).

The current procedure for measuring CSW holdover times simulates a 10ºC temperature differential between the surface temperature and the OAT. Prior to the winter of 1996-97, holdover time testing in CSW conditions was conducted at an ambient temperature of +1ºC (0ºC was the target temperature, but +1ºC was selected to ensure rain and not freezing rain) with box skin temperatures ranging from 0°C to -15°C; the majority of the tests were conducted with box skin temperatures of -10ºC. In October 1996, a report was published (the Transport Canada [TC] report, TP 12899E, *Validation of Methodology for Simulating a Cold-Soaked Wing* [2]) that analysed operational wing skin temperature to OAT differentials and discussed the selection of box skin surface temperature to be used for indoor simulated testing; this analysis was based on data collected by Aviation Research Corporation, McDonnell Douglas, and APS Aviation Inc. (APS), as well as through communications with Scandinavian Airlines (SAS). Based on this analysis, the report indicated that a box temperature with a lower limit of -10°C would be appropriate for the simulated CSW tests.

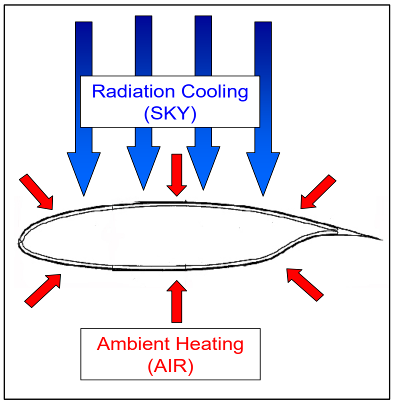
Radiation Cooling
(SKY)
Ambient Heating
(AIR)

Figure 4.1: Radiation Cooling Example During Active Natural Frost

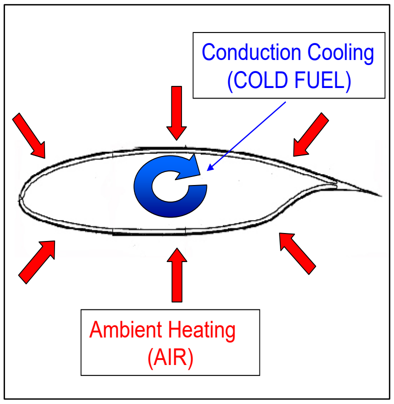
Conduction Cooling
(COLD FUEL)
Ambient Heating
(AIR)

Figure 4.2: Conduction Cooling Example During Cold-Soaked Wing Conditions

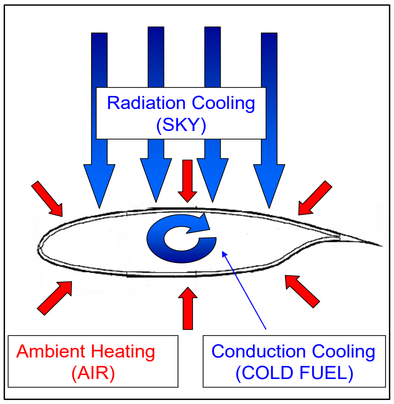
Radiation Cooling
(SKY)
Ambient Heating
(AIR)
Conduction Cooling
(COLD FUEL)

Figure 4.3: Conduction and Radiation Cooling Example Resulting from Cold-Soaked Wing Conditions During Active Natural Frost

Previous research has shown that wing temperatures can drop 6ºC to 9ºC below ambient temperature during natural frost conditions; as a result, a 10ºC temperature differential has been assumed to be representative of typical CSW conditions.

During the November 2009 SAE International (SAE) G-12 HOT Committee meeting, the subject of CSW conditions during active frost conditions was discussed, leading to the work conducted during the winter of 2009-10. Details of this discussion can be found in Section 5 ("HOT Guidelines Update") of the November 2009 SAE G-12 HOT Committee minutes.

4.2 Objective

Testing was required to investigate the effects of a CSW during active frost conditions to determine whether the wing temperatures typically increased, were maintained, or decreased. This was done by monitoring the temperature decay profiles of CSW boxes during natural frost conditions. In addition, preliminary comparative endurance time testing was conducted with Type I fluid to evaluate the current holdover times for use in CSW conditions during active natural frost. Therefore, this report describes the tests and results of the following:

- CSW temperature profile decay analysis; and
- Preliminary endurance time testing with Type I fluid.

4.3 Test Methodology

4.3.1 CSW Temperature Profile Analysis

Two CSW boxes were used for testing: one box was filled with cold Type I fluid to simulate a CSW surface (10ºC below OAT was attempted), and the other box was left empty and at ambient temperature (baseline surface). Type I fluid was applied to the exposed top surface of both CSW boxes to allow for equal radiation; the temperature of the applied fluid was equal to the surface temperature of the box. The rate of frost was measured to ensure that frost was active; this was done using the standard "frosticator" plates. The time for the CSW box surface temperature to stabilize with respect to the empty (baseline) CSW box surface temperature was recorded.

The details of this procedure can be found in Appendix D.

4.3.2 Preliminary CSW Endurance Time Testing

A procedure for this testing was not issued for the winter of 2009-10. Following the CSW temperature profile analysis work, an ad hoc attempt was made to conduct a preliminary evaluation of the frost endurance times for CSW conditions during active natural frost.

Two test surfaces were used: one white-painted aluminum box filled with cold Type I fluid to simulate a CSW surface (filled with fluid 10°C below OAT), and a white-painted "frosticator" aluminum plate (previously used for substantiating frost HOTs). Type I fluid at 20°C and diluted to a 10° buffer was applied to each surface; this is the standard procedure for Type I HOT testing in frost conditions. The Type I fluid endurance time on each surface was recorded and compared.

4.4 Test Results

4.4.1 CSW Temperature Profile Analysis

Three tests were conducted on three separate occasions during the winter of 2009-10. Although a CSW box temperature of 10°C below OAT was targeted for these tests, due to procedural limitations, the three tests were conducted with cold fluid at 3°C, 8.5°C, and 10.5°C below OAT. The baseline CSW box was always close to ambient temperature at the start of the test. OAT during the tests ranged from approximately -3°C to -15°C and is shown in the temperature profile plots.

Table 4.1 summarizes the results from the three tests conducted. The results indicate that the time for the filled CSW box temperature to match the empty CSW box ranged from 90 to 150 minutes for the three tests conducted.

Table 4.1: Time to Stabilization test Results

Test #	Filled CSW Box ΔT	Approximate Time to Stabilization (to match empty CSW box surface temp.)
1	3°C below OAT	90 minutes
2	8.5°C below OAT	100 minutes
3	10.5°C below OAT	150 minutes

Figure 4.4, Figure 4.5, and Figure 4.6 show details of the temperature profiles. For Tests #1 and #2 (Figure 4.4 and Figure 4.5), surface temperatures were recorded using a hand-held probe, whereas a logger and thermistors were used for Test #3 (Figure 4.6). In each graph, the temperature profile for the "Filled CSW Box" and "Empty CSW Box" was plotted as well as the OAT as recorded by Environment Canada. In addition, a "Temperature Delta" was plotted, which was equal to the surface temperature of the filled CSW box, minus the surface temperature of the empty CSW box. The point when this line flattens out and gets closer to zero is considered the stabilization point; a vertical line on the graph indicates the approximate time to stabilization.

In each of the three tests, the filled CSW box was colder than the empty box for a significant duration (90+ minutes). From a holdover time perspective, this will result in a more severe condition for fluids with shorter HOTs in frost conditions (i.e., Type I fluid and Type II, III, and IV fluid dilutions with short HOTs). Following these results, it was recommended that preliminary endurance time testing be conducted to evaluate the endurance times for CSW conditions during active natural frost; this is described in the next subsection.

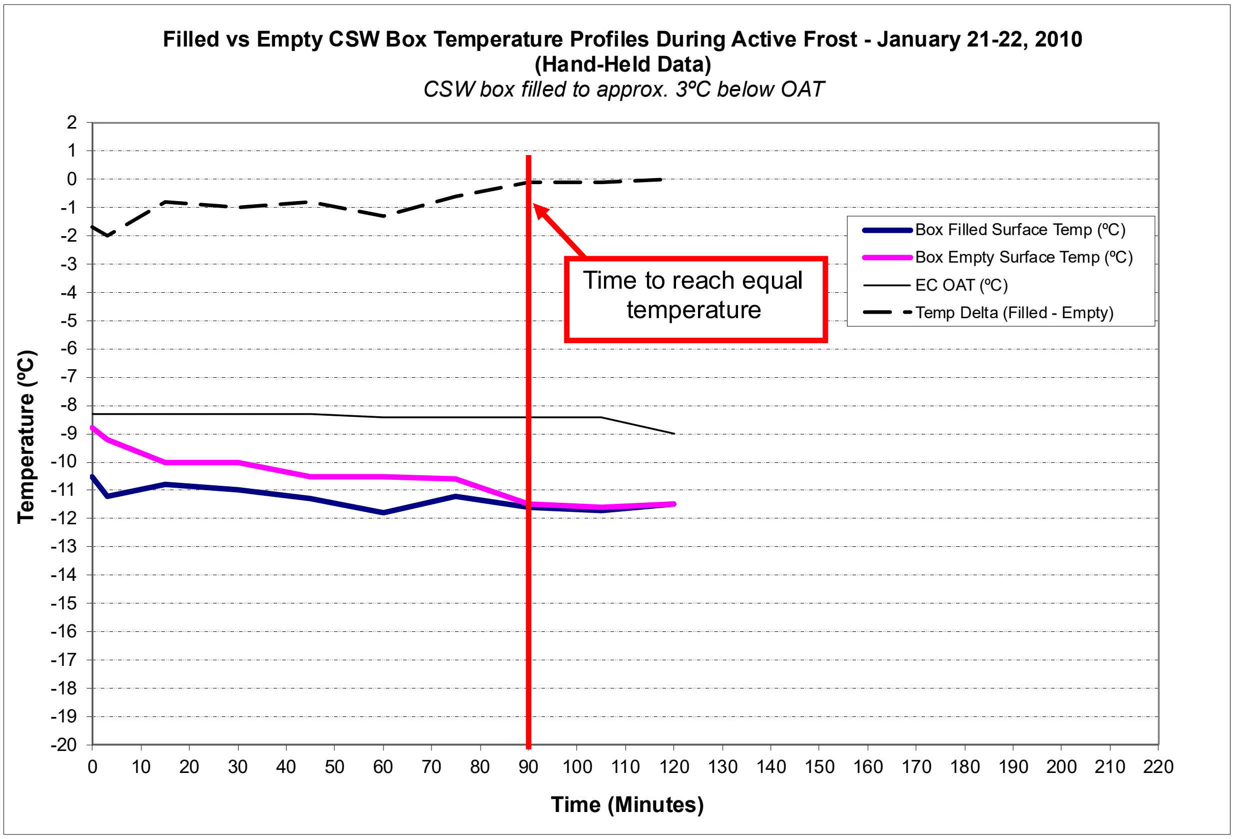

Figure 4.4: Test #1 – Effect of CSW on Temperature Profile

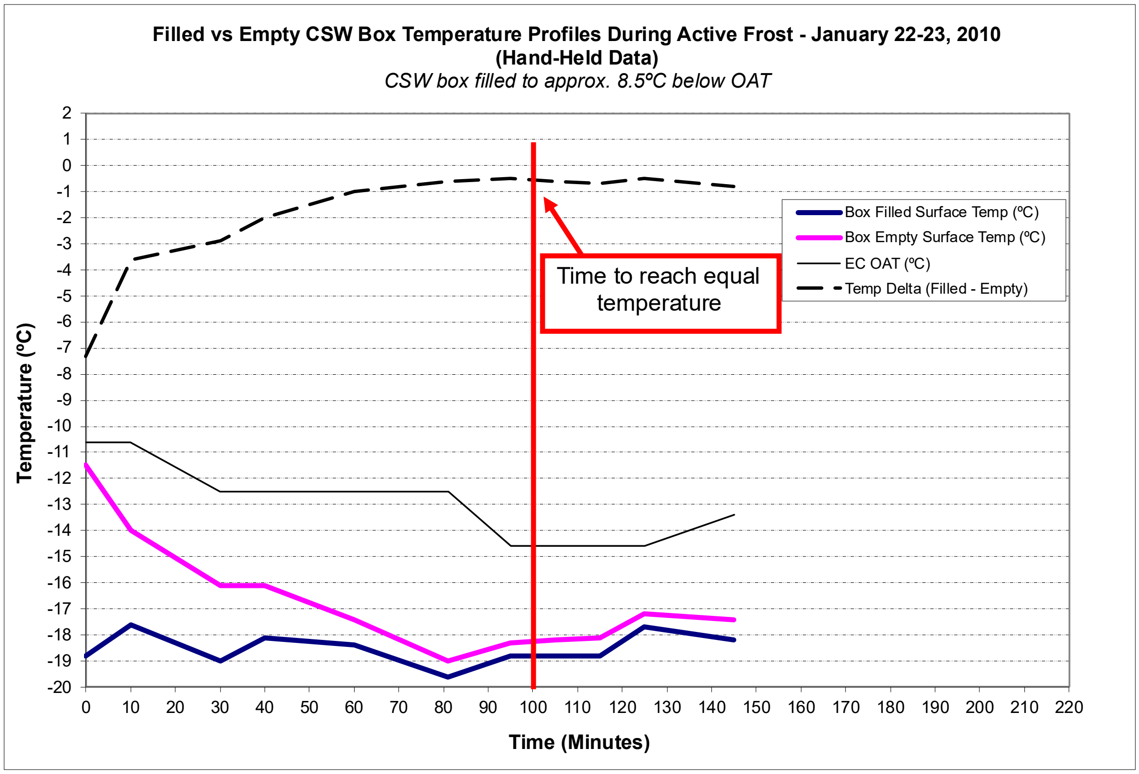

Figure 4.5: Test #2 – Effect of CSW on Temperature Profile

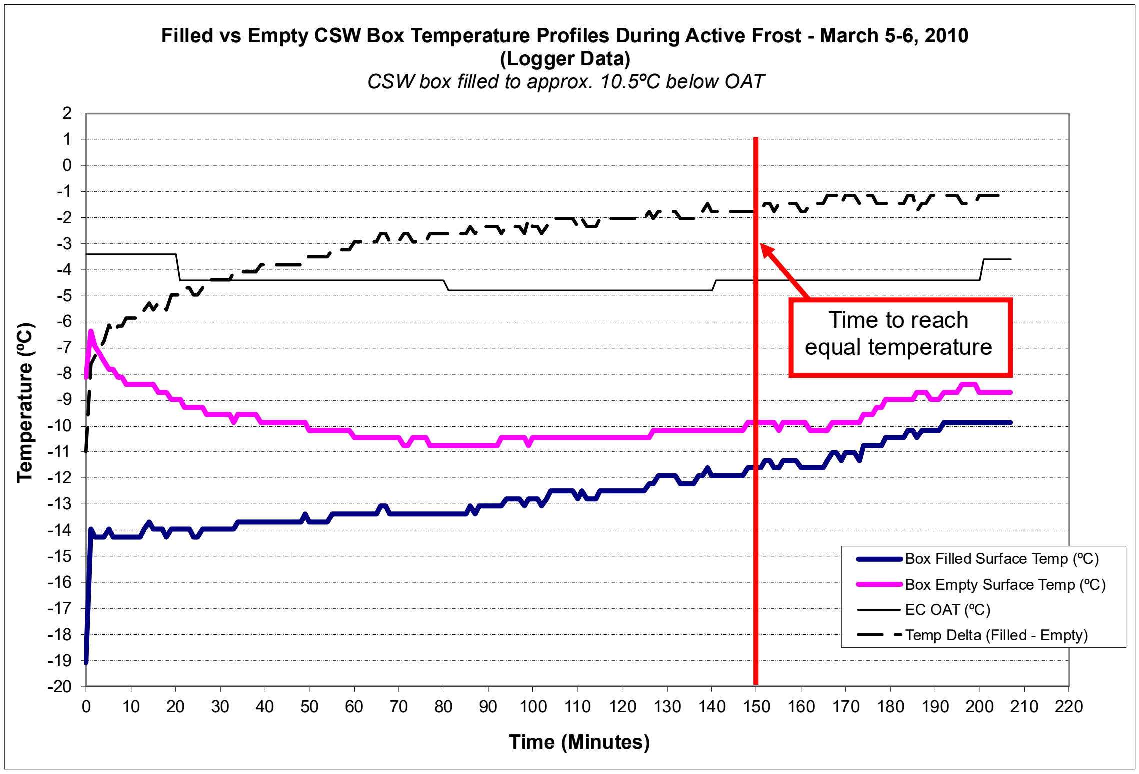

Figure 4.6: Test #3 – Effect of CSW on Temperature Profile

4.4.2 Preliminary Endurance Time Testing

Three preliminary ad hoc tests were conducted on one occasion during the winter of 2009-10. The white-painted CSW box was filled with fluid sufficiently chilled to achieve a temperature of 10ºC below OAT, and the baseline white-painted "frosticator" plate was close to ambient temperature at the start of the test. OAT during the tests ranged from approximately -3ºC to -6ºC.

Table 4.2 summarizes the results from the three tests conducted. The results indicate that the Type I endurance time associated with the filled CSW box was on average 38 percent of the Type I endurance time determined on the "frosticator" plate. Figure 4.7 graphically demonstrates the results obtained in a bar chart format. The 45-minute Type I HOT for frost conditions was also plotted. In all three cases, the CSW frost Type I endurance time tests were below the current 45-minute HOT. The results are indicative of potential reductions to the current frost HOT for use in CSW conditions. In addition, CSW frost conditions could also affect Type II and IV fluids in active frost, but likely to a lesser degree due to the HOTs generally being greater than 90 minutes.

Table 4.2: Endurance Time Comparison

Test #	CSW Box Endurance Time (min)	Baseline Frosticator Plate Endurance Time (min)	Ratio CSW ET/Baseline ET
1	32	70	46%
2	26	77	34%
3	32	98	33%
		Average	38%

4.5 Conclusions and Recommendations

The temperature profile analysis tests indicated that the filled CSW box remains colder than the empty box for a significant amount of time (90+ minutes). From a holdover time perspective, this will result in a more severe condition for fluids with shorter HOTs in frost conditions (i.e., Type I fluid and Type II, III, and IV fluid dilutions with short HOTs). The preliminary Type I fluid endurance time results indicated potential reductions to the current frost HOT for use in CSW conditions (on average 62 percent reduction in endurance time). Similar results could be expected for Type II, III, and IV fluids in active frost, but likely to a lesser degree due to the HOTs generally being greater than 90 minutes.

Future testing should include additional endurance time testing with CSW boxes in active natural frost to potentially develop guidance material for operations. Testing should be conducted at all temperatures and potentially examine different CSW temperatures (10ºC, 5ºC, and 3ºC below OAT).

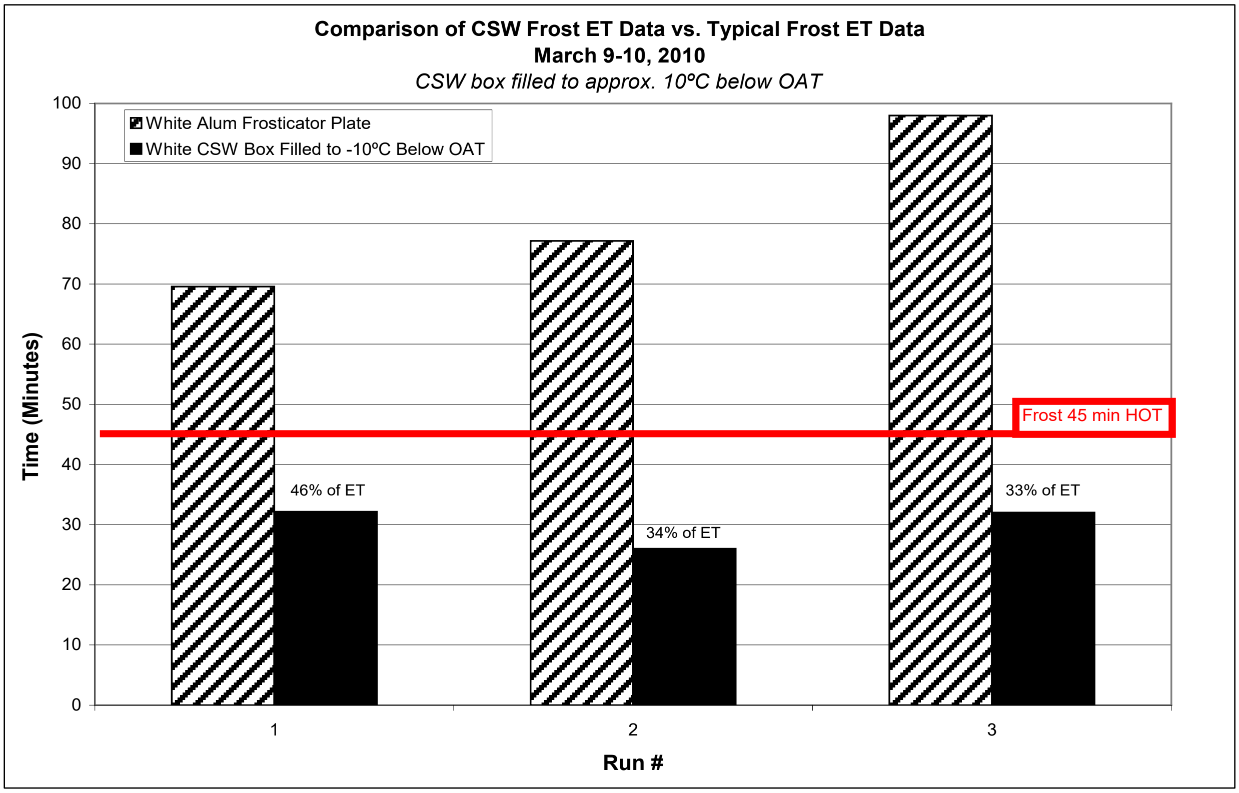

Figure 4.7: Endurance Time in CSW plus Frost vs. Frost-only Conditions

5. HOLDOVER TIMES IN CONDITIONS OF HEAVY SNOW

5.1 Background

In 2003-04, a point-by-point comparison of indoor test data using the National Center for Atmospheric Research (NCAR) snow machine versus outdoor test data had shown that maintaining the snow machine test plate at a set temperature below the test temperature represents a suitable solution for producing reliable holdover times (HOTs). The results are documented in the Transport Canada (TC) report, TP14376E, *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2003-04* (3).

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

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

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

5.2 Sources for Previous Heavy Snow Research

Research has been conducted throughout the years in conditions of heavy snow. While much has been accomplished, research has not been extensive and has usually been added onto other types of activities, such as Falcon 20 and Wind Tunnel testing.

Figure 5.1 details the heavy snow research that has been conducted since 2005. This table includes four columns and five rows; the columns indicate where testing took place (outdoors, indoors, etc.) and the rows indicate the year in which data was collected (2005-06, 2006-07, etc.). Provided within the table are references to TP reports and interim reports where documentation of the heavy snow tests is discussed in detail.

PROJECT YEAR	HEAVY SNOW TESTING ACTIVITY			
	OUTDOOR TESTING	SNOW MACHINE TESTING	FALCON 20 TESTING	WIND TUNNEL TESTING
2005-06	TP14717E *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2005-06*		No Tests	No Tests
2006-07	Interim Report *Preliminary Aircraft Deicing Research in Heavy Snow Conditions*			
2007-08	Interim Report *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2007-08 and Other Artificial Snow Project*		No Tests	No Tests
2008-09	No Tests		No Tests	TP14939E *Exploratory Wind Tunnel Aerodynamic Research Examination of Anti-Icing Fluid Flow-Off Characteristics Winter 2008-09*
2009-10	3 Tests	1 Test	No Tests	TP15057E *Exploratory Wind Tunnel Aerodynamic Research Examination of Anti-Icing Fluid Flow-Off Characteristics Winter 2009-10*

Figure 5.1: Heavy Snow Testing Activities (2005 to 2010)

Previous test results with the NCAR snow machine produced lower endurance times than natural snow testing, approximately half the time of natural snow endurance times. Previous wind tunnel research also tends to indicate heavy snow endurance times are shorter than the natural snow endurance times.

5.3 Objective

The overall objective of this activity was to develop HOTs and guidance material for heavy snow conditions. Research is underway to determine the cause of differences between the outdoor and snow machine endurance times.

For each natural heavy snow test conducted outdoors, the plan was to reproduce the test three times in a controlled laboratory condition using the NCAR snow machine. The plan was to select three random data points from the outdoor test and reproduce them with the snow machine. During these tests, Brix and thickness measurements were taken, as well as photography, to help determine why the differences in endurance times exist.

Because not much data was collected this year, the purpose of this report is to document historical heavy snow research and to document the current year's heavy snow data.

5.4 Methodology

The methodology used for testing is described in detail in the procedure included in Appendix E.

5.5 2009-10 Data/Observations

Four tests were conducted in heavy snow conditions during 2009-10: three outdoor and one snow machine test. Results are described in Table 5.1.

Table 5.1: Outdoor and Indoor Heavy Snow Endurance Times

Test	Date	Fluid	Fluid Type	Endurance Time (min)	Rate (g/dm²/h)	OAT (°C)	Comments
1	09-Dec-09	ABC-S Plus	IV	93.5	28.3	-4.4	Outdoor Test
2	09-Dec-09	Clariant MPIV Launch	IV	65.5	27.0	-4.4	Outdoor Test
3	09-Dec-09	Dow EG106	IV	58.0	24.7	-4.4	Outdoor Test
4	17-May-10	Dow EG106	IV	55.0	25.1	-4.5	Snow Machine Test

Natural snow testing in 2009-10 was very limited with heavy snow not occurring often. An attempt was made during one outdoor session, but heavy snow rates (50-75 g/dm²/h) were not achieved. Testing with the snow machine was limited as well due to the lack of natural heavy snow.

The endurance times of the one set of comparative tests conducted (Tests #3 and #4) showed similar endurance times, but as mentioned above, due to heavy snow rates not achieved during outdoor testing, these tests were not analysed further.

5.6 Wind Tunnel Observations

Wind tunnel results indicated that using half the moderate snow HOTs for heavy snow conditions could be a viable approach for providing guidance during occurrences of heavy snow. See the TC report, TP 15057E, *Exploratory Wind Tunnel Aerodynamic Research Examination of Contaminated Anti-Icing Fluid Flow-Off Characteristics Winter 2009-10* (4), for a detailed explanation of the results obtained.

5.7 Recommendations

This report documents the research done to date. Further work is required in conditions of heavy snow.

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6. DEVELOPMENT AND EVALUATION OF NEW PROTOCOL USING SNOW MACHINE

6.1 Background

As part of SAE International (SAE) Aerospace Recommended Practice (ARP) 5485 (the methodology for testing fluids to develop holdover times [HOTs]), a protocol was developed several years ago for testing with snow machines. This current protocol generates endurance times by conducting simulated snow tests at the most restrictive temperatures and precipitation rates set forth in the current HOT Guidelines.

However, natural snow testing is conducted at random temperatures and precipitation rates, hence providing a scatter of endurance time data points. These data points are then regressed to generate HOTs at the most restrictive temperatures and precipitation rates.

Comparative testing was completed over a three-year period, documented in TP 14717E (2005–06), TP 14776E (2006–07), and an interim Transport Canada (TC) report (2007–08). The objective of these tests was to see how results with the snow machine differ from outdoor tests. It was found that the snow machine could not reproduce the same results as the outdoor tests at colder temperatures and high rates. A special meeting to discuss snow machine activities and results from previous years was held with National Center for Atmospheric Research (NCAR) and APS Aviation Inc. (APS) personnel on December 10, 2008, in Montreal. At this meeting, it was concluded from the three-year testing that the snow machine can reproduce similar results at low rates and warm temperatures; however, results vary when running tests at colder temperatures (i.e., -14°C) and at high rates (i.e., 25 g/dm^2/h). The following points are possible reasons why the current protocol for testing with the snow machine does not provide comparable results:

- The old correlation work was done using natural snow points and testing the snow machine at the same conditions (temperature and rate). Most of the selected natural snow points were at low rates and warm temperatures. The results of this comparative testing provided a good correlation; and
- Based on this correlation, a protocol to test with the snow was developed, but tests were prescribed at the extreme conditions (high rates of 25 g/dm^2/h and cold temperatures of -14°C) for developing HOTs. These extreme conditions had not been tested extensively in the correlation work.

It is for this reason that a new protocol involving tests at more common temperatures and precipitation rates is being considered. This protocol will simulate the randomness of natural snow testing. All data collected will be used in a regression analysis, similar to the methodology used for outdoor natural snow conditions. The conditions are to be identified by APS by using either the winter weather data available or the HOT snow log.

6.2 Objective

The objective of this research was to develop a new protocol in which to best simulate natural snow conditions using the snow machine. A set of flat plate tests will be conducted to evaluate the effectiveness of this new protocol.

6.3 Methodology

The new protocol was to conduct tests at random temperatures and rates to best simulate the variability of natural snow testing. To construct a new test plan, a data set of actual natural snow occurrences was reviewed and analysed. This data was used to select points based on the probability distribution of natural snow conditions.

A two-phase test plan (see detailed procedure in Appendix F) was designed, in which 26 tests would be conducted using a pre-selected representative fluid (Phase I), and an additional 20 tests would be conducted using a current HOT fluid (Phase II). Due to budgetary constraints, other priorities, and the fact that the snow machine was in repair, Phase I was not completed, and only parts of Phase II were completed.

Secondary to both Phase I and Phase II testing, additional tests using the current ARP5485 protocol were also conducted. This protocol, in which testing is completed at restrictive temperatures and conditions, was used to validate the effectiveness of the new protocol.

All the testing with the NCAR snow machine was carried out inside the refrigerated trailer at the APS Dorval test site located at the Montreal–Trudeau Airport. All natural snow testing was also completed at this test site.

The equipment used for this testing was identical to equipment used in previous snow machine testing.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by the NCAR (refer to TP 14148E, *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2002-03* [5]).

The holdover time fluid used was Cryotech Polar Guard Type IV, undiluted, 75/25, and 50/50 dilutions.

6.4 Description of Tests

This subsection describes the artificial snow data collected with the snow machine using the new proposed protocol and the current ARP5485 protocol. From 2008-09 to 2009-10, the snow machine was inoperable due to mechanical failure. For this reason, only a select number of the initial tests proposed were conducted. A log of the tests with both the new proposed protocol and the current ARP5485 protocol is presented in Table 6.1 and Table 6.2.

A total of 13 tests were conducted using the new protocol, and two tests were conducted using the current ARP5485 protocol. The data set provides a suitable representation of actual outdoor conditions. The 50/50 dilution testing, however, was well distributed among varying temperatures and conditions.

Table 6.1: Log of Tests: New Proposed Protocol

Test #	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm^2/h)	Fluid Application Temp. ±3 (°C)	Target Enclosure Temp. (°C)	Plate Set Temp. ±0.5 (°C)	NCAR Results (min)
21	Cryotech Polar Guard	IV	50	1	-3.0	5.5	-6	-6	-3.9	36.0
24	Cryotech Polar Guard	IV	50	1	-3.0	13.5	-6	-6	-4.4	15.2
25	Cryotech Polar Guard	IV	50	1	-3.0	18.5	-7	-7	-4.7	12.3
26	Cryotech Polar Guard	IV	50	1	-3.0	45.0	-8	-8	-6.4	4.4
29	Cryotech Polar Guard	IV	75	1	-8.5	5.5	-11	-11	-9.4	81.5
32	Cryotech Polar Guard	IV	75	1	-4.5	7.5	-7	-7	-5.5	93.0
33	Cryotech Polar Guard	IV	75	1	-5.5	8.5	-8	-8	-6.6	54.0
34	Cryotech Polar Guard	IV	75	1	-5.5	9.5	-8	-8	-6.6	70.0
35	Cryotech Polar Guard	IV	75	1	-3.5	10.5	-6	-6	-4.7	57.0
36	Cryotech Polar Guard	IV	75	1	-3.5	11.5	-6	-6	-4.7	56.0
42	Cryotech Polar Guard	IV	75	1	-8.5	20.5	-11	-11	-10.3	24.0
45	Cryotech Polar Guard	IV	75	1	-4.5	27.5	-7	-7	-6.8	25.0
46	Cryotech Polar Guard	IV	75	1	-6.5	45.0	-9	-9	-9.9	16.5

A total of two tests were conducted using the current ARP5485 protocol.

Table 6.2: Log of Tests: ARP5485 Protocol

Test #	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm^2/h)	Fluid Application Temp. ±3 (°C)	Target Enclosure Temp. (°C)	Plate Set Temp. ±0.5 (°C)	NCAR Results (min)
SNW – A 75/25	Cryotech Polar Guard	IV	75	1	-3.0	10.0	-3	-3	-4.2	71.7
SNW – A 100/0	Cryotech Polar Guard	IV	100	1	-3.0	10.0	-3	-3	-4.2	87.2

6.5 Observations

Figure 6.1 and Figure 6.2 present the data collected using the new proposed protocol. These figures show the effect of temperature and precipitation rate on the simulated fluid endurance time.

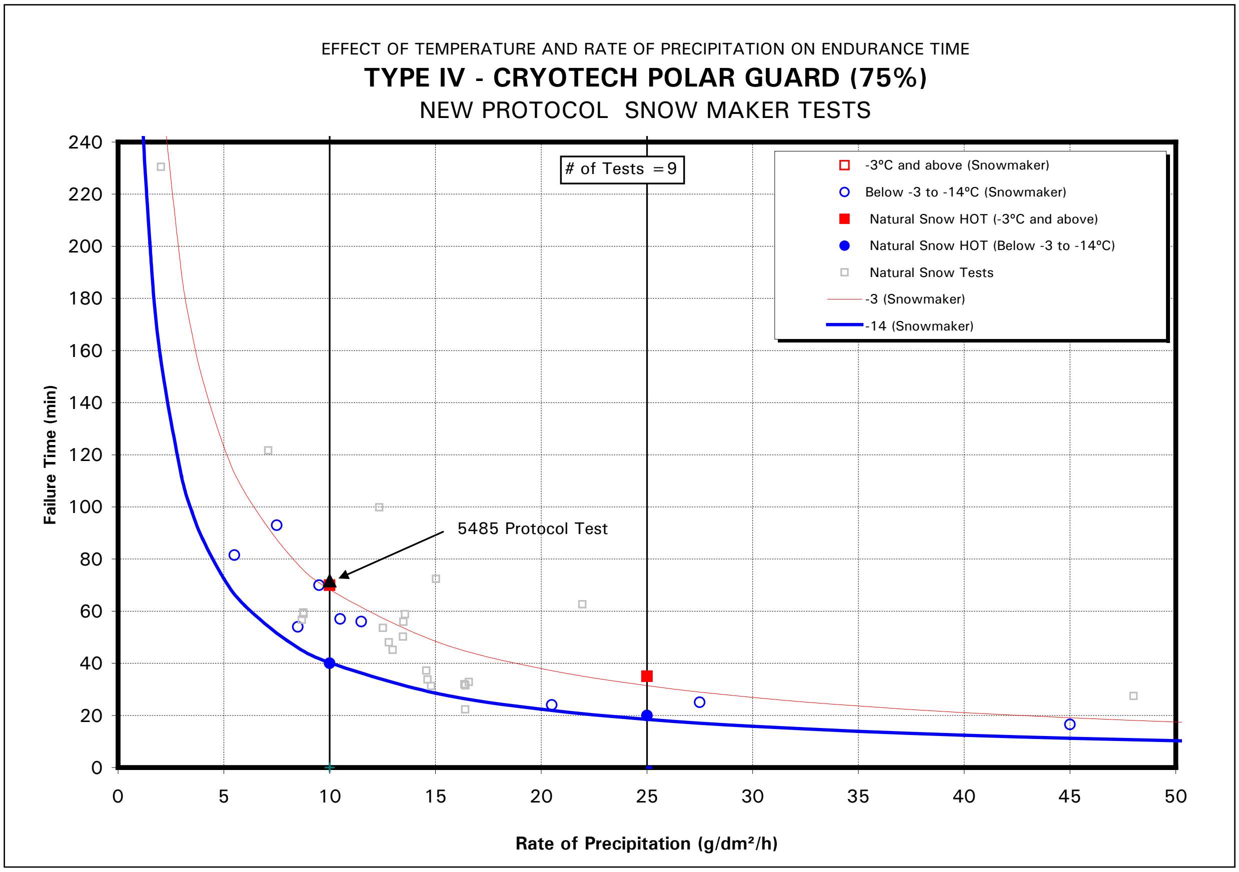


Figure 6.1: New Protocol Snow Machine Tests (75/25)

To better understand the effectiveness of the new protocol, the nine 75/25 test endurance times for the temperature range -3°C to -14°C were plotted along with the current HOTs of that particular fluid. A regression analysis was performed using the standard approach to obtain HOTs. Best-fit curves were plotted using the most restrictive (lowest) temperature for that cell. For example, in cases of tests conducted at ambient temperatures above -14°C, the value of temperature used in the fitting procedure was -14°C.

It was observed that these best-fit curves fell either directly through the current holdover time or within a very close tolerance. This would signify that the test conducted closely simulated that of outdoor conditions.

The 25 outdoor natural snow tests were also plotted in Figure 6.1. These points have been included to demonstrate that the natural snow data and new protocol snow machine data follow a similar scatter. It should be noted that these natural snow data points are not included in the regression analysis performed.

One test was conducted using the current ARP5485 protocol. It can be seen in Figure 6.1 that this test was also similar to the current natural snow holdover time for this fluid.

The same analysis was conducted for the four 50/50 tests. This is presented in Figure 6.2. The results from the test show that the endurance times with the new protocol closely replicated the outdoor holdover time.

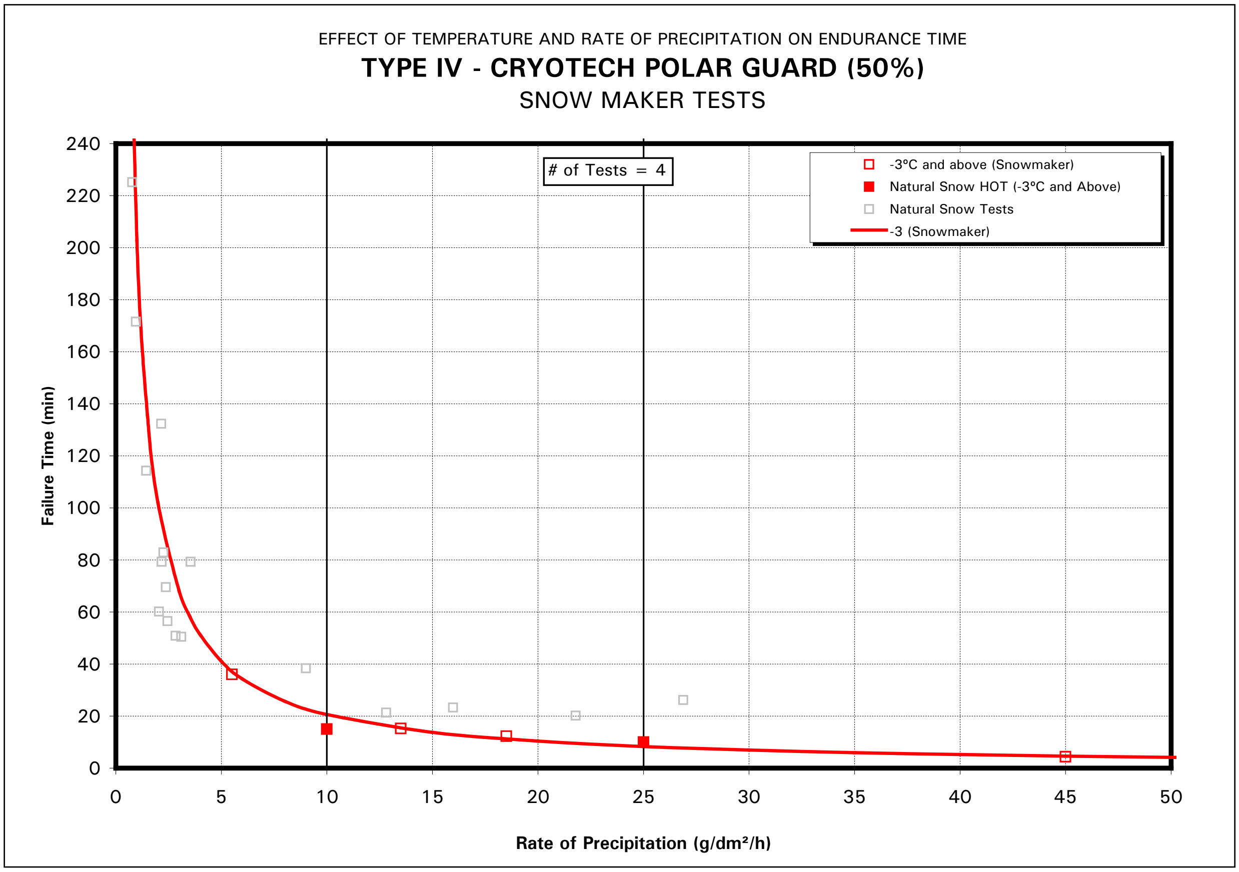


Figure 6.2: New Protocol Snow Machine Tests (50/50)

6.6 Conclusions and Recommendations

Initial results appear to be promising. It has been observed that using this new protocol could provide simulated results of natural snow testing; however, this result is based on very limited data for one fluid brand. It is recommended that further testing be conducted to further validate the use of this new protocol.

As the snow machine was inoperable for a period of time, a complete data set could not be achieved. It is recommended that a maintenance plan be implemented by the NCAR to keep the snow machine operational at all times.

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

Transport Canada (TC) and the Federal Aviation Administration (FAA) have supported research and development of ice detection technology for the aircraft de/anti-icing industry for many years. APS Aviation Inc. (APS) has conducted much of this work on their behalf. The work completed in support of ice detection technology in 2009-10 focused on the end-of-runway application. The 2009-10 work is documented in this section.

7.1 Previous Work

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

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

Over the winters of 2007-08 and 2008-09, APS was part of a working group assisting TC and the FAA in developing an Advisory Circular specifically for the use of ROGIDS as a primary means for post-deicing inspection of clear ice on aircraft. APS again provided expert opinion and document development support for the Advisory Circular. The working group provided the document to TC and the FAA in December 2008. The TC Advisory Circular was published online in April 2009.

https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-602-001.

The FAA has also published a similar Advisory Circular document.

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

During the official project kick-off meeting held in June 2009 in Montreal, focus was directed toward developing a research/action plan and establishing the project timeline. For a detailed description of the work completed during 2008-09, refer to the TC report, TP 14936E, *Aircraft Ground Icing General Research Activities During the 2008-09 Winter* (6).

7.2 Project Objective

The objective of this project for the winter of 2009-10 was to support the development and refinement of a research/action plan for enabling the use of ice detection technology in an end-of-runway application. In this application, ice detection technology (likely ice detection cameras) would be used to perform pre-takeoff contamination checks at the end of the runway just prior to takeoff.

7.3 ROGIDS Working Group Meetings

During the course of this project, members of the ROGIDS Working Group attended the following meetings over the last two years in an attempt to advance this research:

a) Ottawa, Canada, December 2008;
b) Montreal, Canada, June 2009;
c) Toronto, Canada, September 2009;
d) Palm Coast, United States, December 2009; and
e) Atlantic City, United States, September 2010.

7.4 Project Activities 2009-10

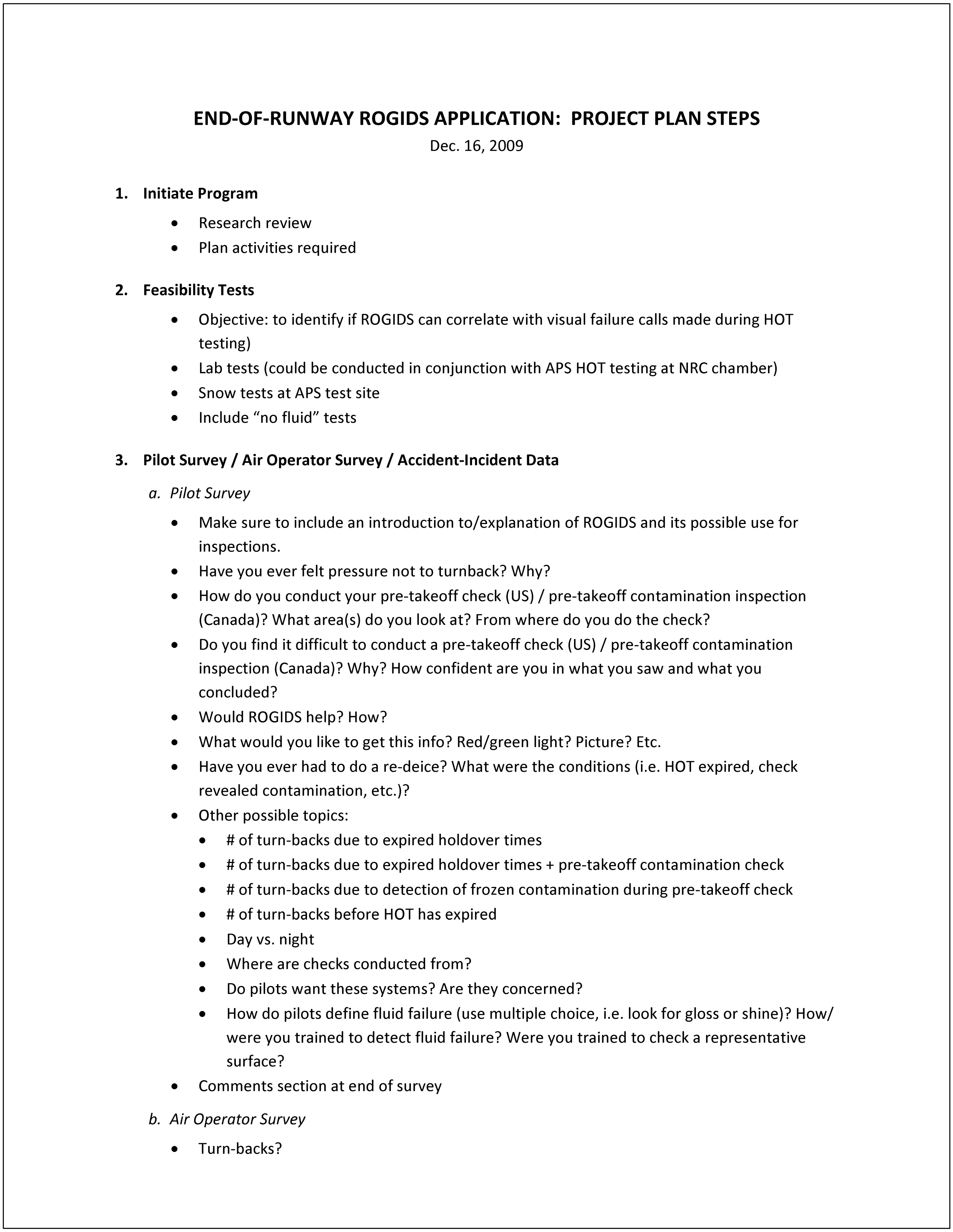
The main activities during the ROGIDS Working Group meeting held in Palm Coast and Atlantic City were as follows:

1) The Project Timeline: The document was reviewed, discussed, and revised (work primarily done during the Palm Coast meeting). See Figure 7.1 for the latest version;
2) The Project Research/Action Plan: The document was reviewed, discussed, and revised (work primarily done during the Palm Coast meeting). See Figure 7.2 for the latest version;
3) The Problem Definition: The document was discussed and revised with additional information on engine icing and pre-deicing application (work done during both the Palm Coast and Atlantic City meetings). See Appendix G for the latest problem definition;

4) Flight Crew Survey: The survey was developed during 2009-10 and discussed in Atlantic City. The survey was finalized and sent to pilots online in US and Canadian versions. The two surveys contain essentially the same questionnaire information; differences include the Canadian survey's reference to pre-takeoff contamination inspections and the American survey's reference to pre-takeoff checks and pre-takeoff contamination checks. See Appendix H for the Canadian version of the *Flight Crew Survey on Pre-Take-Off Contamination Inspections*; and
5) Future Activities: Future activities proposed by the ROGIDS Working Group were discussed in Atlantic City. Here, major activities and approaches were projected in an attempt to extend this research. Refer to Subsection 7.5 of this report for a detailed list of future ROGIDS activities.

Program Step	**2009**		**2010**		**2011**		**2012**		**2013**		**2014**	
1. Initiate Program	▨	▨										
2. Feasibility Tests			▨	▨								
3. Surveys / Accident-Incident Data			▨	▨								
4. Operational Tests with Airline to Document what's on Aircraft Prior to Takeoff				Preliminary	▨	Final	▨					
5. Develop a Standard				▨	▨	▨	▨	▨	▨			
6. Analysis of Heldover Time						▨	▨					
7. Compare Visual Contamination Detection Abilities of Pilots vs. ROGIDS						Phase 1/2	▨	Phase 3/4	▨			
8. Develop Preliminary Thresholds									▨	▨		
9. Develop an AC									▨	▨	▨	
10. Consultations/Tests to Confirm Thresholds										▨	▨	
11. Field Tests to Confirm Lab Correlation of ROGIDS										▨	▨	
12. Develop "Go/No Go" Communication											▨	▨

Figure 7.1: Proposed Project Timeline (December 16, 2009)



END-OF-RUNWAY ROGIDS APPLICATION: PROJECT PLAN STEPS

Dec. 16, 2009

1. **Initiate Program**
    - Research review
    - Plan activities required
2. **Feasibility Tests**
    - Objective: to identify if ROGIDS can correlate with visual failure calls made during HOT testing)
    - Lab tests (could be conducted in conjunction with APS HOT testing at NRC chamber)
    - Snow tests at APS test site
    - Include “no fluid” tests
3. **Pilot Survey / Air Operator Survey / Accident-Incident Data**

    a. Pilot Survey

    - Make sure to include an introduction to/explanation of ROGIDS and its possible use for inspections.
    - Have you ever felt pressure not to turnback? Why?
    - How do you conduct your pre-takeoff check (US) / pre-takeoff contamination inspection (Canada)? What area(s) do you look at? From where do you do the check?
    - Do you find it difficult to conduct a pre-takeoff check (US) / pre-takeoff contamination inspection (Canada)? Why? How confident are you in what you saw and what you concluded?
    - Would ROGIDS help? How?
    - What would you like to get this info? Red/green light? Picture? Etc.
    - Have you ever had to do a re-deice? What were the conditions (i.e. HOT expired, check revealed contamination, etc.)?
    - Other possible topics:
        - # of turn-backs due to expired holdover times
        - # of turn-backs due to expired holdover times + pre-takeoff contamination check
        - # of turn-backs due to detection of frozen contamination during pre-takeoff check
        - # of turn-backs before HOT has expired
        - Day vs. night
        - Where are checks conducted from?
        - Do pilots want these systems? Are they concerned?
        - How do pilots define fluid failure (use multiple choice, i.e. look for gloss or shine)? How/ were you trained to detect fluid failure? Were you trained to check a representative surface?
    - Comments section at end of survey

    b. Air Operator Survey

    - Turn-backs?

Figure 7.2: Proposed Research/Action Plan (December 16, 2009)

  c. *Gather data on related accidents/incidents (three types)*
     - Failing to realize that there is or that the ice present is dangerous so no deicing takes place
     - Aircraft is deiced, HOT respected, but contamination is present at takeoff
     - Aircraft is deiced, contamination is removed, but HOT exceeded

  d. *Report on benefits of ROGIDS for end-of-runway*

4. **Operational Tests with Airline to Document what's on Aircraft Prior to Takeoff**
   - Objectives: To prove aircraft are taking off with contamination, sensitivity analysis/threshold setting tool; to prove ROGIDS, pilot from cockpit, and observer from ground (and possibly cabin) see different amounts of contamination.
   - Goal outputs: "maps" of contamination from pilot, from expert observer (i.e. APS), from current policy for exterior contamination check, from MDA camera and from standard camera photo.

5. **Develop a Standard**

6. **Analysis of "Heldover" Time**
   - APS to bring historical data to next meeting (completed Sept meeting)
   - Obtain information from airports and/or airlines on usage of HOTs: How long are aircraft on the ground prior to departure? What % of HOT is used? How many aircraft did not go for deicing? This may or may not be done at a later date depending on sufficiency of APS historical data.

7. **Compare Visual Contamination Detection Abilities of Pilots vs. ROGIDS**
   - PHASE 1: Human Factors development of test plan
   - PHASE 2: Develop method for producing stable specimens for various types of failure
   - PHASE 3: Conduct preliminary tests with small group of pilots to refine procedure
   - PHASE 4: Conduct tests with large (50-100?) group of pilots
   - Note: Standard camera should be used in parallel with MDA camera

8. **Develop Preliminary Thresholds**

9. **Develop an AC**

10. **Consultations and Tests to Confirm Thresholds**

11. **Field Tests to Confirm Lab Correlation of ROGIDS and Visual Failure Calls Valid on Aircraft**
    - Tests use visual observer from outside aircraft, not pilot from inside cabin.
    - Criteria is wing contamination of 10%, as seen by experienced observer on ground.

12. **Develop Methodology to Communicate "Go/No Go" to Pilot**

Figure 7.2: Proposed Research/Action Plan (December 16, 2009) (cont'd)

7.5 Future Activities

Listed below are anticipated future activities discussed in Atlantic City in support of ice detection technology.

7.5.1 Flight Crew Survey

With the US and Canadian versions now developed and finalized, the focus is on distributing the survey to contacts within the industry, such as air carriers, the Canadian Business Aviation Administration (CBAA), and the Air Transport Association of Canada (ATAC). Participation in this survey appears promising as of November 1, 2010, with approximately 700 responses. Of these responses, an estimated two-thirds are from Canadian participants. Data collection is still ongoing.

7.5.2 Accidents/Incident Reports

Aviation Safety Reporting System (United States) (ASRS) reports were examined and discussed at the Atlantic City meeting. Initial reviews indicate support in the advancement of ROGIDS technology. Civil Aviation Daily Occurrences Reporting System (Canada) (CADORS) reports were briefly discussed at this meeting and found to not have the same useful detailed information as the US reports. Further review of the American reports will be conducted.

7.5.3 ROGIDS Testing and Status

Recent developments of the MacDonald, Dettwiler, and Associates Ltd. (MDA) ice detection technology have taken place. During the Atlantic City meeting, it was brought to the attention of the Working Group that a potential investor (PV Labs) is likely going to market and develop the MDA technology. Terms and conditions of this agreement are currently being negotiated. With regards to future testing in 2010-11 with this technology, it was recommended at the Atlantic City meeting that National Research Council Canada (NRC) Cold Chamber testing and possibly natural snow testing be conducted.

7.5.4 Engine Icing and Pre-Deicing

Discussions during the Atlantic City meeting examined the two areas where ice detection technology could prove to be useful and where it could provide short-term results. These areas were engine icing and pre-deicing. Due to post-deicing activities (end-of-runway application) likely requiring longer introduction within operations, it was concluded that short-term group efforts would focus on engine icing and pre-deicing.

8. FLUID ENDURANCE TIME TESTING IN SNOW PELLET CONDITIONS

8.1 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. They are also brittle and easily crushed. They bounce and break on hard ground.

Although occurrences of snow pellets during aircraft operations have been reported, no HOT Guidelines currently exist for snow pellets. Some aircraft operators have voiced concern regarding the lack of HOT guidance material due to the recent increased frequency of occurrence of snow pellet conditions. In Winter 2005-06, some preliminary work was conducted by APS Aviation Inc. (APS) to examine the melting time properties of simulated snow pellets versus natural snow; this work was presented at the SAE International (SAE) G-12 Lisbon HOT Working Group meeting in May 2006 and was reported in the Transport Canada (TC) report, TP 14713E, *Aircraft Deicing Research in Natural and Simulated Ice Pellet Conditions* (7).

In Winter 2007-08, a total of three preliminary comparative sets of tests were conducted. This work was presented at the SAE G-12 Warsaw HOT Working Group meeting in May 2008 and was reported in the TC report, TP 14872E, *Aircraft Ground Icing Research General Activities During the 2007-08 Winter* (8). Research indicated that the fluid endurance times in simulated snow pellet conditions were similar to simulated snow and that the average final Brix recorded indicated similar levels of fluid dilution for each of the comparative set of tests. APS recommended that further work be conducted with different fluids and dilutions to substantiate the results obtained.

8.2 Objective

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

The purpose of these tests is to identify whether the current HOT Guidelines can be expanded to include snow pellets in the current snow HOT column.

8.3 Methodology

Testing was conducted inside the refrigerated trailer located at the Montreal–Trudeau Airport test site. Snow pellets were manufactured by shaving ice cores to create snow in the National Center for Atmospheric Research (NCAR) snow machine. Once the snow was collected, snow balls were formed manually with the artificial snow and then crushed through the calibrated sieves (see Photo 8.1) to create snow pellets (1.4 to 4 mm) (see Photo 8.2).

The comparative testing was conducted using the standard holdover time (HOT) procedure. Snow pellets were dispensed manually. The tests were conducted using the standard NCAR methodology for snow. A procedure, *Endurance Time Test Requirements for Snow Pellet Flat Plate Testing Type I, II, III, and IV Fluids*, was developed and included in Appendix I.

The procedure contained a series of tests that were to be conducted for different fluids, dilutions, and conditions. Due to budgetary constraints and the fact that the snow machine was inoperable for a period of time, only a limited number of tests in 2009-10 were possible. Ten comparative runs were conducted with a variety of Type I, II, III, and IV fluids at different dilutions. The Anti-Icing Materials International Laboratory (AMIL) also conducted tests with snow pellets, in addition to the tests conducted by APS.

8.4 Test Results

A series of ten comparative tests were conducted with six different fluids. Testing was conducted with 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: three taken at the 15 cm crosshairs and four at the mid-plate crosshairs) was also recorded to quantify the levels of fluid dilution at the end of each test. Table 8.1 contains the results obtained this year as well as data collected in 2007-08. Figure 8.1 to Figure 8.13 demonstrate the comparison in endurance times during snow and snow pellet conditions.

Photo 8.3 to Photo 8.5 demonstrate a few of the visual failures of the different fluids in snow and snow pellets.

The photos show that the randomness of the failures is different in the condition of snow versus snow pellets; however, an identical failure criterion was used for both snow pellet tests and snow tests. Failure is determined when one-third of the plate is considered to be failed. While the dispersion of contamination on the photos appears slightly different, measurements of refractive index (Brix) collected at the time of failure confirmed that the failure determination was accurate and consistent.

Table 8.1: Simulated Snow Pellets vs. Simulated Snow Endurance Time Tests

Run #	Test #	Fluid	Dilution	Precipitation	OAT (°C)	Precip. Rate ($g/dm^2/h$)	Endurance Time in Snow Machine	Avg. Brix (°)	Winter
1	1	Type III PG	100/0	Snow Pellets	-13	11	28	19	2007-08
	2	Type III PG	100/0	Snow Pellets	-13	10	25	20	2007-08
	3	Type III PG	100/0	Snow	-11	10	25	18	2007-08
2	4	Type IV EG	100/0	Snow Pellets	-7*	25*	36	14	2007-08
	5	Type IV EG	100/0	Snow	-7*	25*	33	13	2007-08
3	6	Type IV PG–A	100/0	Snow Pellets	-7*	25*	31	20	2007-08
	7	Type IV PG–A	100/0	Snow	-7*	25*	30	20	2007-08
4	8	Type IV PG–A	50/50	Snow Pellets	-6	26	11	8	2009-10
	9	Type IV PG–A	50/50	Snow	-6	25	11	9	2009-10
5	10	Type IV PG–A	100/0	Snow Pellets	-15*	25*	21	19	2009-10
	11	Type IV PG–A	100/0	Snow	-15	26	20	20	2009-10
6	12	Type IV PG–M	50/50	Snow Pellets	-3	11	7	7	2009-10
	13	Type IV PG–M	50/50	Snow	-3	10	7	8	2009-10
7	14	Type IV PG–M	100/0	Snow Pellets	-17	25	17	19	2009-10
	15	Type IV PG–M	100/0	Snow	-14	25	17	20	2009-10
8	16	Type III PG	50/50	Snow Pellets	-3	10	9	10	2009-10
	17	Type III PG	50/50	Snow	-3	10	8	10	2009-10
9	18	Type III PG	100/0	Snow Pellets	-12	12	39	15	2009-10
	19	Type III PG	100/0	Snow	-10	10	42	16	2009-10
10	20	Type II PG–F	50/50	Snow Pellets	-4	11	47	8	2009-10
	21	Type II PG–F	50/50	Snow	-4	11	45	9	2009-10
11	22	Type II PG–F	100/0	Snow Pellets	-15	25	18	20	2009-10
	23	Type II PG–F	100/0	Snow	-15	25	18	21	2009-10
12	24	Type I EG–A	10˚C Buffer	Snow Pellets	-3	10	9	2	2009-10
	25	Type I EG–A	10˚C Buffer	Snow	-3	10	9	3	2009-10
13	26	Type I PG–D	10˚C Buffer	Snow Pellets	-14	4	9	12	2009-10
	27	Type I PG–D	10˚C Buffer	Snow	-13	4	8	12	2009-10

* OAT and precipitation rate estimates; data unavailable.

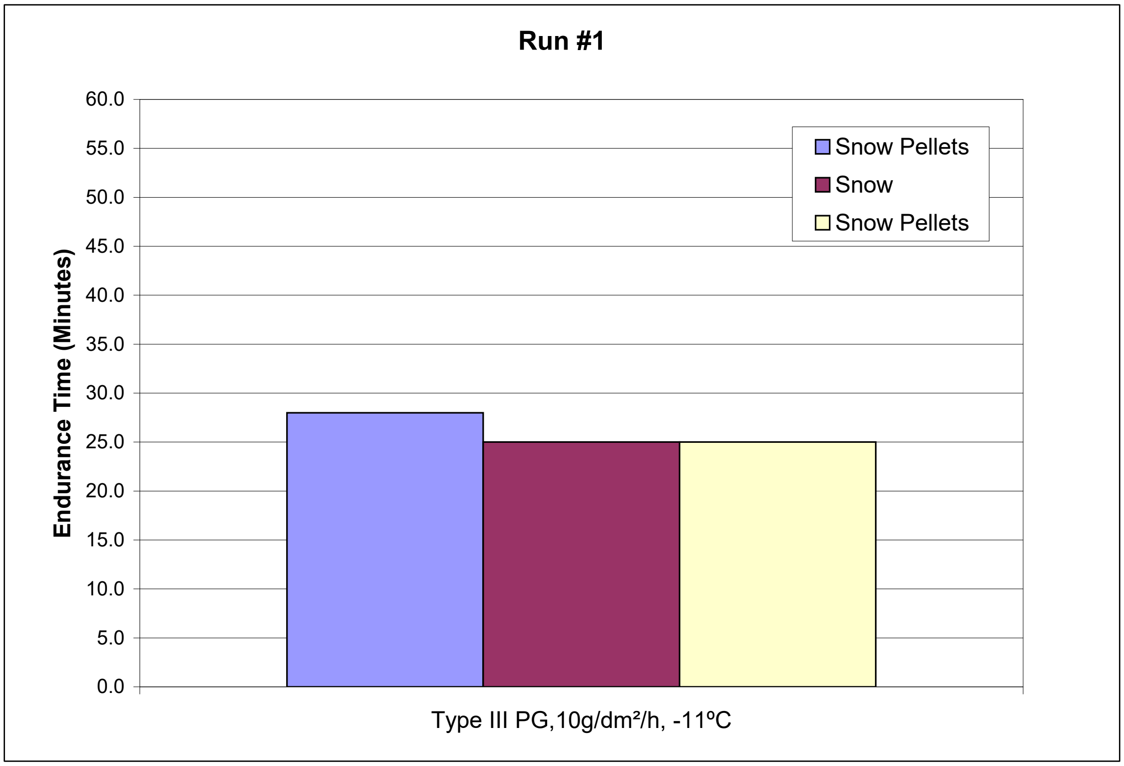


Figure 8.1: Comparison of ETs – Run #1

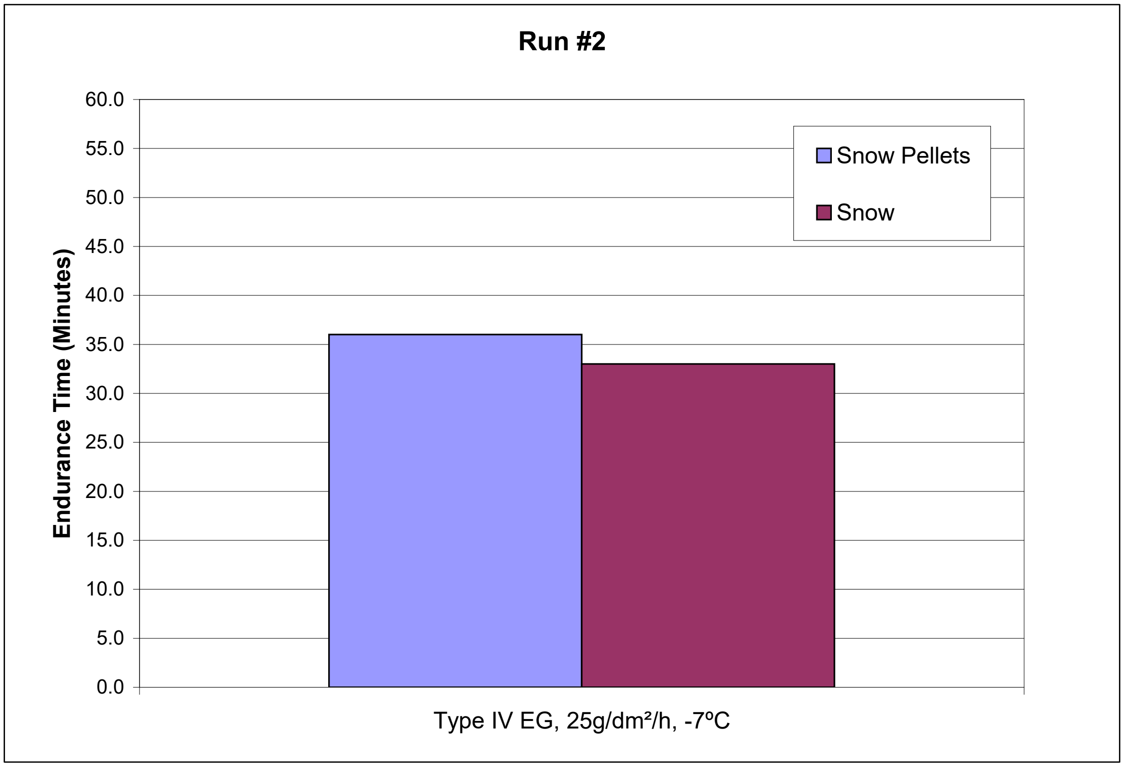


Figure 8.2: Comparison of ETs – Run #2

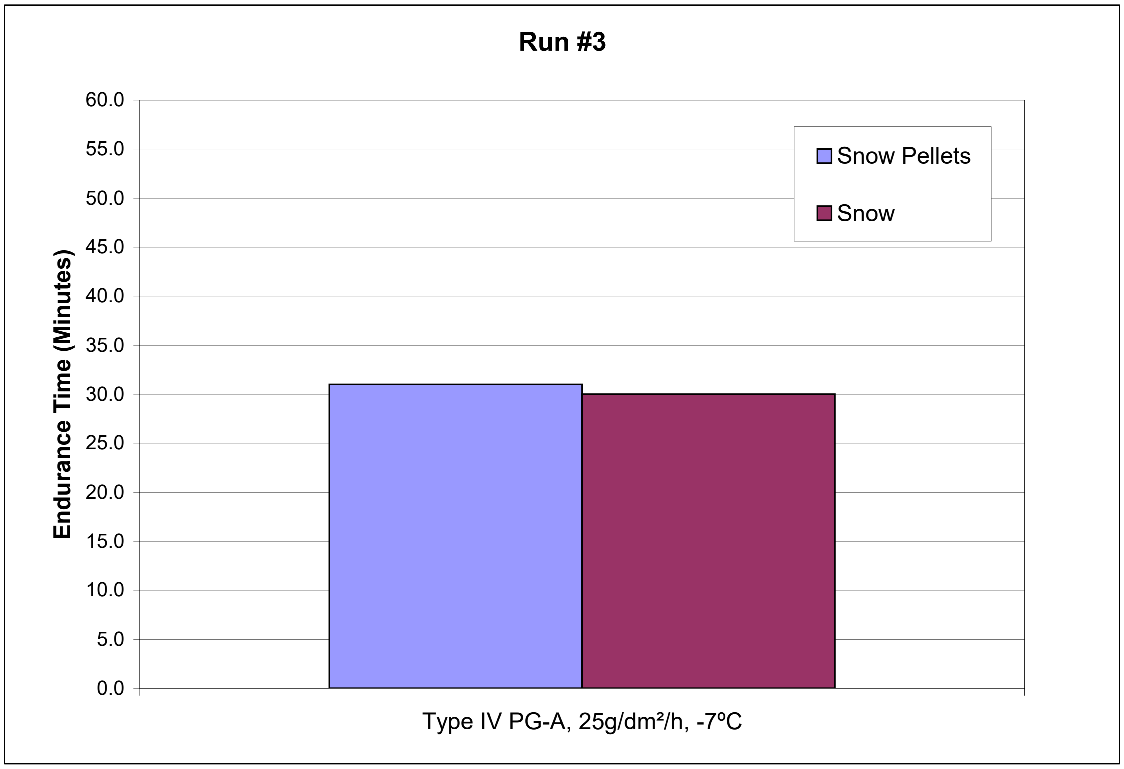


Figure 8.3: Comparison of ETs – Run #3

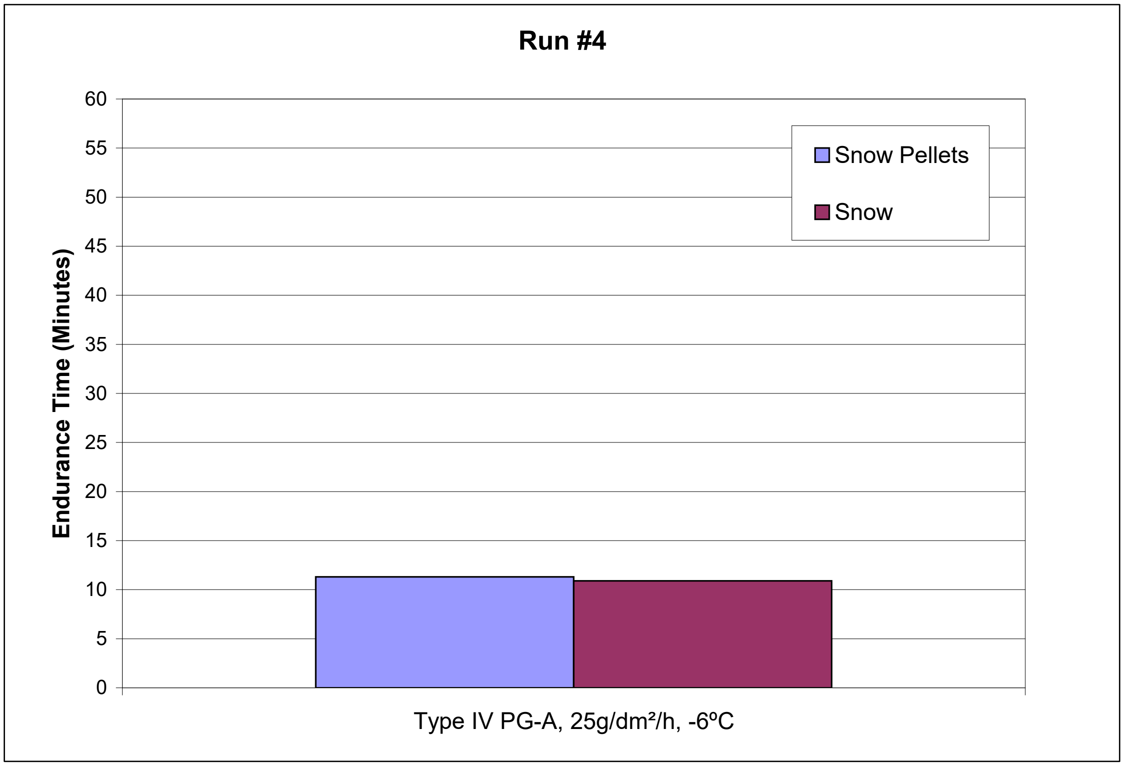


Figure 8.4: Comparison of ETs – Run #4

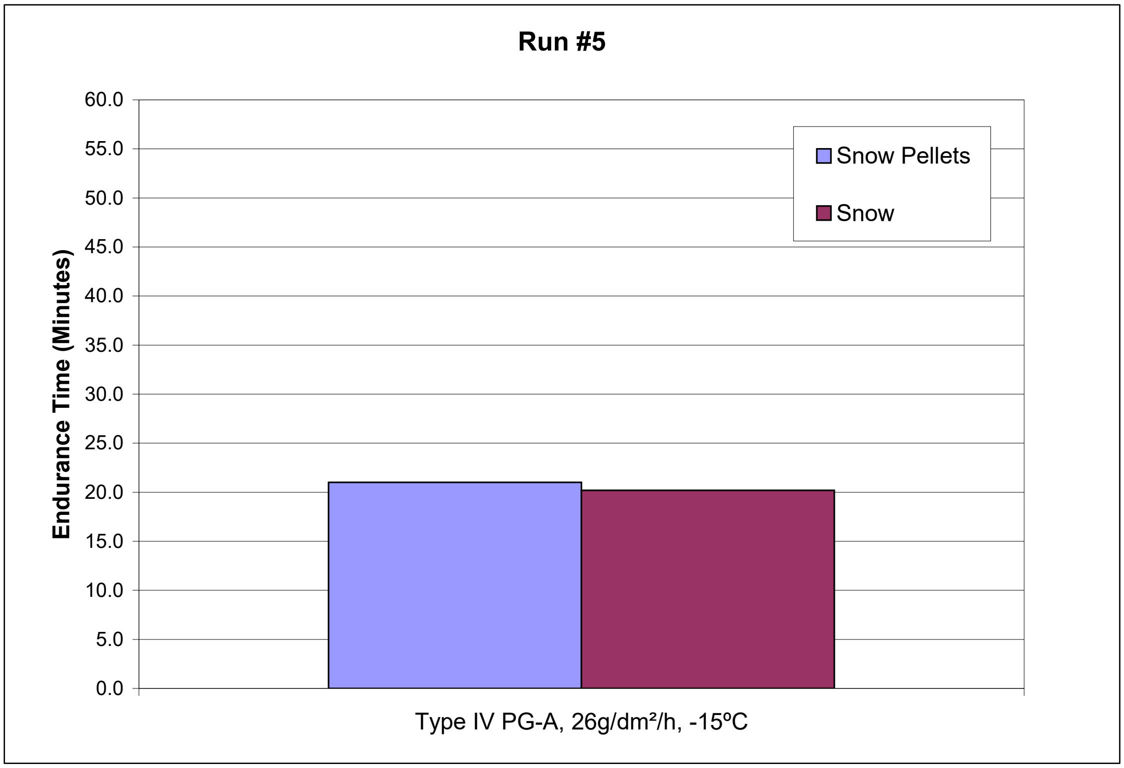


Figure 8.5: Comparison of ETs – Run #5

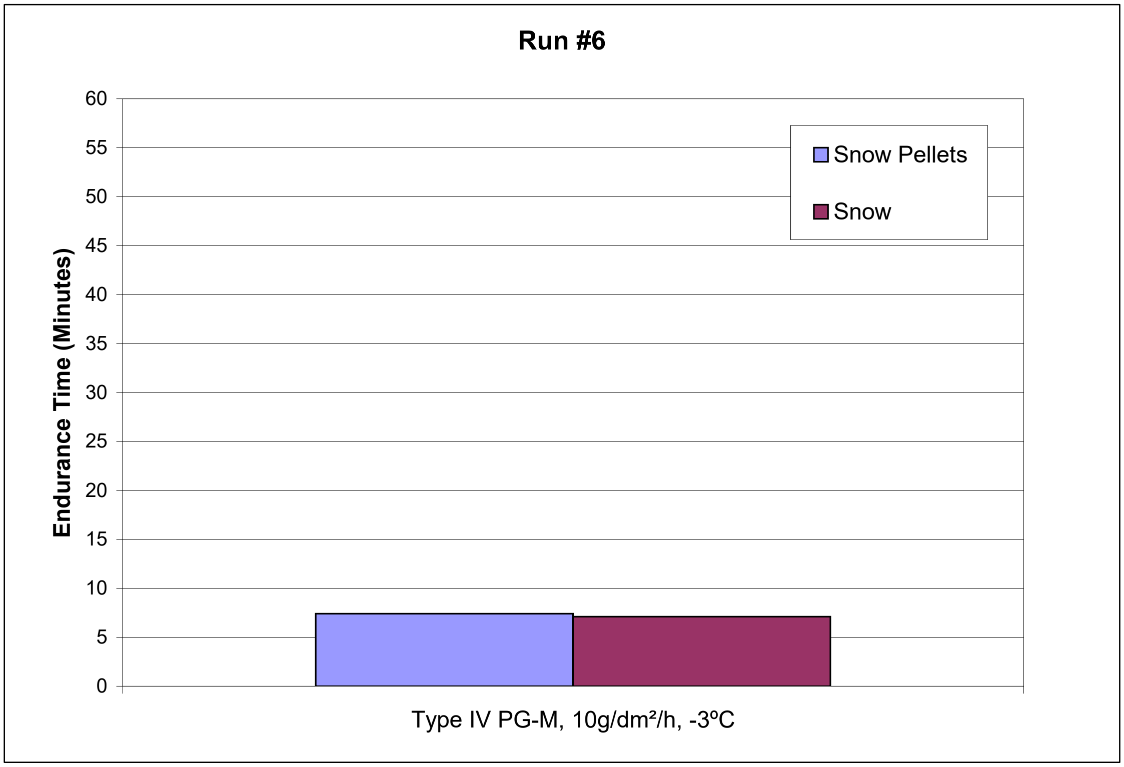


Figure 8.6: Comparison of ETs – Run #6

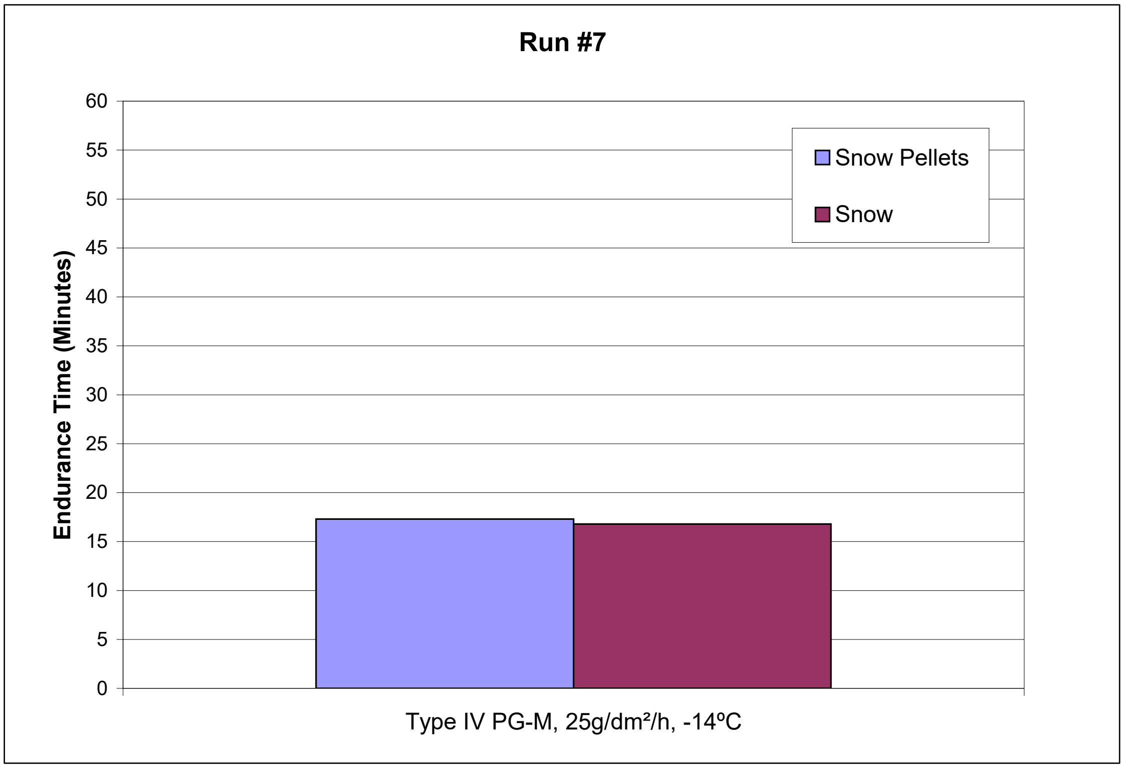


Figure 8.7: Comparison of ETs – Run #7

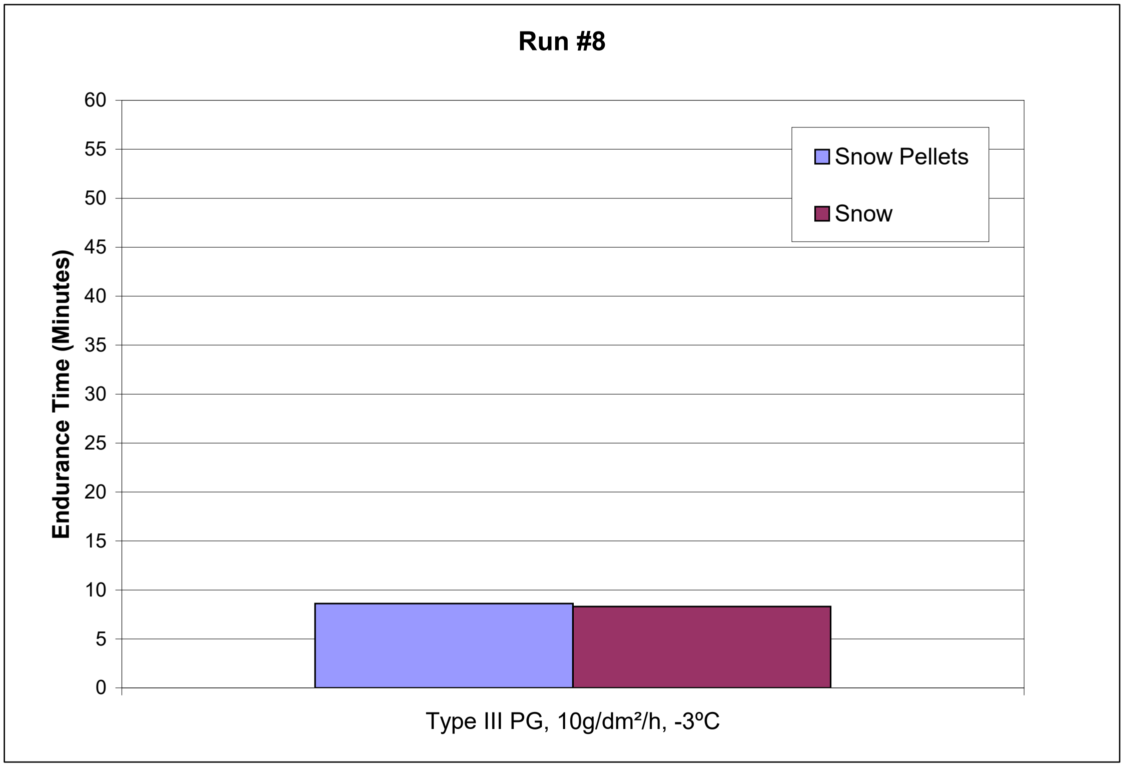


Figure 8.8: Comparison of ETs – Run #8

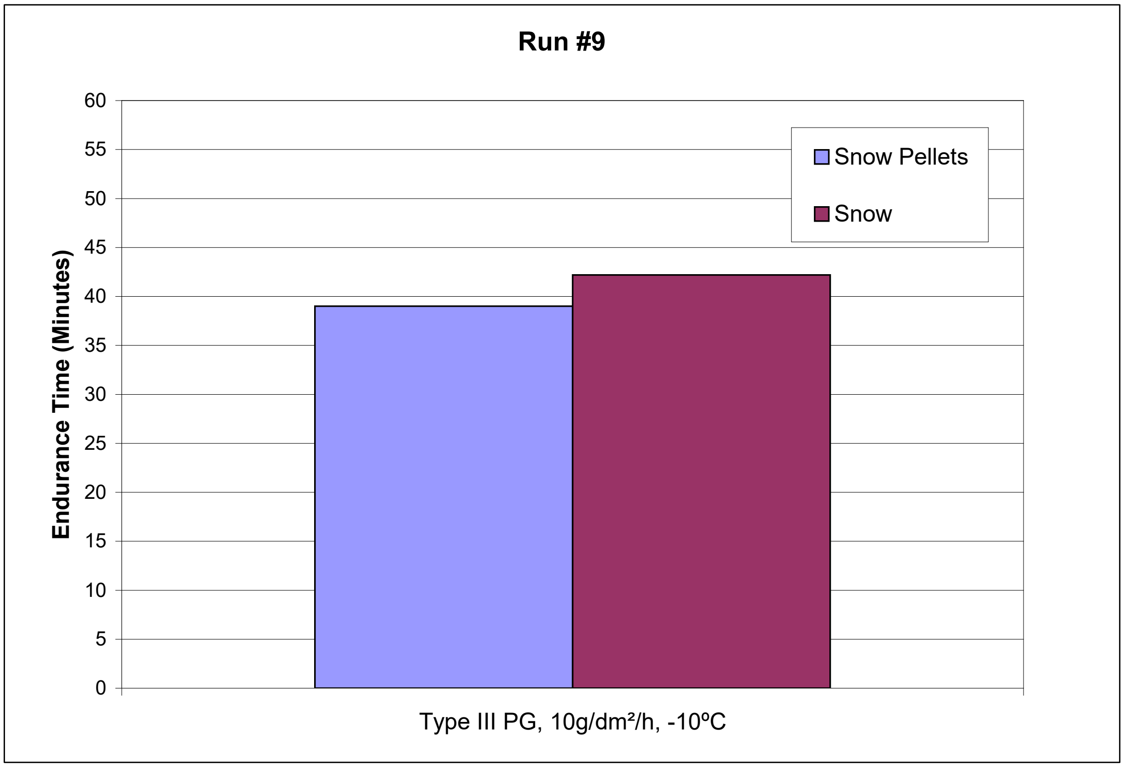


Figure 8.9: Comparison of ETs – Run #9

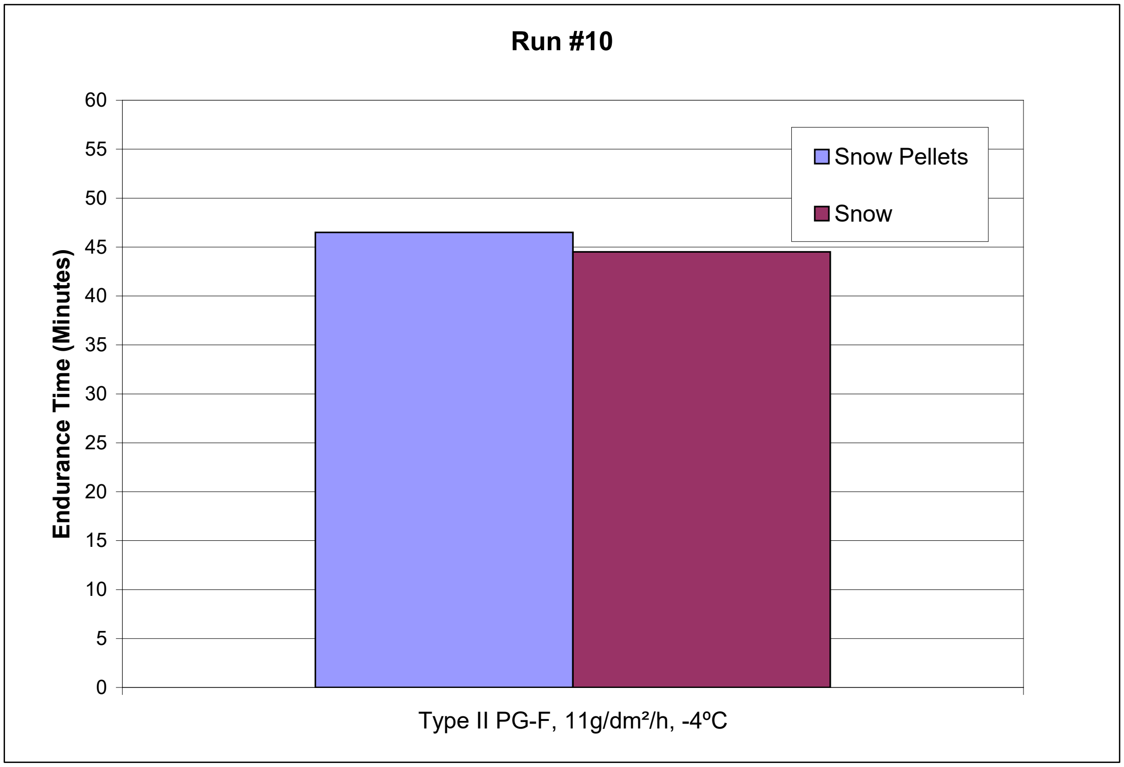


Figure 8.10: Comparison of ETs – Run #10

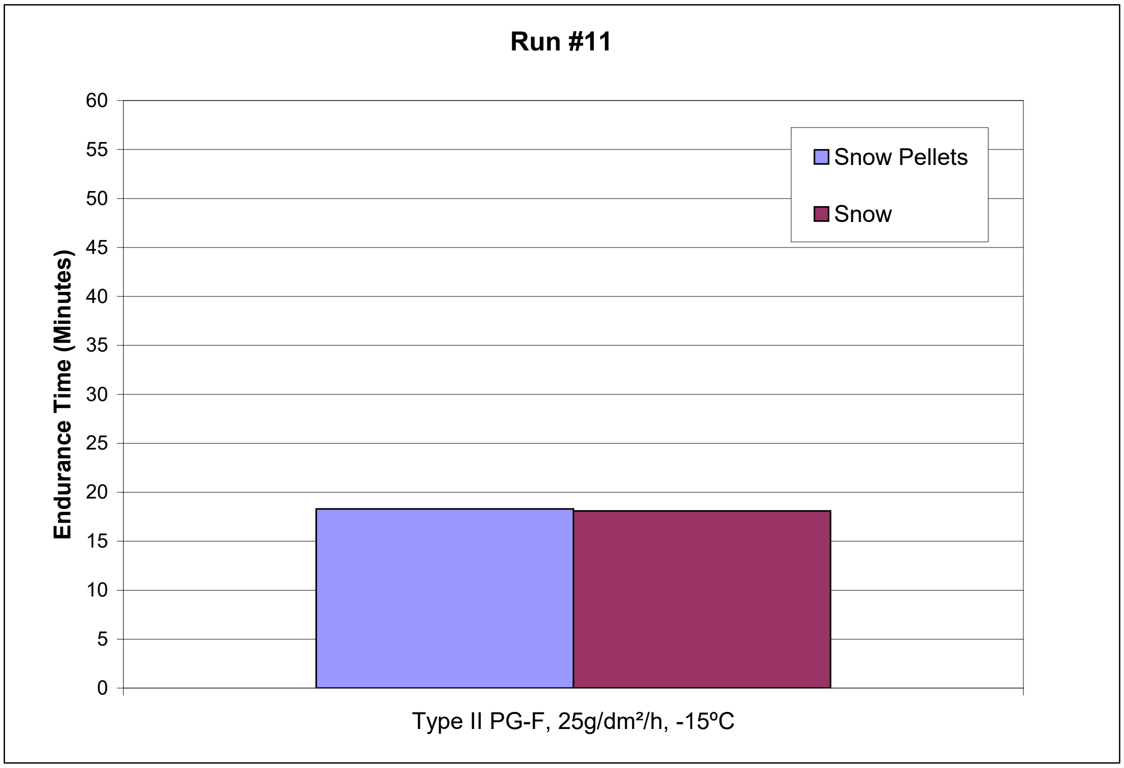


Figure 8.11: Comparison of ETs – Run #11

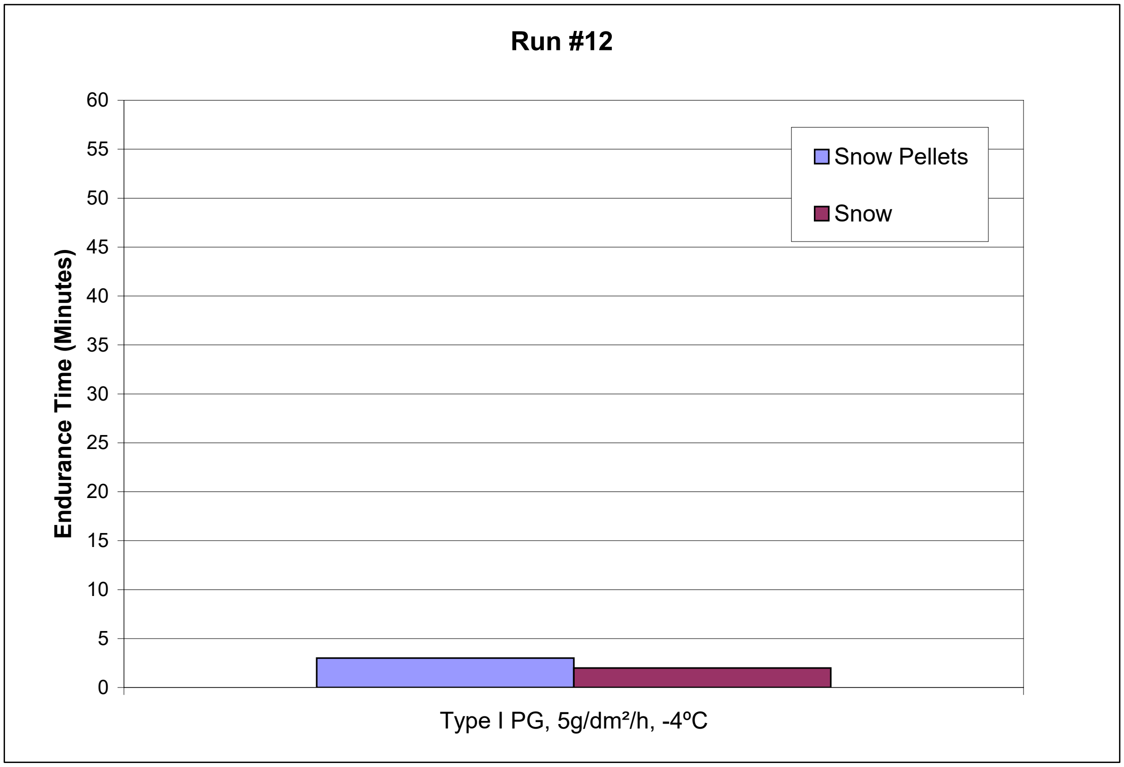


Figure 8.12: Comparison of ETs – Run #12

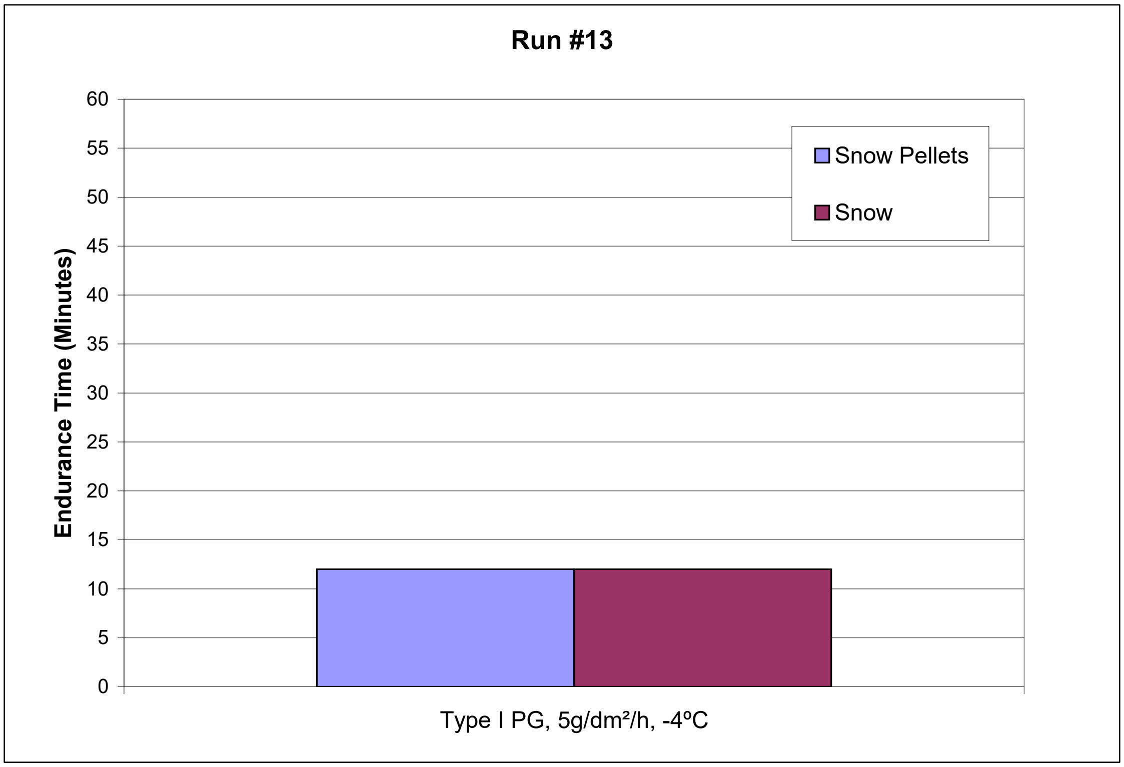


Figure 8.13: Comparison of ETs – Run #13

8.5 Observations and Conclusions

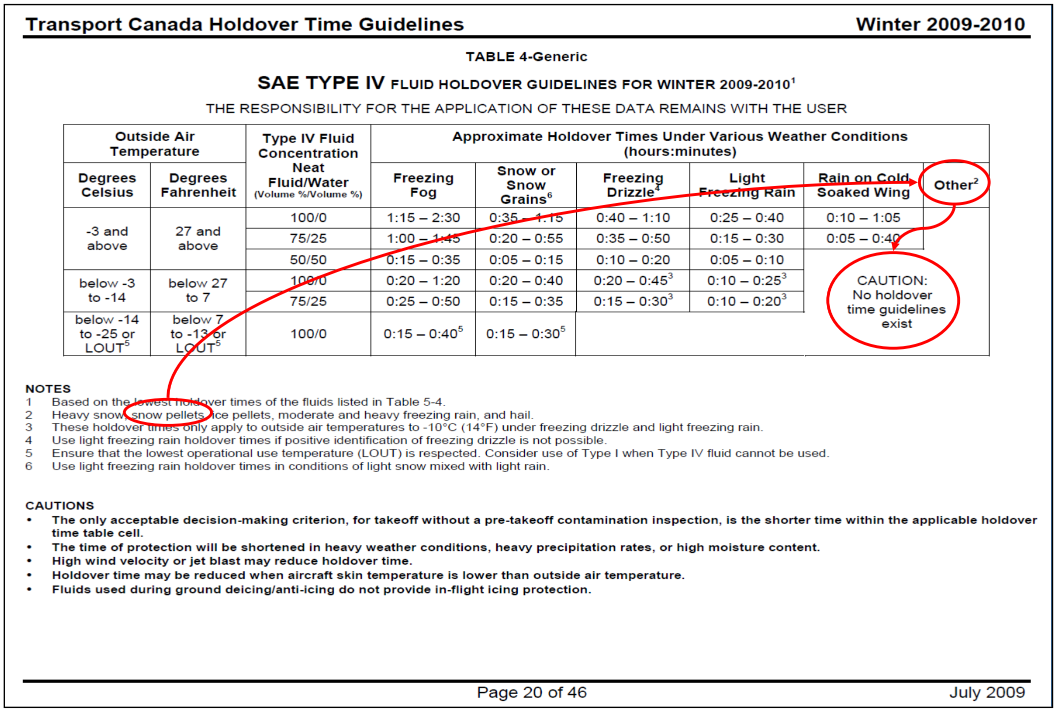
A total of ten comparative tests were conducted during the winter of 2009-10, and a total of three comparative tests had been previously conducted in 2007-08. In conclusion, fluid endurance times in simulated snow pellet conditions were similar to those in simulated snow, and results from 2009-10 were similar to the 2007-08 test results. Generally, the simulated snow pellet tests had endurance times 3 percent ± 3.7 percent longer in comparison to the simulated snow tests. The average final Brix recorded indicated similar levels of fluid dilution for each of the comparative set of tests.

To support the APS results, the AMIL also conducted testing in 2007-08 and in 2009-10. The results from the 2007-08 testing by the AMIL were presented at the SAE G-12 Holdover Time Committee meetings in November 2007 and May 2008. The results indicated that endurance times for snow pellets in comparison to those for snow were found to be similar or up to 30 percent less. However, further data with more fluids were tested by the AMIL, and the results indicated that the endurance times for snow pellets were either similar to or longer than those for snow.

8.6 Recommendations for Holdover Time Guidelines

As a result of this testing, it was recommended and proposed at the SAE G-12 meeting in Berlin, May 2010, to include snow pellets as an additional condition in the current snow HOT column for all Type I, II, III, and IV generic and fluid-specific tables. The proposed column heading would read: "Snow, Snow Grains, or Snow Pellets." Examples of the changes can be seen in Figure 8.14 to Figure 8.17.

It should be noted that data used to generate snow HOTs may already include snow pellets. Snow pellets are usually brief, and endurance time testing conducted during snow conditions may have included snow pellets that were not detected unless the condition was severe. In addition, snow pellets will generally occur during snow conditions, not during freezing rain or freezing drizzle conditions; therefore, there is a low risk of adherence.



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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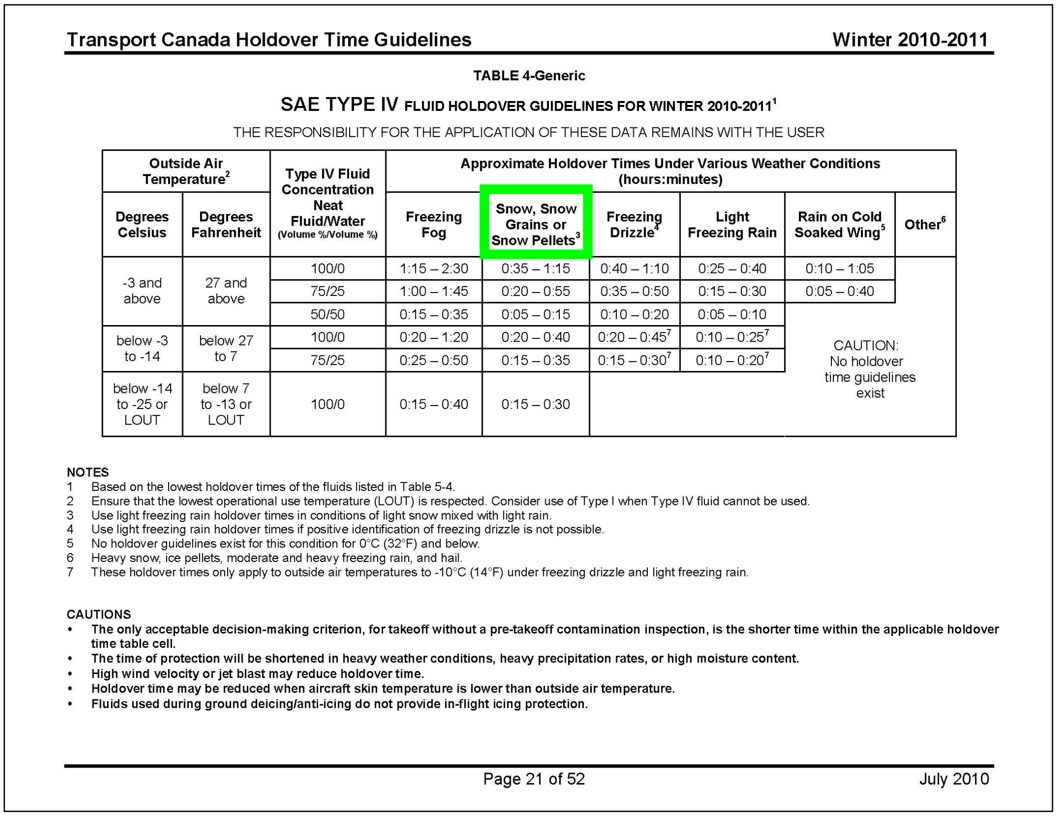
Figure 8.14: Type IV Generic Table – Winter 2009-10



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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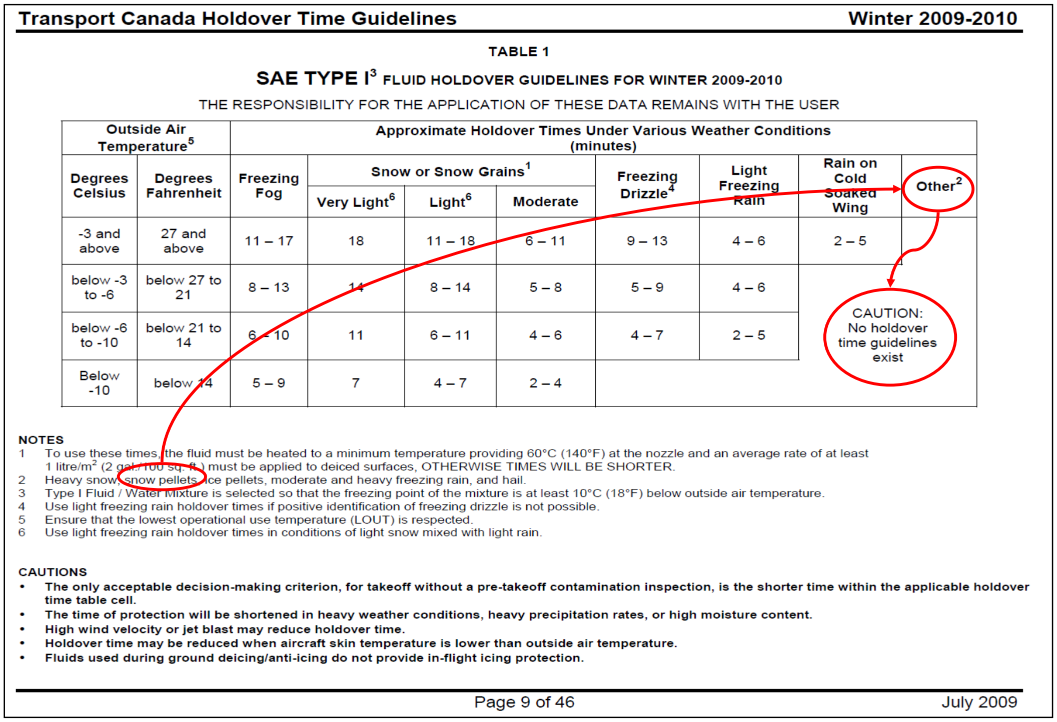
Figure 8.15: Type IV Generic Table – Winter 2010-11



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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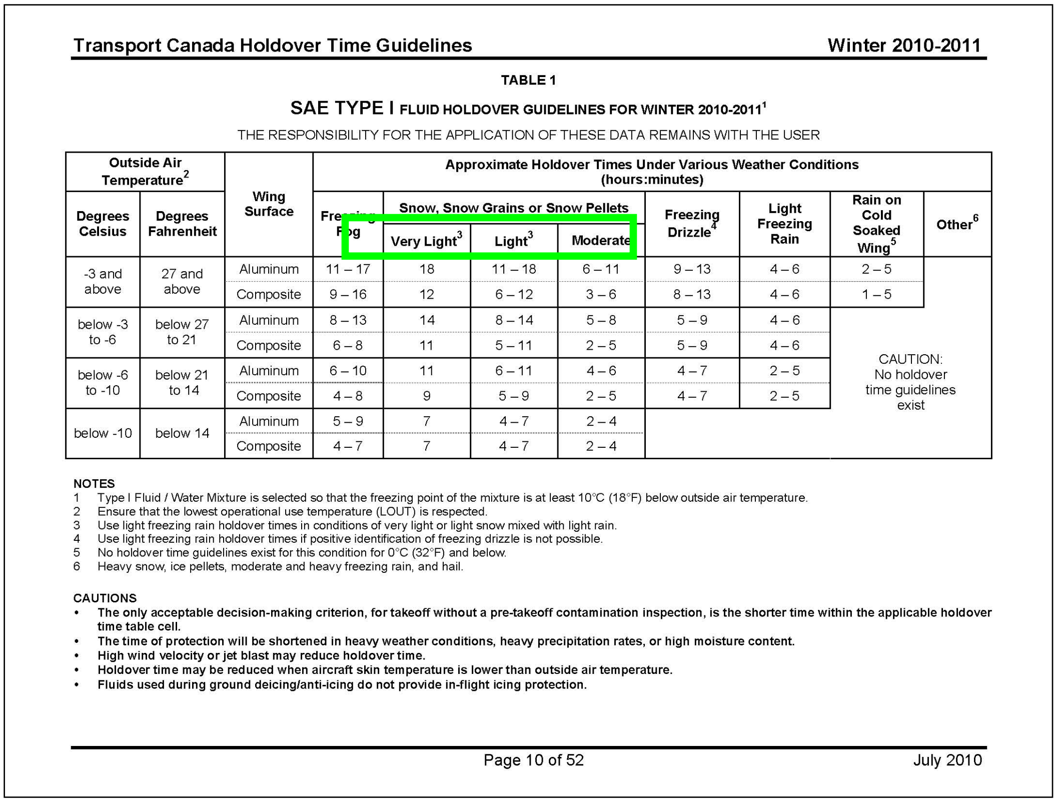
Figure 8.16: Type I Generic Table – Winter 2009-10



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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Figure 8.17: Type I Generic Table – Winter 2010-11

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Photo 8.1: Sieve Used to Manufacture Snow Pellets

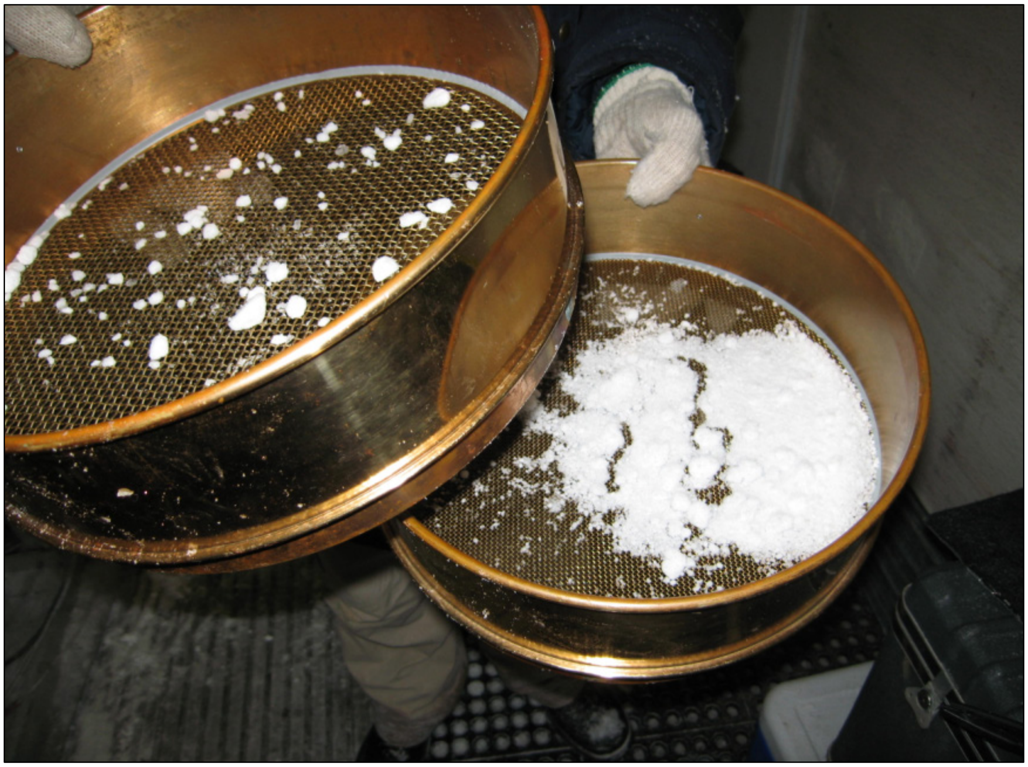


Photo 8.2: Size of Snow Pellets

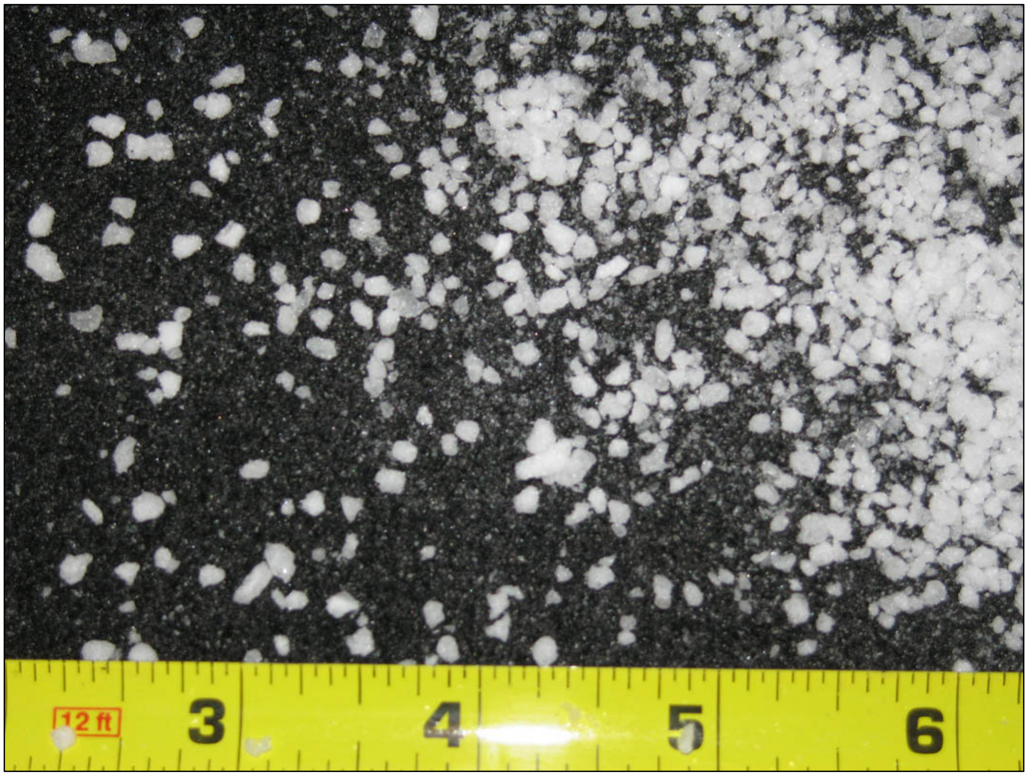
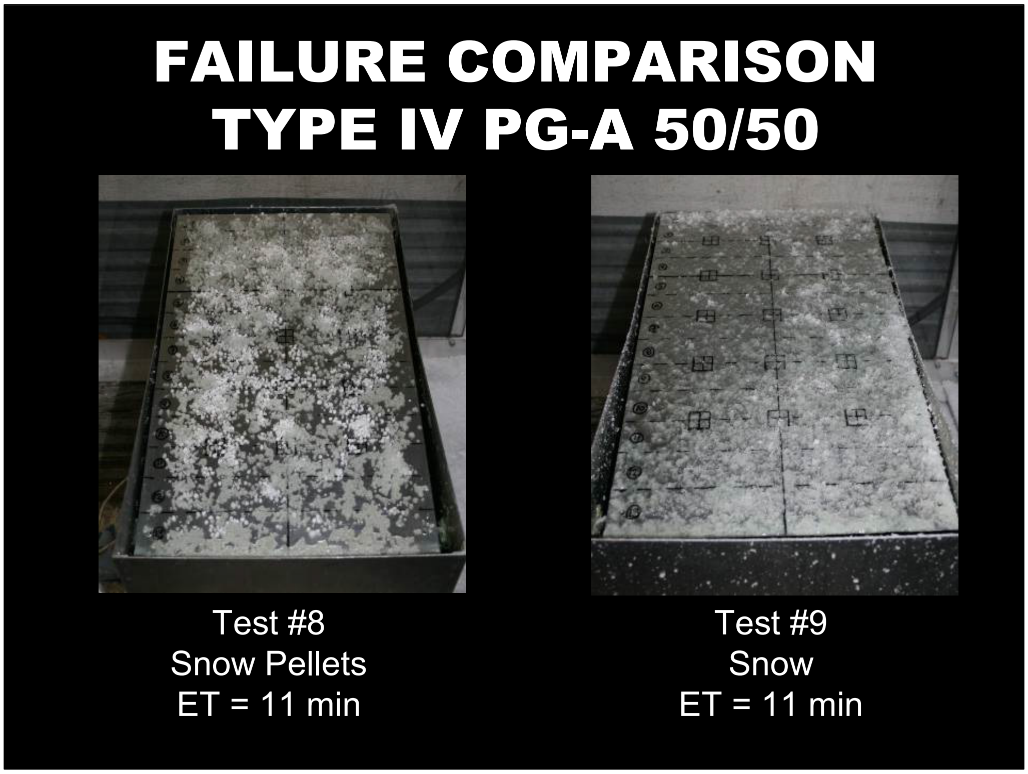


Photo 8.3: Fluid Failure Comparison – Run #4

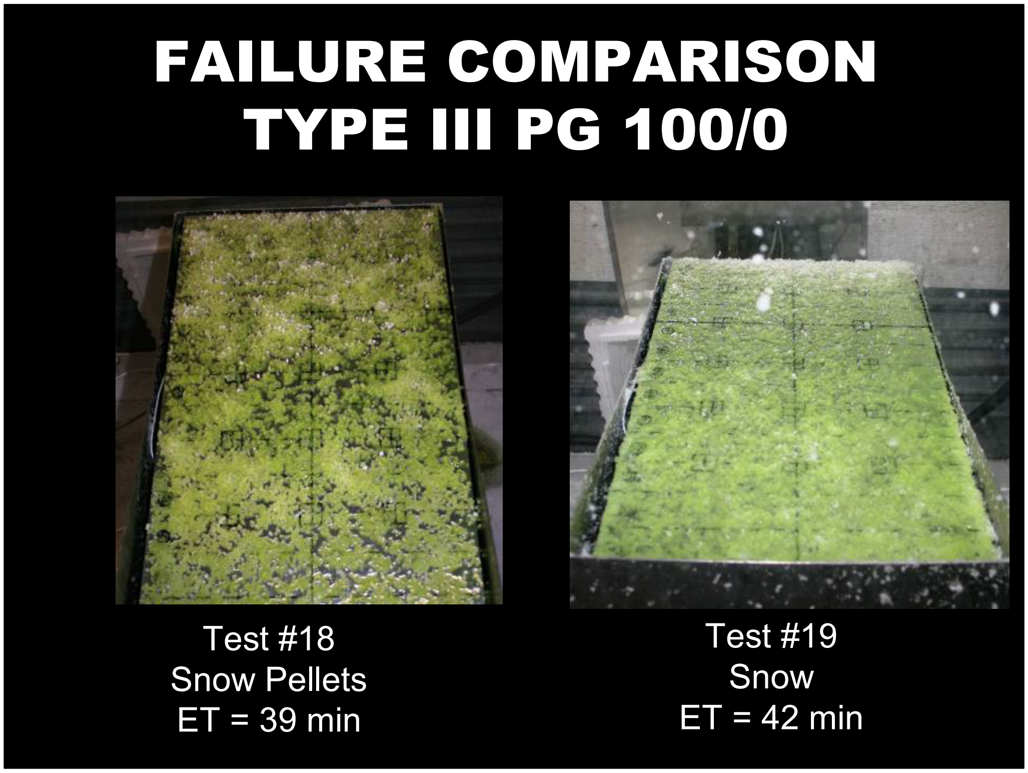


FAILURE COMPARISON
TYPE IV PG-A 50/50

Test #8
Snow Pellets
ET = 11 min

Test #9
Snow
ET = 11 min

Photo 8.4: Fluid Failure Comparison – Run #9

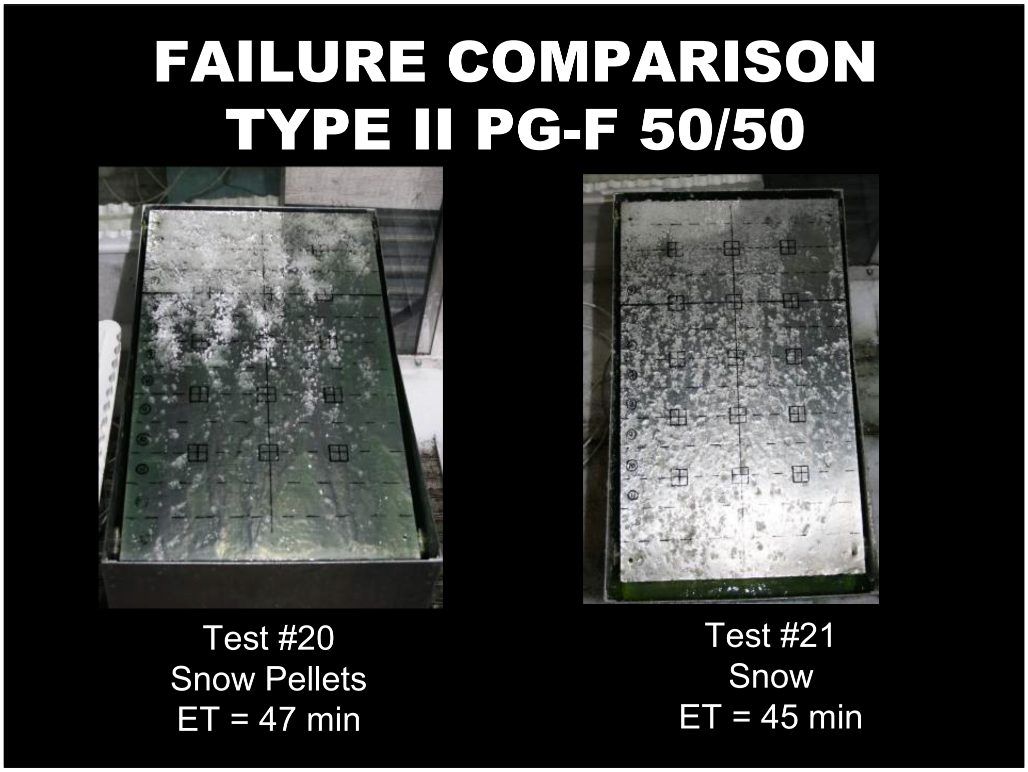


FAILURE COMPARISON
TYPE III PG 100/0

Test #18
Snow Pellets
ET = 39 min

Test #19
Snow
ET = 42 min

Photo 8.5: Fluid Failure Comparison – Run #10



FAILURE COMPARISON
TYPE II PG-F 50/50

Test #20
Snow Pellets
ET = 47 min

Test #21
Snow
ET = 45 min

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9. DEVELOPMENT OF LOUT TABLE FOR HOLDOVER TIME GUIDELINES

9.1 Background

For several years, airlines, deicing service providers, and other users of the Holdover Time (HOT) Guidelines have been asking Transport Canada (TC) and the Federal Aviation Administration (FAA) to include lowest operational use temperature (LOUT) information for qualified fluids in the HOT Guidelines.

The need for a LOUT table was raised once again by the industry at the SAE International (SAE) G-12 HOT Committee meeting in Berlin, Germany (May 2010). The FAA indicated that they intended to publish the LOUT information in their guidelines by winter of 2010-11. TC also indicated that they intended to publish LOUT guidelines, but were not certain of a publication date.

Subsequent to the meetings in Berlin, a meeting between TC, the FAA, and APS Aviation Inc. (APS) was held to discuss the development and revision of the HOT Guidelines for Winter 2010-11. The topic of LOUT was also discussed, specifically issues and concerns relating to the publishing of the LOUT information. One main concern was the limited time for the production of these tables. This would provide difficulty in obtaining all the information needed from manufacturers in a consistent and timely manner. There was a general consensus by the group that the tables should still be produced for Winter 2010-11; however, potential revisions would be probable.

9.2 Objective

APS was tasked with collecting the LOUT information from fluid manufacturers and creating a table of LOUT values with the information provided.

9.3 Brief Explanation and Definition of LOUT

De/anti-icing fluids are tested and used in operations within a specific temperature envelope. The qualification of de/anti-icing fluids is a complex and thorough process, which evaluates a multitude of fluid properties and characteristics. The one of particular interest in this subsection is the LOUT.

In summary, the LOUT is specific to fluid concentration. The LOUT for a given fluid is the higher of the following:

- The lowest temperature at which a fluid meets the aerodynamic acceptance test for a given aircraft type; or
- The actual freezing point of the fluid plus its freezing point buffer of 10ºC (for a Type I fluid) and 7°C (for a Type II, III, or IV fluid).

There are two separate aerodynamic acceptance tests, one for higher takeoff speed aircraft (rotation speed greater than 100 knots) and one for slower aircraft. The objective of these tests is to determine the coldest temperature at which the de/anti-icing fluids have acceptable aerodynamic characteristics.

The two tests are described in SAE Aerospace Standard (AS) 5900 and summarized below as follows:

- High speed test:
  - The high speed aerodynamic test establishes the aerodynamic flow-off requirements for fluids used to deice or anti-ice large transport jet aircraft with high rotation speeds.
- Low speed test:
  - The low speed aerodynamic test establishes the aerodynamic flow-off requirements for fluids used to deice or anti-ice slower aircraft.

Aircraft manufacturers are usually consulted to establish which fluids can be safely used on their models of aircraft.

9.4 Data Collection and LOUT Table Development (Initial Version)

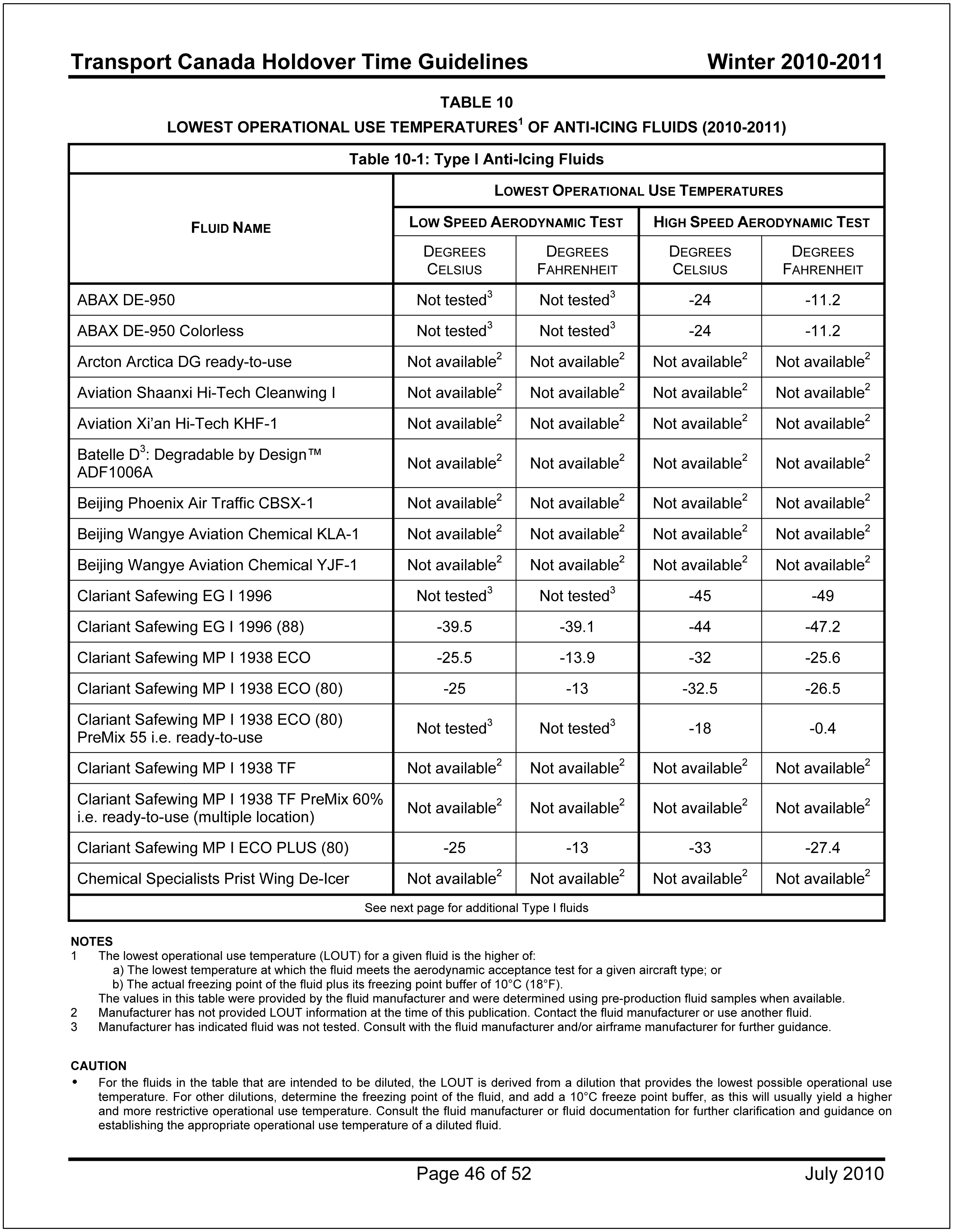
Discussions held between TC, the FAA, and APS concluded that a request for information should be sent to all fluid manufacturers. An initial advice (see Appendix J) was sent on June 17, 2010, informing fluid manufacturers of the intent to publish both low- and high-speed LOUT values for Type I and III fluids. For Type II and IV fluids, the intent was to publish high-speed LOUT values for undiluted fluids only. In addition, LOUT qualification information was requested for all the products from the fluid manufacturers.

Subsequent to the initial advice, several manufacturers inquired as to whether they should provide LOUT values based on their pre-production test report or from the recurring aerodynamic reports for their respective fluids.

It was concluded that the pre-production LOUT values should be used. Since pre-production tests are based upon high-viscosity fluids, this would provide the most restrictive LOUT values. A second advice (see Appendix J) was sent out on July 6, 2010, indicating that pre-production values should be used, and if any manufacturers had previously sent values other than pre-production, adjustments would need to be made. In addition, a copy of the draft LOUT tables was provided to manufacturers for their review, and corrections (if any) were requested.

Subsequently, TC published the LOUT tables on July 28, 2010. An example of a TC LOUT table is shown in Figure 9.1, demonstrating the format for Type I fluids. This table shows that there is a row for each fluid indicating LOUT values for both the low- and high-speed aerodynamic tests. The results are shown in both degrees Celsius and degrees Fahrenheit. Similarly, tables for Type II, III, and IV fluids were developed. Type II and Type IV fluid tables are different in that they only include high-speed aerodynamic tests LOUT values; in addition, the LOUT values are for the 100/0 dilutions. For the Type III fluid, the LOUT was provided for both the low-speed and the high-speed aerodynamic tests for the 100/0 fluid only. The full set of tables published on July 28, 2010, is available on the TC HOT Guideline website (see Appendix K).

The FAA used the same information source to compile a table for their publication. This table was published in October 2010 and has some differences in comparison to the TC table. The primary difference was that the FAA table included dilutions for the Type I fluids specific to the LOUT, as many manufacturers had requested this. In addition, the FAA table contained additional updated values, as the publication date was later than the publication date for TC.



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 10

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2010-2011)

Table 10-1: Type I Anti-Icing Fluids

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX DE-950	Not tested[3]	Not tested[3]	-24	-11.2
ABAX DE-950 Colorless	Not tested[3]	Not tested[3]	-24	-11.2
Arcton Arctica DG ready-to-use	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Aviation Shaanxi Hi-Tech Cleanwing I	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Aviation Xi’an Hi-Tech KHF-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Batelle D^3: Degradable by Design™ ADF1006A	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Phoenix Air Traffic CBSX-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical KLA-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical YJF-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing EG I 1996	Not tested[3]	Not tested[3]	-45	-49
Clariant Safewing EG I 1996 (88)	-39.5	-39.1	-44	-47.2
Clariant Safewing MP I 1938 ECO	-25.5	-13.9	-32	-25.6
Clariant Safewing MP I 1938 ECO (80)	-25	-13	-32.5	-26.5
Clariant Safewing MP I 1938 ECO (80) PreMix 55 i.e. ready-to-use	Not tested[3]	Not tested[3]	-18	-0.4
Clariant Safewing MP I 1938 TF	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing MP I 1938 TF PreMix 60% i.e. ready-to-use (multiple location)	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing MP I ECO PLUS (80)	-25	-13	-33	-27.4
Chemical Specialists Prist Wing De-Icer	Not available[2]	Not available[2]	Not available[2]	Not available[2]

See next page for additional Type I fluids

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
  The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.
2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.
3 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid, and add a 10°C freeze point buffer, as this will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

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Figure 9.1: LOUT Table Format for Type I Fluids

9.5 Challenges in the LOUT Table Development (Initial Version)

9.5.1 Difficulties

TC and the FAA were aware that the data for the first publication was going to be incomplete and that the data may have some discrepancies. The following list outlines some of the challenges:

- Time Limitation: A total of 6 weeks was available to collect all the information to complete the LOUT tables. This proved to be insufficient, and as a result, many of the tables had missing information;
- Amount of Data Needed: There were approximately 120 different cell values that were needed from 12 different fluid manufacturers;
- Fluid Manufacturers Are Worldwide: The fluid manufacturers are located worldwide and there were communication challenges;
- Interpretation of LOUT: During the development of the table, it was found that there was not a clear understanding of the definition of LOUT, specifically the intersection of the freezing point curve (with a 10 °C buffer) and the curve generated from the aerodynamic test;
- Pre-Production Reports: Some manufacturers were unable to locate the pre-production reports for their respective fluids and therefore provided values from their recurring aerodynamic test reports; and
- No Reply: Some manufacturers never replied even after repeated attempts. Many were difficult to locate.

9.5.2 Discrepancies with DOW UCAR

There was a discrepancy that occurred with DOW UCAR fluids that was brought forward after the first publication was released. This discrepancy affected two fluids from this manufacturer:

- DOW UCAR^{TM} ADF XL 54; and
- DOW UCAR^{TM} PG ADF Dilute 55/45.

The information that was collected and provided by DOW had some discrepancies. TC, the FAA, and DOW concluded that there was a potential safety issue. Both TC and DOW sent out a safety alert/bulletin to the users of the DOW products to indicate that there was a discrepancy. Below is an excerpt from the DOW bulletin dated November 24, 2010.

The following errors are related to the lowest operational use temperature (LOUT) of UCAR™ Aircraft Deicing Fluid XL 54 (UCAR™ ADF XL 54) and of UCAR™ PG Aircraft Deicing Fluid Dilute "55/45" (UCAR™ PG ADF Dilute "55/45") in Table 10-1 of the Transport Canada document and in Table 7-1 of the FAA document in the High Speed Aerodynamic Test column:

Lowest Operational Use Temperature (LOUT)

1. DOW UCAR™ ADF XL 54:
    - -41.5 ºC should read -33 ºC and -42.7 ºF should read -27.4 ºF
2. DOW UCAR™ PG ADF Dilute 55/45
    - -29.5 ºC should read -25 ºC and -21.1 ºF should read -13 ºF

9.6 Subsequent Revisions Anticipated

TC intends to publish a revision to the HOT Guidelines in January 2011. The primary purpose of the revision would be to update the LOUT information. The following bullets provide a description of the anticipated changes:

- Updating the LOUT Tables: The potential updates being considered are to incorporate all additional data, to add fluid dilutions associated with the LOUT information, to remove the Fahrenheit information, and to provide clarification on all LOUT guidance information using a supplemental note. Figure 9.2 provides an example (as of early December 2010) of the anticipated changes to the TC table for Type I fluids;
- Adding LOUT Information to Fluid-Specific Tables: The LOUT information contained in the Type II/III/IV LOUT tables for undiluted fluid would be added to the fluid-specific tables. This addition would add clarity and ease-of-use to the tables, as well as eliminate the ambiguity of the "Below -14 to -25 or LOUT" cell; and
- Adding LOUT Restrictions to HOT Tables: In cases where the fluid LOUT is above the lowest temperature in a given temperature band, a note would be added to indicate the restriction on temperature use based on LOUT. This would affect both fluid-specific and generic tables. This change would enhance the clarity and ease-of-use of all tables.

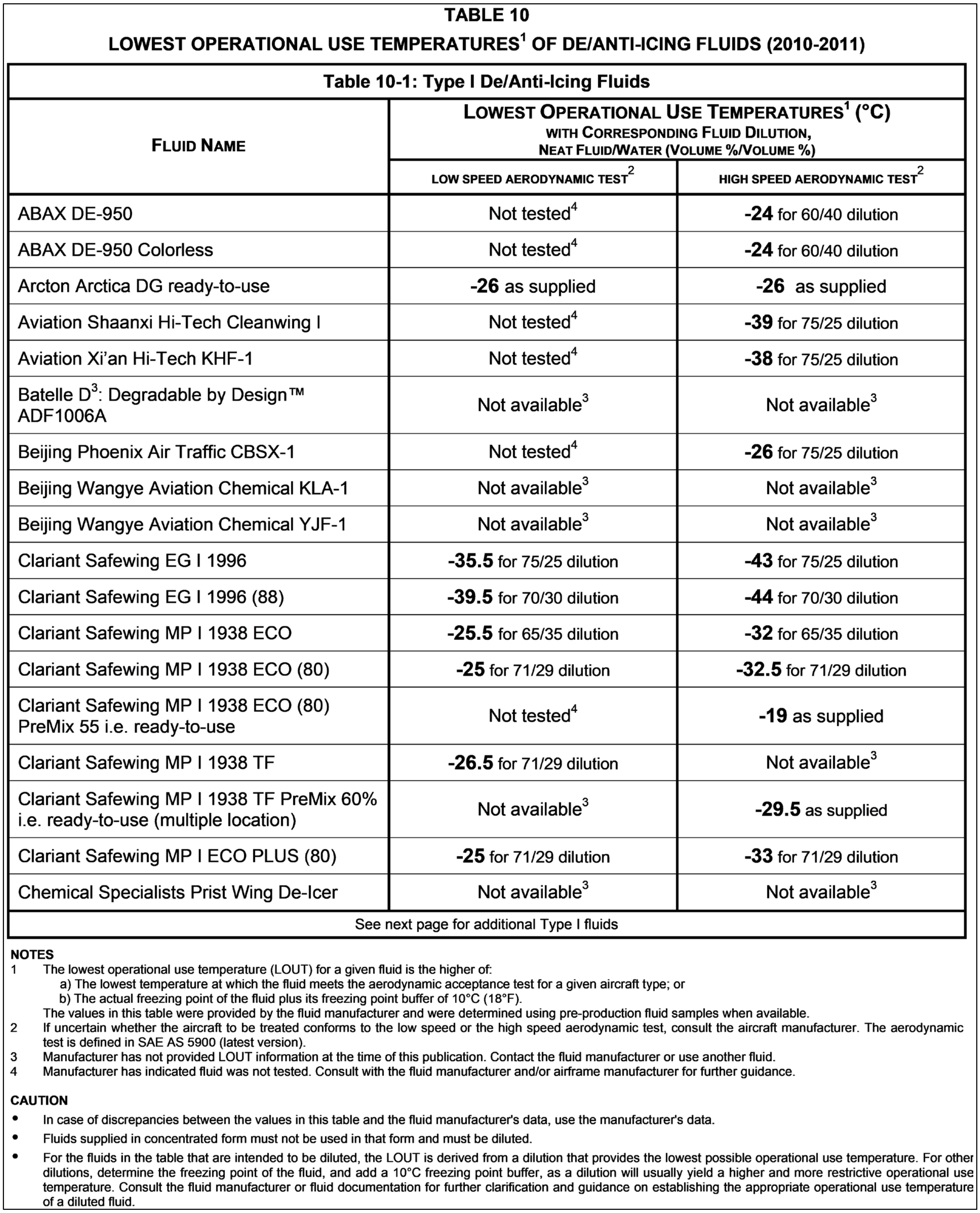

TABLE 10

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2010-2011)

Table 10-1: Type I De/Anti-Icing Fluids

FLUID NAME	**LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)** **WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)**	
	LOW SPEED AERODYNAMIC TEST[2]	**HIGH SPEED AERODYNAMIC TEST[2]**
ABAX DE-950	Not tested[4]	**-24** for 60/40 dilution
ABAX DE-950 Colorless	Not tested[4]	**-24** for 60/40 dilution
Arcton Arctica DG ready-to-use	**-26** as supplied	**-26** as supplied
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[4]	**-39** for 75/25 dilution
Aviation Xi'an Hi-Tech KHF-1	Not tested[4]	**-38** for 75/25 dilution
Batelle D^3: Degradable by Design™ ADF1006A	Not available[3]	Not available[3]
Beijing Phoenix Air Traffic CBSX-1	Not tested[4]	**-26** for 75/25 dilution
Beijing Wangye Aviation Chemical KLA-1	Not available[3]	Not available[3]
Beijing Wangye Aviation Chemical YJF-1	Not available[3]	Not available[3]
Clariant Safewing EG I 1996	**-35.5** for 75/25 dilution	**-43** for 75/25 dilution
Clariant Safewing EG I 1996 (88)	**-39.5** for 70/30 dilution	**-44** for 70/30 dilution
Clariant Safewing MP I 1938 ECO	**-25.5** for 65/35 dilution	**-32** for 65/35 dilution
Clariant Safewing MP I 1938 ECO (80)	**-25** for 71/29 dilution	**-32.5** for 71/29 dilution
Clariant Safewing MP I 1938 ECO (80) PreMix 55 i.e. ready-to-use	Not tested[4]	**-19** as supplied
Clariant Safewing MP I 1938 TF	**-26.5** for 71/29 dilution	Not available[3]
Clariant Safewing MP I 1938 TF PreMix 60% i.e. ready-to-use (multiple location)	Not available[3]	**-29.5** as supplied
Clariant Safewing MP I ECO PLUS (80)	**-25** for 71/29 dilution	**-33** for 71/29 dilution
Chemical Specialists Prist Wing De-Icer	Not available[3]	Not available[3]
See next page for additional Type I fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

2 If uncertain whether the aircraft to be treated conforms to the low speed or the high speed aerodynamic test, consult the aircraft manufacturer. The aerodynamic test is defined in SAE AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

4 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid, and add a 10°C freezing point buffer, as a dilution will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

Figure 9.2: Anticipated LOUT Table for Type I Fluids

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10. DIFFERENCES IN HOT GUIDELINES (TC, FAA, AND AEA)

10.1 Background

Formatting differences existed between Transport Canada (TC), the Federal Aviation Administration (FAA), and the Association of European Airlines (AEA) Holdover Time (HOT) Guidelines. The FAA typically issues the same material as TC, but there were some minor format differences. The AEA guidance material uses the TC and FAA published guidelines as a basis. However, the AEA only publishes generic tables.

Presentations were given at three SAE International (SAE) G-12 Holdover Time Subcommittee meetings (listed below) for the purpose of obtaining industry feedback on five main topics, outlined in Subsection 10.2:

- Montreal, Canada, November 2009;
- Berlin, Germany, May 2009; and
- Montreal, Canada, November 2010.

These presentations can be found in Appendix L of this report and on the SAE G-12 Holdover Time website.

Industry members were informed of the differences that exist between the TC/FAA/AEA guidelines and were given proposed solutions. Members were surveyed at the end of each main topic at the Berlin meeting to determine whether proposed changes were to be made.

In general, it was decided by the members that the proposed changes for each topic were acceptable and should be implemented; the implemented changes were presented at the November 2010 meeting in Montreal.

10.2 Objective

The objective of the series of meetings was to obtain industry feedback in an attempt to harmonize the guidelines by implementing the potential changes. As mentioned above, five potential changes were discussed. They are as follows:

- Ordering of notes appearing in tables;
- Applying the lowest operational use temperature (LOUT) note to all temperatures;
- Lowest applicable temperature note for active frost;
- Limiting cold-soaked wing (CSW) holdover time to above 0°C; and
- Treatment of Type I fluid application note for holdover time conditions.

10.3 Ordering of Notes Appearing in Tables

Footnotes on each HOT table have been used to provide additional information to a specific cell(s). Notes have been added and removed through the development of these tables. The result is a listing of notes that are not in the order of their appearance on the table.

Currently, this issue only affects the TC and AEA guidelines, as they both utilise "numerical" notation. The FAA utilises symbols and therefore requires no change.

The changes proposed were to re-order the notes (in the TC tables), so they appear in a more logical order from the left to the right and from the top to the bottom of the tables. The AEA table notes are in a logical (left to right, top to bottom) order. There was a general consensus of committee members that having a more systematic order of notes would provide greater ease of reference when using the tables.

Figure 10.1 demonstrates the previous order in which notes appeared (using as an example Type I fluids). Figure 10.2 demonstrates the new order of notes.

10.4 Applying LOUT Note to All Temperatures

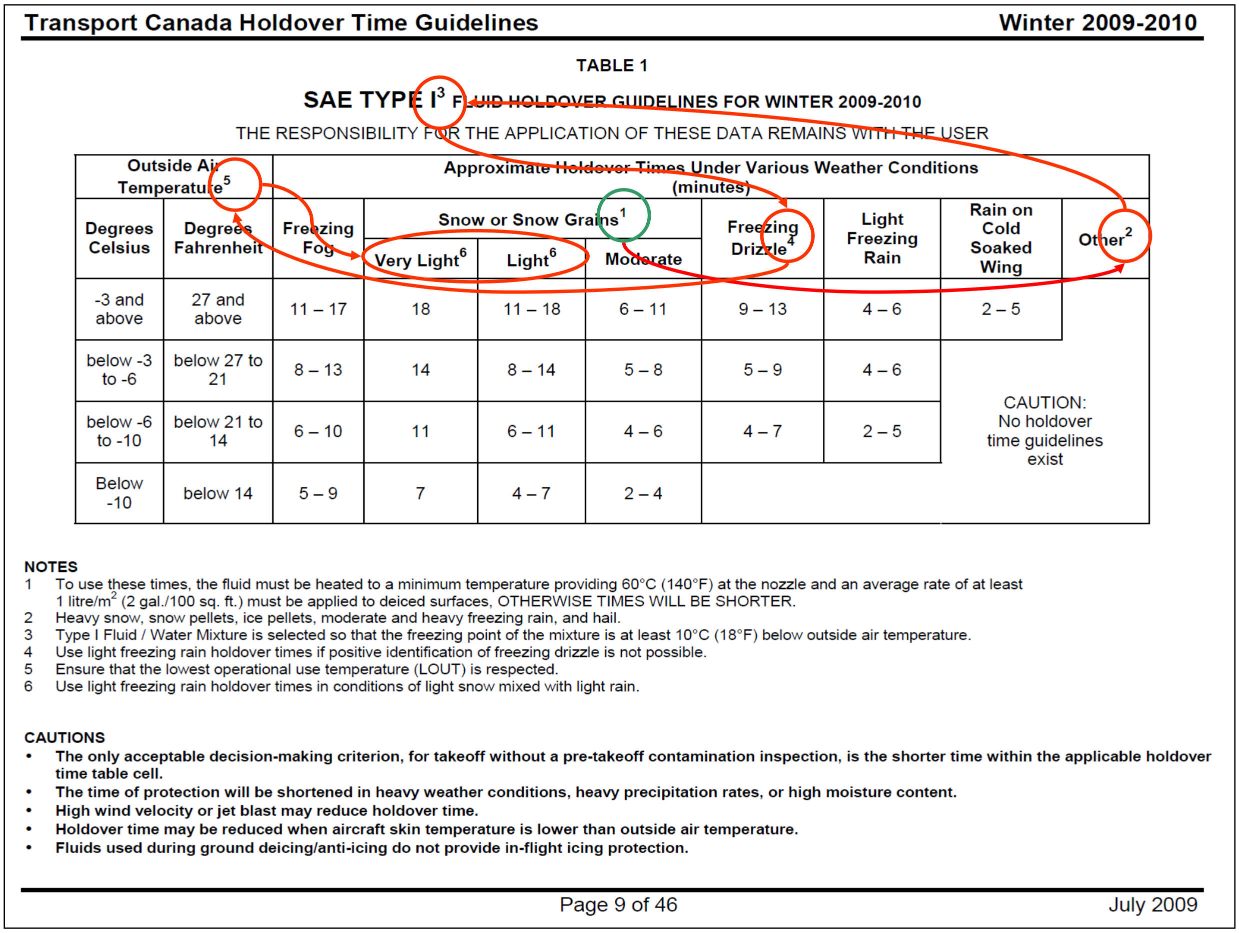
TC guidelines have a discrepancy in how the LOUT is applied to different fluids. The TC Type I and III fluid guidelines have a note attached to the outside air temperature (OAT) column that indicates that the LOUT should be considered. This is true for all temperature ranges, dilutions, and conditions. For Type II and IV fluids, the LOUT note is applied only to two holdover times:

- Freezing Fog "Below -14 to -25°C"; and
- Snow "Below -14 to -25°C."

Currently, the FAA and AEA guidelines do not include a note for LOUT.

Committee members were presented with two proposed changes to resolve this discrepancy:

- The LOUT note could be applied to all dilutions, temperature ranges, and conditions for all fluids; or
- The LOUT note could be removed from all TC tables to be consistent with the FAA and AEA approach.



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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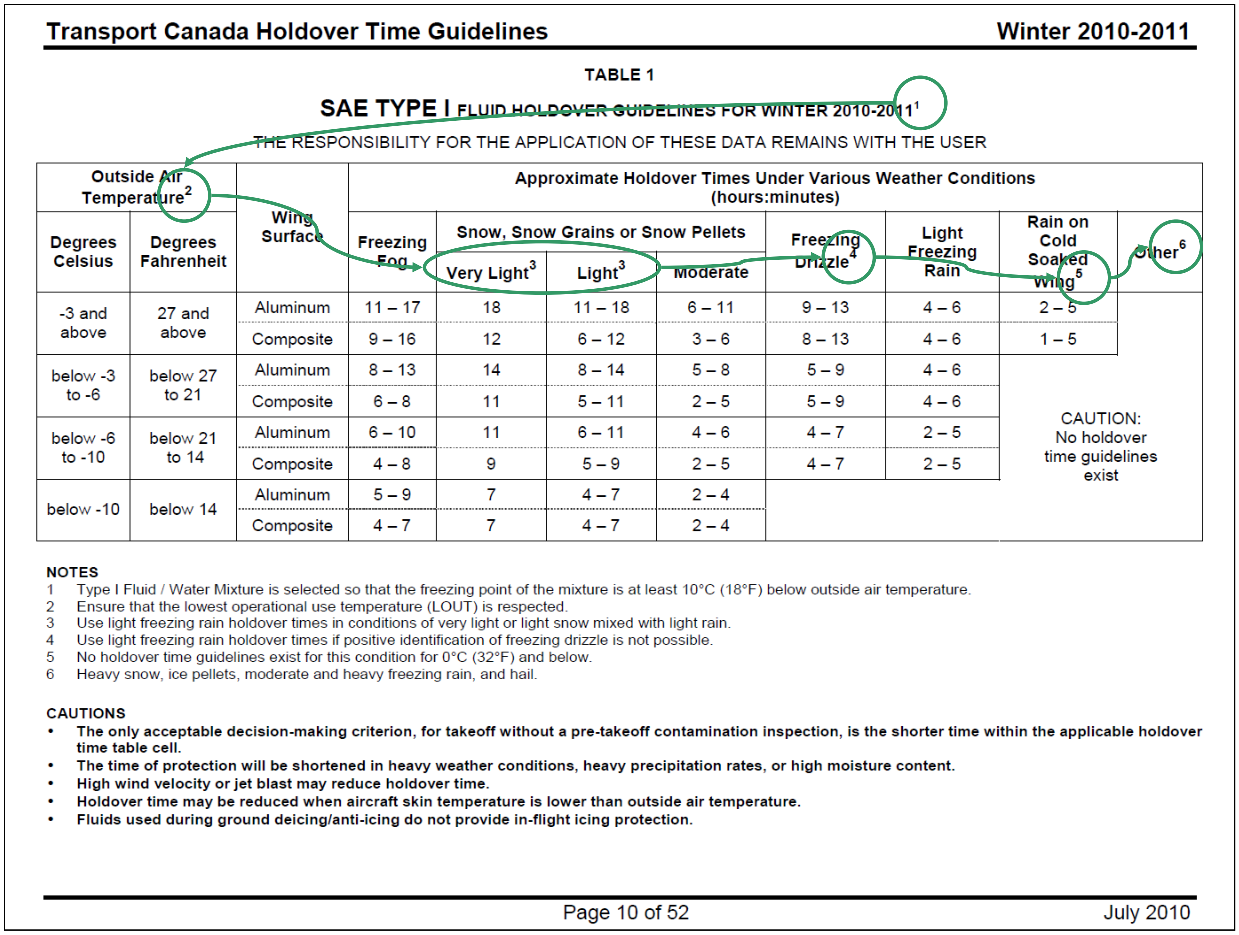
Figure 10.1: Winter 2009-10 Type I Holdover Time Table



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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Figure 10.2: Winter 2010-11 Type I Holdover Time Table

The committee agreed that the first option should be utilised. The LOUT should therefore be applied to all dilutions, temperature ranges, and conditions for all fluids. These changes were made in the respective TC tables; however, neither the FAA nor the AEA has made changes for Winter 2010-11. As the committee recommended applying a note to all tables, it is recommended that the FAA and AEA also apply this note.

10.5 Lowest Applicable Temperature Note for Active Frost

In 2009-10, separate tables were adopted in both TC and FAA guidelines for frost HOTs. The TC table included a note that Type I fluid may be used below -25°C if the LOUT is respected. For the use of Type II, III, and IV fluids, the temperature column limited the OAT to -25°C but did not have an explicit note to emphasize this.

The FAA and AEA guidelines also indicated that Type I fluid may be used below -25°C if the LOUT is respected. The FAA included an additional note for Winter 2009-10 emphasizing that Type II, III, and IV fluids may not be used below -25°C in active frost conditions. The AEA did not include this note.

To harmonize the three sets of guidelines, it was proposed to the committee that the same note should be included in the TC and AEA guidelines. The TC frost table available for Winter 2010-11 now includes the additional note; it is recommended that the AEA include this note.

10.6 Limiting Cold-Soaked Wing Holdover Times to Above 0°C

Prior to 2005-06, all guidelines had an "Above 0°C" row, and therefore all rain on cold-soaked wing (ROCSW) HOTs were applied to above 0°C conditions. After 2005-06, this row was removed and the ROCSW HOTs were included in the "Above -3°C" row.

Both the FAA and AEA include an additional note in the guidance material that restricts the use of ROCSW HOTs to above 0°C. TC did not include a note; the thought process by TC was that rain below 0°C would be freezing rain, and so it was not necessary to include an extra note.

It was proposed to the committee that the three tables should be harmonized and therefore include the same note in all tables. The proposal was adopted by the committee. The new TC tables for Winter 2010-11 now include the note.

10.7 Treatment of Type I Fluid Application Note for Holdover Time Conditions

Certain HOT Guidelines contain an application note indicating that Type I fluid must be heated to 60°C at the nozzle and applied at a minimum rate of 1 L/m^2. This note is based upon the protocol used to develop holdover times on heated fluid plate tests. However, the intent of this protocol was that this application procedure should be followed in all conditions.

10.7.1 Holdover Time Table Guidance

The discrepancy lies in the fact that this note is either applied to the snow and snow grains column only or not at all.

Currently, this note is applied to each set of HOT Guidelines as follows:

- TC applies this note to the “Snow and Snow Grains” column only;
- The FAA applies this note to the “Snow and Snow Grains” column only;
- The AEA does not apply this note to any condition; and
- ARP4737H does not include this note.

The committee was given two options:

- Option 1: TC, the FAA, and the AEA would apply this note to all conditions; or
- Option 2: TC, the FAA, and the AEA would remove this note entirely from all conditions (including snow and snow grains).

To harmonize and simplify all sets of guidelines, it was decided that Option 2 would be implemented: the note would be removed from the HOT Guidelines. Table 10.1 summarizes the changes that were made to the Type I HOT table.

Table 10.1: Changes to the Type I Holdover Time Table

Type I HOT Table		
	Heat (60°C)	Quantity (1 L/m^2)
TC	Snow	Snow
FAA	Snow	Snow
AEA	None	None
ARP4737H	N/A	N/A
Proposed Change	**None**	**None**

10.7.2 Application Table Guidance

The committee indicated that including this note in the HOT Guidelines adds to the complexity of the table and questions its relevance to flight crews. The committee thus suggested that this note should be added to the application tables of each set of guidelines.

Currently, this note is applied to each set of application guidelines as follows:

- TC requires the fluid to be heated to 60°C for all conditions but only recommends using a minimum of 1 L/m^2 for the "Snow and Snow Grains" column;
- The FAA requires the fluid to be heated to 60°C for all conditions but only recommends using a minimum of 1 L/m^2 for the "Snow and Snow Grains" column;
- The AEA requires the fluid to be heated to 60°C for all conditions and requires using a minimum of 1 L/m^2 for all conditions; and
- ARP4737H requires the fluid to be heated to 60°C for all conditions and requires using a minimum of 1 L/m^2 for all conditions.

To harmonize and simplify all sets of application guidelines, it was decided that this note should be applied to all conditions. For Winter 2010-11, both TC and the FAA have updated their guidelines.

Table 10.2 summarizes the changes in the Type I application table.

Table 10.2: Changes to the Type I Application Table

Type I Application Table		
	Heat (60°C)	Quantity (1 L/m^2)
TC	All Conditions	Snow
FAA	All Conditions	Snow
AEA	All Conditions	All Conditions
ARP4737H	All Conditions	All Conditions
Proposed Change	All Conditions	All Conditions

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11. PROVISIONS OF SUPPORT FOR THE DEVELOPMENT OF THE FAA ADVISORY CIRCULAR ON LIQUID WATER EQUIVALENT SYSTEMS

11.1 Background

Liquid water equivalent systems (LWES) are designed for implementation at airports and determine precipitation type and liquid water equivalent (LWE) rates. LWES are intended to provide an automated means of determining holdover times (HOTs) or check times for all, or for selected, types of precipitation covered in the various de/anti-icing fluid HOT tables published by the Federal Aviation Administration (FAA).

In Winter 2005-06, APS Aviation Inc. (APS) was contracted by Transport Canada (TC) to examine implementation issues with holdover time determination systems (HOTDS), the equivalent of FAA's LWES. HOTDS are also designed to be implemented at airports, recording measurements of weather conditions at pre-determined intervals. APS undertook this work, and an exemption was developed for TC. Although this exemption has been published and reviewed on several occasions, the latest exemption was published in December 2007 and can be found in TP 14872E (8).

There has been industry concern due to these systems not being implemented. Recently, there has been some activity by a large Canadian operator to integrate HOTDS into their operations.

The objective of this project was to provide support to the FAA in the development of an Advisory Circular for US operations.

11.2 Support Provided for FAA Advisory Circular Development

Over the past few years, the FAA had been drafting an Advisory Circular that would provide requirements, guidance, and recommendations to assist in approving these systems. Due to the urgent need by the industry for these requirements, the FAA contacted APS in June 2010 to help advance the development of the Advisory Circular.

A working group meeting in Atlantic City between APS and FAA officials was held in July 2010. Pertinent details of the Advisory Circular were discussed, and revisions to the document were made. The main revisions were editorial and structural in nature. The standards within the document are now described in more detail, and the document was re-structured to provide more clarity. The document has also been modified to better align the requirements with those of the TC exemption.

A final draft version of the Advisory Circular document was submitted by APS to the FAA in July 2010.

In discussions with the FAA at the July 2010 meeting, it was recommended to draft an SAE International (SAE) Aerospace Recommended Practice (ARP) or Aerospace Standard (AS) specification for these types of systems. This would then allow all regulators or civil aviation authorities (CAA) to implement the use of HOTDS through an Advisory Circular approach that references the SAE specification.

12. HOLDOVER TIME GUIDELINES WEBSITE

12.1 Background

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

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

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

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

Therefore, in the summer of 2003, TC asked APS Aviation Inc. (APS) to develop and implement a website for official TC HOT Guidelines to standardize the 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.

12.2 Changes to the Website

Each July since 2003, APS has published the HOT Guidelines for the upcoming winter on the website. In July 2010, the 2010-11 HOT Guidelines were published on the website, replacing the 2009-10 HOT Guidelines, which were archived on the site. Appendix K contains the original issue of the 2010-11 HOT Guidelines as they appeared in English on the website. As has been done in previous years, the changes from the previous year's guidelines are summarized on page 3 of the document and explained in detail in the TC report, TP 15050E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2009-10 Winter* (9).

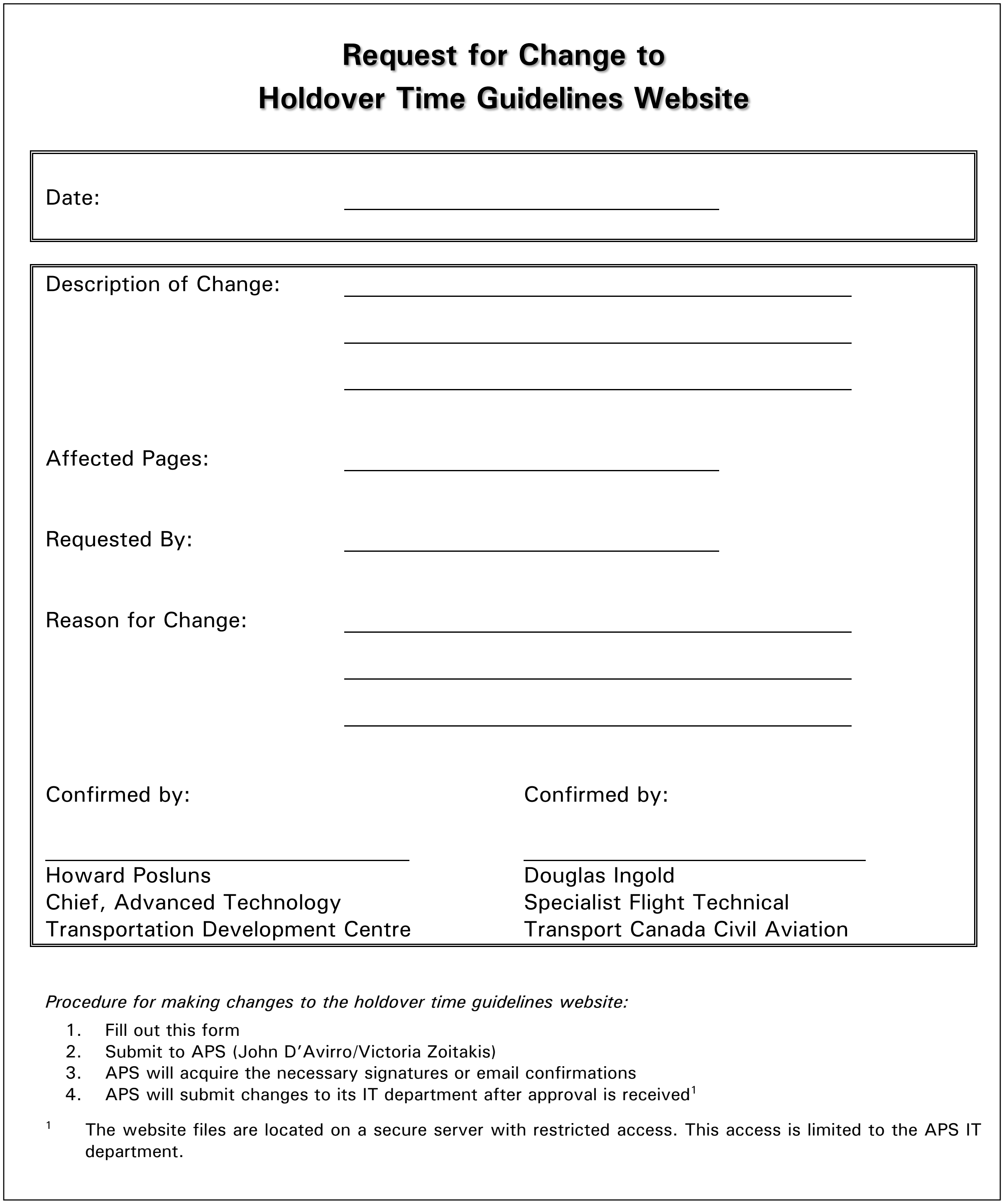
The changes made for the 2010-11 HOT Guidelines include the following:

- Addition of one new Type IV fluid, Cryotech Polar Guard;
- Removal of one current Type IV fluid, Octagon Max Flight;
- Holdover time values for composite surfaces have been added to the Type I table. The HOTs for aluminum surfaces are unchanged;
- The lowest on-wing viscosity for the 75/25 dilution of Clariant Safewing MP II Flight has changed. This resulted in changes being made to the Clariant Safewing MP II Flight fluid-specific HOTs. Specifically, reductions have been made in five 75/25 cells. These changes did not impact the generic HOTs;
- The snow columns in all Type I, II, III, and IV fluid HOT tables have been modified to include snow pellets;
- The Lowest operational use temperature (LOUT) information for Type I, II, III, and IV fluids has been added to the HOT Guidelines;
- A HOT for Type I fluids on composite surfaces has been added;
- Several changes were made to the footnotes of the tables to harmonize with the AEA tables and to structure the notes in an orderly manner; and
- The guidance material for operations during ice pellet conditions was modified. Specifically, changes were made to operations in light ice pellets and moderate ice pellets.

For the changes to be approved, APS is required to obtain approval from both TC and the TDC. The form provided in Figure 12.1 is used for this purpose.

12.3 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 2011, APS intends to update the website with new data from 2010-11 testing and upload the 2011-12 HOT Guidelines.



Request for Change to
Holdover Time Guidelines Website

Date: ____________________

Description of Change: ____________________

Affected Pages: ____________________

Requested By: ____________________

Reason for Change: ____________________

Confirmed by:	Confirmed by:
____________________	____________________
Howard Posluns Chief, Advanced Technology Transportation Development Centre	Douglas Ingold Specialist Flight Technical Transport Canada Civil Aviation

Procedure for making changes to the holdover time guidelines website:

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

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

Figure 12.1: HOT Guideline Change Form

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13. 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 2009-10.

13.1 Procedures

Several procedures were developed to guide and support the research team in the methodology for conducting tests. Table 13.1 at the end of this section provides a list of the procedures developed for each major project. Each major project has been documented in a separate report, and each complete procedure has been included in at least one of these reports.

13.2 Presentations

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

In 2009-10, the following meetings were held:

a) SAE G-12 HOT Committee, Montreal, Canada, November 2009;
b) SAE G-12 Aero Working Group Meeting, Montreal, Canada, November 2009;
c) ROGIDS Working Group Meeting, Palm Coast, United States, December 2009;
d) SAE G-12 HOT Committee, Berlin, Germany, May 2010;
e) SAE G-12 Aero Working Group Meeting, Berlin, Germany, May 2010;
f) SAE G-12 Residues Working Group, Berlin, Germany, May 2010;
g) SAE G-12 Ice Detection Committee, Berlin, Germany, May 2010;
h) ROGIDS Working Group Meeting, Atlantic City, United States, September 2010;
i) SAE G-12 HOT Committee, Montreal, Canada, November 2010; and
j) SAE G-12 Residues Working Group, Montreal, Canada, November 2010.

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 L.

13.2.1 SAE G-12 HOT Committee Meeting, Montreal, Canada, November 2009

Six presentations were prepared for the SAE G-12 HOT Committee meeting in Montreal on November 4, 2009:

1) Data for Airport De-Icer Management System Model;
2) Potential Future Changes to the HOT Guideline Table Format;
3) Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables;
4) Operational Changes to HOT Guidelines Related to 2008-09 R&D Activities;
5) Holdover Time Guidelines Update Fall 2009; and
6) Dissemination of HOT Guidelines Regression Information 2009-10.

13.2.2 SAE G-12 Aero Working Group Meeting, Montreal, Canada, November 2009

One presentation was prepared for the SAE G-12 Aero Working Group meeting in Montreal in November 2009:

1) Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces.

13.2.3 ROGIDS Working Group Meeting, Palm Coast, United States, December 2009

No formal presentation was prepared for the remote on-ground ice detection systems (ROGIDS) Working Group meeting in Palm Coast on December 8-9, 2009.

13.2.4 SAE G-12 HOT Committee Meeting, Berlin, Germany, May 2010

Ten presentations were prepared for the SAE G-12 HOT Committee meeting in Berlin on May 11, 2010:

1) Anti-Icing Endurance Times for Aircraft Hangar Operations;
2) Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid;
3) Development of HOT Guidance Material for Snow Pellet Conditions;

4) Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces;
5) Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables;
6) Development of Holdover Time Guidelines for Cold-Soaked Wing During Natural Frost Conditions;
7) De/Anti-Icing Fluid Endurance Times on Composite Surfaces;
8) Aircraft De/Anti-Icing Fluid Endurance Time Results: Winter 2009-10;
9) Effect of Ice Phobic Products on De/Anti-Icing Fluid HOTs; and
10) Potential Future Changes to the HOT Guideline Table Format.

13.2.5 SAE G-12 Aero Working Group Meeting, Berlin, Germany, May 2010

Two presentations were prepared for the SAE G-12 Aero Working Group meeting in Berlin on May 6-7, 2010:

1) Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces (similar to the presentation for the HOT Committee); and
2) Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables (similar to the presentation for the HOT Committee).

13.2.6 SAE G-12 Residues Working Group Meeting, Berlin, Germany, May 2010

Two presentations were prepared for the SAE G-12 Residues Working Group meeting in Berlin in May 2010:

1) Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid (also presented to the HOT Subcommittee); and
2) Effect of Ice Phobic Products on De/Anti-Icing Fluid HOTs (also presented to the HOT Subcommittee).

13.2.7 SAE G-12 Ice Detection Committee Meeting, Berlin, Germany, May 2010

One presentation was prepared for the SAE G-12 Ice Detection Committee meeting in Berlin on May 12, 2010:

1) SAE Committee G-12 Ice Detection Committee Meeting (parts presented by APS).

13.2.8 ROGIDS Working Group Meeting, Atlantic City, United States, September 2010

No formal presentation was prepared for the ROGIDS Working Group meeting in Atlantic City on September 22-23, 2010.

13.2.9 SAE G-12 HOT Committee Meeting, Montreal, Canada, November 2010

Eight presentations were prepared for the SAE G-12 HOT Committee meeting in Montreal on November 3, 2010:

1) Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid;
2) Holdover Time Guidelines Update Fall 2010;
3) Operational Changes to HOT Guidelines Related to 2009-10 R&D Activities;
4) Dissemination of HOT Guidelines Regression Information 2010-2011;
5) Recommended Changes to ARP5718: Calculating More Precise HOTs;
6) Evaluation of Sensor for Nowcasting Active Frost;
7) Composite Materials HOT Testing Review; and
8) Wind Tunnel R&D Activities: Heavy Snow, Snow on an Unprotected Wing, and Excessive Fluid Application (prepared but not presented).

13.2.10 SAE G-12 Residues Working Group Meeting, Montreal, Canada, November 2010

One presentation was prepared for the SAE G-12 Residues Working Group meeting in Montreal on November 2, 2010:

1) Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid (also presented to the HOT Subcommittee).

13.3 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 HOT use in the industry, while the remaining data is maintained by the fluid manufacturers for research purposes.

During the winter of 2009-10, two 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:

a) Clariant MP II Flight (75/25) (Type II); and
b) Cryotech Polar Guard (Type IV).

As these fluids were qualified in the winter of 2009-10, these reports have also been included as appendices in TP 15050E (9).

Table 13.1: List of Procedures for Winter 2009-10

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
1.2.1	8.1	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Simulated Freezing Precipitation Flat Plate Testing	17-Dec-08	1.0	HOT
1.2.1	8.2	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing	23-Dec-04	1.0	HOT
1.2.1	8.3	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Overall Program of Tests at NRC, March-April 2010	25-Mar-10	1.0	HOT
1.2.1	8.4	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Determination Of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval	14-Dec-07	1.0	HOT
1.2.1	8.5	Aircraft De/Anti-Icing Fluid Endurance Time Testing	Test Requirements for Natural Precipitation Flat Plate Testing (Type III Fluid Use Type I Protocol)	14-Dec-07	1.0	HOT
1.2.2	9.1	Evaluation of Frost HOTs for Use During Cold Soak Wing Frost Conditions	Evaluation of Frost HOTs for Use During Cold Soak Wing Frost Conditions, Effect of Cold Soak Wing Conditions During Active Frost	21-Dec-09	1.0	General & Exploratory
1.2.4	11.1	Development of Type I HOTs for Composite Surfaces and Evaluation of First Step	Evaluation of Type I Endurance Times on Composite, Surfaces, Natural Snow	18-Jan-10	1.0	Composite
1.2.4	11.2	Development of Type I HOTs for Composite Surfaces and Evaluation of First Step	Evaluation of Type I Endurance Times on Composite, Surfaces, Natural Frost	25-Mar-10	1.0	Composite
1.2.4	11.3	Development of Type I HOTs for Composite Surfaces and Evaluation of First Step	Evaluation of Type I Endurance Times on Composite Surfaces, Simulated Freezing Precipitation	26-Mar-10	1.0	Composite
1.2.5	12.1	Endurance Time Testing in Simulated Snow Pellets	Endurance Time Test Requirements for Snow Pellet Flat Plate Testing (Type I, II, III, and IV Fluids)	17-Dec-08	1.0	General & Exploratory

Table 13.1: List of Procedures for Winter 2009-10 (cont'd)

Program Element #	ID #	Program Element	Name of Procedure	Date of Latest Version	Version #	Report
1.2.6	13.1	Endurance Time Testing with Snowmaker	Endurance Time Test Requirements for Simulated Snow Flat Plate Testing	23-Dec-09	1.0	General & Exploratory
1.2.7	14.1	Evaluation Of Endurance Times in Heavy Snow	Endurance Time Testing with Heavy Snow with the Snowmaker in Comparison with Natural Snow	21-Jan-09	1.0	General & Exploratory
1.2.14	21.1	HOTs for Indoor (Aircraft Hanger) Anti-Icing Applications	Evaluation of Endurance Time Values for Indoor Aircraft Hanger (and Pre-Treatment) Anti-Icing Applications	21-Dec-09	1.0	Aircraft Hangar
1.2.14	21.2	HOTs for Indoor (Aircraft Hanger) Anti-Icing Applications	Full-Scale Evaluation of Fluid Thickness on Indoor Aircraft Hanger Anti-Icing Applications	21-Dec-09	1.0	Aircraft Hangar
1.2.15	22.1	Vertical Stabilizer Anti-Icing	Evaluation of Endurance Time Performance on Vertical Surfaces	29-Dec-09	1.0	General & Exploratory
1.2.16	23.1	Effect of Ice Phobic Products on Holdover Times	Effect of Ice Phobic Products on HOTs	24-Dec-09	1.0	Ice Phobic
1.2.16	23.2	Effect of Ice Phobic Products on Holdover Times	Effect of Ice Phobic Products on HOT – Simulated Freezing Precipitation Tests	25-Mar-10	1.0	Ice Phobic
1.3.1	24.1	Wind Tunnel Testing to Refine Allowance Times	Wind Tunnel Tests to Examine Fluid Removed from Aircraft During Takeoff with Mixed Ice Pellet Precipitation Conditions	23-Dec-09	1.0	Ice Pellet Allowance
1.5.2	31.1	Evaluation of Sensors for Determining Active Frost Conditions (for Now-Casting)	Evaluation of Sensors for Determining Active Frost Conditions	23-Dec-09	1.0	General & Exploratory

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2. Dawson, P., *Validation of Methodology for Simulating a Cold-Soaked Wing*, APS Aviation Inc., Transportation Development Centre, Montreal, October 1996, TP 12899E, 92.

3. Moc, N., *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2003-04,* APS Aviation Inc., Transportation Development Centre, Montreal, December 2004, TP 14376E, XX (to be published).

4. Ruggi, M., *Exploratory Wind Tunnel Aerodynamic Research Examination of Contaminated Anti-Icing Fluid Flow-Off Characteristics Winter 2009-10*, APS Aviation Inc., Transportation Development Centre, Montreal, August 2011, TP 15057E, 222.

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7. Ruggi, M., *Aircraft Deicing Research in Natural and Simulated Ice Pellet Conditions,* APS Aviation Inc., Transportation Development Centre, Montreal, January 2007, TP 14713E, 104.

8. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2007-08 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, March 2009, TP 14872E, XX (to be published).

9. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2009-10 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, September 2010, TP 15050E, 86.

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2009-10

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2009-10

5.1 WEATHER RESEARCH

5.1.5 Implementation of HOTDS for U.S. Airport Deicing Operations

It should be noted that this activity is to provide technical advice and general evaluation and does not include testing or detailed assessment of U.S. HOTDS installations.

a) Conduct research on behalf of FAA into the requirements for operating and maintaining the accuracy as related to hardware and software of a HOTDS;

b) Determine best operational practices for HOTDS information to be used by an air carrier to replace the current methodology for determining holdover times;

c) Propose strategies to resolve any concerns that arise from this activity; and

d) Report the findings.

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

5.2.2 Evaluation of Frost HOT's for Use During Cold Soak Wing (CSW) Frost Conditions

a) Review historical cold soak wing data collected;

b) Analyze ambient temperature to wing skin temperature differentials, and compare results to flat plate testing results used to develop the 2009-10 frost HOT's;

c) If cold soak wing temperature differentials are greater than what is typically observed on flat plates during natural frost tests, prepare a test procedure, and conduct flat plate testing to observe and record the cold soak plate temperature decay in active frost conditions. Three nights of testing for two people are anticipated to obtain preliminary data for this activity;

d) Analyze the preliminary data collected;

e) Report the preliminary findings;

f) Develop and review potential alternatives for issuing HOT's for cold soak wing frost; and

g) Present the preliminary results and proposed alternatives at the SAE G-12 annual meeting.

5.2.3 Use of OAT for Determining Frost HOT's

a) Review and analyze flat plate data to determine typical temperature fluctuations during overnight active frost conditions;

b) Develop alternatives for the interpretation of the temperature fluctuations for typical overnight preventative anti-icing frost applications;

c) i.e. use OAT at start of application, the minimum temperature achieved between time of application and time of take-off, or temperature at time of take-off;

d) Consult with the HOT/Frost working group; discussions should aim at establishing the appropriate use for OAT in determining the HOT available during frost conditions, and

e) Report the findings.

5.2.5 Endurance Time Testing in Simulated Snow Pellets

a) Review and modify procedure and methodology for testing:

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

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

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

c) Recent intra-laboratory preliminary results have indicated 1:1 correlation for snow pellets and snow conditions. This activity will required the conduct of additional endurance time testing with representative Type I/II/III/IV fluids at standard dilutions, in simulated snow pellets and in snow. Testing should be conducted at various precipitation intensities and temperatures. 20 days of testing are anticipated to do a total of 30 comparative tests. In an attempt to minimize costs, a total of 30 comparative tests are scheduled, of which approximately 15 will be conducted during a first phase. Following the first phase, testing may either proceed to complete the balance of the scheduled tests, or will be stopped if the results are consistent and conclusive; this decision will be at the discretion of a TDC officer;

d) Analyze the data collected;

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

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

5.2.6 Endurance Time Testing with the NCAR Snowmaker

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

b) Type II/IV Fluid Endurance Time Testing with Snowmaker for New Fluids;

   i. Review and modify procedure for testing selected fluids with the snowmaker. The new procedure should reflect the new proposed methodology to test a variety of temperatures and precipitation rates (to simulate typical outdoor data collection), rather than the testing the most restrictive temperatures and precipitation rates (as was previously done). All data will be used in a regression analysis, similar to the methodology used for outdoor natural snow conditions;

   ii. Conduct flat plate tests under conditions of artificial snow in the refrigerated trailer at the P.E.T. test site to record fluid endurance times, in accordance with ARP5485. It is anticipated that a series of 20 representative test conditions will be conducted with neat fluid and a series of 6 representative test conditions will be conducted with 50/50 diluted fluid. Previous or new fluids will be tested over a period of 8 days. It is anticipated that testing be conducted over long days;

   iii. Analyze the data collected and determine if any changes should be made to further selected tests which are to be conducted. Test parameters will be determined based on likely precipitation rate and temperatures. The test parameters will be randomly selected and within the confines of the snow machine and HOT tables;

   iv. Conduct a second series of a series of 20 representative test conditions will be conducted with neat fluid with a previous or new fluid and a series of 20 representative test conditions will be conducted with 75/25 diluted fluid. Previous or new fluids will be tested over a period of 12 days. It is anticipated that testing be conducted over long days;

   v. Analyze the data collected; and

   vi. Report the findings, and prepare presentation material for the SAE G-12 annual meeting.

c) Type I Fluid Endurance Time Testing with NCAR Snowmaker.
   i. Described in Section 1.2.9 b).

5.2.7 Evaluation of Endurance Times in Heavy Snow

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

b) Develop procedure and methodology for further testing;

c) Conduct testing to define failure criteria in simulated heavy snow tests to correlate against outdoor data. Parameters investigated should include Brix, snow type, and possible intermittent simulated heavy snow to allow for absorption of precipitation;
   i. Conduct testing outdoors and record Brix at 5-minute intervals. It is anticipated that 3 fluids will be tested on 3 different occasions for a total of 3 tests;
   ii. Simulate outdoor test conditions for indoor Snowmaker test reproduction;
   iii. Monitor indoor Brix and dilution during indoor test to isolate potential differences in fluid dilution.

d) Analyze the data collected; and

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

5.2.9 Exploratory Research and Standards

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

a) Provide support to modifying and updating ARP5485;

b) Further develop, advance and ballot, as required, SAE Aerospace Recommended Practice ARP5945 for Type I fluids. For simulated snow, a procedure should be developed for endurance time testing with Type I fluid and included in ARP5945;

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

d) Support activities of SAE G-12 Residues Workgroup;

e) Support activities of SAE G-12 Aerodynamics Workgroup;

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

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

h) Runway deicer fluid performance;

i) Evaluate the effect of runway deicer fluids on anti-icing fluid endurance times. Potential testing should simulate runway deicer fluid blown up on a clean wing during landing with reverse thrusters, followed by preventative one-step anti-icing;

j) Determination of runway conditions based on advanced technologies such as HOTDS systems or ice detectors;

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

l) Investigate the dispersion of fluids on airport surfaces;

m) Evaluate the limitations of hot water deicing;

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

o) Evaluation of the 5-minute rule for pre-takeoff contamination checks.

5.2.15 Vertical Stabilizer Anti-Icing

a) Review historical data collected regarding vertical stabilizer anti-icing, and consult with TC aerodynamicist regarding aircraft certification tests (vertical stabilizer leading edge flight tests with ice shapes) and potential impacts of contaminated vertical surfaces;

b) Develop methodology and procedure for simulating vertical stabilizer anti-icing.

c) Consideration should be given to examination of adhesion when vertical surfaces fail rapidly with and without fluids;

d) Conduct preliminary endurance time testing with limited fluids in natural snow conditions at the P.E.T test site. Testing should be conducted in various wind speed conditions. It is anticipated that testing will be conducted in conjunction with standard HOT testing because wind effects have a major influence on this activity;

e) Analyze data and results;

f) Develop alternatives for potential guidance material for anti-icing vertical stabilizer surfaces;

g) Consult with the SAE G-12 Aerodynamics working group regarding best practice solutions; and

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

5.5 SENSORS RESEARCH

5.5.1 Support: Runway Threshold Ice Detection

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

b) Identify the limitations of current technologies;

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

d) Determine testing requirements for preliminary full-scale or flat plate testing based on the recommendations from industry meetings. These tests will be defined during the meetings. While it would be desirable to do testing outdoors in natural snow, testing in simulated indoor conditions may be less costly and more realistic due to time constraints on the equipment;

e) Develop methodology and procedure for indoor NRC testing;

f) Conduct testing at the NRC Climatic Environment Facility (CEF). 8 days of testing are anticipated at the NRC facility. This will require one persons for all conditions;

g) Analyze data and results; and

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

5.5.2 Evaluation of Sensors for Determining Active Frost Conditions (For Now-Casting)

The following activity shall include a preliminary investigation. A long term development and implementation plan will likely span over several years:

a) Consult industry to determine technology currently used in aircraft operations for detecting active frost conditions, if any;

b) Potentially acquire off-the-shelf frost sensor technology, or develop simple prototype for testing;

c) Prepare a test plan to evaluate the use of the off-the-shelf technology or newly developed prototype for determining active frost conditions;

d) Conduct testing according to test plan;

e) Determine feasibility of implementing this technology into current aircraft ground icing programs;

f) Evaluate potential use of technology for Now-Casting active frost conditions;

g) Analyze data collected; and

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

5.7 RESEARCH INFORMATION DISSEMINATION

5.7.1 Provision of Support Services and Other Activities

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

5.7.2 Web Site for HOT Guidelines Tables

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

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

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

d) Implement changes to the website, post the new HOT Guidelines in the summer of 2010 for use in winter of 2010-11 and post any other updates that may be needed in special circumstances.

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APPENDIX B

PROCEDURE:
EVALUATION OF ENDURANCE TIME PERFORMANCE ON VERTICAL SURFACES

CM2169.002

PROCEDURE: EVALUATION OF ENDURANCE TIME PERFORMANCE ON VERTICAL SURFACES

Winter 2009-10

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro

December 21, 2009
Final Version 1.0

EXPERIMENTAL PROCEDURE
EVALUATION OF ENDURANCE TIME PERFORMANCES ON VERTICAL SURFACES

Winter 2009-10

1. BACKGROUND

Aircraft deicing fluid is typically used to clean all aircraft surfaces from frozen contamination, and aircraft anti-icing fluid is used to protect critical aircraft surfaces from icing conditions within a specified holdover time. Critical aircraft surfaces include aircraft wings and horizontal stabilizers, which are typically deiced and anti-iced during winter icing conditions, however also includes the aircraft vertical stabilizer. Typically, the vertical stabilizer is deiced in icing conditions, however the requirement to anti-ice varies among operators. When applying anti-icing fluid to vertical surfaces, the fluid quickly flows off and results in a reduced fluid thickness layer, and consequently shortened fluid endurance times. Due to the lack of data to quantify actual endurance times on vertical surfaces the industry has requested that testing be conducted to evaluate and potentially develop guidance material for operating with anti-iced vertical stabilizer surfaces.

Preliminary work was conducted during the winter of 1999-2000, and is documented in the report TP 13659E. In total 8 preliminary tests were conducted with Type I, II, and IV fluids. In each test, the standard plate outperformed the vertical plate. For the Type I tests, the vertical endurance times recorded were 49% of standard endurance times. For the Type II and IV tests, the vertical endurance times recorded were 31% of standard endurance times. The horizontal air component was found to be an important factor for the reduced endurance times as it increased the catch rate on vertical surfaces and greatly reduced the endurance time.

It was recommended that additional testing be conducted to substantiate the results observed and to potentially develop guidance material for anti-icing aircraft vertical stabilizers.

2. OBJECTIVE

To evaluate the endurance time performance of vertical surfaces, and potentially develop guidance material for anti-icing aircraft vertical stabilizers.

Approximately eight days of outdoor testing in natural conditions (three test runs per day) for two people are planned to obtain the data required for this activity.

3. PROCEDURE

Endurance time tests will be conducted with various Type I and Type II/IV fluids at the Pierre Elliott Trudeau airport test site. Standard fluid endurance time test procedures will apply. Four tests will be conducted simultaneously: the baseline conducted at 10° from the horizontal, and three tests conducted at 80° from the horizontal. Figure 1 demonstrates the general setup for the conduct of the tests.

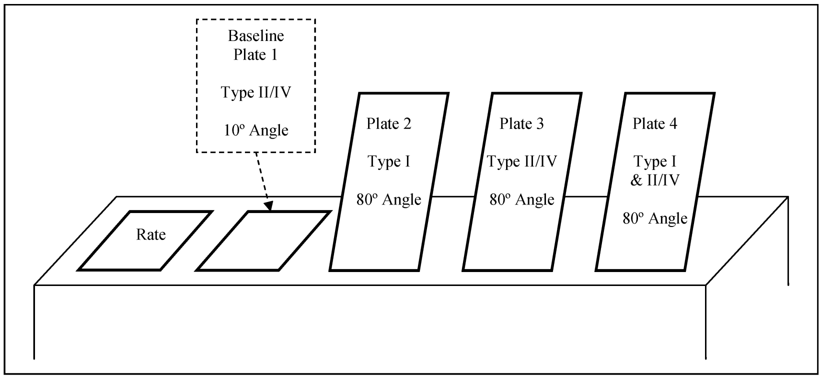

Figure 1: General Setup

3.1 General Fluid Application Procedure

- Rate measurements should be conducted before fluid application, after each plate failure, and every 5-10 minutes during the test;
- Final step fluid should be poured simultaneously on all four test plates. For the two-step application test (plate 4), the Type IV fluid should be applied 3-minute following the application of the heated Type I fluid;
- For the Type I fluids, 0.5L of fluid should be applied at 60°C with a warm 12-hole spreader;
- For the Type II and Type IV Fluid, 1L of fluid should be applied at OAT using a typical pour container;
- Measure Brix, and thickness at 5-min after application, at time of failure, and again at the time of failure of Plate 1 for Plates 2, 3, and 4.
- Endurance times should be recorded for the fluid applied to each of the four test surfaces.

3.2 End of Test

- Testing should be stopped only once Plate 1 fails (Plate 2, 3, and 4 will typically be run past fluid failure);

- At the time of failure on Plate 1, adherence measurements should be taken on all four tests to verify any potential differences in adhered contamination;
- Final drawings of the adhesion and failure patterns should be drawn on the data form for all four test plates at the time of failure for Plate 1.

4. TEST SURFACES

Four standard aluminum test plates will be used for testing. The baseline plate will be positioned at 10° from the horizontal, and the three plates simulating a vertical stabilizer will be positioned at 80° from the horizontal. The following describes the configuration for the four test surfaces:

- Plate 1: 10° Plate with Type II/IV fluid (Baseline test);
    - To simulate the standard HOT test;
- Plate 2: 80° Plate with Type I fluid;
    - To simulate a vertical stabilizer that has only been deiced and not anti-iced;
- Plate 3: 80° Plate with Type II/IV fluid; and
    - To compare the effects of the angle of the plate on fluid endurance time;
- Plate 4: 80° Plate with Type I and Type II/IV fluid (two-step application);
    - To simulate a vertical stabilizer that has been both deiced and anti-iced using a two-step procedure;

Note: Outdoor Type I testing in natural snow conditions is typically conducted using a leading edge thermal equivalent box. As reduced endurance times are expected on vertical surfaces, the Type I tests will be conducted using a test plate rather than a box to simplify the methodology.

5. TEST PLAN

Testing is to be conducted in natural conditions. A test plan is included in Table 5.1. The test runs are not specific to precipitation rate or outside temperature, however a variety of different conditions are preferred.

6. FLUIDS

The fluids in Table 6.1 will be used for the comparative endurance time testing.

Table 5.1: Test Plan - Natural Snow Conditions

					(Put "X" in cell when completed)					
Setup	**Plate 1 10º**	**Plate 2 80º**	**Plate 3 80º**	**Plate 4 80º**	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**
1	ABC-2000	Octaflo	ABC-2000	Octaflo + ABC-2000						
2	Launch	Octaflo	Launch	Octaflo + Launch						
3	EG106	Octaflo	EG106	Octaflo + EG106						
4	ABC-S+	Octaflo	ABC-S+	Octaflo + ABC-S+						

Note: To be conducted in any precipiation rate and temperature.
Type I fluid should be 10ºC Buffer dilution, and Type II/IV fluid should be 100/0 dilution.

Table 6.1: Fluids Requirements

Fluid Name	Fluid Type	Quantity Needed	Batch #
Octagon Octaflo	I	12L	N/A
Kilfrsot ABC-2000	II	20L	KIL08-09LOWV
Clariant Launch	IV	20L	C15012009IV or C02192009IV
Dow EG106	IV	20L	XA2201GK16
Kilfrost ABC-S+	IV	20L	K21012009IV

7. EQUIPMENT

Standard equipment used for endurance tests outdoors will be used, with the exception of the stands required to position the test plates at 80º from the horizontal; these are being manufactured specifically for these tests.

8. DATA FORMS

The following data form will be used to document fluid endurance time, Brix, and thickness data:

- Attachment I: End Condition Form for Endurance Time Testing.

Rate measurements will be done using the electronic rate form typically used for endurance time testing.

9. PERSONNEL

Two persons will be required for the conduct of these tests.

ATTACHMENT I: END CONDITION FORM FOR ENDURANCE TIME TESTING

END CONDITION FORM FOR ENDURANCE TIME TESTING

LOCATION: DORVAL TEST SITE DATE: RUN #: STAND #:

		Baseline Type II/IV	Type I	Type II/IV	Type II/IV & Type I
FLUID NAME					
		10º Plate 1	80º Plate 2	80º Plate 3	80º Plate 4

DESCRIBED ADHESION
AND DRAW FAILURE
AT TIME OF
PLATE 1 FAILURE

10º Plate 1

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

80º Plate 2

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

80º Plate 3

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

80º Plate 4

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

TIME OF FLUID APPLICATION					
TIME OF FLUID FAILURE					
FAILURE TIME (MIN)					
BRIX MEASUREMENTS TIME / BRIX	5 MIN	/	/	/	/
	END	/	/	/	/
	AT P1 FAIL		/	/	/
THICKNESS MEAS. TIME / THICKNESS	5 MIN	/	/	/	/
	END	/	/	/	/
	AT P1 FAIL		/	/	/
FAILURES CALLED BY:					

M:\Projects\PM2169.002 (TC-Deicing 09-10)\Procedures\V-Stab\Final Version 1.0\V-stab Procedure Final Version 1.0.doc
Final Version 1.0, December 09

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APPENDIX C

PROCEDURE:
EVALUATION OF SENSORS FOR DETERMINING ACTIVE FROST CONDITIONS

CM2169.002

PROCEDURE:
EVALUATION OF SENSORS FOR DETERMINING ACTIVE FROST CONDITIONS

Winter 2009-10

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Michelle Pineau

Reviewed by: John D'Avirro

December 23, 2009
Final Version 1.0

EVALUATION OF SENSORS FOR DETERMINING ACTIVE FROST CONDITIONS

WINTER 2009-10

1. BACKGROUND

Frost is an important consideration in aircraft deicing. The irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. This potential hazard is amplified by the frequent occurrence of frost accretion in winter operations.

The ideal conditions for frost accretion are the following:

i) Outside Ambient Temperature: Below 3°C
ii) Relative Humidity: Above 60%
iii) Wind Speed: Less than 5 km/h
iv) Sky Condition: Clear, or mostly unobstructed
v) Dew Point Relative to OAT

2. OBJECTIVE

The objective of this research is to investigate the accuracy of predicting frost using data obtained from Environment Canada and the data acquired from APS frost equipment. To achieve this objective, a series of preliminary frost tests will be conducted in natural frost conditions during the 2009-10 testing season. Testing will be conducted overnight during suitable frost conditions, however not all tests will be run under ideal frost conditions. This is because the non-active frost data will be valuable during analysis in determining the accuracy of APS frost collection equipment. These tests will aid in implementing frost technology into current aircraft ground icing programs. This long term development and implementation may span over a few years.

3. TEST PLAN

A typical test run has been compiled and is included in Attachment I. It illustrates a sample run beginning at 9 PM. One test run will take approximately 1.5 hours complete, from start to finish. It is anticipated that these frost tests will be conducted during three overnight sessions. APS will measure frost accretion rates at the YUL test site using the historical frost rate measurement methodology. This will enable a determination, as well as an indication of the severity, of active frost conditions at YUL. Weather information that will be collected from the Environment Canada website includes outside air temperature and humidity (see Attachment II)

4. PROCEDURE

The following outlines the steps necessary to conduct frost tests (See Attachment I for a sample test run).

1) Site/plate Set-up:
    a) Upon arrival at the APS test site, ensure data logger is operational and is properly connected to the test plate (See Figure 1);
    b) Setup the APS RH meter. The RH information collected will be used solely for APS purposes, and will not be used in the analysis stage.
2) Plate Positioning:
    a) Once plate is prepared for testing, bring outdoors and place on test stand upside down. The plate is brought outdoors before the start of the test so it can reach ambient temperature. Positioning the plate face down will prevent frost from accumulating on the test surface before testing commences; and
    b) Zero the scale and record the initial plate weight on the *General Data Form* (See Attachment V)*.* Record other pertinent information prior to the start of the test run.
3) Test Run Preparation:
    a) Once the plate surface reaches the approximate outdoor OAT, return the plate face side up; and
    b) Remove any frost that has formed on the plate. A scrapper and cloth will be used to remove any frost that may have accumulated before testing begins.
4) Start of Test Run:
    a) Begin test run. Plate to begin collecting frost.
5) Visual Verification of Frost:
    a) During the frost gathering stage, record on the data form whether or not frost has begun to accumulate on the plate. This observation of frost will be done close to the hour of each test run conducted.

6) Plate Temperature Data:
    a) One test run will collect approximately 30 minutes worth of frost temperature data. For analysis purposes, APS is only concerned about the data collected on the hour (an average will be taken, 1 min before and after the hour).

7) Environment Canada Data:
    a) Collect Environment Canada data on the hour (temperature and RH) from the website and record on the *General Data Form*. Attachment II illustrates typical Environment Canada data;
        i) http://weatheroffice.gc.ca; and
    b) Determine the Ice Point using Attachment III.

8) Plate Measurement of Weight and Visual Observation of Frost:
    a) Following the end of the frost collection period, bring plate indoors to weigh. Record weight and temperature measurements on the data form;
    b) A visual observation of the APS test site environment is needed following the completion of the test. In this inspection, record any observations of frost that may have accumulated near the surrounding testing area, such as on cars.

9) Determination of Frost Occurrence (Analytical):
    a) Analyze APS and Environment Canada data. Using the determined Ice Point, compare APS data with that collected from Environment Canada. A comparison of the data will determine if the method employed is a feasible way of predicting frost. Should the APS plate temperature exceed the Ice Point, theoretically frost should have occurred.

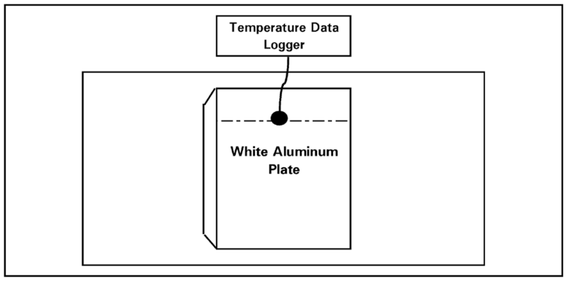


Figure 1: White-painted Aluminum Test Plate with Insulated Backing

10) EQUIPMENT

See Attachment IV for a detailed list of equipment necessary to conduct frost tests.

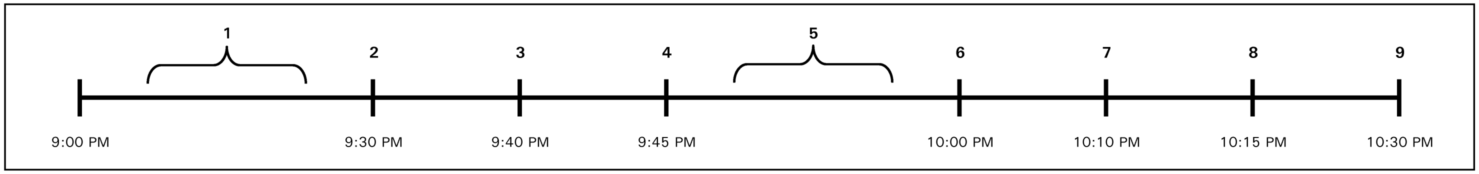
11) PERSONNEL

One person will be required to conduct tests. To optimize resources, APS personnel may conduct testing simultaneously with the composite frost project. A second person may be required for initial setup.

12) DATA FORMS

Frost tests will require the use of the *General Data Form*, which can be found in Attachment V. Each test run will require the completion of this form.

ATTACHMENT I
TEST PLAN
SAMPLE TEST RUN



*Example of Test Run Performed from 9:00 PM to 10:30 PM

1.	9:00-9:30 PM:	Site/Plate Set-up
2.	9:30 PM	Plate Positioning (Outdoors, Upside Down)
3.	9:40 PM	Test Run Preparation
4.	9:45 PM	Start of Test Run
5.	9:45-10:00 PM:	Visual Verification of Frost (Visual)
6.	10:00 PM:	Plate Temperature Data Collection
7.	10:10 PM:	Environment Canada Data (Determine Ice Point)
8.	10:15 PM:	Plate Measurement of Weight; Visual Observation of Frost (Observe Environment ie: Cars)
9.	10:30 PM:	Determination of Frost Occurrence (Analytical)

ATTACHMENT II
SAMPLE OF ENVIRONMENT CANADA WEATHER TRENDS FOR MONTREAL

http://weatheroffice.gc.ca

MONTREAL/PIERRE ELLIOTT TRUDEAU INTL
QUEBEC

Hourly Data Report for November 17th 2009

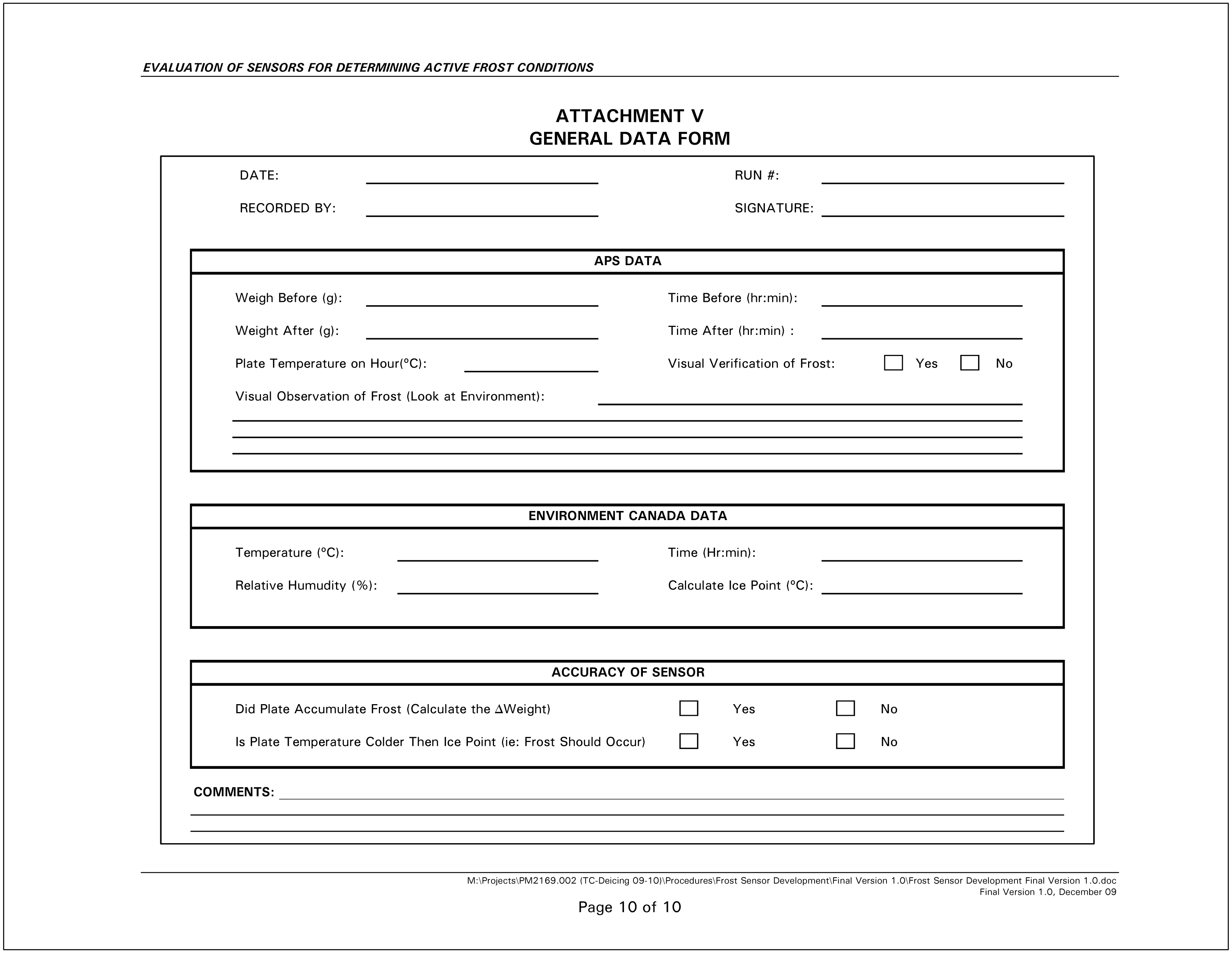
Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00	-0.9	-5.0	74	29	9	25.0	101.89		-4	Clear
01:00	0.1	-4.5	71	29	7	25.0	101.95			Clear
02:00	1.3	-3.6	70	4	4	25.0	102.01			Clear
03:00	-0.1	-4.1	74	1	6	25.0	102.09		-2	Clear
04:00	-1.2	-4.3	79	34	9	25.0	102.15		-4	Clear
05:00	-2.0	-5.0	80	35	7	25.0	102.24		-5	Clear
06:00	-1.8	-5.2	78	36	7	25.0	102.28		-4	Clear
07:00	-0.6	-4.7	74	2	7	48.3	102.33		-3	Clear
08:00	0.1	-4.2	73	3	6	48.3	102.41			Clear
09:00	1.7	-3.7	67	2	15	24.1	102.49			Clear
10:00	2.8	-4.4	59	4	15	24.1	102.55			Clear
11:00	3.5	-4.8	55	3	13	24.1	102.54			Clear
12:00	3.8	-5.1	52	4	7	24.1	102.53			Clear
13:00	4.4	-4.6	52	9	4	24.1	102.50			Clear
14:00	5.1	-4.5	50		0	24.1	102.49			Clear
15:00	5.2	-3.8	52	22	7	24.1	102.50			Clear
16:00	4.4	-3.5	56	21	9	24.1	102.51			Clear
17:00	2.8	-3.6	63	23	4	25.0	102.55			Clear
18:00	1.9	-3.7	66	25	4	25.0	102.57			Mainly Clear
19:00	2.4	-3.1	67	13	4	25.0	102.61			Clear
20:00	1.5	-3.8	68	15	4	25.0	102.64			Mainly Clear
21:00	1.4	-3.2	71	13	4	25.0	102.66			Clear
22:00	0.4	-4.0	72		0	25.0	102.66			Clear
23:00	-1.1	-4.3	79		0	25.0	102.64			Clear

ATTACHMENT III
ICE POINT CHART

OAT °C	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30
RH%																																				
50	-3.5	-4.4	-5.3	-6.3	-7.2	-8.2	-9.1	-10.0	-11.0	-11.9	-12.9	-13.8	-14.7	-15.7	-16.6	-17.6	-18.5	-19.4	-20.4	-21.3	-22.3	-23.2	-24.2	-25.1	-26.0	-27.0	-27.9	-28.9	-29.8	-30.8	-31.7	-32.7	-33.6	-34.5	-35.5	-36.4
51	-3.2	-4.2	-5.1	-6.0	-7.0	-7.9	-8.9	-9.8	-10.8	-11.7	-12.6	-13.6	-14.5	-15.5	-16.4	-17.4	-18.3	-19.2	-20.2	-21.1	-22.1	-23.0	-24.0	-24.9	-25.8	-26.8	-27.7	-28.7	-29.6	-30.6	-31.5	-32.5	-33.4	-34.4	-35.3	-36.3
52	-3.0	-3.9	-4.9	-5.8	-6.8	-7.7	-8.6	-9.6	-10.5	-11.5	-12.4	-13.4	-14.3	-15.3	-16.2	-17.1	-18.1	-19.0	-20.0	-20.9	-21.9	-22.8	-23.8	-24.7	-25.7	-26.6	-27.6	-28.5	-29.4	-30.4	-31.3	-32.3	-33.2	-34.2	-35.1	-36.1
53	-2.8	-3.7	-4.7	-5.6	-6.5	-7.5	-8.4	-9.4	-10.3	-11.3	-12.2	-13.2	-14.1	-15.0	-16.0	-16.9	-17.9	-18.8	-19.8	-20.7	-21.7	-22.6	-23.6	-24.5	-25.5	-26.4	-27.4	-28.3	-29.3	-30.2	-31.2	-32.1	-33.1	-34.0	-35.0	-35.9
54	-2.5	-3.5	-4.4	-5.4	-6.3	-7.3	-8.2	-9.2	-10.1	-11.1	-12.0	-13.0	-13.9	-14.8	-15.8	-16.7	-17.7	-18.6	-19.6	-20.5	-21.5	-22.4	-23.4	-24.3	-25.3	-26.2	-27.2	-28.1	-29.1	-30.0	-31.0	-31.9	-32.9	-33.8	-34.8	-35.7
55	-2.3	-3.3	-4.2	-5.2	-6.1	-7.1	-8.0	-9.0	-9.9	-10.9	-11.8	-12.8	-13.7	-14.6	-15.6	-16.5	-17.5	-18.4	-19.4	-20.3	-21.3	-22.2	-23.2	-24.1	-25.1	-26.1	-27.0	-28.0	-28.9	-29.9	-30.8	-31.8	-32.7	-33.7	-34.6	-35.6
56	-2.1	-3.1	-4.0	-5.0	-5.9	-6.9	-7.8	-8.8	-9.7	-10.7	-11.6	-12.6	-13.5	-14.5	-15.4	-16.4	-17.3	-18.3	-19.2	-20.2	-21.1	-22.1	-23.0	-24.0	-24.9	-25.9	-26.8	-27.8	-28.7	-29.7	-30.6	-31.6	-32.5	-33.5	-34.5	-35.4
57	-1.9	-2.9	-3.8	-4.8	-5.7	-6.7	-7.6	-8.6	-9.5	-10.5	-11.4	-12.4	-13.3	-14.3	-15.2	-16.2	-17.1	-18.1	-19.0	-20.0	-20.9	-21.9	-22.8	-23.8	-24.7	-25.7	-26.7	-27.6	-28.6	-29.5	-30.5	-31.4	-32.4	-33.3	-34.3	-35.2
58	-1.7	-2.6	-3.6	-4.5	-5.5	-6.5	-7.4	-8.4	-9.3	-10.3	-11.2	-12.2	-13.1	-14.1	-15.0	-16.0	-16.9	-17.9	-18.8	-19.8	-20.8	-21.7	-22.7	-23.6	-24.6	-25.5	-26.5	-27.4	-28.4	-29.3	-30.3	-31.3	-32.2	-33.2	-34.1	-35.1
59	-1.5	-2.4	-3.4	-4.3	-5.3	-6.3	-7.2	-8.2	-9.1	-10.1	-11.0	-12.0	-12.9	-13.9	-14.8	-15.8	-16.8	-17.7	-18.7	-19.6	-20.6	-21.5	-22.5	-23.4	-24.4	-25.4	-26.3	-27.3	-28.2	-29.2	-30.1	-31.1	-32.1	-33.0	-34.0	-34.9
60	-1.3	-2.2	-3.2	-4.1	-5.1	-6.1	-7.0	-8.0	-8.9	-9.9	-10.8	-11.8	-12.7	-13.7	-14.7	-15.6	-16.6	-17.5	-18.5	-19.4	-20.4	-21.4	-22.3	-23.3	-24.2	-25.2	-26.1	-27.1	-28.1	-29.0	-30.0	-30.9	-31.9	-32.9	-33.8	-34.8
61	-1.1	-2.0	-3.0	-4.0	-4.9	-5.9	-6.8	-7.8	-8.7	-9.7	-10.7	-11.6	-12.6	-13.5	-14.5	-15.4	-16.4	-17.4	-18.3	-19.3	-20.2	-21.2	-22.1	-23.1	-24.1	-25.0	-26.0	-26.9	-27.9	-28.9	-29.8	-30.8	-31.7	-32.7	-33.7	-34.6
62	-0.9	-1.8	-2.8	-3.8	-4.7	-5.7	-6.6	-7.6	-8.6	-9.5	-10.5	-11.4	-12.4	-13.3	-14.3	-15.3	-16.2	-17.2	-18.1	-19.1	-20.1	-21.0	-22.0	-22.9	-23.9	-24.9	-25.8	-26.8	-27.7	-28.7	-29.7	-30.6	-31.6	-32.6	-33.5	-34.5
63	-0.7	-1.7	-2.6	-3.6	-4.5	-5.5	-6.5	-7.4	-8.4	-9.3	-10.3	-11.2	-12.2	-13.2	-14.1	-15.1	-16.1	-17.0	-18.0	-18.9	-19.9	-20.9	-21.8	-22.8	-23.7	-24.7	-25.7	-26.6	-27.6	-28.6	-29.5	-30.5	-31.4	-32.4	-33.4	-34.3
64	-0.5	-1.5	-2.4	-3.4	-4.3	-5.3	-6.3	-7.2	-8.2	-9.2	-10.1	-11.1	-12.0	-13.0	-14.0	-14.9	-15.9	-16.8	-17.8	-18.8	-19.7	-20.7	-21.7	-22.6	-23.6	-24.5	-25.5	-26.5	-27.4	-28.4	-29.4	-30.3	-31.3	-32.3	-33.2	-34.2
65	-0.3	-1.3	-2.2	-3.2	-4.2	-5.1	-6.1	-7.1	-8.0	-9.0	-9.9	-10.9	-11.9	-12.8	-13.8	-14.8	-15.7	-16.7	-17.6	-18.6	-19.6	-20.5	-21.5	-22.5	-23.4	-24.4	-25.4	-26.3	-27.3	-28.2	-29.2	-30.2	-31.1	-32.1	-33.1	-34.0
66	-0.1	-1.1	-2.1	-3.0	-4.0	-4.9	-5.9	-6.9	-7.8	-8.8	-9.8	-10.7	-11.7	-12.7	-13.6	-14.6	-15.6	-16.5	-17.5	-18.4	-19.4	-20.4	-21.3	-22.3	-23.3	-24.2	-25.2	-26.2	-27.1	-28.1	-29.1	-30.0	-31.0	-32.0	-32.9	-33.9
67	0.0	-0.9	-1.9	-2.8	-3.8	-4.8	-5.7	-6.7	-7.7	-8.6	-9.6	-10.6	-11.5	-12.5	-13.5	-14.4	-15.4	-16.4	-17.3	-18.3	-19.3	-20.2	-21.2	-22.2	-23.1	-24.1	-25.1	-26.0	-27.0	-28.0	-28.9	-29.9	-30.9	-31.8	-32.8	-33.8
68	0.2	-0.7	-1.7	-2.7	-3.6	-4.6	-5.6	-6.5	-7.5	-8.5	-9.4	-10.4	-11.4	-12.3	-13.3	-14.3	-15.2	-16.2	-17.2	-18.1	-19.1	-20.1	-21.0	-22.0	-23.0	-23.9	-24.9	-25.9	-26.8	-27.8	-28.8	-29.7	-30.7	-31.7	-32.7	-33.6
69	0.4	-0.6	-1.5	-2.5	-3.5	-4.4	-5.4	-6.4	-7.3	-8.3	-9.3	-10.2	-11.2	-12.2	-13.1	-14.1	-15.1	-16.0	-17.0	-18.0	-18.9	-19.9	-20.9	-21.9	-22.8	-23.8	-24.8	-25.7	-26.7	-27.7	-28.6	-29.6	-30.6	-31.5	-32.5	-33.5
70	0.6	-0.4	-1.4	-2.3	-3.3	-4.3	-5.2	-6.2	-7.2	-8.1	-9.1	-10.1	-11.0	-12.0	-13.0	-13.9	-14.9	-15.9	-16.9	-17.8	-18.8	-19.8	-20.7	-21.7	-22.7	-23.6	-24.6	-25.6	-26.6	-27.5	-28.5	-29.5	-30.4	-31.4	-32.4	-33.4
71	0.8	-0.2	-1.2	-2.2	-3.1	-4.1	-5.1	-6.0	-7.0	-8.0	-8.9	-9.9	-10.9	-11.9	-12.8	-13.8	-14.8	-15.7	-16.7	-17.7	-18.6	-19.6	-20.6	-21.6	-22.5	-23.5	-24.5	-25.4	-26.4	-27.4	-28.4	-29.3	-30.3	-31.3	-32.3	-33.2
72	0.9	0.0	-1.0	-2.0	-3.0	-3.9	-4.9	-5.9	-6.8	-7.8	-8.8	-9.8	-10.7	-11.7	-12.7	-13.6	-14.6	-15.6	-16.6	-17.5	-18.5	-19.5	-20.4	-21.4	-22.4	-23.4	-24.3	-25.3	-26.3	-27.3	-28.2	-29.2	-30.2	-31.1	-32.1	-33.1
73	1.1	0.1	-0.9	-1.8	-2.8	-3.8	-4.7	-5.7	-6.7	-7.7	-8.6	-9.6	-10.6	-11.5	-12.5	-13.5	-14.5	-15.4	-16.4	-17.4	-18.4	-19.3	-20.3	-21.3	-22.2	-23.2	-24.2	-25.2	-26.1	-27.1	-28.1	-29.1	-30.0	-31.0	-32.0	-33.0
74	1.3	0.3	-0.7	-1.7	-2.6	-3.6	-4.6	-5.6	-6.5	-7.5	-8.5	-9.4	-10.4	-11.4	-12.4	-13.3	-14.3	-15.3	-16.3	-17.2	-18.2	-19.2	-20.2	-21.1	-22.1	-23.1	-24.1	-25.0	-26.0	-27.0	-28.0	-28.9	-29.9	-30.9	-31.9	-32.8
75	1.4	0.4	-0.5	-1.5	-2.5	-3.4	-4.4	-5.4	-6.4	-7.3	-8.3	-9.3	-10.3	-11.2	-12.2	-13.2	-14.2	-15.1	-16.1	-17.1	-18.1	-19.0	-20.0	-21.0	-22.0	-22.9	-23.9	-24.9	-25.9	-26.9	-27.8	-28.8	-29.8	-30.8	-31.7	-32.7
76	1.6	0.6	-0.4	-1.3	-2.3	-3.3	-4.3	-5.2	-6.2	-7.2	-8.2	-9.1	-10.1	-11.1	-12.1	-13.0	-14.0	-15.0	-16.0	-17.0	-17.9	-18.9	-19.9	-20.9	-21.8	-22.8	-23.8	-24.8	-25.7	-26.7	-27.7	-28.7	-29.7	-30.6	-31.6	-32.6
77	1.7	0.8	-0.2	-1.2	-2.2	-3.1	-4.1	-5.1	-6.1	-7.0	-8.0	-9.0	-10.0	-10.9	-11.9	-12.9	-13.9	-14.9	-15.8	-16.8	-17.8	-18.8	-19.7	-20.7	-21.7	-22.7	-23.7	-24.6	-25.6	-26.6	-27.6	-28.6	-29.5	-30.5	-31.5	-32.5
78	1.9	0.9	0.0	-1.0	-2.0	-3.0	-4.0	-4.9	-5.9	-6.9	-7.9	-8.8	-9.8	-10.8	-11.8	-12.8	-13.7	-14.7	-15.7	-16.7	-17.7	-18.6	-19.6	-20.6	-21.6	-22.6	-23.5	-24.5	-25.5	-26.5	-27.4	-28.4	-29.4	-30.4	-31.4	-32.3
79	2.1	1.1	0.1	-0.9	-1.9	-2.8	-3.8	-4.8	-5.8	-6.7	-7.7	-8.7	-9.7	-10.7	-11.6	-12.6	-13.6	-14.6	-15.6	-16.5	-17.5	-18.5	-19.5	-20.5	-21.4	-22.4	-23.4	-24.4	-25.4	-26.3	-27.3	-28.3	-29.3	-30.3	-31.2	-32.2
80	2.2	1.2	0.3	-0.7	-1.7	-2.7	-3.7	-4.6	-5.6	-6.6	-7.6	-8.6	-9.5	-10.5	-11.5	-12.5	-13.5	-14.4	-15.4	-16.4	-17.4	-18.4	-19.4	-20.3	-21.3	-22.3	-23.3	-24.3	-25.2	-26.2	-27.2	-28.2	-29.2	-30.1	-31.1	-32.1
81	2.4	1.4	0.4	-0.6	-1.6	-2.5	-3.5	-4.5	-5.5	-6.5	-7.4	-8.4	-9.4	-10.4	-11.4	-12.3	-13.3	-14.3	-15.3	-16.3	-17.3	-18.2	-19.2	-20.2	-21.2	-22.2	-23.1	-24.1	-25.1	-26.1	-27.1	-28.1	-29.0	-30.0	-31.0	-32.0
82	2.5	1.5	0.6	-0.4	-1.4	-2.4	-3.4	-4.4	-5.3	-6.3	-7.3	-8.3	-9.3	-10.2	-11.2	-12.2	-13.2	-14.2	-15.2	-16.1	-17.1	-18.1	-19.1	-20.1	-21.1	-22.0	-23.0	-24.0	-25.0	-26.0	-27.0	-27.9	-28.9	-29.9	-30.9	-31.9
83	2.7	1.7	0.7	-0.3	-1.3	-2.2	-3.2	-4.2	-5.2	-6.2	-7.2	-8.1	-9.1	-10.1	-11.1	-12.1	-13.1	-14.0	-15.0	-16.0	-17.0	-18.0	-19.0	-19.9	-20.9	-21.9	-22.9	-23.9	-24.9	-25.9	-26.8	-27.8	-28.8	-29.8	-30.8	-31.8
84	2.8	1.8	0.9	-0.1	-1.1	-2.1	-3.1	-4.1	-5.1	-6.0	-7.0	-8.0	-9.0	-10.0	-11.0	-11.9	-12.9	-13.9	-14.9	-15.9	-16.9	-17.9	-18.8	-19.8	-20.8	-21.8	-22.8	-23.8	-24.8	-25.7	-26.7	-27.7	-28.7	-29.7	-30.7	-31.7
85	3.0	2.0	1.0	0.0	-1.0	-2.0	-2.9	-3.9	-4.9	-5.9	-6.9	-7.9	-8.9	-9.8	-10.8	-11.8	-12.8	-13.8	-14.8	-15.8	-16.7	-17.7	-18.7	-19.7	-20.7	-21.7	-22.7	-23.6	-24.6	-25.6	-26.6	-27.6	-28.6	-29.6	-30.6	-31.5
86	3.1	2.1	1.1	0.2	-0.8	-1.8	-2.8	-3.8	-4.8	-5.8	-6.8	-7.7	-8.7	-9.7	-10.7	-11.7	-12.7	-13.7	-14.6	-15.6	-16.6	-17.6	-18.6	-19.6	-20.6	-21.6	-22.5	-23.5	-24.5	-25.5	-26.5	-27.5	-28.5	-29.5	-30.4	-31.4
87	3.3	2.3	1.3	0.3	-0.7	-1.7	-2.7	-3.7	-4.6	-5.6	-6.6	-7.6	-8.6	-9.6	-10.6	-11.6	-12.5	-13.5	-14.5	-15.5	-16.5	-17.5	-18.5	-19.5	-20.4	-21.4	-22.4	-23.4	-24.4	-25.4	-26.4	-27.4	-28.4	-29.3	-30.3	-31.3
88	3.4	2.4	1.4	0.4	-0.6	-1.5	-2.5	-3.5	-4.5	-5.5	-6.5	-7.5	-8.5	-9.5	-10.4	-11.4	-12.4	-13.4	-14.4	-15.4	-16.4	-17.4	-18.4	-19.3	-20.3	-21.3	-22.3	-23.3	-24.3	-25.3	-26.3	-27.3	-28.2	-29.2	-30.2	-31.2
89	3.5	2.6	1.6	0.6	-0.4	-1.4	-2.4	-3.4	-4.4	-5.4	-6.4	-7.3	-8.3	-9.3	-10.3	-11.3	-12.3	-13.3	-14.3	-15.3	-16.3	-17.2	-18.2	-19.2	-20.2	-21.2	-22.2	-23.2	-24.2	-25.2	-26.2	-27.1	-28.1	-29.1	-30.1	-31.1
90	3.7	2.7	1.7	0.7	-0.3	-1.3	-2.3	-3.3	-4.2	-5.2	-6.2	-7.2	-8.2	-9.2	-10.2	-11.2	-12.2	-13.2	-14.2	-15.1	-16.1	-17.1	-18.1	-19.1	-20.1	-21.1	-22.1	-23.1	-24.1	-25.1	-26.0	-27.0	-28.0	-29.0	-30.0	-31.0
91	3.8	2.8	1.8	0.8	-0.1	-1.1	-2.1	-3.1	-4.1	-5.1	-6.1	-7.1	-8.1	-9.1	-10.1	-11.1	-12.0	-13.0	-14.0	-15.0	-16.0	-17.0	-18.0	-19.0	-20.0	-21.0	-22.0	-23.0	-24.0	-24.9	-25.9	-26.9	-27.9	-28.9	-29.9	-30.9
92	4.0	3.0	2.0	1.0	0.0	-1.0	-2.0	-3.0	-4.0	-5.0	-6.0	-7.0	-8.0	-8.9	-9.9	-10.9	-11.9	-12.9	-13.9	-14.9	-15.9	-16.9	-17.9	-18.9	-19.9	-20.9	-21.9	-22.8	-23.8	-24.8	-25.8	-26.8	-27.8	-28.8	-29.8	-30.8
93	4.1	3.1	2.1	1.1	0.1	-0.9	-1.9	-2.9	-3.9	-4.9	-5.8	-6.8	-7.8	-8.8	-9.8	-10.8	-11.8	-12.8	-13.8	-14.8	-15.8	-16.8	-17.8	-18.8	-19.8	-20.8	-21.7	-22.7	-23.7	-24.7	-25.7	-26.7	-27.7	-28.7	-29.7	-30.7
94	4.2	3.2	2.2	1.2	0.2	-0.7	-1.7	-2.7	-3.7	-4.7	-5.7	-6.7	-7.7	-8.7	-9.7	-10.7	-11.7	-12.7	-13.7	-14.7	-15.7	-16.7	-17.7	-18.7	-19.6	-20.6	-21.6	-22.6	-23.6	-24.6	-25.6	-26.6	-27.6	-28.6	-29.6	-30.6
95	4.4	3.4	2.4	1.4	0.4	-0.6	-1.6	-2.6	-3.6	-4.6	-5.6	-6.6	-7.6	-8.6	-9.6	-10.6	-11.6	-12.6	-13.6	-14.6	-15.6	-16.5	-17.5	-18.5	-19.5	-20.5	-21.5	-22.5	-23.5	-24.5	-25.5	-26.5	-27.5	-28.5	-29.5	-30.5
96	4.5	3.5	2.5	1.5	0.5	-0.5	-1.5	-2.5	-3.5	-4.5	-5.5	-6.5	-7.5	-8.5	-9.5	-10.5	-11.5	-12.5	-13.4	-14.4	-15.4	-16.4	-17.4	-18.4	-19.4	-20.4	-21.4	-22.4	-23.4	-24.4	-25.4	-26.4	-27.4	-28.4	-29.4	-30.4
97	4.6	3.6	2.6	1.6	0.6	-0.4	-1.4	-2.4	-3.4	-4.4	-5.4	-6.4	-7.3	-8.3	-9.3	-10.3	-11.3	-12.3	-13.3	-14.3	-15.3	-16.3	-17.3	-18.3	-19.3	-20.3	-21.3	-22.3	-23.3	-24.3	-25.3	-26.3	-27.3	-28.3	-29.3	-30.3
98	4.7	3.7	2.7	1.8	0.8	-0.2	-1.2	-2.2	-3.2	-4.2	-5.2	-6.2	-7.2	-8.2	-9.2	-10.2	-11.2	-12.2	-13.2	-14.2	-15.2	-16.2	-17.2	-18.2	-19.2	-20.2	-21.2	-22.2	-23.2	-24.2	-25.2	-26.2	-27.2	-28.2	-29.2	-30.2
99	4.9	3.9	2.9	1.9	0.9	-0.1	-1.1	-2.1	-3.1	-4.1	-5.1	-6.1	-7.1	-8.1	-9.1	-10.1	-11.1	-12.1	-13.1	-14.1	-15.1	-16.1	-17.1	-18.1	-19.1	-20.1	-21.1	-22.1	-23.1	-24.1	-25.1	-26.1	-27.1	-28.1	-29.1	-30.1
100	5.0	4.0	3.0	2.0	1.0	0.0	-1.0	-2.0	-3.0	-4.0	-5.0	-6.0	-7.0	-8.0	-9.0	-10.0	-11.0	-12.0	-13.0	-14.0	-15.0	-16.0	-17.0	-18.0	-19.0	-20.0	-21.0	-22.0	-23.0	-24.0	-25.0	-26.0	-27.0	-28.0	-29.0	-30.0

ATTACHMENT IV
EQUIPMENT LIST

FROST RATE DATA COLLECTION
1-position Test Stand
White-painted Aluminum Test Plate with Insulated Backing
Thermistor Probe to be Installed at the 15 cm Line
Thermistor Probe with Shield, for Air Temperature (Optional)
Weigh Scale (accuracy of 0.1 g or better)
RH Meter (Optional)
Data Forms
PC or laptop
Scraper
Cloth



EVALUATION OF SENSORS FOR DETERMINING ACTIVE FROST CONDITIONS

ATTACHMENT V
GENERAL DATA FORM

DATE: ____________________ RUN #: ____________________

RECORDED BY: ____________________ SIGNATURE: ____________________

APS DATA

Weigh Before (g): ____________________ Time Before (hr:min): ____________________

Weight After (g): ____________________ Time After (hr:min) : ____________________

Plate Temperature on Hour(°C): ____________ Visual Verification of Frost: ☐ Yes ☐ No

Visual Observation of Frost (Look at Environment): ____________________

ENVIRONMENT CANADA DATA

Temperature (°C): ____________________ Time (Hr:min): ____________________

Relative Humudity (%): ____________________ Calculate Ice Point (°C): ____________________

ACCURACY OF SENSOR

Did Plate Accumulate Frost (Calculate the ΔWeight) ☐ Yes ☐ No

Is Plate Temperature Colder Then Ice Point (ie: Frost Should Occur) ☐ Yes ☐ No

COMMENTS: ____________________

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APPENDIX D

PROCEDURE:
EVALUATION OF FROST HOT'S FOR USE DURING COLD SOAK WING FROST CONDITIONS

Effect of Cold Soak Wing Conditions During Active Frost

CM2169.002

PROCEDURE:
EVALUATION OF FROST HOT'S FOR USE DURING COLD SOAK WING FROST CONDITIONS
Effect of Cold Soak Wing Conditions During Active Frost

Winter 2009-10

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro

December 21, 2009
Final Version 1.0

PROCEDURE:
EVALUATION OF FROST HOT'S FOR USE DURING COLD SOAK WING FROST CONDITIONS

Effect of Cold Soak Wing Conditions During Active Frost

Winter 2009-10

1. BACKGROUND

Frost is an important consideration in aircraft deicing. The irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. Frost can be an insidious type of threat to the safety of aircraft operations. Because it often has the appearance of being a minor degree of contamination, it does not offer the same obvious signal of danger as do other types of contamination such as snow or ice. However, certain characteristics of frost cause it to be of genuine concern: it is always adhered to the aircraft surface, and it is always rough.

The current frost HOT's for Type I, II, III, and IV fluids have been evaluated and substantiated for use during natural active frost conditions, however it is not known if these holdover times can also be applied to cold soak wing frost. The fundamental difference between both types of frost is how the wing skin temperature is cooled below ambient: radiation cooling versus conduction cooling. During natural active frost, the wing skin temperature will be cooled below ambient temperature as a result of radiation cooling from the cold clear sky. During cold soak wing conditions, however, the wing skin temperature is cooled and maintained at a temperature below ambient as a result of conduction cooling from the cold fluid stored inside the wing; either the aircraft was refuelled with cold fuel, or following a flight, the wing and fluid will be cold soaked.

The current procedure for measuring cold soak wing HOT's simulates a 10ºC temperature differential between the surface temperature and the OAT. Prior to the winter of 1996-97, HOT testing in CSW conditions was conducted at an ambient temperature of +2°C (0°C was the target temperature but 2°C was selected to ensure rain and not freezing rain) with box skin temperature ranging from 0°C to -15°C; the majority of the tests were conducted with box skin temperatures of -10ºC. In October 1996, a report was published (TP 12899E) which analyzed operational wing skin temperature to OAT differentials and discussed the selection of box skin surface temperature to be used for indoor simulated testing; based on data collected by ARC, McDonnell Douglas, APS, as well as through communications with SAS. Based on this analysis, the report indicated that a box temperature with a lower a lower limit of -10ºC would be appropriate for the simulated CSW tests.

Previous research has shown that wing temperature can drop 6 °C to 9°C below ambient temperature during natural frost conditions. Historically, a 10°C temperature differential has been assumed representative of typical cold soak wing conditions. Testing is required to investigate the effects of a cold soaked wing during active frost conditions; are the wing temperatures typically increased, maintained, or reduced. This will provide a worst case scenario and provide a starting point for potentially developing guidance for operating in cold soak wing frost conditions. This activity will be described in this procedure.

It should be noted that a separate activity will be conducted requiring a historical review of cold soak wing data collected. The skin temperature differential data will be analyzed and compared to the flat plate testing results used to develop the 2009-10 frost HOT's. The objective is determine if the HOT's can be potentially expanded to include cold soak wing frost based on typical skin temperature differentials.

Dependant on the preliminary results from this work, it may be necessary to develop a more extensive test program to develop guidance for cold soak wing frost conditions.

2. OBJECTIVES

To investigate the effects of a cold soaked wing during active frost conditions. Testing will be conducted with cold soak wing boxes, and not operational aircraft. Testing will monitor the standard frost plate and the cold soak box surface temperatures. The objective is to determine if the surface temperature on the box will typically be increased, maintained, or reduced, as this will indicate whether the current frost HOT's are applicable based on the temperature differentials observed.

Three nights of testing for two people are planned to obtain preliminary data for this activity, however one night of testing may provide enough information. A review of the data should be conducted following the first test event.

3. PROCEDURE

Four steps required for the conduct of the tests are described in the following sections:

1) General (Section 3.1),
2) Frost rate measurement (Section 3.2),
3) Cold soak box preparation (Section 3.3), and
4) Evaluation of skin temperature differential (Section 3.4).

Figure 1 demonstrates the general setup for the conduct of the tests. Three nights of testing are anticipated with 2-3 test runs conducted per night, however one night of testing may provide enough information. A review of the data should conducted after the first test run to evaluate if changes are necessary to the procedure and if additional testing is required.

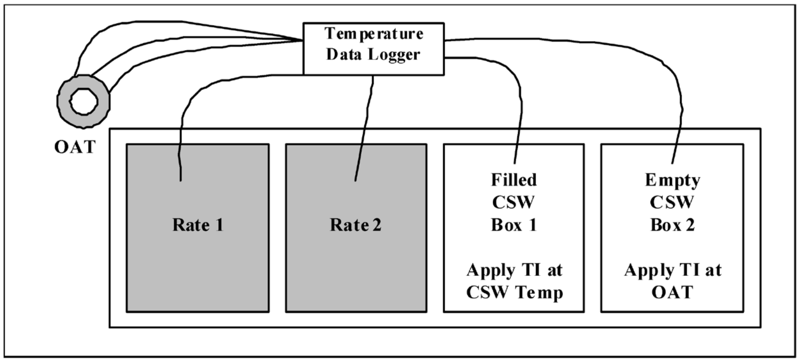


Figure 1: General Setup

3.1 General

1) Monitor weather forecasts to select a time for testing. The ideal conditions for the development of frost are:
    a) OAT near or below 0ºC
    b) Less than 10 km of wind; and
    c) Clear sky overnight.
2) At the beginning of the data gathering session:
    a) Clear the data logger and ensure that new data is logging.
    b) Synchronize time on all data collection devices.
    c) Label loggers and computer files indicating date of test.
3) At the end of the data gathering session:
    a) Download the data from data logger to the PC. Label files indicating date of test;
    b) Provide a copy of data files (by diskette or e-mail) to APS for project record where they will be saved to the network;

c) Download or print the Environment Canada Weather data for the test period from the following website:

http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

d) A complete set of test records for each session includes:

- Computer files of downloaded surface temperature logger data;
- Completed data sheets; and
- Printed or emailed copy of the Environment Canada Weather data.

3.2 Frost Rate Measurement

1. Weigh two clean test surfaces before start of test. Test surfaces should be the standard insulated white painted aluminum plates
2. Wait for frost to accrete on rate plates.
3. Once frost accretion is observed, testing (Section 3.4) can begin.
4. At 60-minute intervals and as required (see Section 3.4), record data as follows:
   a. Weigh the test surface, recording weight and time; and
   b. The two surfaces collecting frost will be used in a staggered routine
5. After each test, the surface collecting frost should be replaced by a clean surface that was maintained at ambient temperature, or cleaned of accreted frost.

3.3 Cold Soak Box Preparation

1. Put containers (20 l) of CSW box fluid (propylene 65/35) in cold (-30 ± 5°C) freezer overnight.
2. Ensure boxes are cooled to ambient (should be left outdoors).
3. Monitor ambient temperature prior to start of test.
4. Prepare fluid to -12 ± 1°C below the ambient temperature by mixing (use small amounts of hot water and/or cold fluid). Agitate fluid mixture frequently.
5. Fill boxes, ensure -11 ± 1°C below the ambient temperature on surface of box. This process shall be done while rates are being measured.
6. Conduct a rate measurement.
7. Position on stand. Connect thermocouples.

8. Start test.
9. At end of test, remove box from stand, and go to step (4).

3.4 Procedure for Monitoring Cold Soak Wing Temperature Differentials

1. Testing will be conducted with two boxes.
    a. Box #1 filled with cold soaked Type I fluid; and
    b. Box #2 empty and at ambient temperature.
2. Box #1: Apply 0.5L of the CSW box fluid onto the top surface of the CSW wing box (prepared according to Section 3.3). Fluid temperature should be equivalent to the fluid used to fill the box.
3. Box #2: Apply 0.5L of the CSW box fluid onto the top surface of the empty CSW wing box. Fluid and box temperature should be equivalent to the ambient temperature.
4. Ensure that the temperature logger is reading box surface temperature and OAT accurately. If problems arise, use hand held temperature probe and environment Canada OAT data.
5. Measure frost rate at the beginning and at the end of the test, as well as at 1hour intervals in between.
6. Monitor box surface temperatures and cross reference with frost rate plates and OAT. Record measurements using the form in Attachment A;
7. Once the filled CSW box surface temperature has stabilized with respect to the empty CSW box surface temperature, record the times elapsed, and stop the test. It is anticipated that the surface temperature profiles will follow the trend demonstrated in Figure 2.
8. Repeat.

4. EQUIPMENT

The equipment required to collect frost rates includes:

a) An electronic balance;
b) Two white-painted aluminum test plates with one thermistor probe installed at the 15 cm line, linked to the thermistor logger.
c) Three screened thermistor probes to measure air temperature linked to the thermistor logger;

Standard equipment used for endurance tests outdoors will be used, with the exception that the test surface will be cold soak wing boxes filled with Type I fluid. The surfaces will be instrumented with a thermistor probe installed at the 15 cm line, linked to the logger.

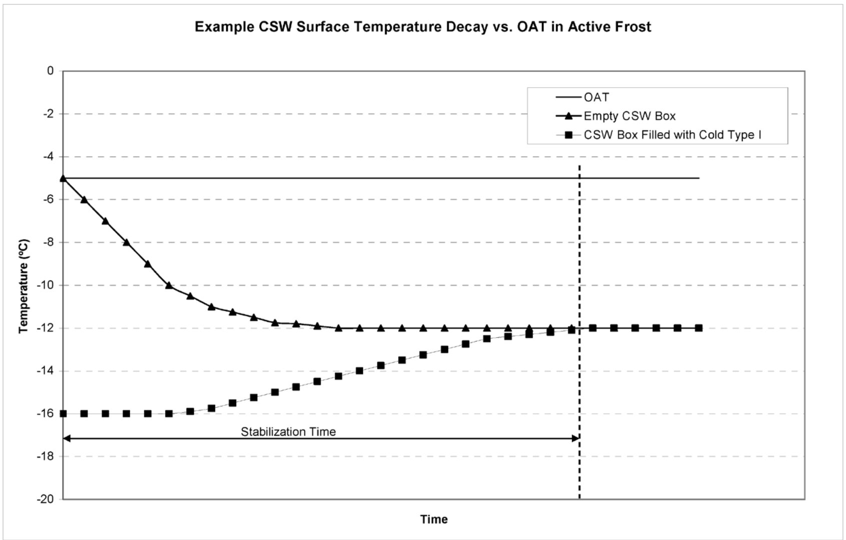


Figure 2: Anticipated Surface Temperature Decay Trend

5. DATA FORMS

For frost rate data collection, see Attachment B.

6. PERSONNEL

Two persons will be required for the conduct of these tests.

ATTACHMENT A
DATA FORM
SKIN TEMPERATURE / OAT

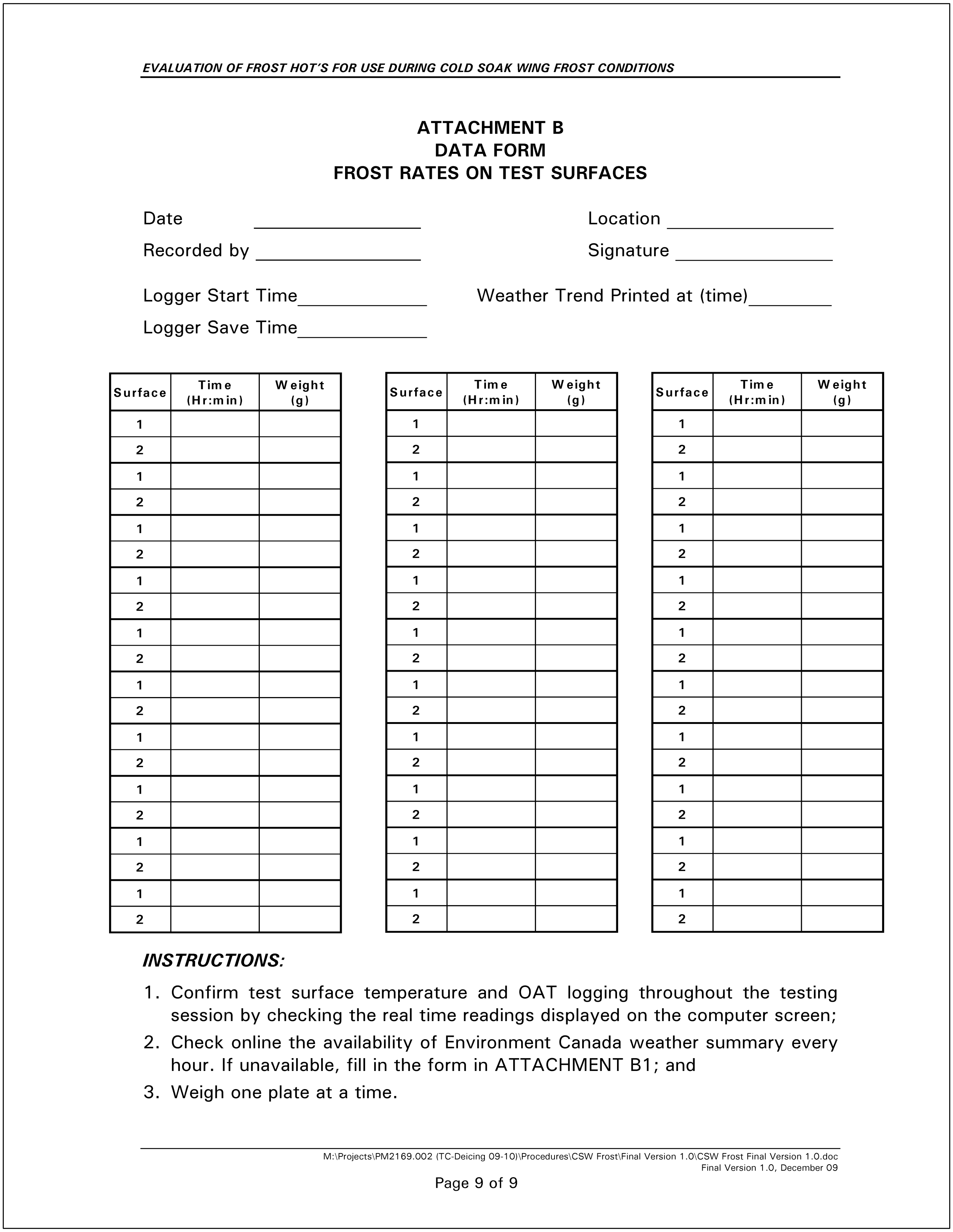
DATE: ________________ **PERFORMED BY:** ________________

RUN #: ________________ **WRITTEN BY:** ________________

STAND: ________________ **LOCATION:** ________________

Time *	Box 1 (Filled) Surface Temp (ºC)	Box 2 (Empty) Surface Temp (ºC)	Avg OAT (ºC)	Avg Rate Surface Temp (ºC)

* Should be recorded every 15-30 minutes for the duration of the test with a final measurement when stabilization of the CSW surfaces is achieved.



ATTACHMENT B
DATA FORM
FROST RATES ON TEST SURFACES

Date ________________ Location ________________

Recorded by ________________ Signature ________________

Logger Start Time____________ Weather Trend Printed at (time)________

Logger Save Time____________

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
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2		

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
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2		
1		
2		
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1		
2		

INSTRUCTIONS:

1. Confirm test surface temperature and OAT logging throughout the testing session by checking the real time readings displayed on the computer screen;
2. Check online the availability of Environment Canada weather summary every hour. If unavailable, fill in the form in ATTACHMENT B1; and
3. Weigh one plate at a time.

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APPENDIX E

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

BM5611.00

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

Winter 2008-09

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: for Victoria Zoitakis

Reviewed by: John D'Avirro

January 2, 2009
Final Version 1.0

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

1. BACKGROUND

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

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

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

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

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

2. OBJECTIVES

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

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

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

OUTDOOR TEST	**SNOWMAKER TEST#1**	**SNOWMAKER TEST#2**	**SNOWMAKER TEST#3**
This test is conducted at a high rate and a random temperature.	This test is a replicate of the outdoor test but is conducted indoors at the same rate and temperature.	This test is a replicate of the outdoor test but is conducted indoors at the same rate and temperature.	This test is a replicate of the outdoor test but is conducted indoors at the same rate and temperature.

Figure 2.1: Anticipated Tests

3. TEST REQUIREMENTS

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

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

4. EQUIPMENT

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

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

4.1 Fluids

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

5. PERSONNEL

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

6. SUMMARY OF PROCEDURES

6.1 Outdoor Test Procedure

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

6.2 NCAR Snowmaker Operation

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

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

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

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

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

1) Empty fluid collection bucket;

2) Prepare and secure ice core;
3) Begin precipitation and **set desired icing intensity**;
4) **Set desired plate temperature** on Omega controller;
5) Clean panels;
6) Apply one litre of fluid to test panel. Type I fluids are at room temperature. Type II and Type IV fluids are at the test air temperature. Fluids are poured using a single–step fluid application;
7) Using Labview "*start experiment*" and **set linear rate function**;
8) Record the start of the endurance time test after fluid is applied;
9) Record crosshair end condition times;
10) Continue testing until at least five crosshairs or 1/3 of the plate have failed; and
11) In Labview "*end experiment*" and record pertinent data in Labview.

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

6.2.1 Plate Temperature Set Point

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

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

6.3 Brix Measurements

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

Brix should be taken at the 15 cm line:

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

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

6.4 Photo Documentation

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

7. DATA FORM

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

8. SAFETY PRECAUTIONS

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

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

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

Attachment I
Test Equipment Checklist

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

Attachment II
NCAR Snowmaker Test Parameters Guidelines

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

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

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

where:

TP – Plate Temperature in °C;

TT – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

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

$$TE <= -5°C$$

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

$$TE = TP - 2°C$$

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

$$TF = TE \pm 3°C$$

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

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

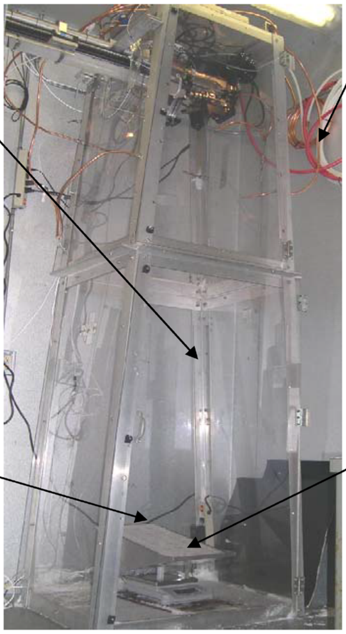
EXAMPLE:

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

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

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

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



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

Example:
T_F = -17.2°C ± 3°C

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

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

***Plate Temperature Equation**

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

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

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

ATTACHMENT III:
Fluid Brix/Thickness Data Form

DATE: ______________

RUN #: ______________

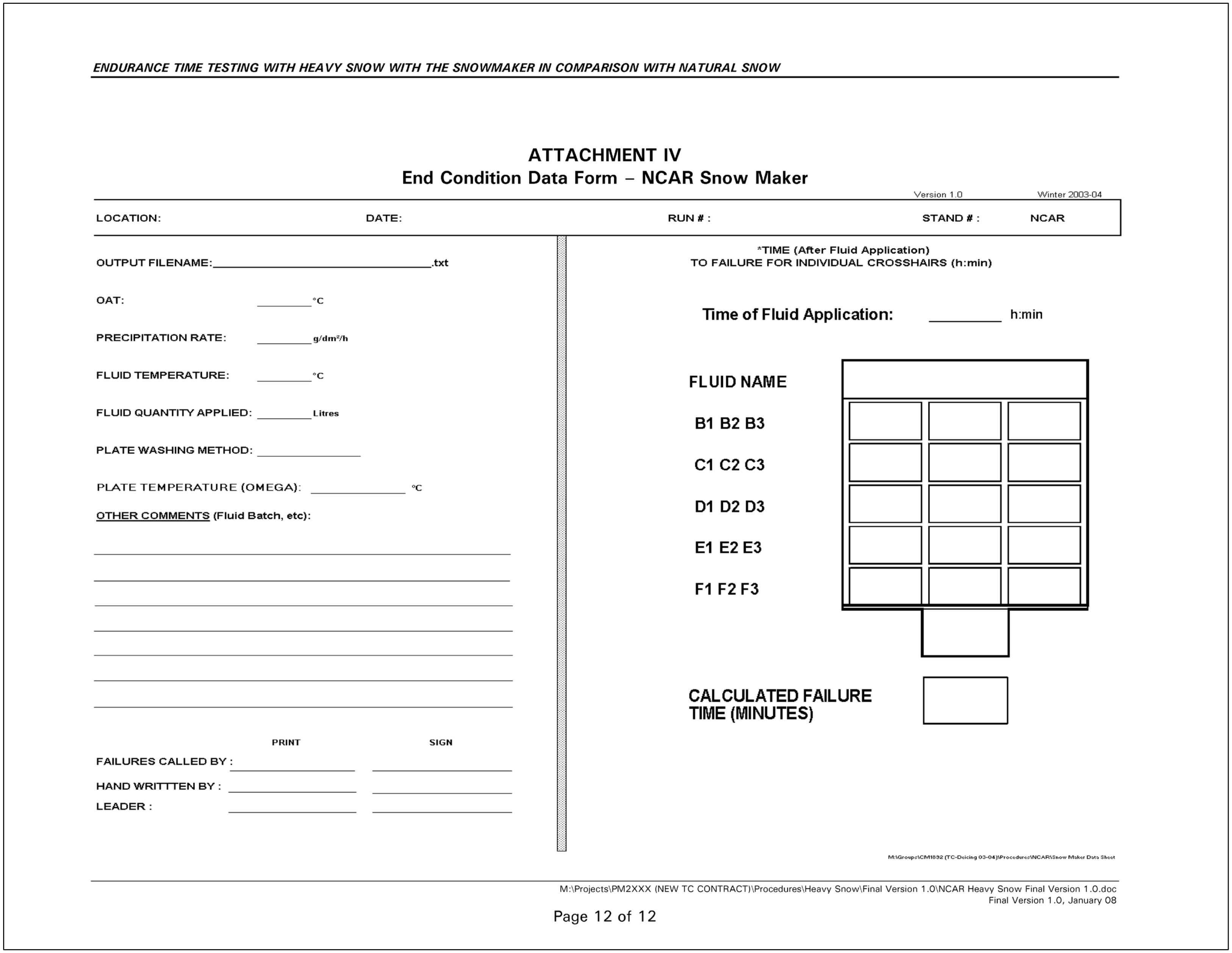
STAND: ______________

PERFORMED BY: ______________

WRITTEN BY: ______________

LOCATION: ______________

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



ATTACHMENT IV
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2003-04

LOCATION:	DATE:	RUN # :	STAND # :	NCAR

OUTPUT FILENAME:______________________________.txt

OAT: _________°C

PRECIPITATION RATE: _________g/dm²/h

FLUID TEMPERATURE: _________°C

FLUID QUANTITY APPLIED: _________Litres

PLATE WASHING METHOD: ________________

PLATE TEMPERATURE (OMEGA): _______________ °C

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

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

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

Time of Fluid Application: __________ h:min

FLUID NAME			
B1 B2 B3			
C1 C2 C3			
D1 D2 D3			
E1 E2 E3			
F1 F2 F3			
CALCULATED FAILURE TIME (MINUTES)			

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

APPENDIX F

PROCEDURE:
EVALUATION OF NEW REGRESSION-BASED PROTOCOL FOR DEVELOPING HOLDOVER TIMES USING SIMULATED SNOW

CM2169.002

PROCEDURE:
EVALUATION OF NEW REGRESSION-BASED PROTOCOL FOR DEVELOPING HOLDOVER TIMES USING SIMULATED SNOW

2009-2010

Prepared for

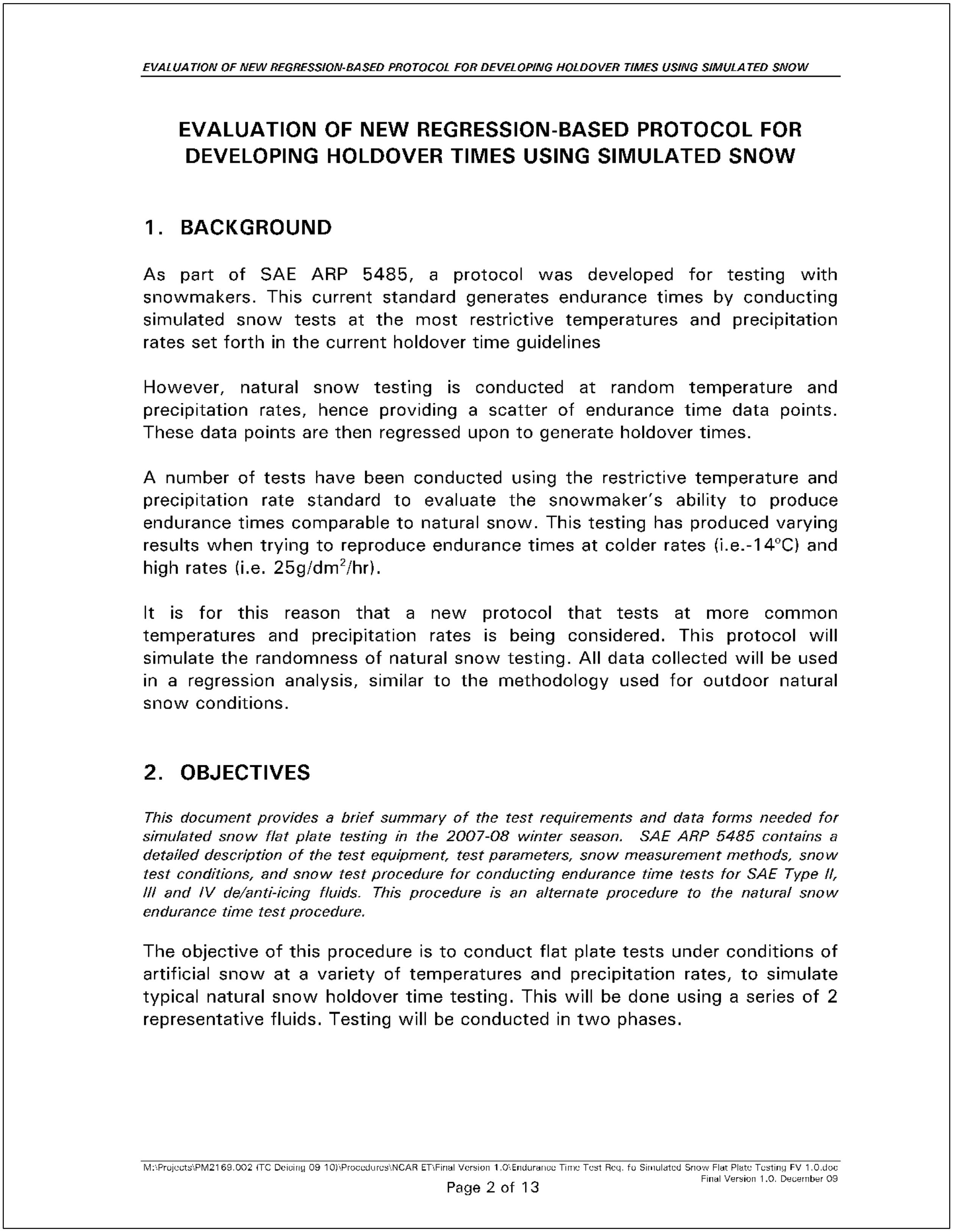
Transportation Development Centre
Transport Canada

Prepared by: David Youssef

Reviewed by: John D'Avirro

APS Aviation Inc.

December 23, 2009
Final Version 1.0



EVALUATION OF NEW REGRESSION-BASED PROTOCOL FOR DEVELOPING HOLDOVER TIMES USING SIMULATED SNOW

1. BACKGROUND

As part of SAE ARP 5485, a protocol was developed for testing with snowmakers. This current standard generates endurance times by conducting simulated snow tests at the most restrictive temperatures and precipitation rates set forth in the current holdover time guidelines

However, natural snow testing is conducted at random temperature and precipitation rates, hence providing a scatter of endurance time data points. These data points are then regressed upon to generate holdover times.

A number of tests have been conducted using the restrictive temperature and precipitation rate standard to evaluate the snowmaker's ability to produce endurance times comparable to natural snow. This testing has produced varying results when trying to reproduce endurance times at colder rates (i.e.-14°C) and high rates (i.e. 25g/dm^2/hr).

It is for this reason that a new protocol that tests at more common temperatures and precipitation rates is being considered. This protocol will simulate the randomness of natural snow testing. All data collected will be used in a regression analysis, similar to the methodology used for outdoor natural snow conditions.

2. OBJECTIVES

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

The objective of this procedure is to conduct flat plate tests under conditions of artificial snow at a variety of temperatures and precipitation rates, to simulate typical natural snow holdover time testing. This will be done using a series of 2 representative fluids. Testing will be conducted in two phases.

2.1 Phase I

In phase I, 26 tests will be conducted using two representative fluids. They are as follows:

- 20 tests will be conducted with Neat fluid; and
- 6 tests will be conducted with 50/50 fluid.

Upon completion of these tests, the data will be analysed. Additional tests may be proposed based upon the results of this analysis.

2.2 Phase II

Depending on the results of phase I, up to an additional 40 tests can be run in phase II. They are as follows:

- 20 tests will be conducted with Neat fluid; and
- 20 tests will be conducted with 75/25 fluid.

3. TEST REQUIREMENTS

Indoor snow tests will be conducted in the refrigerated trailer at the P.E.T test site.

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

4. TEST PLAN

4.1 New Proposed Protocol

The new protocol will conduct tests at random temperatures and rates. In order to construct the new test plan, a dataset of actual natural snow occurrences was reviewed and analyzed. This data was used to select points based on the probability distribution of natural snow.

The constraints of the snowmaker and the current HOT guidelines were also built into this analysis. Therefore, the test plan does not include tests above -5 °C or below -14 °C.

Attachment I contains a detailed test plan.

4.2 Current Protocol

Secondary to the above test plan, additional tests using the current protocol will be conducted. In other words, supplementary tests subject to the specific test conditions outlined in SAE ARP 5485 will be conducted.

It is anticipated that four conditions will be conducted for both neat and 75/25 dilutions, and two conditions for 50/50 dilutions.

An extract from SAE ARP 5485 is included as Attachment II, outlining the snow test conditions that are performed using the snowmaker. For comparison with the new protocol, only test conditions SNW-A, SNW-B, SNW-E, and SNW-F will be conducted.

5. EQUIPMENT

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

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

6. PERSONNEL

One person is required to pour the fluids, call the failure on the plate and take Brix measurements at the 15 cm line after fluid failure and

7. FLUID

Two representative fluids in Neat, 75/25, and 50/50 form will be used in this testing.

- Kilfrost ABC-4^{sustain} will be used for Phase I tests.
- For Phase II tests, a fluid will selected at a later date.

8. SUMMARY OF PROCEDURES

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

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

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

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

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

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

7) Record the start of the endurance time test after fluid is applied;
8) Record crosshair end condition times;
9) Continue testing until at least five crosshairs or 30% of the plate has failed; and
10) In Labview *"end experiment"* and record pertinent data in Labview.

Attachment IV details the setting of the snowmaker tests parameters.

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

9. DATA FORM

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

10. SAFETY PRECAUTIONS

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

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

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

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

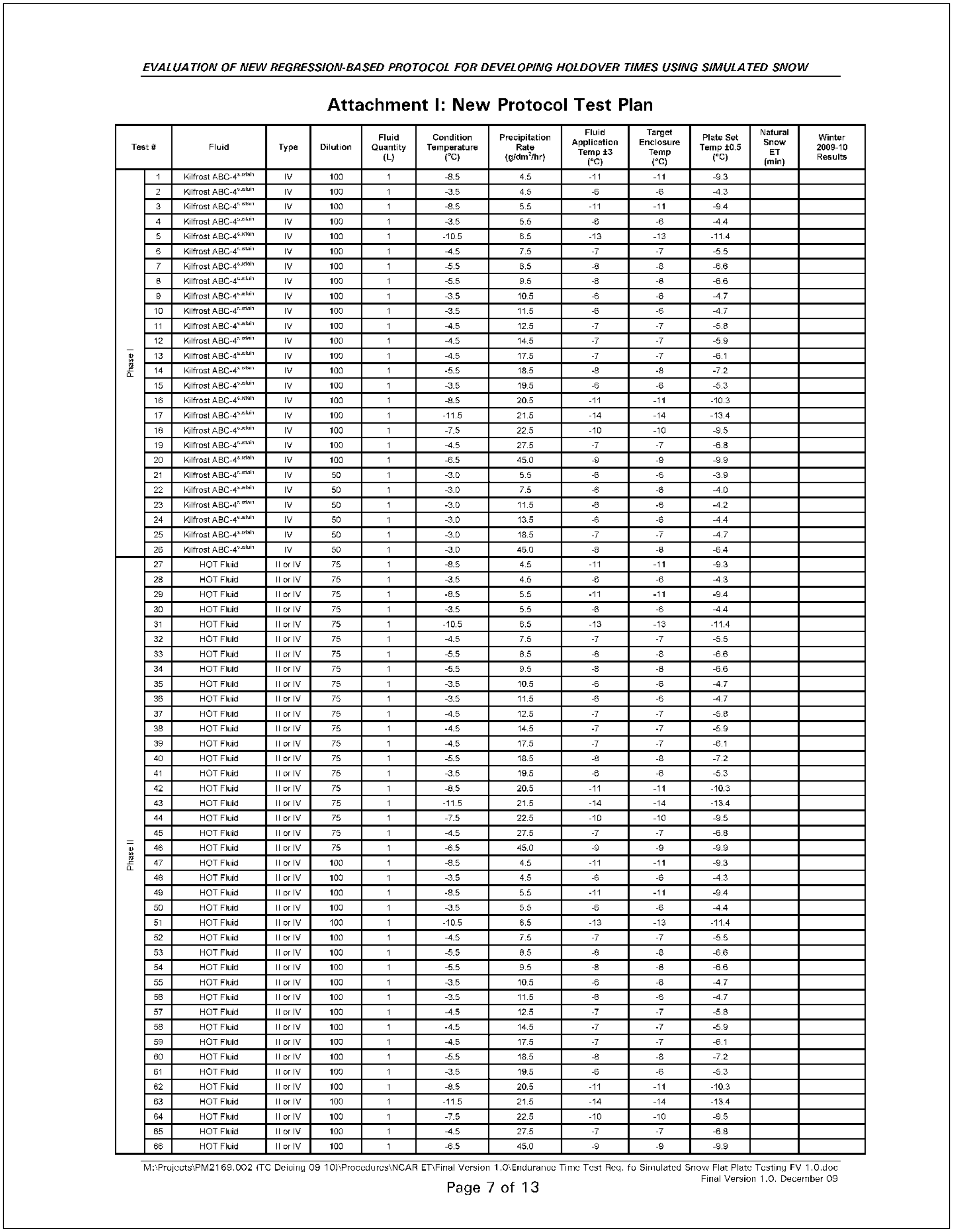
d) Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;

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

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

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

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



Attachment I: New Protocol Test Plan

Test #		Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm^2/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Winter 2009-10 Results
Phase I	1	Kilfrost ABC-4^{sustain}	IV	100	1	-8.5	4.5	-11	-11	-9.3		
	2	Kilfrost ABC-4^{sustain}	IV	100	1	-3.5	4.5	-6	-6	-4.3		
	3	Kilfrost ABC-4^{sustain}	IV	100	1	-8.5	5.5	-11	-11	-9.4		
	4	Kilfrost ABC-4^{sustain}	IV	100	1	-3.5	5.5	-6	-6	-4.4		
	5	Kilfrost ABC-4^{sustain}	IV	100	1	-10.5	6.5	-13	-13	-11.4		
	6	Kilfrost ABC-4^{sustain}	IV	100	1	-4.5	7.5	-7	-7	-5.5		
	7	Kilfrost ABC-4^{sustain}	IV	100	1	-5.5	8.5	-8	-8	-6.6		
	8	Kilfrost ABC-4^{sustain}	IV	100	1	-5.5	9.5	-8	-8	-6.6		
	9	Kilfrost ABC-4^{sustain}	IV	100	1	-3.5	10.5	-6	-6	-4.7		
	10	Kilfrost ABC-4^{sustain}	IV	100	1	-3.5	11.5	-6	-6	-4.7		
	11	Kilfrost ABC-4^{sustain}	IV	100	1	-4.5	12.5	-7	-7	-5.8		
	12	Kilfrost ABC-4^{sustain}	IV	100	1	-4.5	14.5	-7	-7	-5.9		
	13	Kilfrost ABC-4^{sustain}	IV	100	1	-4.5	17.5	-7	-7	-6.1		
	14	Kilfrost ABC-4^{sustain}	IV	100	1	-5.5	18.5	-8	-8	-7.2		
	15	Kilfrost ABC-4^{sustain}	IV	100	1	-3.5	19.5	-6	-6	-5.3		
	16	Kilfrost ABC-4^{sustain}	IV	100	1	-8.5	20.5	-11	-11	-10.3		
	17	Kilfrost ABC-4^{sustain}	IV	100	1	-11.5	21.5	-14	-14	-13.4		
	18	Kilfrost ABC-4^{sustain}	IV	100	1	-7.5	22.5	-10	-10	-9.5		
	19	Kilfrost ABC-4^{sustain}	IV	100	1	-4.5	27.5	-7	-7	-6.8		
	20	Kilfrost ABC-4^{sustain}	IV	100	1	-6.5	45.0	-9	-9	-9.9		
	21	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	5.5	-6	-6	-3.9		
	22	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	7.5	-6	-6	-4.0		
	23	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	11.5	-6	-6	-4.2		
	24	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	13.5	-6	-6	-4.4		
	25	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	18.5	-7	-7	-4.7		
	26	Kilfrost ABC-4^{sustain}	IV	50	1	-3.0	45.0	-8	-8	-6.4		
Phase II	27	HOT Fluid	II or IV	75	1	-8.5	4.5	-11	-11	-9.3		
	28	HOT Fluid	II or IV	75	1	-3.5	4.5	-6	-6	-4.3		
	29	HOT Fluid	II or IV	75	1	-8.5	5.5	-11	-11	-9.4		
	30	HOT Fluid	II or IV	75	1	-3.5	5.5	-6	-6	-4.4		
	31	HOT Fluid	II or IV	75	1	-10.5	6.5	-13	-13	-11.4		
	32	HOT Fluid	II or IV	75	1	-4.5	7.5	-7	-7	-5.5		
	33	HOT Fluid	II or IV	75	1	-5.5	8.5	-8	-8	-6.6		
	34	HOT Fluid	II or IV	75	1	-5.5	9.5	-8	-8	-6.6		
	35	HOT Fluid	II or IV	75	1	-3.5	10.5	-6	-6	-4.7		
	36	HOT Fluid	II or IV	75	1	-3.5	11.5	-6	-6	-4.7		
	37	HOT Fluid	II or IV	75	1	-4.5	12.5	-7	-7	-5.8		
	38	HOT Fluid	II or IV	75	1	-4.5	14.5	-7	-7	-5.9		
	39	HOT Fluid	II or IV	75	1	-4.5	17.5	-7	-7	-6.1		
	40	HOT Fluid	II or IV	75	1	-5.5	18.5	-8	-8	-7.2		
	41	HOT Fluid	II or IV	75	1	-3.5	19.5	-6	-6	-5.3		
	42	HOT Fluid	II or IV	75	1	-8.5	20.5	-11	-11	-10.3		
	43	HOT Fluid	II or IV	75	1	-11.5	21.5	-14	-14	-13.4		
	44	HOT Fluid	II or IV	75	1	-7.5	22.5	-10	-10	-9.5		
	45	HOT Fluid	II or IV	75	1	-4.5	27.5	-7	-7	-6.8		
	46	HOT Fluid	II or IV	75	1	-6.5	45.0	-9	-9	-9.9		
	47	HOT Fluid	II or IV	100	1	-8.5	4.5	-11	-11	-9.3		
	48	HOT Fluid	II or IV	100	1	-3.5	4.5	-6	-6	-4.3		
	49	HOT Fluid	II or IV	100	1	-8.5	5.5	-11	-11	-9.4		
	50	HOT Fluid	II or IV	100	1	-3.5	5.5	-6	-6	-4.4		
	51	HOT Fluid	II or IV	100	1	-10.5	6.5	-13	-13	-11.4		
	52	HOT Fluid	II or IV	100	1	-4.5	7.5	-7	-7	-5.5		
	53	HOT Fluid	II or IV	100	1	-5.5	8.5	-8	-8	-6.6		
	54	HOT Fluid	II or IV	100	1	-5.5	9.5	-8	-8	-6.6		
	55	HOT Fluid	II or IV	100	1	-3.5	10.5	-6	-6	-4.7		
	56	HOT Fluid	II or IV	100	1	-3.5	11.5	-6	-6	-4.7		
	57	HOT Fluid	II or IV	100	1	-4.5	12.5	-7	-7	-5.8		
	58	HOT Fluid	II or IV	100	1	-4.5	14.5	-7	-7	-5.9		
	59	HOT Fluid	II or IV	100	1	-4.5	17.5	-7	-7	-6.1		
	60	HOT Fluid	II or IV	100	1	-5.5	18.5	-8	-8	-7.2		
	61	HOT Fluid	II or IV	100	1	-3.5	19.5	-6	-6	-5.3		
	62	HOT Fluid	II or IV	100	1	-8.5	20.5	-11	-11	-10.3		
	63	HOT Fluid	II or IV	100	1	-11.5	21.5	-14	-14	-13.4		
	64	HOT Fluid	II or IV	100	1	-7.5	22.5	-10	-10	-9.5		
	65	HOT Fluid	II or IV	100	1	-4.5	27.5	-7	-7	-6.8		
	66	HOT Fluid	II or IV	100	1	-6.5	45.0	-9	-9	-9.9		

Attachment II: Current Protocol
Snow Test Conditions
(Extract of Proposed ARP 5485)

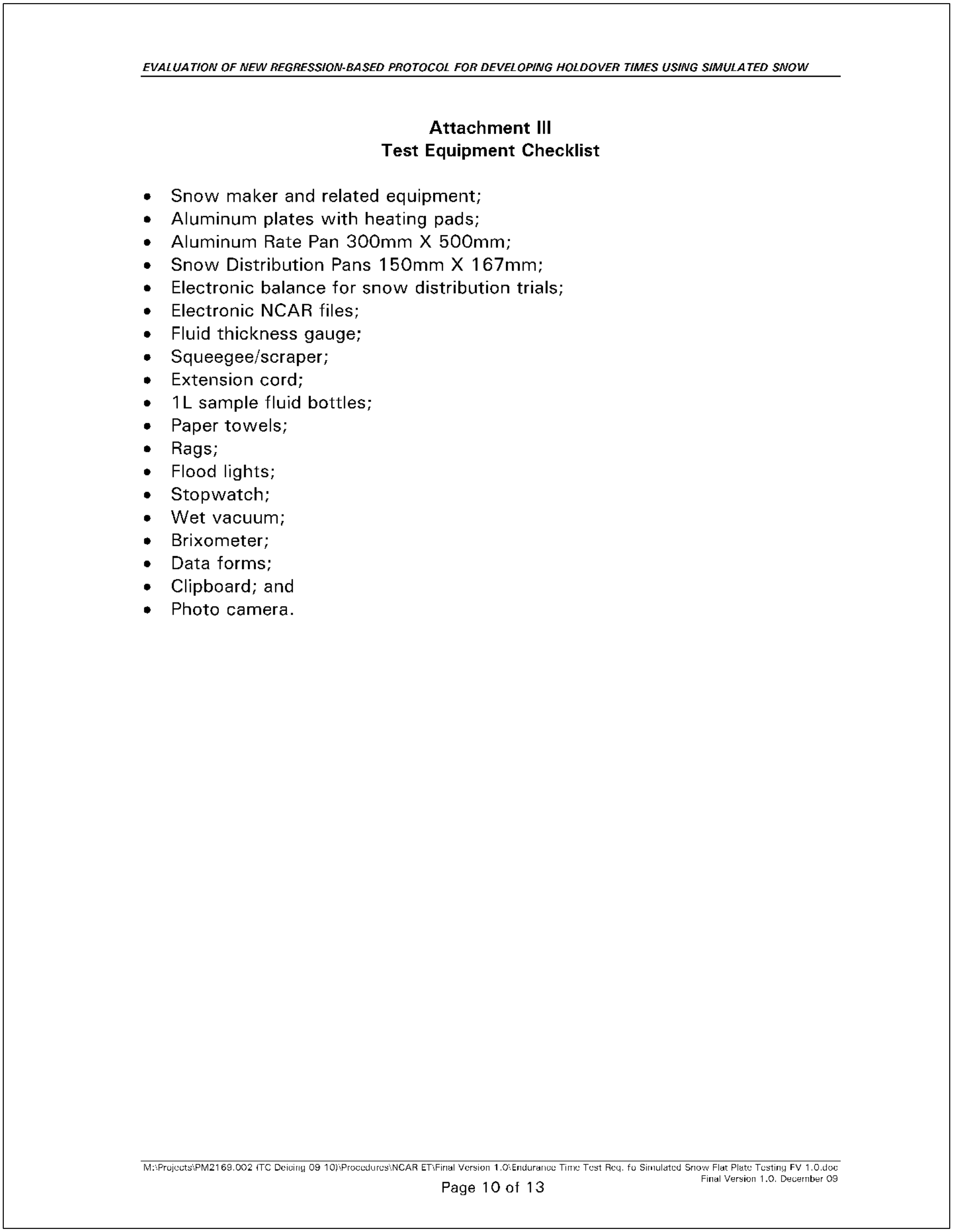
Test Condition	SNW-A	SNW-B	SNW-C	SNW-D	SNW-E	SNW-F	SNW-G	SNW-H
Types II and IV, neat	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes	No	No	Yes	Yes	No	No
Types II and IV, 50/50 (neat fluid/water)	Yes	Yes	No	No	No	No	No	No
Types III, neat	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Types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

*after stabilization, typically 5 minutes

***Note:** Shaded columns pertain to testing for this procedure.*

Attachment II (Cont.): Current Protocol
Artificial Snow Test Matrix

Test #	Test Condition	Dilution	Condition Temperature (°C)	Plate Temperature (°C)	Snow Intensity (g/dm²/hr)	Notes
1	SNW-A	100	-3	-4.2	10	
2	SNW-B	100	-3	-5.1	25	
3	SNW-A	75	-3	-4.2	10	
4	SNW-B	75	-3	-5.1	25	
5	SNW-A	50	-3	-4.2	10	
6	SNW-B	50	-3	-5.1	25	
7	SNW-E	100	-14	-15.2	10	
8	SNW-F	100	-14	-16.1	25	
9	SNW-E	75	-14	-15.2	10	
10	SNW-F	75	-14	-16.1	25	



Attachment III
Test Equipment Checklist

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

Attachment IV
NCAR Snowmaker Test Parameters Guidelines

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

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

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

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

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

$$T_E <= -5°C$$

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

$$T_E = T_P - 2°C$$

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

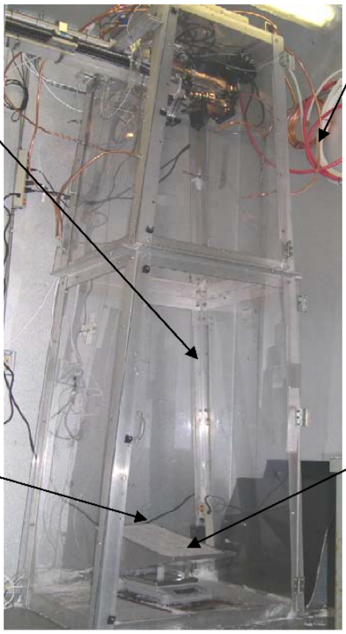
$$T_F = T_E \pm 3°C$$

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

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

EXAMPLE:

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



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

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

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

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

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

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

Example:
T_F = -17.2°C ± 3°C

***Plate Temperature Equation**

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

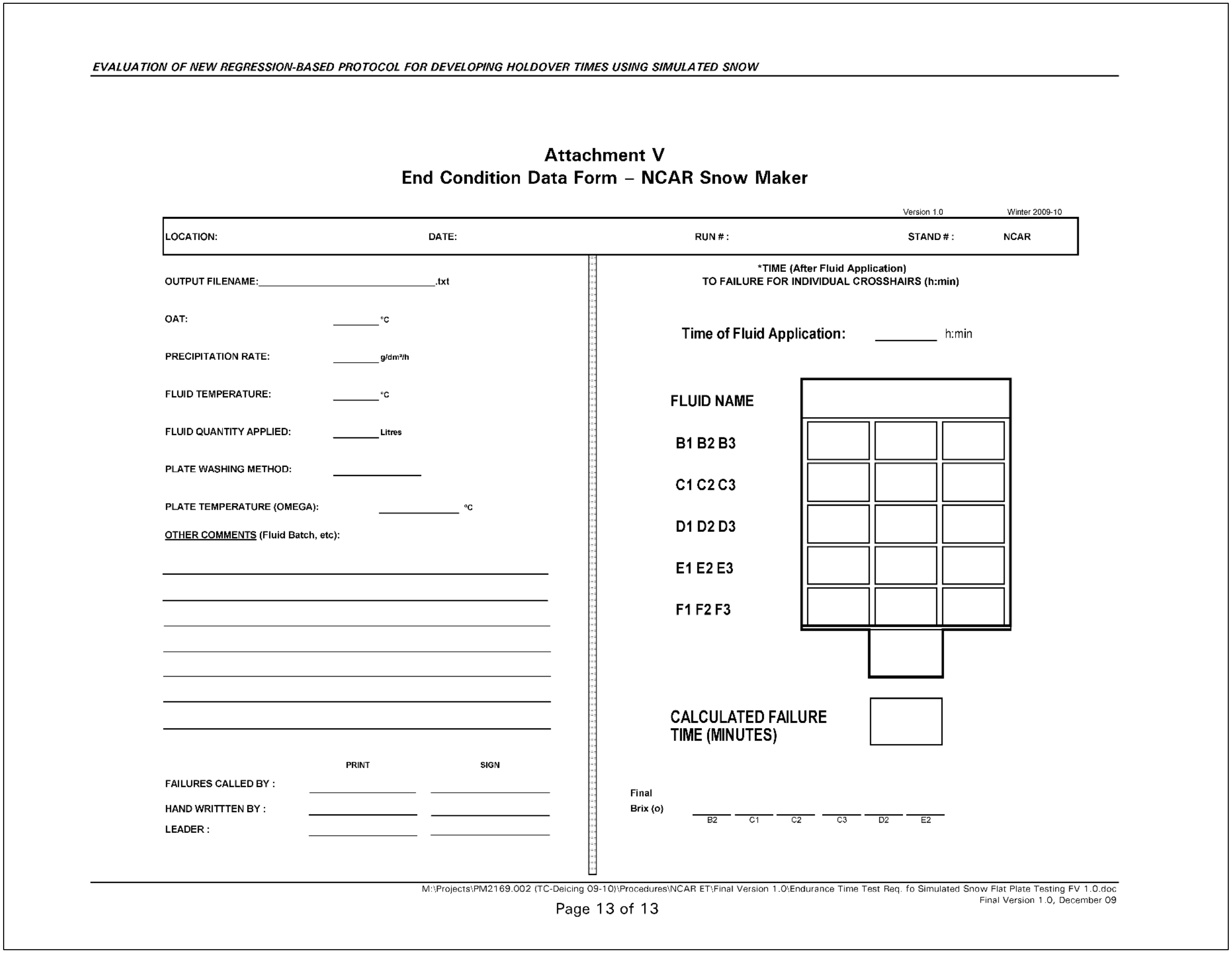
$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).



Attachment V
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2009-10

LOCATION: DATE: RUN # : STAND # : NCAR

OUTPUT FILENAME:____________________________.txt

OAT: ________°C

PRECIPITATION RATE: ________g/dm²/h

FLUID TEMPERATURE: ________°C

FLUID QUANTITY APPLIED: ________Litres

PLATE WASHING METHOD: ____________

PLATE TEMPERATURE (OMEGA): ____________ °C

OTHER COMMENTS (Fluid Batch, etc):

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

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

Time of Fluid Application: ________ h:min

FLUID NAME

B1 B2 B3

C1 C2 C3

D1 D2 D3

E1 E2 E3

F1 F2 F3

CALCULATED FAILURE TIME (MINUTES)

Final
Brix (o)

B2	C1	C2	C3	D2	E2

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Final Version 1.0, December 09

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APPENDIX G

ROGIDS PROBLEM DEFINITION

ADDITIONAL ROGIDS APPLICATIONS: PROBLEM DEFINITION

Sept 23, 2010

1. DEFINITION OF PROBLEM: (End of Runway Application)

- Unreliable assessment of the wing during pre-takeoff checks due to:
    - Difficulty seeing through passenger windows (presence of precipitation and/or de/anti-icing fluids, scratched plexiglass, etc.).
        - Need to look over 2-3 passenger seats
    - Poor visibility due to poor lighting conditions (nighttime, etc.) and/or weather conditions.
    - Subjectiveness of viewing, training of crew, etc.
    - Inability to evaluate the entire wing or the most critical part of the wing (which can change); only a portion is evaluated due to inability to see entire wing (or due to “representative surface” training).
    - Cargo carriers may not be able to see wing surface from inside the aircraft
    - Pilots of high-wing aircraft can not see wings from inside the aircraft
- The current process (pre-takeoff contamination checks from inside aircraft) is time-consuming and subjective, and possibly over-conservative (too many pilot checks, throughput unnecessarily reduced).
- There can be commercial or self-imposed pressure on pilots to takeoff (from airlines, airports, passengers).
- The current de/anti-icing process sometimes fails. Four ways it may fail:
    - Failing to realize that there is ice, or that the ice present is dangerous, so no deicing takes place
        - Most incidents fall into this category
        - Fokker France January 2007 accident
        - Air Canada Grand Forks incident (media report) October 2009
    - Aircraft is deiced, HOT respected, but contamination is present at takeoff
        - 767 with ice on wings during flight
        - Airbus 330/340 Frankfurt (cold-soaked wing deiced with fluid mixed for OAT, fluid froze)
        - Could be incomplete / asymmetrical deicing
    - Aircraft is deiced, contamination is removed, but HOT exceeded
        - Fokker 28 LaGuardia 1992 accident (Type I)
        - Other accidents under investigation
    - Weather conditions change quickly, “wrong” HOT used
        - Bombardier Moscow Feb 2007 accident (moderate snow assumed, actual conditions heavy snow showers; Clariant Type I/II)
    - Contamination accumulates after pre-deicing inspection completed (frost)
    - Accident Safety Reporting (ASR) from airlines may provide “incident” statistics (Action item: Working group to try to obtain data)
- Definition of fluid failure is unknown/unclear among pilots
    - Fluid failure is subjective and individuals who currently determine fluid failure during HOT development rely heavily on extensive experience
    - Fluid failure looks very different depending on fluid type, fluid brand, OAT, precipitation type and precipitation rate

    - Current training (text / pictures) is not adequate to educate pilots to the level required by the variables above
    - Even if training could be made adequate, the distance to the wing is a large obstacle and makes identifying fluid failure very difficult

2. **DEFINITION OF PROBLEM (Engine Icing Application)**

- Ice accumulates on fan blades (front and back) and bottom of inlet
- Note: Engines are a critical surface and therefore must be inspected for contamination
- Three opportunities to inspect for this ice:
    - At gate: part of walk-around inspection (by pilot or maintenance, make sure no ice accumulation in engine, spin fan).
    - At CDF: as part of deicing process
    - At End of Runway: due to additional accumulation of ice during taxi
- Current solution (fan blade ice): engine runup
    - Weakness: there are practical difficulties with this practice (jet blast)
- Current solution (inlet ice): brush out contamination or use hot air, light spray at top of cowling and let it run down (fluid goes through fan not core)

3. **DEFINITION OF PROBLEM (Pre-Deicing Application)**

- Inspection required to check for presence of contamination (including frost) on wings, engines and other critical surfaces to determine if deicing required
- Current solution: walk-around inspection (by pilot or maintenance, make sure no contamination on wings, critical surfaces, engine).
    - Weakness: Limited by ability to see/inspect some surfaces.
    - Weakness: Limited ability to do complete visual and/or tactile check of all surfaces.
    - Weakness: Contamination may occur after the check is completed, but before takeoff.

4. **RECOMMENDED SOLUTION**

- Solution (End of Runway): Approving the use of GIDS for pre-takeoff contamination checks
- Solution (Engine Icing): Provide guidance material (SAE Aerospace Recommended Practice, possibly Advisory Circular)
- Solution (Pre-Deicing): Approving the use of GIDS for pre-deicing inspections

5. **POTENTIAL BENEFITS (End of Runway)**

- Benefit: Improving safety
    - Remove subjectivity from determining fluid failure
    - Giving pilots more confidence in wing condition / removing one subjective decision
    - Standardize inspections between airlines / pilots (i.e. catch aircraft that bypass deicing)
    - Enabling pre-takeoff checks for high-wing and cargo aircraft
    - Making pre-takeoff contamination checks more feasible for all aircraft
    - The conditions of the aircraft will be recorded (i.e. if contamination present, pilot chooses to takeoff, accident occurs… evidence is available. The information can also be used to assess the pilot's decision following an incident).

- Benefit: Cost savings / operational benefits
    - Preventing unnecessary multiple deicings with associated fluid, fuel and other IROPS (irregular operations) savings by confirming when/if fluid is still good even if HOT is exceeded.
    - Increasing airport through-put
        - Increasing the probability of using all available take-off slots by having a more efficient number of aircraft in takeoff queue following deicing (when estimating throughput you can use actual holdover time instead of predicted worst-case holdover time).
    - Potentially decreasing use of Type IV fluid
        - Pilots are concerned with HOT so take Type IV fluid as a precautionary measure (or want to avoid doing an inspection so take Type IV to extend time until inspection required); will be more willing to use Type I only
    - Potential safety enhancement related to FAA pre-takeoff contamination check – "5 minute rule" – especially related to Type I fluids and Type II/IV fluids in conditions where they have shorter holdover times.
- Benefit: Process validation / improvement

6. POTENTIAL BENEFITS (Engine Icing Application)

- Benefit: Reducing damage to fan blades and engines (cost savings)
- Benefit: Improving safety (decreasing risk of engine failure during takeoff)
- Benefit: Improving health and safety of maintenance staff
- Benefit: Creating accessibility to aft-mounted engines
- Benefit: Preventing delays (cost savings)
- Benefit: Process validation / improvement

7. POTENTIAL BENEFITS (Pre-Deicing Application)

- Benefit: Reducing unnecessary de/anti-icings (cost savings, environmental benefits, airport flow improvements)
- Benefit: Safety improvement (decreasing risk of takeoff by contaminated aircraft)
- Benefit: Process validation / improvement

8. RESEARCH REQUIRED (End of Runway Application)

- Operational issues:
    - Do current airport standards allow setup of GIDS near taxiway/runway? Look at regulation of acceptable zones.
    - How will information be communicated to pilot?
    - What information will be communicated? i.e. a picture, red/green, go/no go, score (i.e. 0-100)?
    - How will information be interpreted and by who?
    - Who will make final go/no go decision based on the ROGIDS report?
- Feasibility tests to identify if ROGIDS can correlate with visual failure calls
    - Work to correlate between HOT test (1/3 plate), 10% coverage of actual wing, and ROGIDS "red light / green light", i.e. if it detects 10% contaminated surface of wing (regardless of adherence) it would give red light.
    - Several thresholds may be required: fluid, non-fluid, frost

- Analysis of heldover time
- Air operator/pilot surveys/benefits summary
- Operational tests with airline to document what's on aircraft prior to takeoff
- Determine detection abilities of pilots
- Develop preliminary thresholds
- Consultations/tests to confirm thresholds
- Tune ROGIDS to correlate with visual failure calls (to be reviewed as part of Project Plan steps document, may be removed)

9. RESEARCH REQUIRED (Engine Icing Application)

- Determine the details of the problem:
    - Research why it is happening, other solutions, possible preventative measures, potential outcomes
- Gather operational information:
    - engine information (location, heights), how ROGIDS would be used (process) and what shape it would take (how to present information to user, which information to provide)
- Determine if different embodiments are needed for where you use it (at gate, CDF and EOR) and what you are looking for (ice on blades, ice in bottom of inlet)
- Threshold detection testing (frost, ice)
- Lab research (simulate inlet ice and ice behind fan blades)
- Field research (to see how the camera works)

10. RESEARCH REQUIRED (Pre-Deicing Application)

- Threshold detection testing (frost, ice)
- Research to determine what is the critical frost / ice level that is aerodynamically acceptable

11. POTENTIAL REGULATORY IMPLICATIONS

- Who operates the system?
- Who polices the system?
- Is the information recorded?
- Is the system mandated for use? by regulators?
- Validity of GIDS results for Type I fluids: may be an implication for regulations due to
    - Transport Canada's 5 minute rule
    - the speed of failure of Type I fluid in some conditions
    - the location of GIDS and amount of time from GIDS check to takeoff

APPENDIX H

FLIGHT CREW SURVEY (CANADIAN)

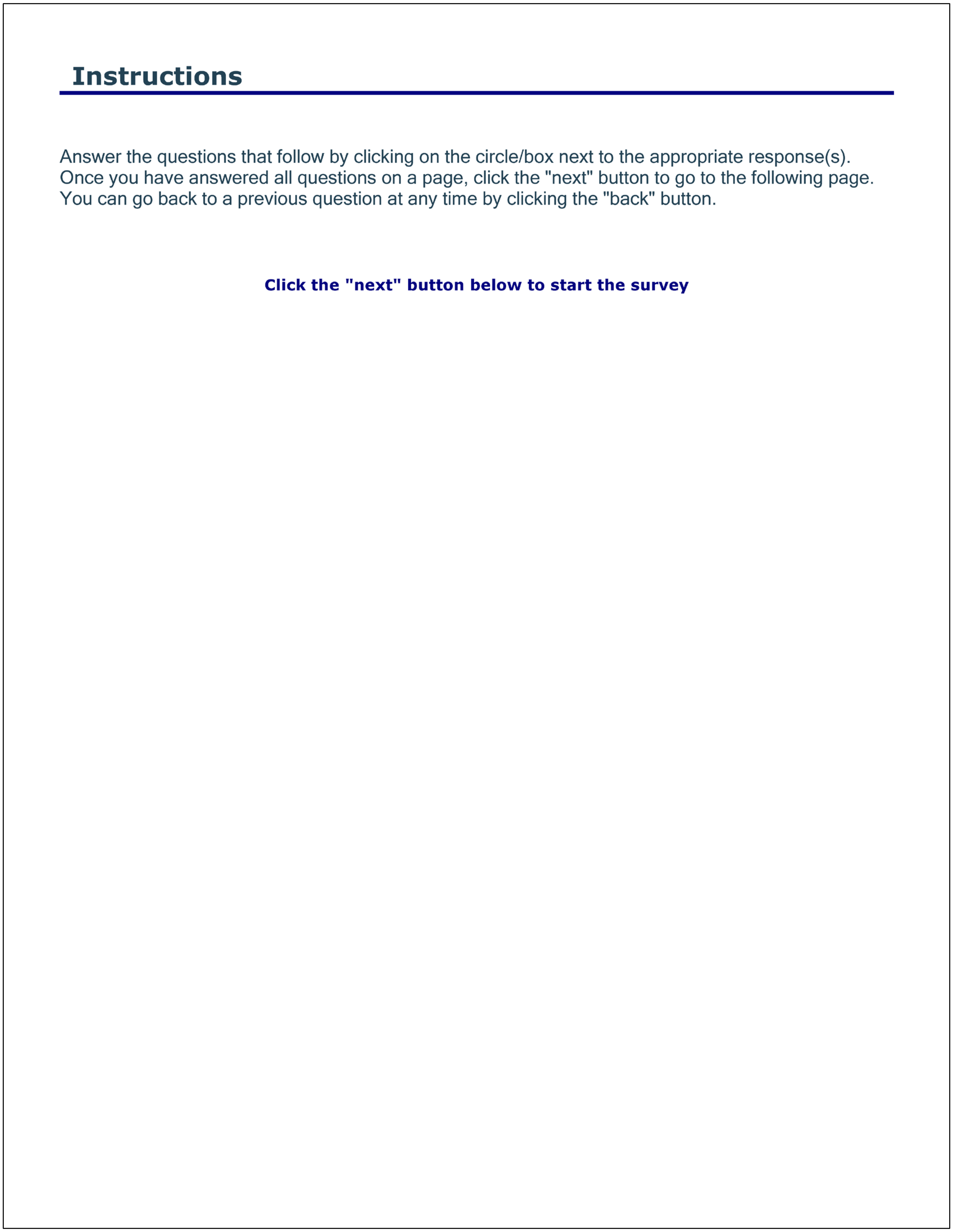
Flight Crew Survey on Pre-Take-Off Contamination Inspections

In recent years there has been an increasing demand to find an alternative to the current methods used to perform pre-take-off contamination inspections. The SAE G-12 Aircraft Ice Detection Committee - with representatives from Transport Canada, the FAA, air operators, pilots and deicing service providers - is conducting a survey to gain a better understanding of the operational practices flight crews currently use to conduct these inspections.

We would be grateful if you could spend 5-10 minutes completing this survey so that we can learn from your operational experiences and gather your feedback on a new technology. Your participation will assist industry leaders and government regulators assess the potential advances in safety that could be gained by the development and operational approval of this technology.

NOTICE OF CONFIDENTIALITY: *This survey is being conducted confidentially. Your responses are anonymous and can't be linked to you.*

TECHNICAL SUPPORT: *For technical support please contact the Survey Administrator, Stephanie Bendickson, at sbendickson@telus.net.*



Instructions

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 the "next" button to go to the following page. You can go back to a previous question at any time by clicking the "back" button.

Click the "next" button below to start the survey

Pre-Take-off Contamination Inspections

Q1 Have you ever conducted a pre-take-off contamination inspection on your aircraft?

○ Yes
○ No

If "no" go to Q8

Q2 From where does your company (you or others) conduct pre-take-off inspections? Select any/all that apply.

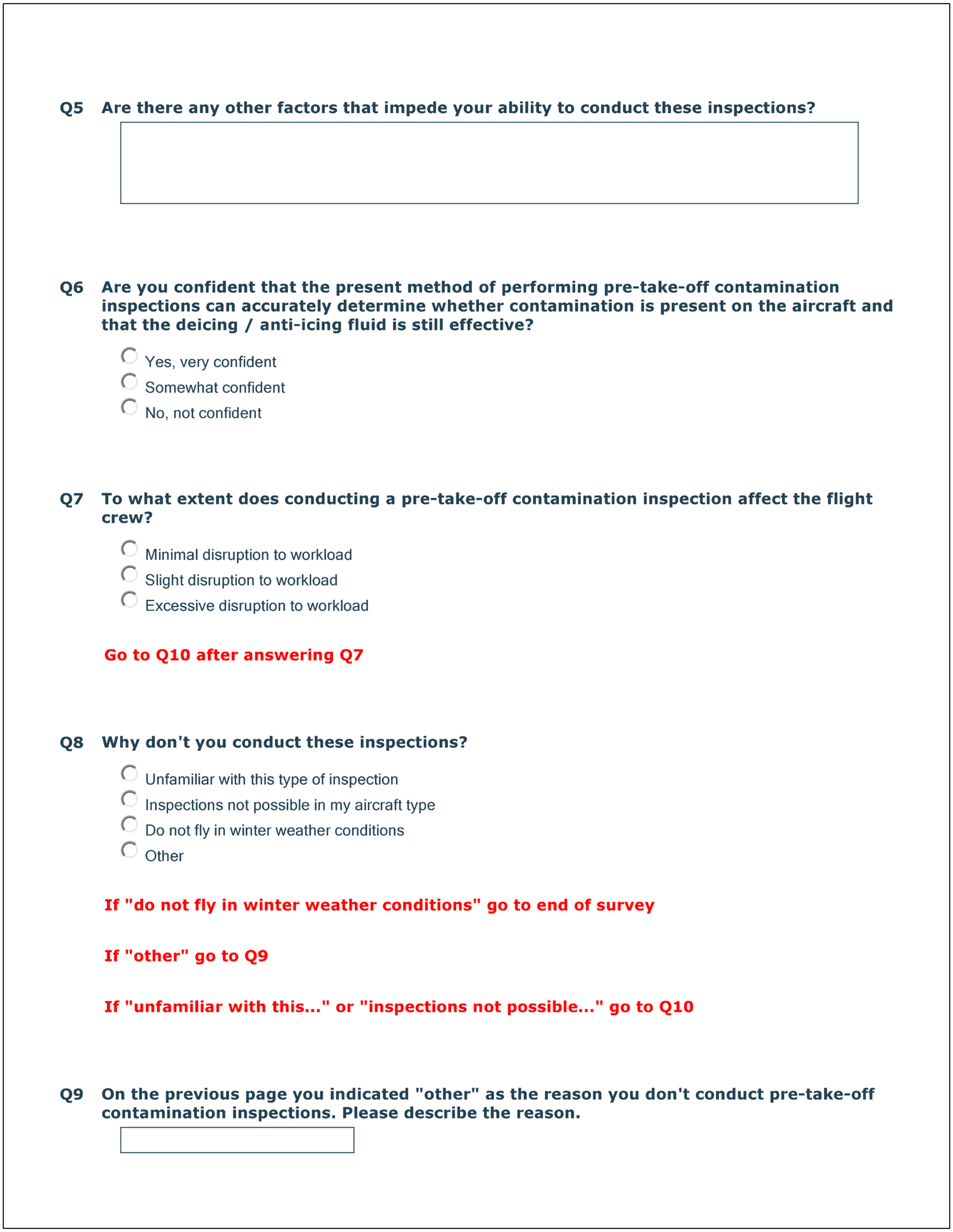
☐ Cockpit / flight deck
☐ Cabin
☐ Outside the aircraft
☐ Other (specify below)

Other, specify:

Q3 What area(s) of the aircraft do you inspect when performing a pre-take-off contamination inspection? Please be as specific as possible.

Q4 Do any of the following impede your ability to conduct these inspections? Select any/all that apply.

☐ Inadequate lighting (night time visibility, insufficient artificial lighting)
☐ Cabin configuration (difficulty seeing wing due to location of passengers and cabin windows)
☐ No windows in cabin
☐ High wing configuration
☐ Large distances to wing tips
☐ Crazed windows
☐ Visibility impeded by winter precipitation
☐ Visibility impeded by de/anti-icing fluid
☐ Time constraints
☐ Uncertainty in what to look for
☐ None of the above



Q5 Are there any other factors that impede your ability to conduct these inspections?

Q6 Are you confident that the present method of performing pre-take-off contamination inspections can accurately determine whether contamination is present on the aircraft and that the deicing / anti-icing fluid is still effective?

○ Yes, very confident
○ Somewhat confident
○ No, not confident

Q7 To what extent does conducting a pre-take-off contamination inspection affect the flight crew?

○ Minimal disruption to workload
○ Slight disruption to workload
○ Excessive disruption to workload

Go to Q10 after answering Q7

Q8 Why don't you conduct these inspections?

○ Unfamiliar with this type of inspection
○ Inspections not possible in my aircraft type
○ Do not fly in winter weather conditions
○ Other

If "do not fly in winter weather conditions" go to end of survey

If "other" go to Q9

If "unfamiliar with this..." or "inspections not possible..." go to Q10

Q9 On the previous page you indicated "other" as the reason you don't conduct pre-take-off contamination inspections. Please describe the reason.

Repeat De/Anti-icing Operations

Q10 After being deiced and/or anti-iced and having departed the gate/pad/deicing centre, have you ever had to request a second de/anti-icing be conducted?

○ Yes
○ No

If "no" go to Q19

How many times you have had to request a second de/anti-icing for each of the reasons given below?

		Never	1	2	3	4	5	6-10	11-15	16-20	> 20
Q11	Holdover time expired	○	○	○	○	○	○	○	○	○	○
Q12	Flight crew OBSERVED contamination	○	○	○	○	○	○	○	○	○	○
Q13	Flight crew SUSPECTED contamination (i.e. flight crew unable to determine aircraft was clean)	○	○	○	○	○	○	○	○	○	○
Q14	Cabin crew / passenger reported contamination	○	○	○	○	○	○	○	○	○	○
Q15	Weather changed and take-off was deemed unsafe	○	○	○	○	○	○	○	○	○	○
Q16	Exceeded the requirement to become airborne within 5 minutes of contamination inspection	○	○	○	○	○	○	○	○	○	○
Q17	Other (specify below)		○	○	○	○	○	○	○	○	○

Q18

Q19 How do you identify de/anti-icing fluid failure? This can be based on any training you have received and/or on your personal experience. Please select any/all that apply.

☐ Build-up of ice crystals in or on the fluid
☐ Loss of colour in fluid
☐ Buildup of snow on fluid
☐ Ice or slush in fluid
☐ Progressive surface freezing
☐ Dulling of surface reflectivity (loss of gloss)
☐ Other (specify below)

Other, specify:

Q20 Does your company provide training to help you identify when de/anti-icing fluids have failed?

○ Yes
○ No

If "no" go to Q23

Q21 Briefly describe the de/anti-icing fluid failure training you receive (i.e. pictures, descriptions, demonstrations, etc.)

Q22 Do you feel this training adequately prepares you to conduct an accurate de/anti-icing fluid failure inspection in operations?

○ Yes
○ No

Potential Use of ROGIDS

*Remote on-ground ice detection systems (ROGIDS) are currently being developed to check for ice during **post-deicing checks** (checks conducted immediately following deicing). Further development may allow the use of ROGIDS to replace the **pre-take-off contamination inspection** (ROGIDS equipment would be installed near the end of the runway).*

Q23 Assuming ROGIDS are proven to have the ability to accurately determine de/anti-icing fluid failure, would you support their use as an alternative to flight crews performing pre-take-off contamination inspections?

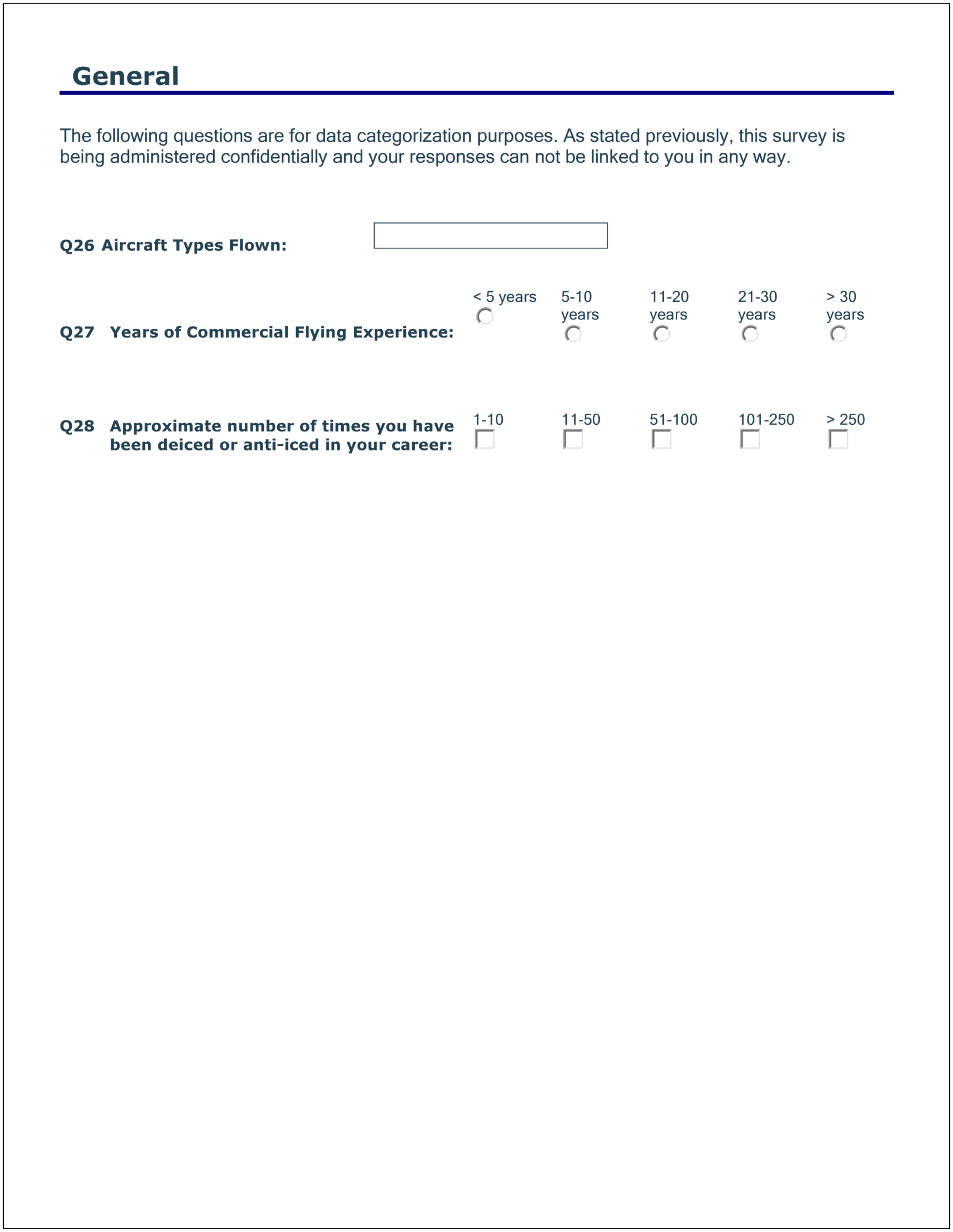
○ Yes, I would allow ROGIDS to replace my pre-take-off contamination inspection
○ Yes, I would use ROGIDS in conjunction with my pre-take-off contamination inspection
○ No, I would not support the use of ROGIDS for this application (please explain why below)

Q24 The information available from ROGIDS could be provided to flight crews in a number of ways. What do you think flight crews would prefer?

○ A go/no go system
○ A picture showing contamination on the examined part of the aircraft
○ Other (specify below)

Other, specify:

Q25 The development and regulatory approval of ROGIDS for this application may take several years. Do you have any suggestions for alternate methods/procedures/equipment that could improve the inspection process in the interim?

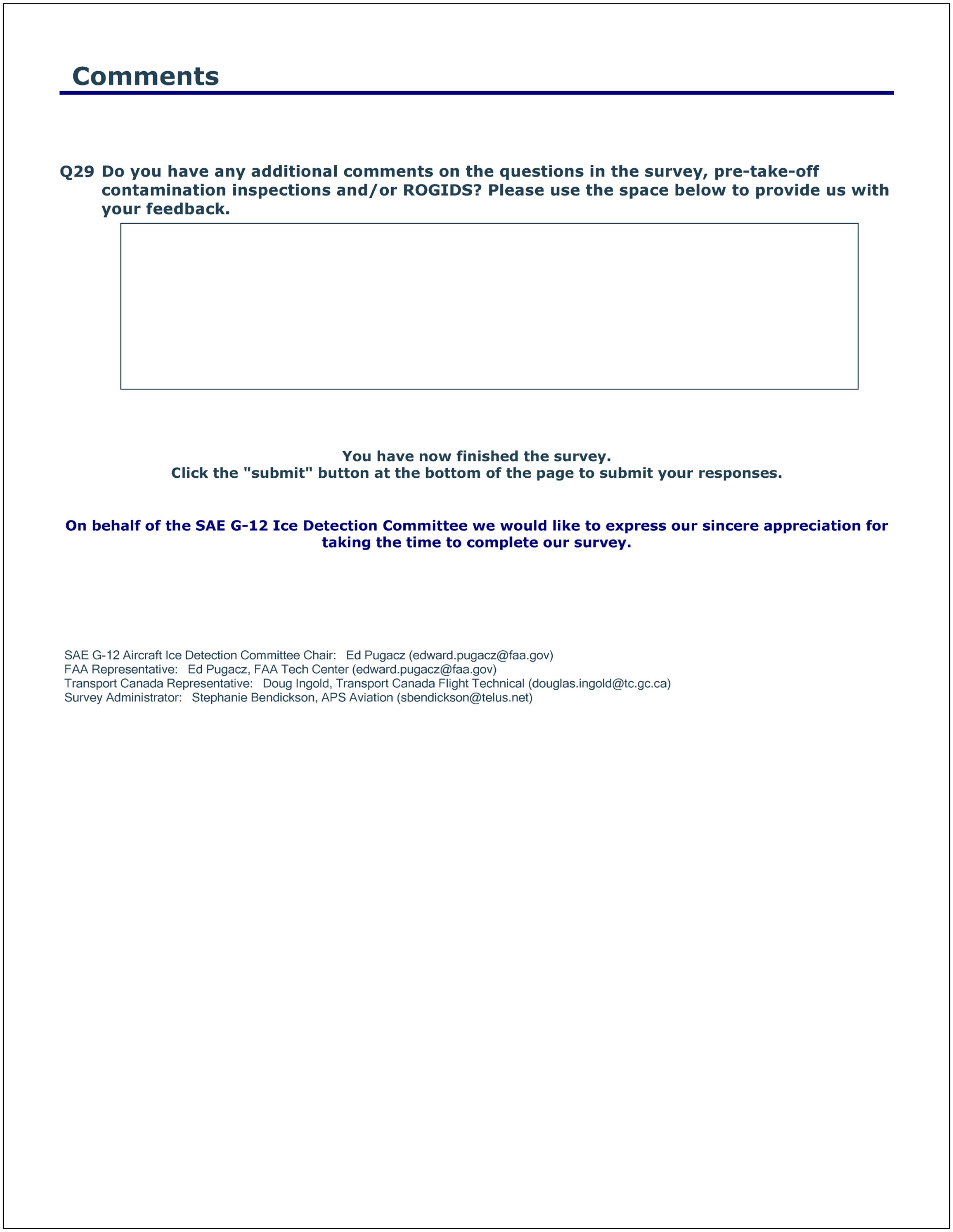


General

The following questions are for data categorization purposes. As stated previously, this survey is being administered confidentially and your responses can not be linked to you in any way.

Q26 Aircraft Types Flown: ☐

Q27 Years of Commercial Flying Experience:	< 5 years ○	5-10 years ○	11-20 years ○	21-30 years ○	> 30 years ○
Q28 Approximate number of times you have been deiced or anti-iced in your career:	1-10 ☐	11-50 ☐	51-100 ☐	101-250 ☐	> 250 ☐



Comments

Q29 Do you have any additional comments on the questions in the survey, pre-take-off contamination inspections and/or ROGIDS? Please use the space below to provide us with your feedback.

You have now finished the survey.
Click the "submit" button at the bottom of the page to submit your responses.

On behalf of the SAE G-12 Ice Detection Committee we would like to express our sincere appreciation for taking the time to complete our survey.

SAE G-12 Aircraft Ice Detection Committee Chair: Ed Pugacz (edward.pugacz@faa.gov)
FAA Representative: Ed Pugacz, FAA Tech Center (edward.pugacz@faa.gov)
Transport Canada Representative: Doug Ingold, Transport Canada Flight Technical (douglas.ingold@tc.gc.ca)
Survey Administrator: Stephanie Bendickson, APS Aviation (sbendickson@telus.net)

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APPENDIX I

PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SNOW PELLET FLAT PLATE TESTING
TYPE I, II, III, AND IV FLUIDS

BM5611.00

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

TYPE I,II,III, AND IV FLUIDS

2008-09

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: for Victoria Zoitakis

Reviewed by: John D'Avirro

December 17, 2008
Final Version 1.0

ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW PELLET FLAT PLATE TESTING

TYPE I, II, III, AND IV FLUIDS

1. BACKGROUND

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

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

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

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

2. OBJECTIVES

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

3. TEST REQUIREMENTS

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

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

4. TEST PLAN

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

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

5. EQUIPMENT

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

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

6. PERSONNEL

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

7. SUMMARY OF PROCEDURES

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

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

7.1 Making of Artificial Snow Pellets

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

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

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

7.2 Artificial Snow Pellet Flat Plate Test Procedure

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

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

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

8. DATA FORM

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

9. SAFETY PRECAUTIONS

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

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

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

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

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

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

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

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

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

ATTACHMENT I
TEST MATRIX - SNOW PELLET ENDURANCE TIME TESTS

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

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

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

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

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

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

Test #	Priority	Fluid	Type	Dilution	Fluid Quantity (L)	Condition Temperature (°C)	Precipitation Rate (g/dm^2/hr)	Fluid Application Temp ±3 (°C)	Target Enclosure Temp (°C)	Plate Set Temp ±0.5 (°C)	Natural Snow ET (min)	Estimated Snow Pellets Needed (g)	Fluid Comments
SP25	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	16	Fluid Freeze Point: -16 / Brix: 23.5
SN25	3	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-6	4	60	-8	N/A	11	N/A	Fluid Freeze Point: -16 / Brix: 23.5
SP26	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	10	Fluid Freeze Point: -20 / Brix: 27
SN26	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	N/A	Fluid Freeze Point: -20 / Brix: 27
SP27	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	10	Fluid Freeze Point: -20 / Brix: 27
SN27	1	Octagon Octaflo EF (PG)	I	10°c Buffer	0.5	-10	4	60	-12	N/A	7	N/A	Fluid Freeze Point: -20 / Brix: 27
SP28	3	HOT Fluid #1	II or IV	50	1	-3	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN28	3	HOT Fluid #1	II or IV	50	1	-3	25	-7	-7	-5.1	N/A	N/A	HOT Fluid that is submitted
SP29	3	HOT Fluid #1	II or IV	75	1	-3	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN29	3	HOT Fluid #1	II or IV	75	1	-3	25	-7	-7	-5.1	N/A	N/A	HOT Fluid that is submitted
SP30	3	HOT Fluid #1	II or IV	100	1	-10	25	-7	-7	-5.1		0	HOT Fluid that is submitted
SN30	3	HOT Fluid #1	II or IV	100	1	-10	25	-14	-14	-12.1	N/A	N/A	HOT Fluid that is submitted
SP31	3	HOT Fluid #1	II or IV	100	1	-14	25	-14	-14	-12.1		0	HOT Fluid that is submitted
SN31	3	HOT Fluid #1	II or IV	100	1	-14	25	-18	-18	-16.1	N/A	N/A	HOT Fluid that is submitted
SP32	3	HOT Fluid #1	II or IV	75	1	-14	25	-18	-18	-16.1		0	HOT Fluid that is submitted
SN32	3	HOT Fluid #1	II or IV	75	1	-14	25	-18	-18	-16.1	N/A	N/A	HOT Fluid that is submitted

ATTACHMENT II
Test Equipment List

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

Attachment III
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2008-09

LOCATION: **DATE:** **RUN # :** **STAND # :** **NCAR**

OUTPUT FILENAME:______________________________.txt

OAT: ________°C

PRECIPITATION RATE: ________g/dm²/h

FLUID TEMPERATURE: ________°C

FLUID QUANTITY APPLIED: ________Litres

PLATE WASHING METHOD: ______________

PLATE TEMPERATURE (OMEGA): _____________ °C

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

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

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

Time of Fluid Application: ________ h:min

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

CALCULATED FAILURE TIME (MINUTES) ☐

Final Brix (o)

______	______	______	______	______	______
B2	C1	C2	C3	D2	E2

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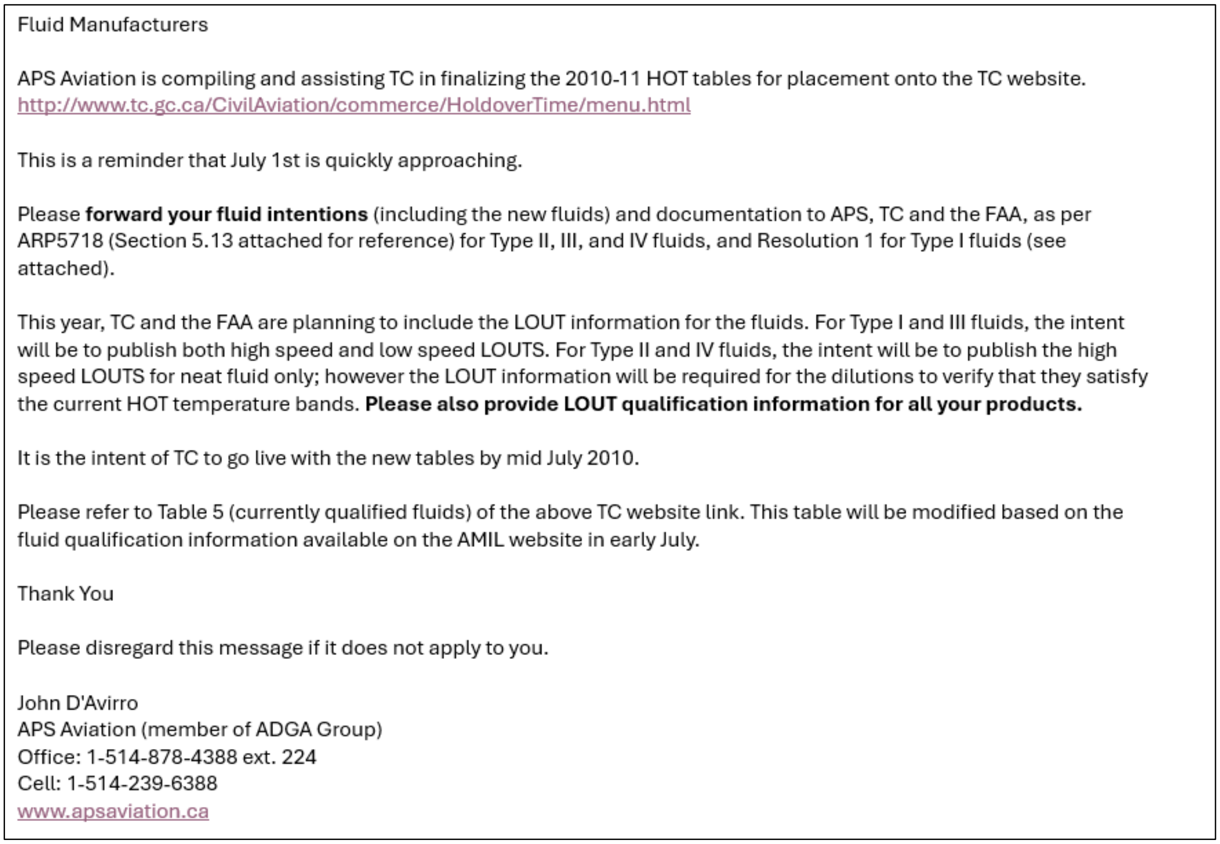
APPENDIX J

LETTER SENT TO MANUFACTURERS
REQUEST FOR LOUT VALUES



Fluid Manufacturers

APS Aviation is compiling and assisting TC in finalizing the 2010-11 HOT tables for placement onto the TC website.
http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.html

This is a reminder that July 1st is quickly approaching.

Please **forward your fluid intentions** (including the new fluids) and documentation to APS, TC and the FAA, as per ARP5718 (Section 5.13 attached for reference) for Type II, III, and IV fluids, and Resolution 1 for Type I fluids (see attached).

This year, TC and the FAA are planning to include the LOUT information for the fluids. For Type I and III fluids, the intent will be to publish both high speed and low speed LOUTS. For Type II and IV fluids, the intent will be to publish the high speed LOUTS for neat fluid only; however the LOUT information will be required for the dilutions to verify that they satisfy the current HOT temperature bands. **Please also provide LOUT qualification information for all your products.**

It is the intent of TC to go live with the new tables by mid July 2010.

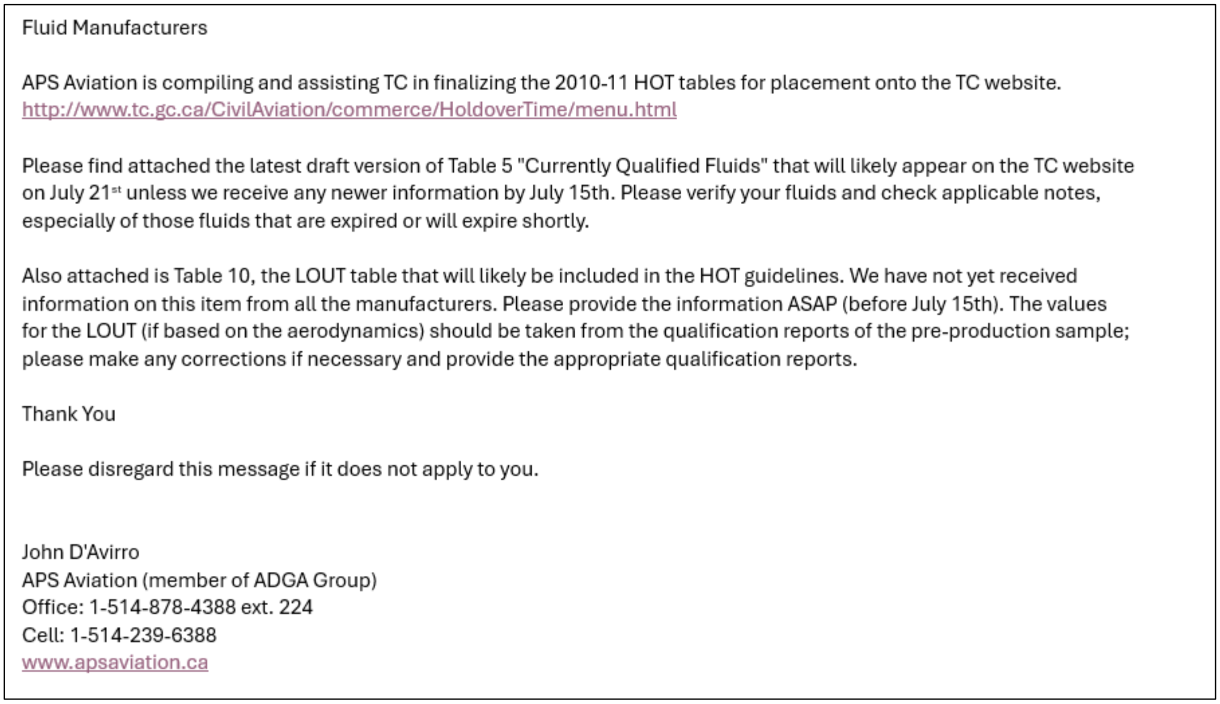
Please refer to Table 5 (currently qualified fluids) of the above TC website link. This table will be modified based on the fluid qualification information available on the AMIL website in early July.

Thank You

Please disregard this message if it does not apply to you.

John D'Avirro
APS Aviation (member of ADGA Group)
Office: 1-514-878-4388 ext. 224
Cell: 1-514-239-6388
www.apsaviation.ca

Letter sent June 17, 2010



Fluid Manufacturers

APS Aviation is compiling and assisting TC in finalizing the 2010-11 HOT tables for placement onto the TC website.
http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.html

Please find attached the latest draft version of Table 5 "Currently Qualified Fluids" that will likely appear on the TC website on July 21st unless we receive any newer information by July 15th. Please verify your fluids and check applicable notes, especially of those fluids that are expired or will expire shortly.

Also attached is Table 10, the LOUT table that will likely be included in the HOT guidelines. We have not yet received information on this item from all the manufacturers. Please provide the information ASAP (before July 15th). The values for the LOUT (if based on the aerodynamics) should be taken from the qualification reports of the pre-production sample; please make any corrections if necessary and provide the appropriate qualification reports.

Thank You

Please disregard this message if it does not apply to you.

John D'Avirro
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Letter sent July 6, 2010

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APPENDIX K

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2010-2011

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2010-2011

Original Issue, July 2010

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

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

CHANGE CONTROL RECORDS

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

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

REVISION	***DATE***	***DESCRIPTION OF CHANGES***	***AFFECTED PAGES***	***AUTHOR***

SUMMARY OF CHANGES FROM PREVIOUS YEAR

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

Type I Fluid

- As a result of extensive research and testing showing that holdover times of Type I fluids are shorter on composite surfaces than on aluminum surfaces, holdover time values for composite surfaces have been added to the Type I table. The holdover times for aluminum surfaces are unchanged.
- The snow column has been modified to include snow pellets (see below).

Type II Fluid

- The lowest on-wing viscosity for the 75/25 dilution of Clariant Safewing MP II Flight has changed. This resulted in changes being made to the Clariant Safewing MP II Flight fluid-specific holdover times. Specifically, reductions have been made in five 75/25 cells. These changes did not impact the generic holdover times.
- The snow column has been modified to include snow pellets (see below).

Type III Fluid

- The Type III holdover time guideline values are unchanged.
- The snow column has been modified to include snow pellets (see below).

Type IV Fluid

- A fluid-specific table has been created for a new Type IV fluid: Cryotech Polar Guard. The addition of this fluid did not impact the generic holdover times.
- A fluid-specific table has also been created for another Type IV fluid: Dow Chemical UCAR™ FlightGuard AD-49. This fluid is identical to ABAX Ecowing AD-49. Its holdover time table and viscosity values are also identical to those of ABAX Ecowing AD-49.
- Octagon Max-Flight has been removed from the Type IV guidelines as per the protocol for removing obsolete data. Removal of this fluid did not impact the generic holdover times.
- The snow column has been modified to include snow pellets (see below).

Frost Table

- The “above -1°C” / “above 30°F” row has been corrected to “-1°C and above” / “30°F and above”.
- A holdover time for Type I fluids on composite surfaces has been added (see Type I fluid).

Snow Pellets

- Recent testing has shown that snow holdover times can be used in snow pellet conditions. As a result of this testing, the snow columns in all Type I, Type II, Type III and Type IV fluid holdover time tables have been modified to include snow pellets.

Lowest Operational Use Temperature (LOUT) Table

- At the request of users, Lowest Operational Use Temperature (LOUT) information for Type I, II, III and IV fluids has been added to the holdover time guidelines. This information has been provided to Transport Canada by the fluid manufacturers. The LOUT information can be found in Table 10. Contact the fluid manufacturer if further clarification with respect to the information in these tables is required.

Operations during Ice Pellet Conditions

- Research has shown that propylene glycol (PG) and ethylene glycol (EG) fluids behave differently under certain temperature and ice pellet precipitation conditions. Specifically, higher aircraft rotation speeds are required to effectively remove PG fluid contaminated with light or moderate ice pellets at temperatures less than -10°C. Therefore, there are no allowance times associated with the use of PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10°C.
- Furthermore, recent research with newer generation type airfoils has shown that the allowance times are shorter when using PG fluids under certain conditions. Since it is challenging to determine exactly which aircraft may be affected, the allowance time when using PG fluids at temperatures of -5°C and above is limited to 15 minutes in moderate ice pellets.

General Format of Holdover Tables

- Several changes were made to the footnotes of the tables in an attempt to harmonize with the Association of European Airline tables and to structure the notes in an orderly fashion.

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 10.4 (6th paragraph), "Procedure Selection", with the following:

The temperature of cold soaked wings can be considerably below the ambient temperature; therefore frost can build up in localized areas. When active frost is anticipated, the holdover times will be shortened when the wings are cold soaked, particularly when using Type I fluids. Consider applying SAE Type II or IV fluid to the surfaces as these will provide greater holdover times than Type I, along with better safety margins to prevent frost accumulation. Both wings should receive a symmetrical treatment for aerodynamic reasons.

Replace Sub-Paragraph 10.4.2 (2nd paragraph), "Two Step Deicing/Anti-Icing", with the following:

If a two-step procedure is used, the first step is typically performed using a deicing fluid; however, alternate deicing technology or mechanical methods may be used depending on the circumstances. The selection of fluid type and concentration depends on the ambient temperature, the weather conditions and the desired holdover time. When performing a two-step process, the freezing point of a fluid used for the first step must not be more than 3°C above ambient temperature. The freezing point of an SAE Type I fluid used for a one-step process, or as the second step of a two-step operation, must be at least 10°C below the ambient temperature. The second step must be completed as quickly as possible following first step fluid application (not more than 3 minutes). The two-step process may need to be performed area-by-area. When deicing fluid is used in step 1, the application of the second step fluid will flush away the first step fluid and leave a film of anti-icing fluid which, is designed to be of adequate thickness. If freezing of the deicing fluid has occurred, step 1 must be repeated. Refer to the SAE ARP 4737 document for additional details.

Replace Sub-Paragraph 10.11, "Applying Anti-Icing Fluid in a Hangar", with the following:

There are operational conditions when air operators may choose to anti-ice their aircraft while the aircraft is in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely on the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Unless otherwise approved in an air operator's program, the holdover time clock must be started at the time of the first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to freezing/frozen precipitation.

Replace Sub-Paragraph 10.12.1 (5th paragraph), "Brooms", with the following:

Using the wing broom to remove contamination does not always mean that the wing surface is clean and safe for flight. Every time a broom is used to remove contamination, a tactile inspection must be performed.

Replace Sub-Paragraph 10.13.3, "Hot Water", with the following:

Hot water may be used to remove large amounts of contamination (such as ice) from an aircraft, provided that the Outside Air Temperature is -3°C and above as per the application procedures for SAE Type I, II, III and IV fluids described in tables 6 & 7 of the Transport Canada HOT Guidelines document.

Delete Sub-Paragraph 10.13.3.1 Item g) only.

Replace entire contents of 10.13.5 to 10.13.5.4 with the following:

10.13.5 Ground Ice Detection Systems (GIDS)

The development of ground ice detection sensors has been stimulated by the difficulty in determining whether an aircraft is free of frozen contaminants prior to takeoff. Humans have a limited ability to accurately evaluate the condition of an aircraft's critical surface during ground icing operations. Impediments to ensuring the aircraft is free of frozen contaminants include poor lighting conditions, visibility restrictions due to blowing snow, and the difficulty in determining whether clear ice is present.

For the purposes of this document, these sensors are referred to as Remote on Ground Ice Detection Systems (ROGIDS). A Minimum Operational Performance Specification (MOPS) for these systems is identified in the SAE document AS 5681.

Air operators or service providers seeking authorization to incorporate ROGIDS into their operations should consult Transport Canada Advisory Circular AC 602-001, "Operational Use of Remote on Ground Ice Detection Systems (ROGIDS) for Post De-Icing Applications". This document is available at the following website:

http://www.tc.gc.ca/media/documents/ca-opssvs/602-001.pdf

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

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

Replace Sub-Paragraph 11.1.5, "Elapsed time is less than the lowest time in the HOT cell", with the following:

Transport Canada has previously considered that, under an approved ground icing program, if the lowest time in a cell has NOT been exceeded for conditions covered by the Guidelines, there is no requirement to inspect the aircraft's critical surfaces prior to commencing a takeoff.

This position was based on evidence gained during fluids testing. The HOT values are conservative for the lowest number in the cell, if:

a) The conditions present are NOT in excess of those conditions represented by the table (e.g. for snow, it would be a moderate snow condition); and

b) The impact of other factors (e.g. jet blast) has been considered and deemed not to affect the HOT.

If there is doubt surrounding the conditions associated with using the lowest time as a decision-making criterion, an inspection prior to takeoff would be prudent. This inspection should be conducted in accordance with the procedures described in the Air Operator's Approved Ground Icing Program.

Replace 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) Hail; b) Moderate and Heavy Freezing Rain; and c) Heavy Snow.

Note: Operators need to assess whether operations can be safely conducted under these conditions.

Additionally, holdover time guidelines have not been assessed for ice pellets, since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have yet been identified for ice pellet conditions. Instead, an allowance time based upon research has been developed for operations during ice pellet conditions.

Add Paragraph 11.1.12: Type I HOT Guidelines for Aircraft with Critical Surfaces Constructed Using Composite Materials

The recent introduction of new aircraft constructed primarily with composite materials required a review of Type I fluid holdover time performance when used on these aircraft. This review has shown that the holdover time performance of Type I fluids on composite surfaces is reduced when compared to aluminum surfaces. Type I fluid holdover time evaluations were conducted and holdover times have been developed for use with aircraft critical surfaces constructed primarily with composite materials.

It is not the intent that the composite holdover times be used on aircraft which are already in service (unless those aircraft have predominately or entirely composite critical surfaces) where previous experience has shown the acceptable use of aluminum holdover times. If there is any doubt, consult with the aircraft manufacturer to determine whether to use aluminum or composite holdover times.

Replace Paragraph 12.1.2 with the following:

Holdover time guidelines have not been assessed for ice pellets, since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have been identified for ice pellet conditions.

However, comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for allowance times for operations in light and moderate ice pellets, as well as allowance times for operations in light ice pellets mixed with other forms of precipitation.

Replace Sub-Paragraph 12.3 (5th paragraph), "Configuration During Deicing Procedures", with the following:

Two possible options are: delaying slat/flap deployment until just prior to take-off; or deploying the devices prior to deicing/anti-icing so that the surfaces under these devices are treated. With the second option, the holdover time will be reduced due to the steeper angles of the slat/flap in the deployed configuration.

Delaying the slat/flap deployment may be the preferred option for optimum protection from ice buildup. If it is necessary to remove contamination from the slats/flaps, it may be best to deploy the slats/flaps for deicing and then retract them prior to the anti-icing process. Consult the Aircraft Operating Manual and/or aircraft manufacturer for more details.

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2010-2011

Table 0	Active Frost Holdover Guidelines
Table 1	SAE Type I Fluid Holdover Guidelines
Table 2-Generic	SAE Type II Fluid Holdover Guidelines
Table 2-A-E26	ABAX Type II Fluid Holdover Guidelines Ecowing 26
Table 2-AS-Cleanwing II	Aviation Shaanxi Hi-Tech Type II Fluid Holdover Guidelines Cleanwing II
Table 2-C-2025	Clariant Type II Fluid Holdover Guidelines Safewing MP II 2025 ECO
Table 2-C-Flight	Clariant Type II Fluid Holdover Guidelines Safewing MP II Flight
Table 2-K-ABC-2000	Kilfrost Type II Fluid Holdover Guidelines ABC-2000
Table 2-K-ABC-K+	Kilfrost Type II Fluid Holdover Guidelines ABC-K PLUS
Table 2-N-FCY-2	Newave Aerochemical Type II Fluid Holdover Guidelines FCY-2
Table 2-O-EM-II	Octagon Type II Fluid Holdover Guidelines E Max II
Table 3	SAE Type III Fluid Holdover Guidelines
Table 4-Generic	SAE Type IV Fluid Holdover Guidelines
Table 4-A-AD-480	ABAX Type IV Fluid Holdover Guidelines AD-480
Table 4-A-Ecowing AD-49	ABAX Type IV Fluid Holdover Guidelines Ecowing AD-49
Table 4-C-2001	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2001
Table 4-C-2012	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV 2012 Protect
Table 4-C-Launch	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV Launch
Table 4-CR-Polar Guard	Cryotech Type IV Fluid Holdover Guidelines Polar Guard
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-D-AD-49	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ FlightGuard AD-49
Table 4-K-ABC-4^{sustain}	Kilfrost Type IV Fluid Holdover Guidelines ABC-4^{sustain}
Table 4-K-ABC-S	Kilfrost Type IV Fluid Holdover Guidelines ABC-S
Table 4-K-ABC-S PLUS	Kilfrost Type IV Fluid Holdover Guidelines ABC-S PLUS
Table 4-L-ARCTIC Shield	Lyondell Type IV Fluid Holdover Guidelines ARCTIC Shield™
Table 4-O-MF-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	Lowest Operational Use Temperatures for Anti-Icing Fluids
Table 11	Ice Pellet Allowance Times

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature		**Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times (hours:minutes)**			
			Active Frost			
Degrees Celsius	**Degrees Fahrenheit**		**Type I**[1,2]	**Type II**[3]	**Type III**[3]	**Type IV**[3]
-1 and above	30 and above	100/0	0:45 *(0:35)*[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parentheses is for composite surfaces.

CAUTIONS

- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		**Wing Surface**	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[7]	0:10 – 0:20[7]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[7]	0:05 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

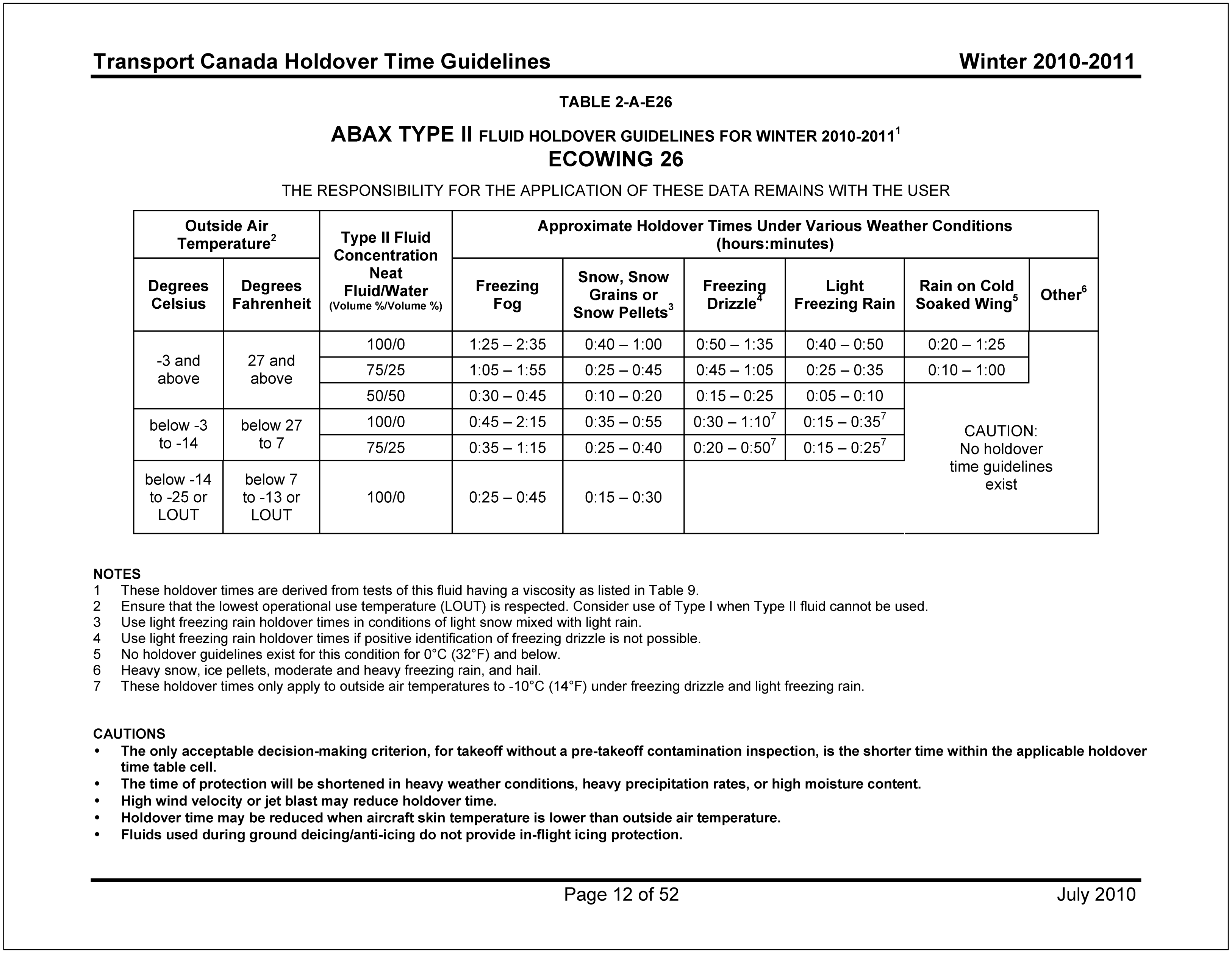

TABLE 2-A-E26

ABAX TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ECOWING 26

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-AS-CLEANWING II

AVIATION SHAANXI HI-TECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
CLEANWING II

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	0:55 – 1:50	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:10 – 0:55	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:20	0:25 – 0:45	0:35 – 1:00	0:20 – 0:30	0:05 – 0:50	
		50/50	0:35 – 1:00	0:15 – 0:30	0:20 – 0:40	0:10 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:30 – 0:55	0:30 – 0:55[7]	0:20 – 0:25[7]		
		75/25	0:40 – 1:45	0:25 – 0:45	0:35 – 0:40[7]	0:20 – 0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:50	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-C-2025

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
SAFEWING MP II 2025 ECO

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:30 – 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	0:55 – 1:45	0:25 – 0:45	0:25 – 0:45	0:20 – 0:25	0:05 – 0:50	
		50/50	0:20 – 0:35	0:05 – 0:15	0:10 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:35 – 1:00	0:35 – 1:05[7]	0:20 – 0:35[7]		
		75/25	0:40 – 1:20	0:25 – 0:45	0:30 – 0:40[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-C-Flight

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
SAFEWING MP II FLIGHT

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	3:30 – 4:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	1:50 – 2:45	0:40 – 1:20	1:10 – 1:30	0:30 – 0:55	0:05 – 0:50	
		50/50	0:55 – 1:45	0:10 – 0:25	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:55 – 1:45	0:40 – 1:05	0:35 – 1:30[7]	0:25 – 0:45[7]		
		75/25	0:25 – 1:05	0:20 – 0:40	0:25 – 1:10[7]	0:20 – 0:35[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 0:50	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-K-ABC-2000

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

ABC-2000

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:30 – 3:05	0:30 – 1:00	0:55 – 1:35	0:40 – 0:50	0:15 – 1:10	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 3:30	0:30 – 1:05	0:45 – 1:15	0:40 – 0:50	0:15 – 1:40	
		50/50	1:00 – 2:10	0:15 – 0:30	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:35 – 1:25	0:25 – 0:45	0:25 – 0:50[7]	0:10 – 0:30[7]		
		75/25	0:35 – 1:15	0:25 – 0:50	0:25 – 0:55[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:45	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3. Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-K-ABC-K+

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ABC-K PLUS

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:15 – 3:45	1:00 – 1:40	1:50 – 2:00	1:00 – 1:25	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:30	0:35 – 1:10	1:25 – 2:00	0:50 – 1:10	0:15 – 2:00	
		50/50	0:35 – 1:05	0:05 – 0:15	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:30 – 1:05	0:50 – 1:25	0:25 – 1:00[7]	0:15 – 0:35[7]		
		75/25	0:25 – 1:25	0:35 – 1:05	0:20 – 0:55[7]	0:05 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 0:55	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

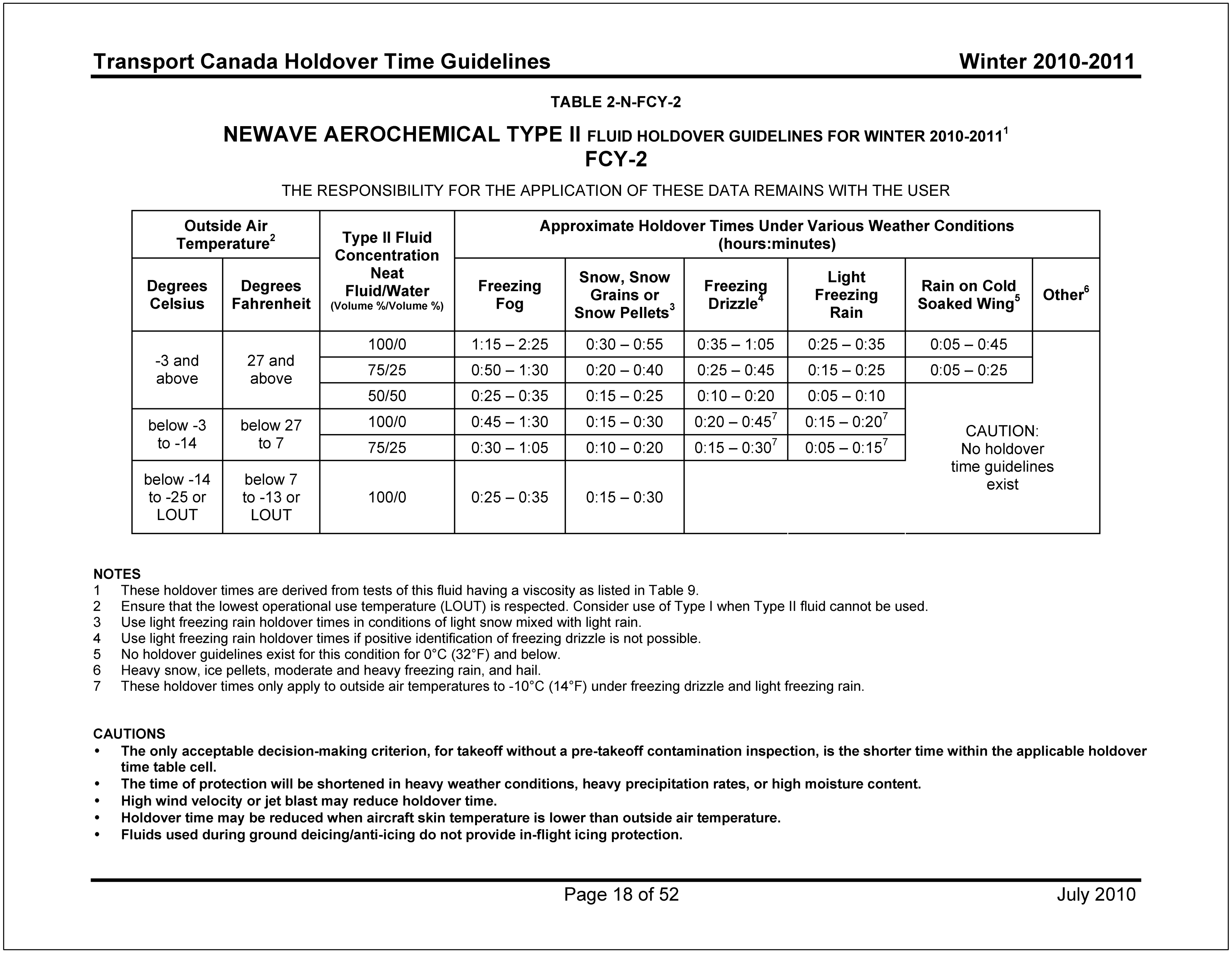

TABLE 2-N-FCY-2

NEWAVE AEROCHEMICAL TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

FCY-2

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:15 – 2:25	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:05 – 0:45	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:30	0:20 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:25	
		50/50	0:25 – 0:35	0:15 – 0:25	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45[7]	0:15 – 0:20[7]		
		75/25	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30[7]	0:05 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:25 – 0:35	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 2-O-EM-II

OCTAGON TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
E MAX II

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	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	1:25 – 2:50	0:25 – 0:55	0:40 – 1:10	0:20 – 0:30	0:10 – 1:05	
		50/50	0:30 – 0:55	0:10 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:50 – 1:45	0:35 – 1:10	0:35 – 1:00[7]	0:20 – 0:30[7]		
		75/25	0:30 – 1:20	0:25 – 0:50	0:35 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:35	0:15 – 0:30				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature[1]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
				Very Light[2]	Light[2]	Moderate				
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25[6]	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
2 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4 No holdover guidelines exist for this condition for 0°C (32°F) and below.
5 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
6 For aircraft with rotation speeds less than 100 knots, these holdover times only apply to outside air temperatures of -9°C (15.8°F) and above.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:15 – 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	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-A-AD-480

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
AD-480

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below -7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-A-Ecowing AD-49

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ECOWING AD-49

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	3:20 – 4:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25 – 4:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	1:20 – 1:40	0:15 – 1:05[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below -7 to -13 or LOUT	100/0	0:25 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-C-2001

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
SAFEWING MP IV 2001

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:20 – 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	1:20 – 2:00	0:35 – 1:00	0:35 – 1:10	0:25 – 0:35	0:10 – 1:25	
		50/50	0:15 – 0:40	0:10 – 0:20	0:10 – 0:20	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:35	0:30 – 0:50	0:55 – 1:35[7]	0:30 – 0:45[7]		
		75/25	0:30 – 1:00	0:20 – 0:35	0:40 – 1:10[7]	0:20 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

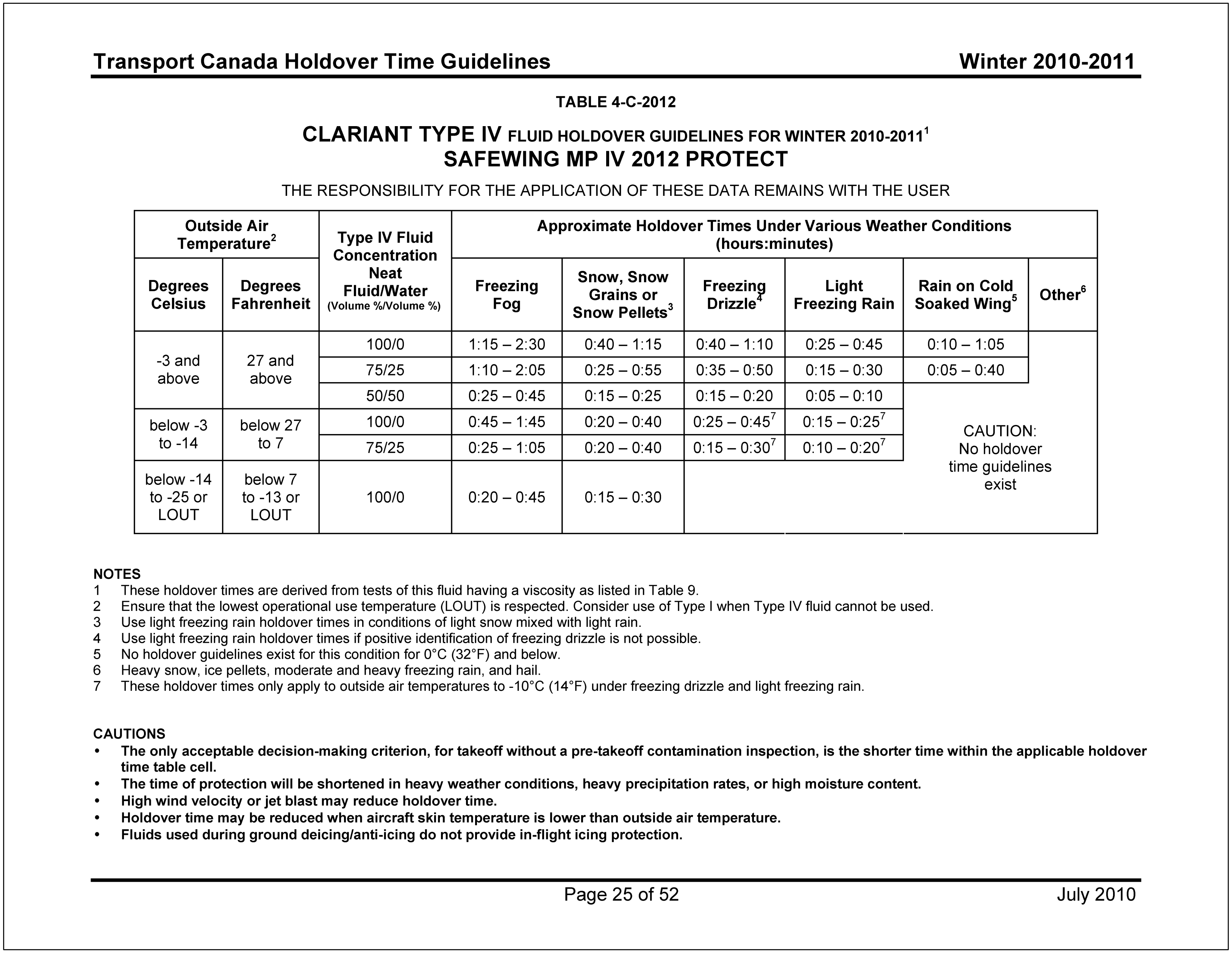

TABLE 4-C-2012

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
SAFEWING MP IV 2012 PROTECT

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 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	1:10 – 2:05	0:25 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:25 – 0:45	0:15 – 0:25	0:15 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:45	0:20 – 0:40	0:25 – 0:45[7]	0:15 – 0:25[7]		
		75/25	0:25 – 1:05	0:20 – 0:40	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-C-Launch

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

SAFEWING MP IV LAUNCH

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	4:00 – 4:00	1:05 – 1:45	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		75/25	3:40 – 4:00	1:00 – 1:45	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45	
		50/50	1:25 – 2:45	0:25 – 0:45	0:30 – 0:50	0:20 – 0:25		
below -3 to -14	below 27 to 7	100/0	1:00 – 1:55	0:50 – 1:20	0:35 – 1:40[7]	0:25 – 0:45[7]		
		75/25	0:40 – 1:20	0:45 – 1:25	0:25 – 1:10[7]	0:25 – 0:45[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 0:50	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-CR-Polar Guard

CRYOTECH TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
POLAR GUARD

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:15 – 3:30	0:50 – 1:30	1:15 – 2:00	0:50 – 1:15	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:40	0:35 – 1:10	1:05 – 1:25	0:35 – 1:00	0:10 – 1:15	
		50/50	0:25 – 0:40	0:10 – 0:15	0:15 – 0:25	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:45	0:30 – 0:55	0:25 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:30	0:20 – 0:40	0:25 – 1:05[7]	0:20 – 0:30[7]		
below -14 to -23.5	below 7 to -10.3	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-ULTRA+

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
UCAR™ ADF/AAF ULTRA+

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:35 – 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	1:25 – 3:00	0:25 – 0:55	0:45 – 1:25[7]	0:30 – 0:45[7]		
		75/25						
below -14 to -24	below 7 to -11	100/0	0:40 – 2:10	0:20 – 0:45				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **luids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-E106

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
UCAR™ ENDURANCE EG106

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:05 – 3:10	0:40 – 1:20	1:10 – 2:00	0:50 – 1:15	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25						
		50/50						
below -3 to -14	below 27 to 7	100/0	1:50 – 3:20	0:30 – 1:05	0:55 – 1:50[7]	0:45 – 1:10[7]		
		75/25						
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 1:05	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-AD-480

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
UCAR™ FLIGHTGUARD AD-480

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-AD-49

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
UCAR™ FLIGHTGUARD AD-49

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	3:20 – 4:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25 – 4:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	1:20 – 1:40	0:15 – 1:05[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below -7 to -13 or LOUT	100/0	0:25 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-K-ABC-4^{sustain}

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ABC-4^{sustain}

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:45 – 3:55	1:00 – 1:45	1:35 – 2:00	1:05 – 1:30	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:50	0:30 – 0:55	0:40 – 1:05	0:25 – 0:40	0:10 – 1:20	
		50/50	0:20 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:55	1:00 – 1:45	0:35 – 1:50[7]	1:05 – 1:25[7]		
		75/25	0:35 – 2:10	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:40[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:40 – 1:00	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-K-ABC-S

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

ABC-S

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:35 – 4:00	1:00 – 1:40	1:20 – 1:50	1:00 – 1:25	0:20 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:35 – 0:50	0:10 – 0:50	
		50/50	0:20 – 0:35	0:05 – 0:15	0:15 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:05	0:45 – 1:20	0:20 – 1:00[7]	0:10 – 0:30[7]		
		75/25	0:25 – 1:00	0:25 – 0:50	0:20 – 1:10[7]	0:10 – 0:35[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-K-ABC-S PLUS

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

ABC-S PLUS

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:10 – 4:00	1:15 – 2:00	1:50 – 2:00	1:05 – 2:00	0:25 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:25 – 2:40	0:45 – 1:15	1:00 – 1:20	0:30 – 0:50	0:10 – 1:20	
		50/50	0:30 – 0:55	0:15 – 0:30	0:15 – 0:40	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 3:30	1:00 – 1:45	0:25 – 1:35[7]	0:20 – 0:30[7]		
		75/25	0:45 – 1:50	0:35 – 1:00	0:20 – 1:10[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:40 – 1:00	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-L-ARCTIC Shield

LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ARCTIC SHIELD™

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:55 – 3:10	0:50 – 1:25	0:55 – 1:40	0:45 – 1:05	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:20 – 2:15	0:40 – 1:05	0:55 – 1:25	0:30 – 0:45	0:05 – 1:20	
		50/50	0:35 – 0:45	0:20 – 0:35	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	1:00 – 2:25	0:45 – 1:15	0:25 – 1:30[7]	0:25 – 0:30[7]		
		75/25	0:50 – 1:45	0:35 – 0:55	0:30 – 1:15[7]	0:25 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-O-MF-04

OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

MAX-FLIGHT 04

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:40 – 4:00	1:25 – 2:00	2:00 – 2:00	1:10 – 1:30	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:05 – 3:15	1:05 – 2:00	1:50 – 2:00	1:00 – 1:20	0:20 – 2:00	
		50/50	0:55 – 1:45	0:25 – 1:15	0:35 – 1:10	0:25 – 0:35		
below -3 to -14	below 27 to 7	100/0	0:50 – 2:30	0:35 – 1:10	0:25 – 1:30[7]	0:20 – 0:40[7]		
		75/25	0:30 – 1:05	0:40 – 1:20	0:20 – 1:00[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:20 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 4-O-MFLO

OCTAGON TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
MAXFLO

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog**	**Snow, Snow Grains or Snow Pellets[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:20 – 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	1:25 – 2:00	0:20 – 0:55	0:40 – 1:05	0:20 – 0:35	0:05 – 1:15	
		50/50	0:20 – 0:40	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	1:10 – 2:20	0:25 – 1:00	0:35 – 1:45[7]	0:30 – 0:50[7]		
		75/25	0:40 – 1:25	0:15 – 0:40	0:35 – 1:15[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 1:00	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.

2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.

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

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

5 No holdover guidelines exist for this condition for 0°C (32°F) and below.

6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

TABLE 5
CURRENTLY QUALIFIED FLUIDS (2010-2011)

Table 5-1: Qualified Type I Anti-icing Fluids(1) (2)

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
1-1	ABAX Industries	DE-950	12-06-25
1-2	ABAX Industries	DE-950 Colorless	12-06-26
1-3	Arcton Ltd.	Arctica DG ready-to-use	13-04-08
1-4	Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I	12-01-06
1-5	Aviation Xi'an High-Tech Physical Co. Ltd.	KHF-1	11-09-20
1-6	*Battelle Memorial Institute*	*D^3: Degradable by Design™ ADF1006A*	*08-01-13*(3)
1-7	Beijing Phoenix Air Traffic Product Development and Trading Co.	CBSX-1	12-04-21
1-8	Beijing Wangye Aviation Chemical Product Co.	KLA-1	11-09-20
1-9	Beijing Wangye Aviation Chemical Product Co.	*YJF-1*	*09-02-23*(3)
1-10	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP I 1938 TF*	*08-08-21*(3)
1-11	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP I 1938 TF* *PreMix 60% i.g. ready-to-use (multiple location)*	*07-09-14*(3)
1-12	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	12-07-24
1-13	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) PreMix 55% i.g. ready-to-use	13-05-20
1-14	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	12-06-10
1-15	Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996	12-06-10
1-16	Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	11-08-26
1-17	Clariant Produkte (Deutschland) GmbH	Safewing MP I ECO PLUS (80)	11-03-20
1-18	*Chemical Specialists Development Inc.*	*Prist Wing De-Icer*	*08-05-17*(3)
1-19	Cryotech Deicing Technology	Polar Plus	12-02-09
1-20	Dow Chemical Company	UCAR™ Aircraft Deicing Fluid Concentrate	11-09-10
1-21	Dow Chemical Company	UCAR™ ADF XL54	13-01-21
1-22	Dow Chemical Company	UCAR™ PG Aircraft Deicing Fluid Concentrate	12-02-05
1-23	Dow Chemical Company	UCAR™ PG ADF Dilute 55/45	12-02-05
1-24	Harbin Aeroclean Aviation Tech Co. Ltd.	HJF-1	13-10-05
1-25	*HOC Industries*	*SafeTemp I ES*	*07-10-27*(3)
1-26	HOC Industries	SafeTemp ES Plus	11-10-04
1-27	Kilfrost Limited	DF Plus	11-09-27
1-28	Kilfrost Limited	DF Plus (80)	12-07-21
1-29	Kilfrost Limited	DF Plus (88)	11-09-27
1-30	Kilfrost Limited	DFsustain™	13-02-10
1-31	*Lyondell Chemical Company*	*ARCOPlus*	*08-02-14*(3)
1-32	Newave Aerochemical Co. Ltd.	FCY-1A	11-08-21
1-33	Octagon Process Inc.	EcoFlo Concentrate	13-07-06
1-34	Octagon Process Inc.	Octaflo EF Concentrate	14-03-25
1-35	Octagon Process Inc.	Octaflo EF-80	13-12-21
1-36	Octagon Process Inc.	Octaflo EG Concentrate	13-06-10
1-37	*Viterbo S.A.*	*Jarkleer SAE Type I*	*07-01-20*(3)

(1) Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Québec à Chicoutimi. Web site: http://www.uqac.ca/amil/index.htm. The expiry date was determined based upon the earliest qualification date of the High Speed Aerodynamic Test or Water Spray Endurance Test.

For other specification requirements for Type I fluids, see SAE AMS 1424 (latest version). Fluids that successfully qualify after the issuance of this list will appear in a later update.

(2) Concentrate fluids have also been qualified at 50/50 (glycol/water) dilution.

(3) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(4) Currently in qualification/re-qualification process.

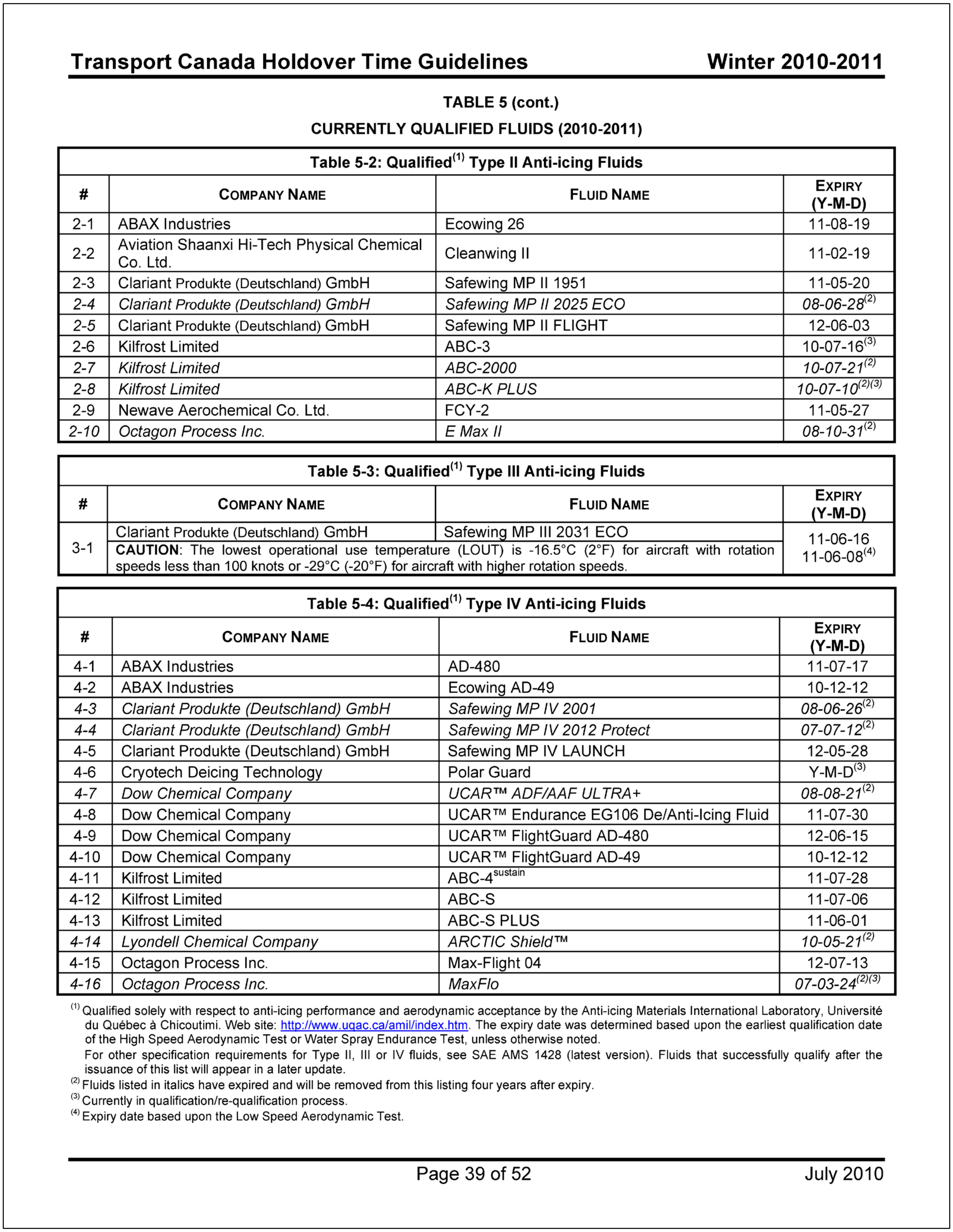

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TABLE 5 (cont.)

CURRENTLY QUALIFIED FLUIDS (2010-2011)

Table 5-2: Qualified(1) Type II Anti-icing Fluids

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
2-1	ABAX Industries	Ecowing 26	11-08-19
2-2	Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	11-02-19
2-3	Clariant Produkte (Deutschland) GmbH	Safewing MP II 1951	11-05-20
2-4	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP II 2025 ECO*	*08-06-28*(2)
2-5	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	12-06-03
2-6	Kilfrost Limited	ABC-3	10-07-16(3)
2-7	*Kilfrost Limited*	*ABC-2000*	*10-07-21*(2)
2-8	*Kilfrost Limited*	*ABC-K PLUS*	*10-07-10*(2)(3)
2-9	Newave Aerochemical Co. Ltd.	FCY-2	11-05-27
2-10	*Octagon Process Inc.*	*E Max II*	*08-10-31*(2)

Table 5-3: Qualified(1) Type III Anti-icing Fluids

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
3-1	Clariant Produkte (Deutschland) GmbH	Safewing MP III 2031 ECO	11-06-16 11-06-08(4)
	CAUTION: The lowest operational use temperature (LOUT) is -16.5°C (2°F) for aircraft with rotation speeds less than 100 knots or -29°C (-20°F) for aircraft with higher rotation speeds.		

Table 5-4: Qualified(1) Type IV Anti-icing Fluids

#	COMPANY NAME	FLUID NAME	EXPIRY (Y-M-D)
4-1	ABAX Industries	AD-480	11-07-17
4-2	ABAX Industries	Ecowing AD-49	10-12-12
4-3	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP IV 2001*	*08-06-26*(2)
4-4	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP IV 2012 Protect*	*07-07-12*(2)
4-5	Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	12-05-28
4-6	Cryotech Deicing Technology	Polar Guard	Y-M-D(3)
4-7	*Dow Chemical Company*	*UCAR™ ADF/AAF ULTRA+*	*08-08-21*(2)
4-8	Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	11-07-30
4-9	Dow Chemical Company	UCAR™ FlightGuard AD-480	12-06-15
4-10	Dow Chemical Company	UCAR™ FlightGuard AD-49	10-12-12
4-11	Kilfrost Limited	ABC-4^{sustain}	11-07-28
4-12	Kilfrost Limited	ABC-S	11-07-06
4-13	Kilfrost Limited	ABC-S PLUS	11-06-01
4-14	*Lyondell Chemical Company*	*ARCTIC Shield™*	*10-05-21*(2)
4-15	Octagon Process Inc.	Max-Flight 04	12-07-13
4-16	*Octagon Process Inc.*	*MaxFlo*	*07-03-24*(2)(3)

(1) Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Québec à Chicoutimi. Web site: http://www.uqac.ca/amil/index.htm. The expiry date was determined based upon the earliest qualification date of the High Speed Aerodynamic Test or Water Spray Endurance Test, unless otherwise noted.

For other specification requirements for Type II, III or IV fluids, see SAE AMS 1428 (latest version). Fluids that successfully qualify after the issuance of this list will appear in a later update.

(2) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(3) Currently in qualification/re-qualification process.

(4) Expiry date based upon the Low Speed Aerodynamic Test.

TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

[1] Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).

[2] To be applied before first step fluid freezes, typically within 3 minutes.

NOTES

- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**

TABLE 7

SAE TYPE II, TYPE III and TYPE IV ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type II, III and IV fluid mixtures
(minimum concentrations in % by volume) as a function of outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	50/50 Heated[3] Type II/III/IV	Heated water or a heated mix of Type I, II, III or IV with water	50/50 Type II/III/IV
-14°C (7°F) and above	75/25 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	75/25 Type II/III/IV
-25°C (-13°F) and above	100/0 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	100/0 Type II/III/IV
Below -25°C (-13°F)	Type II/III/IV fluid may be used below -25°C (-13°F) provided that the OAT is at or above the LOUT. Consider the use of Type I when Type II/III/IV fluid cannot be used (see Table 6).		

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
2 To be applied before first step fluid freezes, typically within 3 minutes.
3 Clean aircraft may be anti-iced with unheated fluid.

NOTES

- For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. When the first step is performed using a fluid/water mix with a freezing point above OAT, the temperature at the nozzle shall be at least 60°C and at least 1 litre/m^2 (2 gal./100 sq. ft.) shall be applied to the surfaces to be de-iced.
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  - b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II, III or IV shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

TABLE 8

VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART[1]

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	ºC	ºF	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1	>1 to 2½	>2½ to 4	>4
	Below -1	Below 30	≤3/4	>3/4 to 1½	>1½ to 3	>3
Daylight	-1 and above	30 and above	≤½	>½ to 1½	>1½ to 3	>3
	Below -1	Below 30	≤3/8	>3/8 to 7/8	>7/8 to 2	>2

[1] Based on: *Relationship between Visibility and Snowfall Intensity* (TP 14151E), Transportation Development Centre, Transport Canada, November 2003; and *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (TP 12893E), Transportation Development Centre, Transport Canada, November 1998.

HOW TO READ AND USE THE TABLE

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

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

TABLE 9

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS

(See Table 9 endnotes)

Table 9-1: Type II Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4 900 [e]	4 600 [g]
	75/25	2 200 [g]	2 200 [g]
	50/50	50 [g]	50 [g]
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 [c]	4 500 [g]
	75/25	9 450 [c]	10 000 [g]
	50/50	10 150 [c]	10 200 [g]
Clariant Safewing MP II 2025 ECO	100/0	5 500 [b]	5 750 [g]
	75/25	10 000 [b]	10 000 [g]
	50/50	3 000 [b]	3 250 [g]
Clariant Safewing MP II Flight	100/0	3 340 [g]	3 340 [g]
	75/25	12 900 [l]	12 900 [l]
	50/50	11 500 [g]	11 500 [g]
Clariant Safewing MP II 1951	100/0	2 500 [b]	2 750 [g]
	75/25	2 900 [b]	3 000 [g]
	50/50	50 [b]	50 [g]
Kilfrost ABC-3	100/0	2 500 [c]	2 500 [j]
	75/25	2 000 [c]	2 000 [j]
	50/50	400 [c]	400 [j]
Kilfrost ABC-2000	100/0	2 350 [c]	2 350 [g]
	75/25	3 000 [c]	3 000 [j]
	50/50	1 000 [c]	1 000 [j]
Kilfrost ABC-K Plus	100/0	2 850 [c]	2 640 [g]
	75/25	12 650 [c]	12 650 [c]
	50/50	4 200 [c]	5 260 [g]
Newave Aerochemical FCY-2	100/0	7 000 [c]	8 920 [g]
	75/25	18 550 [c]	18 550 [c]
	50/50	6 750 [c]	7 030 [g]
Octagon E Max II	100/0	13 520 [d]	13 520 [g]
	75/25	11 400 [g]	11 400 [g]
	50/50	2 820 [g]	2 820 [g]

Table 9-2: Type III Anti-Icing Fluids

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

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS

(See Table 9 endnotes)

Table 9-3: Type IV Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX AD-480	100/0	15 200 [e]	12 800 [c]
	75/25	16 000 [e]	12 400 [c]
	50/50	4 000 [e]	3 800 [g]
ABAX Ecowing AD-49	100/0	12 150 [k]	11 000 [g]
	75/25	30 700 [k]	32 350 [l]
	50/50	19 450 [k]	21 150 [l]
Clariant Safewing MP IV 2001	100/0	18 000 [b]	18 000 [c]
	75/25	8 000 [b]	11 500 [g]
	50/50	1 200 [b]	1 750 [g]
Clariant Safewing MP IV 2012 Protect	100/0	7 800 [b]	7 250 [g]
	75/25	17 800 [b]	17 700 [c]
	50/50	4 500 [b]	4 250 [g]
Clariant Safewing MP IV Launch	100/0	7 550 [g]	7 550 [g]
	75/25	18 000 [g]	18 000 [g]
	50/50	17 800 [g]	17 800 [g]
Cryotech Polar Guard	100/0	32 100 [m]	36 300 [l]
	75/25	24 200 [m]	27 800 [l]
	50/50	6 200 [m]	7 500 [g]
Dow UCAR™ ADF/AAF ULTRA+	100/0	36 000 [f]	28 000 [c]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ Endurance EG106	100/0	24 850 [f]	2 230 [g]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	15 200 [e]	12 800 [c]
	75/25	16 000 [e]	12 400 [c]
	50/50	4 000 [e]	3 800 [g]
Dow UCAR™ FlightGuard AD-49	100/0	12 150 [k]	11 000 [g]
	75/25	30 700 [k]	32 350 [l]
	50/50	19 450 [k]	21 150 [l]
Kilfrost ABC-4^{sustain}	100/0	18 400 [c]	18 400 [c]
	75/25	15 400 [c]	15 400 [c]
	50/50	4 700 [c]	5 050 [g]
Kilfrost ABC-S	100/0	17 000 [c]	17 000 [c]
	75/25	12 000 [c]	12 000 [c]
	50/50	2 000 [c]	2 000 [j]
Kilfrost ABC-S PLUS	100/0	17 900 [c]	17 900 [c]
	75/25	18 300 [c]	18 300 [c]
	50/50	7 500 [c]	7 500 [j]

See next page for additional Type IV fluids

TABLE 9 (cont.)
LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS
(See Table 9 endnotes)

Table 9-3: Type IV Anti-Icing Fluids (cont.)

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Lyondell ARCTIC Shield™	100/0	23 150 [i]	28 000 [c]
	75/25	21 700 [i]	22 100 [c]
	50/50	6 400 [i]	7 640 [g]
Octagon Max-Flight 04	100/0	5 540 [d]	5 540 [g]
	75/25	15 000 [g]	15 000 [g]
	50/50	5 200 [g]	5 200 [g]
Octagon MaxFlo	100/0	8 670 [g]	8 670 [g]
	75/25	8 200 [g]	8 200 [g]
	50/50	2 200 [g]	2 200 [g]

NOTES

a The Aerospace Information Report (AIR) 9968 Revision A (December 2004) viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method.
b Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20ºC, 0.3 rpm, for 15 minutes 0 seconds.
c Brookfield Spindle LV2-disc with guard leg, 150 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
d Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20ºC, 0.3 rpm, for 33 minutes 20 seconds.
e Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20ºC, 0.3 rpm, for 30 minutes 0 seconds.
f Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 0ºC, 0.3 rpm, for 10 minutes 0 seconds.
g Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
h Brookfield Spindle LV0, UL-Adapter, 16 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
i Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20ºC, 0.3 rpm, for 33 minutes 0 seconds.
j Brookfield Spindle LV1 with guard leg, 150 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
k Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
l Brookfield Spindle LV-2 disc with guard leg, 500 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.
m Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.

SIGNIFICANCE OF THIS TABLE

The viscosity values of the fluids in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing is not lower than that listed.

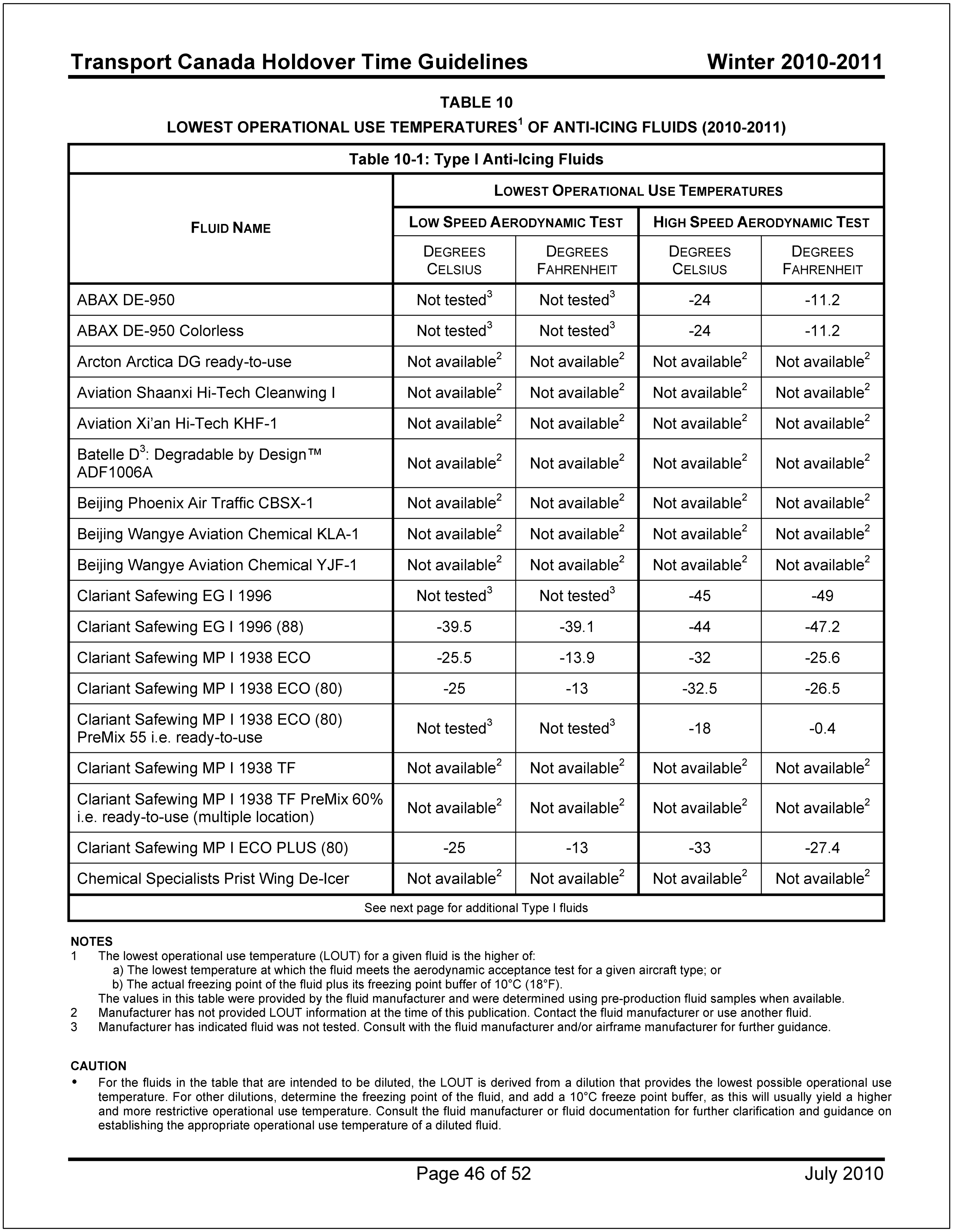

TABLE 10

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2010-2011)

Table 10-1: Type I Anti-Icing Fluids

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX DE-950	Not tested[3]	Not tested[3]	-24	-11.2
ABAX DE-950 Colorless	Not tested[3]	Not tested[3]	-24	-11.2
Arcton Arctica DG ready-to-use	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Aviation Shaanxi Hi-Tech Cleanwing I	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Aviation Xi'an Hi-Tech KHF-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Batelle D^3: Degradable by Design™ ADF1006A	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Phoenix Air Traffic CBSX-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical KLA-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical YJF-1	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing EG I 1996	Not tested[3]	Not tested[3]	-45	-49
Clariant Safewing EG I 1996 (88)	-39.5	-39.1	-44	-47.2
Clariant Safewing MP I 1938 ECO	-25.5	-13.9	-32	-25.6
Clariant Safewing MP I 1938 ECO (80)	-25	-13	-32.5	-26.5
Clariant Safewing MP I 1938 ECO (80) PreMix 55 i.e. ready-to-use	Not tested[3]	Not tested[3]	-18	-0.4
Clariant Safewing MP I 1938 TF	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing MP I 1938 TF PreMix 60% i.e. ready-to-use (multiple location)	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Clariant Safewing MP I ECO PLUS (80)	-25	-13	-33	-27.4
Chemical Specialists Prist Wing De-Icer	Not available[2]	Not available[2]	Not available[2]	Not available[2]

See next page for additional Type I fluids

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

3 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid, and add a 10°C freeze point buffer, as this will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2010-2011)

Table 10-1: Type I Anti-Icing Fluids (cont.)

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
Cryotech Polar Plus	-27	-16.6	-32	-25.6
Dow UCAR™ ADF XL54	Not tested[3]	Not tested[3]	-41.5	-42.7
Dow UCAR™ Aircraft Deicing Fluid Concentrate	-36.5	-33.7	-45	-49
Dow UCAR™ PG ADF Dilute 55/45	Not tested[3]	Not tested[3]	-29.5	-21.1
Dow UCAR™ PG Aircraft Deicing Fluid Concentrate	-25	-13	-32	-25.6
Harbin Aeroclean Aviation HJF-1	Not tested[3]	Not tested[3]	-19	-2.2
HOC SafeTemp I ES	Not tested[3]	Not tested[3]	-23.5	-10.3
HOC SafeTemp ES Plus	Not tested[3]	Not tested[3]	-29	-20.2
Kilfrost DF Plus	-24	-11.2	-32	-25.6
Kilfrost DF Plus (80)	-23.5	-10.3	-31.5	-24.7
Kilfrost DF Plus (88)	-24	-11.2	-32	-25.6
Kilfrost DF^{sustain}™	-36	-32.8	-41.5	-42.7
Lyondell ARCOPlus	Not available[2]	Not available[2]	Not available[2]	Not available[2]
Newave FCY-1A	-34.5	-30.1	-35.5	-31.9
Octagon EcoFlo Concentrate	-27	-16.6	-30.5	-22.9
Octagon Octaflo EF Concentrate	-25	-13	-33	-27.4
Octagon Octaflo EF-80 Concentrate	-33	-27.4	-33	-27.4
Octagon Octaflo EG Concentrate	-40.5	-40.9	-44	-47.2
Viterbo Jarkleer SAE Type I	Not available[2]	Not available[2]	Not available[2]	Not available[2]

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
   The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.
2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.
3 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid, and add a 10°C freeze point buffer, as this will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2010-2011)

Table 10-2: Type II (100/0) Anti-Icing Fluids		
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES	
	HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX Ecowing 26	-29	-20.2
Aviation Shaanxi Hi-Tech Cleanwing II	Not available[2]	Not available[2]
Clariant Safewing MP II 1951	-29	-20.2
Clariant Safewing MP II 2025 ECO	-28	-18.4
Clariant Safewing MP II Flight	-29	-20.2
Kilfrost ABC-3	-27	-16.6
Kilfrost ABC-2000	Not available[2]	Not available[2]
Kilfrost ABC-K Plus	-29	-20.2
Newave Aerochemical FCY-2	-28	-18.4
Octagon E Max II	-28	-18.4

Table 10-3: Type III (100/0) Anti-Icing Fluids				
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
Clariant Safewing MP III 2031	-16.5	2.3	-29	-20.2

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the 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).
  The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2010-2011)

Table 10-4: Type IV (100/0) Anti-Icing Fluids

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES HIGH SPEED AERODYNAMIC TEST DEGREES CELSIUS	 DEGREES FAHRENHEIT
ABAX AD-480	-29	-20.2
ABAX Ecowing AD-49	-26	-14.8
Clariant Safewing MP IV 2001	-28	-18.4
Clariant Safewing MP IV 2012 Protect	-27	-16.6
Clariant Safewing MP IV LAUNCH	-28.5	-19.3
Cryotech Polar Guard	-23.5	-10.3
Dow UCAR™ ADF/AAF ULTRA+	Not available[2]	Not available[2]
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	-27	-16.6
Dow UCAR™ FlightGuard AD-480	-29	-20.2
Dow UCAR™ FlightGuard AD-49	-26	-14.8
Kilfrost ABC-4^{sustain}	-29	-20.2
Kilfrost ABC-S	-28	-18.4
Kilfrost ABC-S PLUS	-28	-18.4
Lyondell ARCTIC Shield™	Not available[2]	Not available[2]
Octagon Max-Flight 04	-28	-18.4
Octagon MaxFlo	-28	-18.4

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
   The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

Comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light or moderate) and light ice pellets mixed with other forms of precipitation.

Results of this research provide the basis for allowance times for operations in ice pellets (light or moderate) and operations in light ice pellets mixed with other forms of precipitation.

Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times.

Operational Guidelines

1) Tests have shown that ice pellets generally remain in a frozen state embedded in Type IV anti-icing fluid and are not dissolved by the fluid in the same manner as other forms of precipitation. Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not dissolved by the fluid (remaining embedded) is an indication that the fluid has failed. These embedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination inspection procedures.

2) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and light ice pellets mixed with other forms of precipitation in Type IV fluid will not prevent the fluid from flowing off of the aerodynamic surfaces during takeoff.

3) The allowance times were developed based on this aerodynamic testing and are contained in Table 11.

4) Research has also shown that propylene glycol (PG) and ethylene glycol (EG) fluids behave differently under certain temperature and ice pellet precipitation conditions. Specifically, higher aircraft rotation speeds are required to effectively remove PG fluid contaminated with light or moderate ice pellets at temperatures less than -10°C. Therefore, there are no allowance times associated with the use of PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10°C.

5) Furthermore, recent research with newer generation type airfoils has shown that the allowance times are shorter when using PG fluids under certain conditions. Since it is challenging to determine exactly which aircraft may be affected, the allowance time when using PG fluids at temperatures of -5°C and above is limited to 15 minutes in moderate ice pellets.

6) The ice pellet allowances are contingent on the operator's approved ground icing program being updated to incorporate the ice pellet information contained herein, including the following conditions and restrictions that must be satisfied:

   a) The aircraft critical surfaces must be properly deiced before the application of Type IV anti-icing fluid;

   b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid;

   c) These allowance times are applicable from the start of the Type IV anti-icing fluid application;

d) The allowance time is limited to aircraft with a rotation speed of 100 knots or greater (subject to 4) above);

e) If the takeoff is not accomplished within the applicable allowance time in Table 11, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff;

f) The allowance time cannot be extended by an inspection of the aircraft critical surfaces from either inside or outside the aircraft;

g) If the temperature decreases below the temperature on which the allowance time was based, where the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit;

h) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used;

i) If the precipitation condition stops at, or before, the time limit of the applicable allowance time in Table 11 and does not restart, the aircraft may take off up to 90 minutes after the start of the application of the Type IV anti-icing fluid. However, under conditions of light ice pellets mixed with light freezing rain, the OAT must not decrease during the 90-minute period.

7) Examples:

a) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50; the aircraft may take off without any further action until 11:30.

b) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25; however, provided no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

c) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with light freezing rain falls until 10:10, stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25; however, provided that the OAT remains constant or increases and no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

d) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, stops and restarts at 10:30, with the allowance time stopping at 10:25, the aircraft may not take off, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 11

ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

1. No allowance times exist for propylene glycol (PG) fluids, when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).
2. Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

APPENDIX L

PRESENTATIONS AT VARIOUS MEETINGS

PRESENTATIONS AT VARIOUS MEETINGS

1. SAE G-12 HOT Committee Meeting, Montreal, Canada, November 2009

a. Data for Airport De-Icer Management System Model;

b. Potential Future Changes to the HOT Guideline Table Format;

c. Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables;

d. Operational Changes to HOT Guidelines Related to 2008-09 R&D Activities;

e. Holdover Time Guidelines Update Fall 2009; and

f. Dissemination of HOT Guidelines Regression Information 2009-10.

2. SAE G-12 Aero Working Group Meeting, Montreal, Canada, November 2009

a. Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces.

3. ROGIDS Working Group Meeting, Palm Coast, United States, December 2009

No formal presentation was prepared for the ROGIDS Working Group meeting in Palm Coast on December 8-9, 2009.

4. SAE G-12 HOT Committee Meeting, Berlin, Germany, May 2010

a. Anti-Icing Endurance Times for Aircraft Hangar Operations;

b. Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid;

c. Development of HOT Guidance Material for Snow Pellet Conditions;

d. Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces;

e. Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables;

f. Development of Holdover Time Guidelines for Cold-Soaked Wing During Natural Frost Conditions;

g. De/Anti-Icing Fluid Endurance Times on Composite Surfaces;

h. Aircraft De/Anti-Icing Fluid Endurance Time Results: Winter 2009-10;

i. Effect of Ice Phobic Products on De/Anti-Icing Fluid HOTs; and

j. Potential Future Changes to the HOT Guideline Table Format.

5. SAE G-12 Aero Working Group Meeting, Berlin, Germany, May 2010

a. Preliminary Evaluation of Endurance Time Performance on Vertical Surfaces (similar to presentation for the HOT Committee); and

b. Update: Wind Tunnel Research to Support the Development of Ice Pellet Allowance Time Tables (similar to presentation for the HOT Committee).

6. SAE G-12 Residues Working Group Meeting, Berlin, Germany, May 2010

a. Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid (also presented to the HOT Subcommittee); and

b. Effect of Ice Phobic Products on De/Anti-Icing Fluid HOTs (also presented to the HOT Subcommittee).

7. SAE G-12 Ice Detection Committee Meeting, Berlin, Germany, May 2010

a. SAE Committee G-12 Ice Detection Committee Meeting (parts presented by APS).

8. ROGIDS Working Group Meeting, Atlantic City, United States, September 2010

No formal presentation was prepared for the ROGIDS Working Group meeting in Palm Coast on December 8-9, 2009.

9. SAE G-12 HOT Committee Meeting, Montreal, Canada, November 2010

a. Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid;

b. Holdover Time Guidelines Update Fall 2010;

c. Operational Changes to HOT Guidelines Related to 2009-10 R&D Activities;

d. Dissemination of HOT Guidelines Regression Information 2010-2011;

e. Recommended Changes to ARP5718: Calculating More Precise HOTs;

f. Evaluation of Sensor for Nowcasting Active Frost;

g. Composite Materials HOT Testing Review; and

h. Wind Tunnel R&D Activities: Heavy Snow, Snow on an Unprotected Wing, and Excessive Fluid Application (prepared but not presented).

10. SAE G-12 Residues Working Group Meeting, Montreal, Canada, November 2010

a. Degraded Anti-Icing Fluid Performance Following Contamination with Runway Deicing Fluid (also presented to the HOT Subcommittee).

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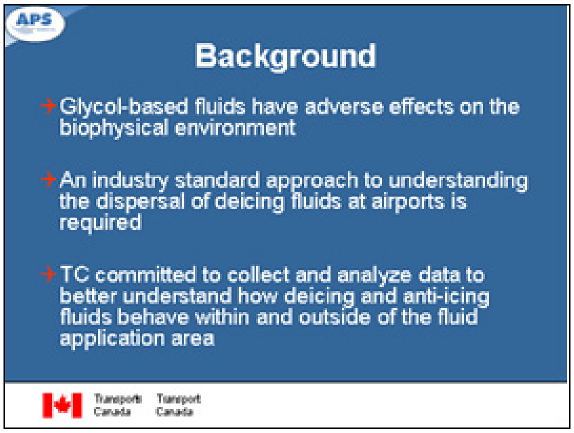
DATA FOR AIRPORT DE-ICER MANAGEMENT SYSTEM MODEL

APS Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING
MONTREAL – NOVEMBER 4, 2009

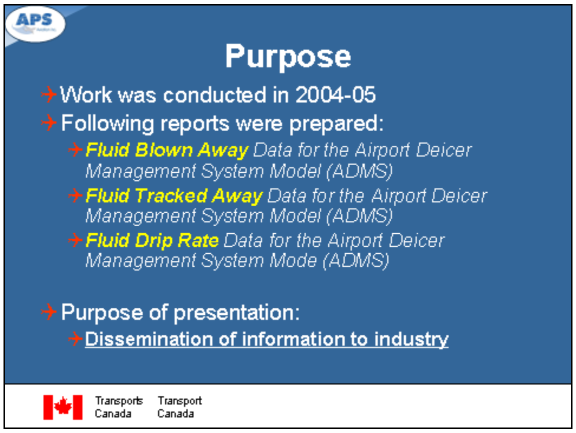
PRESENTED BY MARCO RUGGI



Background

- Glycol-based fluids have adverse effects on the biophysical environment
- An industry standard approach to understanding the dispersal of deicing fluids at airports is required
- TC committed to collect and analyze data to better understand how deicing and anti-icing fluids behave within and outside of the fluid application area

Transports Canada Transport Canada



Purpose

- Work was conducted in 2004-05
- Following reports were prepared:
  - ***Fluid Blown Away*** *Data for the Airport Deicer Management System Model (ADMS)*
  - ***Fluid Tracked Away*** *Data for the Airport Deicer Management System Model (ADMS)*
  - ***Fluid Drip Rate*** *Data for the Airport Deicer Management System Mode (ADMS)*
- Purpose of presentation:
  - Dissemination of information to industry

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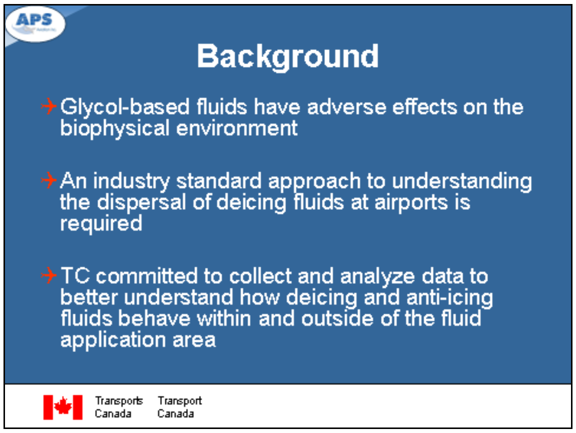

Background

- Glycol-based fluids have adverse effects on the biophysical environment
- An industry standard approach to understanding the dispersal of deicing fluids at airports is required
- TC committed to collect and analyze data to better understand how deicing and anti-icing fluids behave within and outside of the fluid application area

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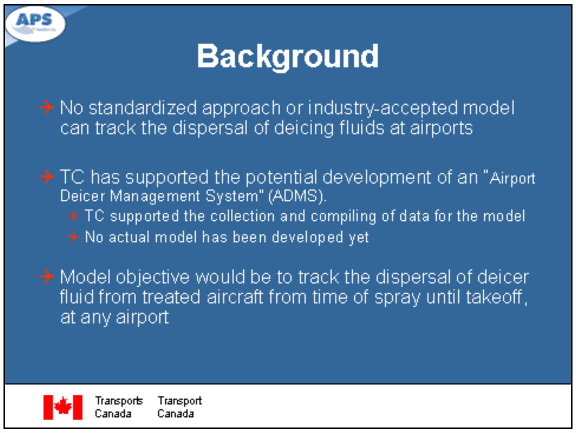

Background

- No standardized approach or industry-accepted model can track the dispersal of deicing fluids at airports
- TC has supported the potential development of an "Airport Deicer Management System" (ADMS).
  - TC supported the collection and compiling of data for the model
  - No actual model has been developed yet
- Model objective would be to track the dispersal of deicer fluid from treated aircraft from time of spray until takeoff, at any airport

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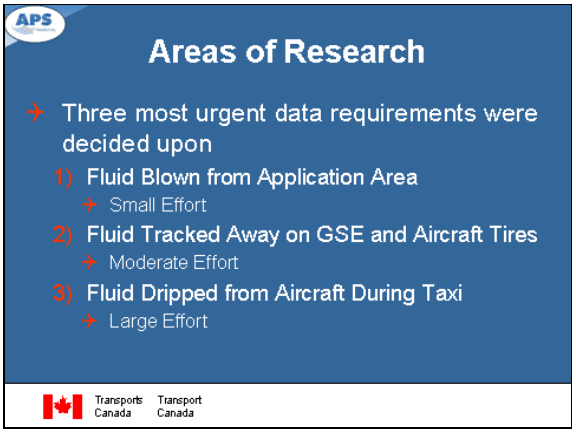

Areas of Research

- Three most urgent data requirements were decided upon
  1) Fluid Blown from Application Area
     - Small Effort
  2) Fluid Tracked Away on GSE and Aircraft Tires
     - Moderate Effort
  3) Fluid Dripped from Aircraft During Taxi
     - Large Effort

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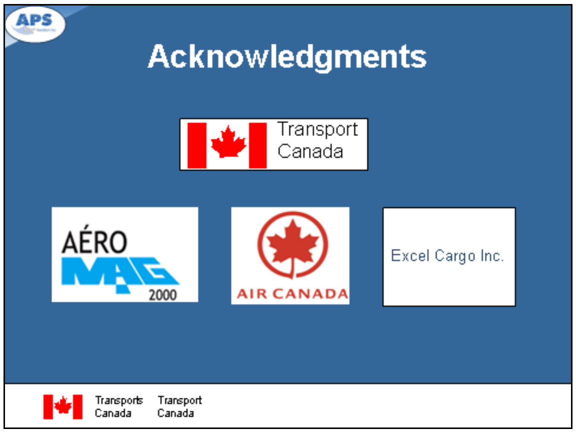

Acknowledgments

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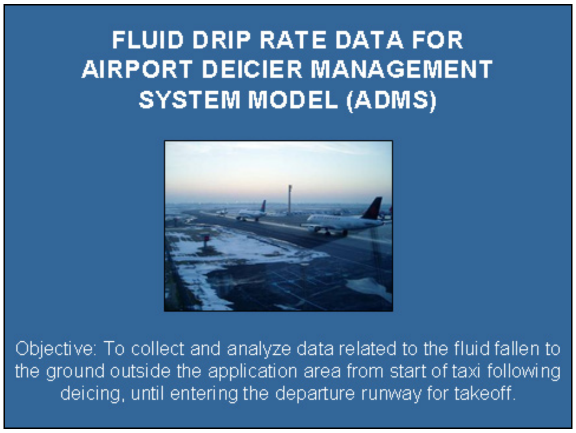
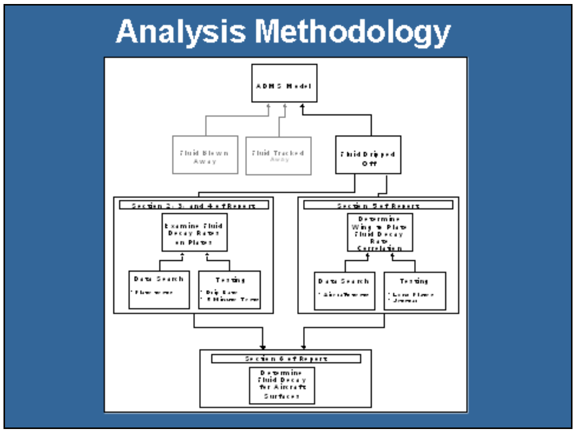


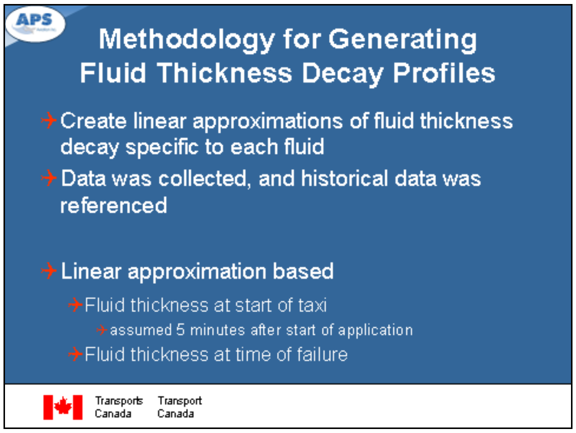
FLUID DRIP RATE DATA FOR AIRPORT DEICIER MANAGEMENT SYSTEM MODEL (ADMS)

Objective: To collect and analyze data related to the fluid fallen to the ground outside the application area from start of taxi following deicing, until entering the departure runway for takeoff.



Analysis Methodology

ADMS Model
Fluid Blown Away
Fluid Tracked Away
Fluid Dripped Off
Section 2, 3, and 4 of Report
Examine Fluid Decay Rates on Plates
Data Search
Testing
Drip Rate
Section 5 of Report
Determine Wing vs Plate Fluid Decay Rate Correlation
Data Search
Testing
Section 6 of Report
Determine Fluid Decay for Aircraft Surfaces



Methodology for Generating Fluid Thickness Decay Profiles

- Create linear approximations of fluid thickness decay specific to each fluid
- Data was collected, and historical data was referenced
- Linear approximation based
  - Fluid thickness at start of taxi
    - assumed 5 minutes after start of application
  - Fluid thickness at time of failure

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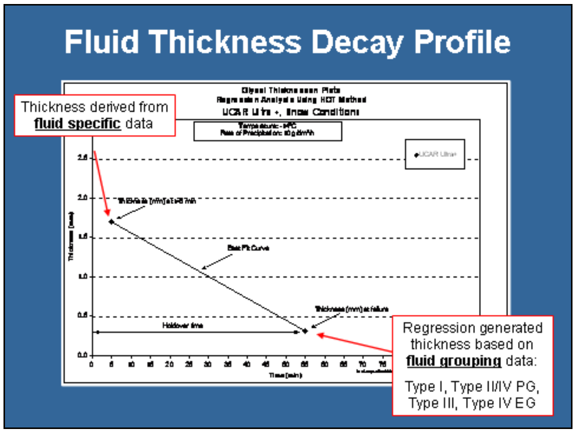
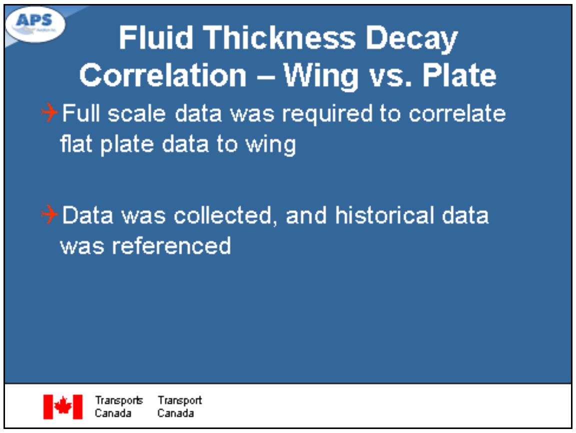


Fluid Thickness Decay Profile

Thickness derived from **fluid specific** data

Regression generated thickness based on **fluid grouping** data:

Type I, Type II/IV PG, Type III, Type IV EG



Fluid Thickness Decay Correlation – Wing vs. Plate

- Full scale data was required to correlate flat plate data to wing
- Data was collected, and historical data was referenced

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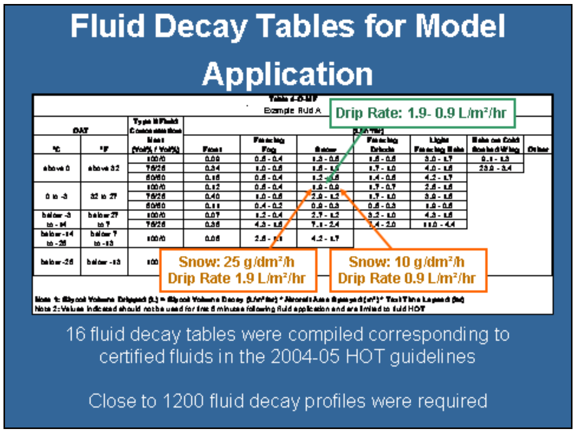


Fluid Decay Tables for Model Application

Example Fluid A
OAT
°C
°F
above 0
above 32
0 to -3
32 to 27
below -3 to -14
below 27 to 7
below -14 to -25
below 7 to -13
below -25
below -13
100/0
75/25
50/50
Frost
Freezing Fog
Snow
Freezing Drizzle
Light Freezing Rain
Rain on Cold Soaked Wing
Other

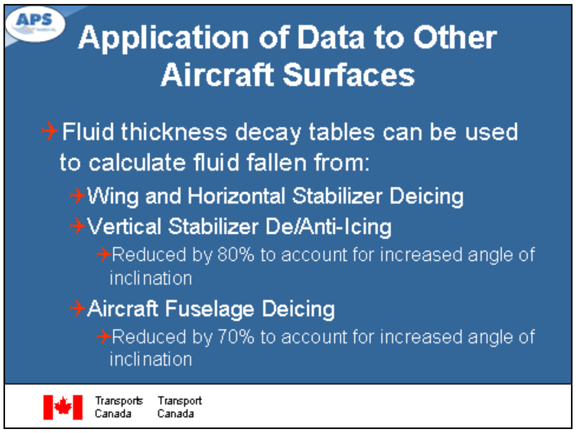
Drip Rate: 1.9- 0.9 L/m²/hr

Snow: 25 g/dm²/h
Drip Rate 1.9 L/m²/hr

Snow: 10 g/dm²/h
Drip Rate 0.9 L/m²/hr

16 fluid decay tables were compiled corresponding to certified fluids in the 2004-05 HOT guidelines

Close to 1200 fluid decay profiles were required



Application of Data to Other Aircraft Surfaces

- Fluid thickness decay tables can be used to calculate fluid fallen from:
  - Wing and Horizontal Stabilizer Deicing
  - Vertical Stabilizer De/Anti-Icing
    - Reduced by 80% to account for increased angle of inclination
  - Aircraft Fuselage Deicing
    - Reduced by 70% to account for increased angle of inclination

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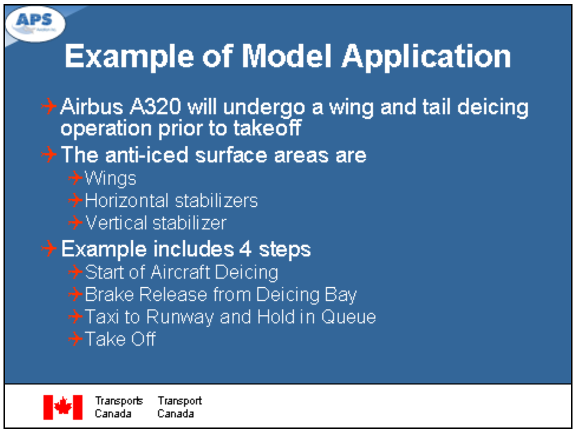

Example of Model Application

- Airbus A320 will undergo a wing and tail deicing operation prior to takeoff
- The anti-iced surface areas are
  - Wings
  - Horizontal stabilizers
  - Vertical stabilizer
- Example includes 4 steps
  - Start of Aircraft Deicing
  - Brake Release from Deicing Bay
  - Taxi to Runway and Hold in Queue
  - Take Off

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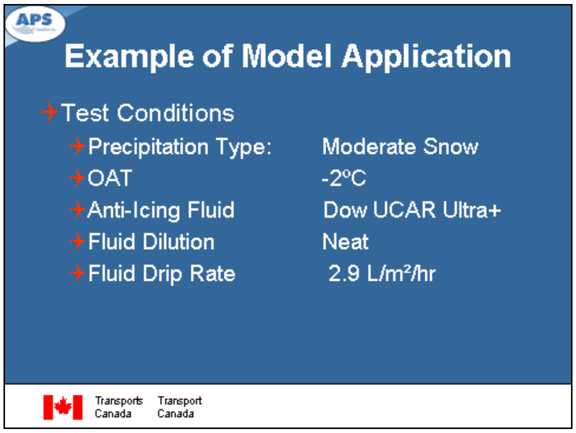

Example of Model Application

- Test Conditions

Precipitation Type:	Moderate Snow
OAT	-2ºC
Anti-Icing Fluid	Dow UCAR Ultra+
Fluid Dilution	Neat
Fluid Drip Rate	2.9 L/m²/hr

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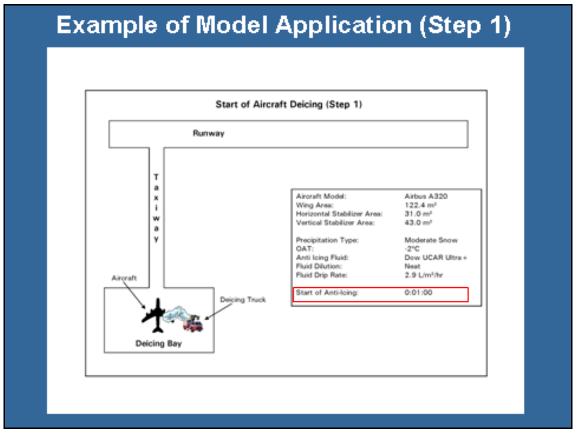
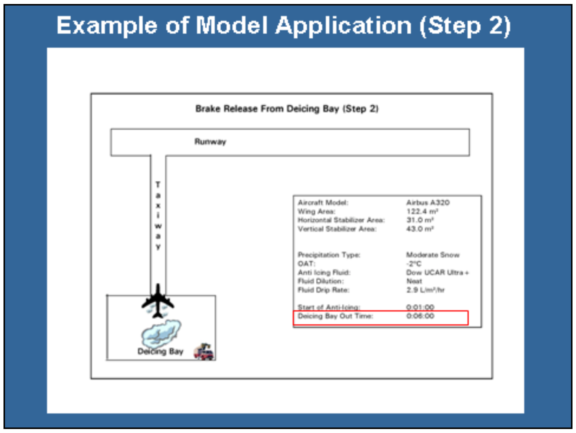


Example of Model Application (Step 1)

Start of Aircraft Deicing (Step 1)

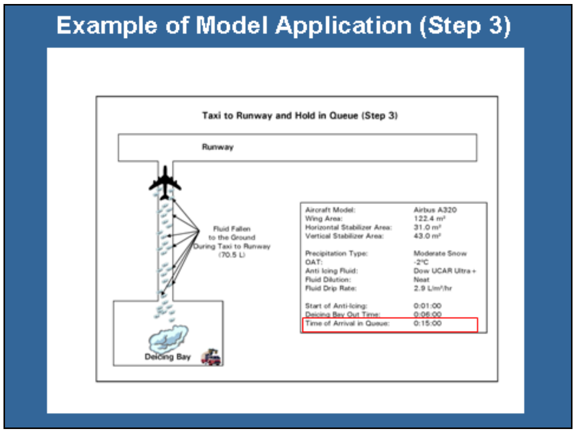
Aircraft Model:	Airbus A320
Wing Area:	122.4 m^2
Horizontal Stabilizer Area:	31.0 m^2
Vertical Stabilizer Area:	43.0 m^2
Precipitation Type:	Moderate Snow
OAT:	-2°C
Anti Icing Fluid:	Dow UCAR Ultra +
Fluid Dilution:	Neat
Fluid Drip Rate:	2.9 L/m^2/hr
Start of Anti-Icing:	0:01:00



Example of Model Application (Step 2)

Brake Release From Deicing Bay (Step 2)

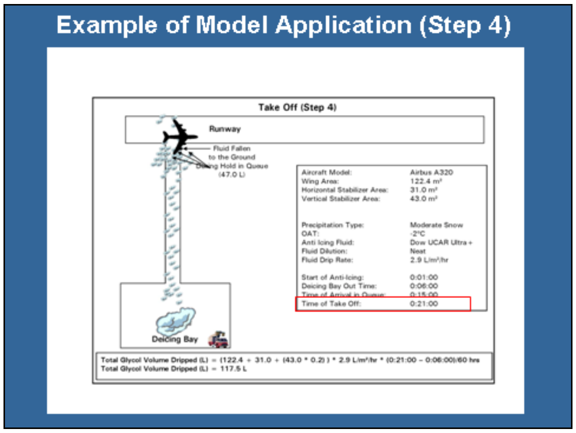
Aircraft Model:	Airbus A320
Wing Area:	122.4 m^2
Horizontal Stabilizer Area:	31.0 m^2
Vertical Stabilizer Area:	43.0 m^2
Precipitation Type:	Moderate Snow
OAT:	-2°C
Anti Icing Fluid:	Dow UCAR Ultra +
Fluid Dilution:	Neat
Fluid Drip Rate:	2.9 L/m^2/hr
Start of Anti-Icing:	0:01:00
Deicing Bay Out Time:	0:06:00



Example of Model Application (Step 3)

Taxi to Runway and Hold in Queue (Step 3)

Aircraft Model:	Airbus A320
Wing Area:	122.4 m^2
Horizontal Stabilizer Area:	31.0 m^2
Vertical Stabilizer Area:	43.0 m^2
Precipitation Type:	Moderate Snow
OAT:	-2°C
Anti Icing Fluid:	Dow UCAR Ultra +
Fluid Dilution:	Neat
Fluid Drip Rate:	2.9 L/m^2/hr
Start of Anti-Icing:	0:01:00
Deicing Bay Out Time:	0:06:00
Time of Arrival in Queue:	0:15:00



Example of Model Application (Step 4)

Take Off (Step 4)

Runway
Fluid Fallen
to the Ground
During Hold in Queue
(47.0 L)
Deicing Bay

Aircraft Model:	Airbus A320
Wing Area:	122.4 m²
Horizontal Stabilizer Area:	31.0 m²
Vertical Stabilizer Area:	43.0 m²
Precipitation Type:	Moderate Snow
OAT:	-2°C
Anti Icing Fluid:	Dow UCAR Ultra +
Fluid Dilution:	Neat
Fluid Drip Rate:	2.9 L/m²/hr
Start of Anti-Icing:	0:01:00
Deicing Bay Out Time:	0:06:00
Time of Arrival in Queue:	0:15:00
Time of Take Off:	0:21:00

Total Glycol Volume Dripped (L) = (122.4 + 31.0 + (43.0 * 0.2)) * 2.9 L/m²/hr * (0:21:00 – 0:06:00)/60 hrs
Total Glycol Volume Dripped (L) = 117.5 L

Example Results

- 71 liters of neat glycol fluid will have fallen to the ground during taxi to the runway
- 47liters of neat glycol fluid will have fallen to the ground during the hold in queue

- **118 liters of neat glycol fluid will have dripped onto the ground outside the application area**

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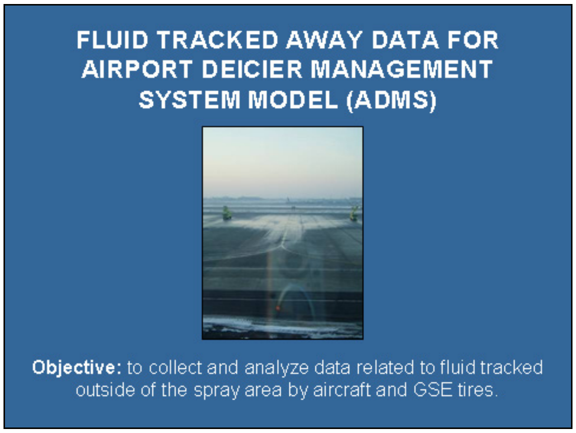
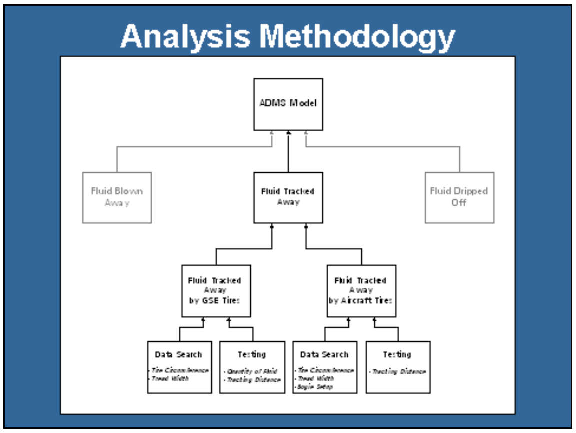


FLUID TRACKED AWAY DATA FOR AIRPORT DEICIER MANAGEMENT SYSTEM MODEL (ADMS)

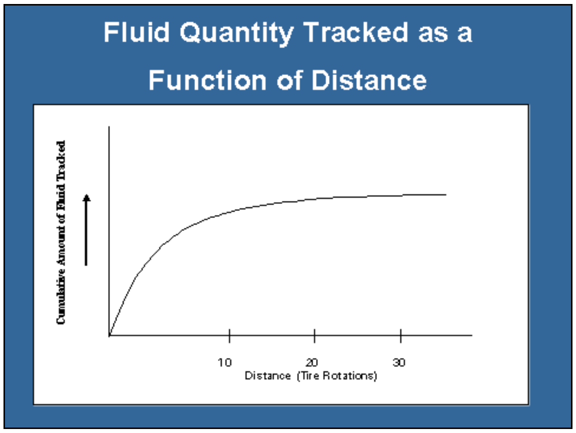
Objective: to collect and analyze data related to fluid tracked outside of the spray area by aircraft and GSE tires.



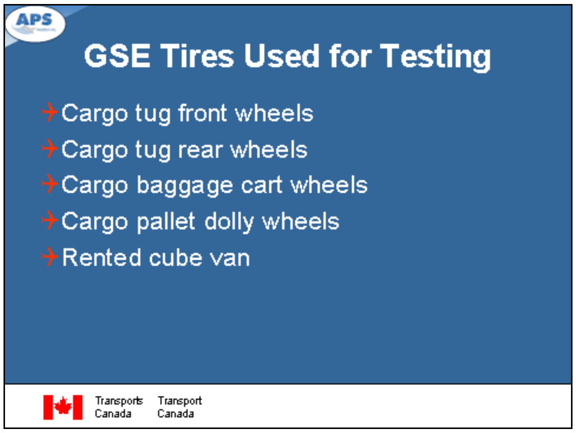
Analysis Methodology

ADMS Model
Fluid Blown Away
Fluid Tracked Away
Fluid Dripped Off
Fluid Tracked Away by GSE Tires
Fluid Tracked Away by Aircraft Tires
Data Search
- Tire Circumference
- Tread Width
Testing
- Quantity of Fluid
- Tracking Distance
Data Search
- Tire Circumference
- Tread Width
- Bogie Setup
Testing
- Tracking Distance

Fluid Tracked Away by GSE Tires



Fluid Quantity Tracked as a Function of Distance



GSE Tires Used for Testing

- Cargo tug front wheels
- Cargo tug rear wheels
- Cargo baggage cart wheels
- Cargo pallet dolly wheels
- Rented cube van

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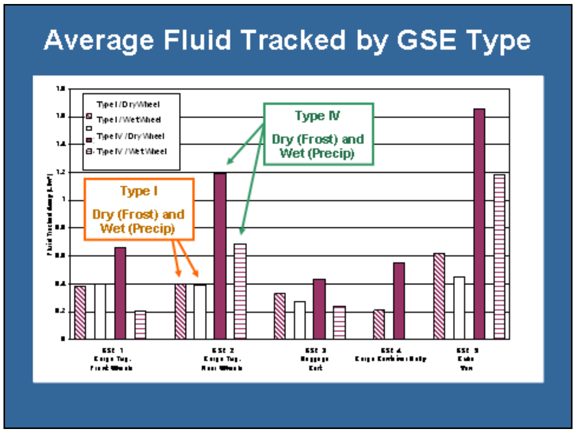
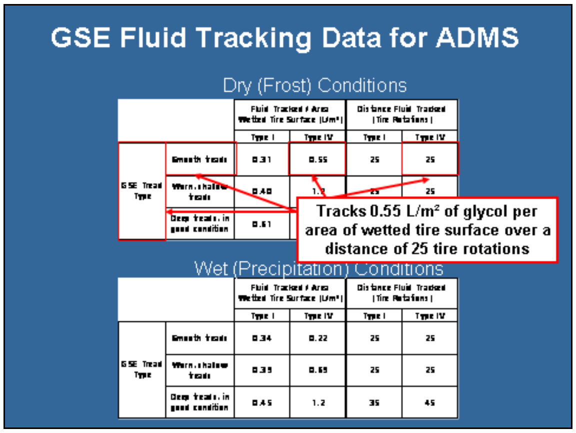


Average Fluid Tracked by GSE Type



GSE Fluid Tracking Data for ADMS

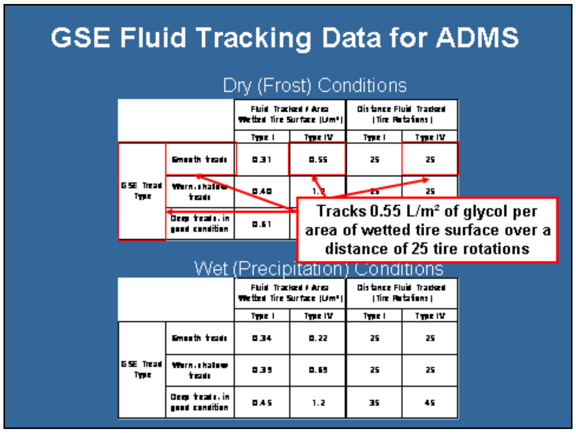
Dry (Frost) Conditions

		Fluid Tracked / Area Wetted Tire Surface (L/m²)		Distance Fluid Tracked (Tire Rotations)	
		Type I	Type IV	Type I	Type IV
GSE Tread Type	Smooth treads	0.31	0.55	25	25
	Worn, shallow treads	0.40	[illegible]	25	25
	Deep treads, in good condition	0.61	[illegible]	[illegible]	[illegible]

Tracks 0.55 L/m² of glycol per area of wetted tire surface over a distance of 25 tire rotations

Wet (Precipitation) Conditions

		Fluid Tracked / Area Wetted Tire Surface (L/m²)		Distance Fluid Tracked (Tire Rotations)	
		Type I	Type IV	Type I	Type IV
GSE Tread Type	Smooth treads	0.34	0.22	25	25
	Worn, shallow treads	0.39	0.69	25	25
	Deep treads, in good condition	0.45	1.2	35	45



GSE Fluid Tracking Data for ADMS

Dry (Frost) Conditions

		Fluid Tracked / Area Wetted Tire Surface (L/m²)		Distance Fluid Tracked (Tire Rotations)	
		Type I	Type IV	Type I	Type IV
GSE Tread Type	Smooth treads	0.31	0.55	25	25
	Worn, shallow treads	0.40	[illegible]	25	25
	Deep treads, in good condition	0.61	[illegible]	[illegible]	[illegible]

Tracks 0.55 L/m² of glycol per area of wetted tire surface over a distance of 25 tire rotations

Wet (Precipitation) Conditions

		Fluid Tracked / Area Wetted Tire Surface (L/m²)		Distance Fluid Tracked (Tire Rotations)	
		Type I	Type IV	Type I	Type IV
GSE Tread Type	Smooth treads	0.34	0.22	25	25
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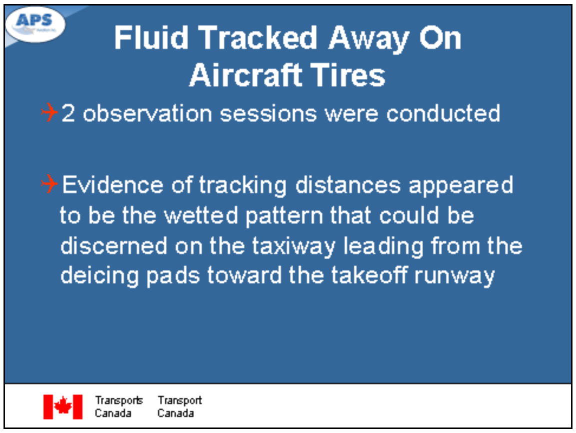
	Deep treads, in good condition	0.45	1.2	35	45



Fluid Tracked Away On Aircraft Tires

- 2 observation sessions were conducted
- Evidence of tracking distances appeared to be the wetted pattern that could be discerned on the taxiway leading from the deicing pads toward the takeoff runway

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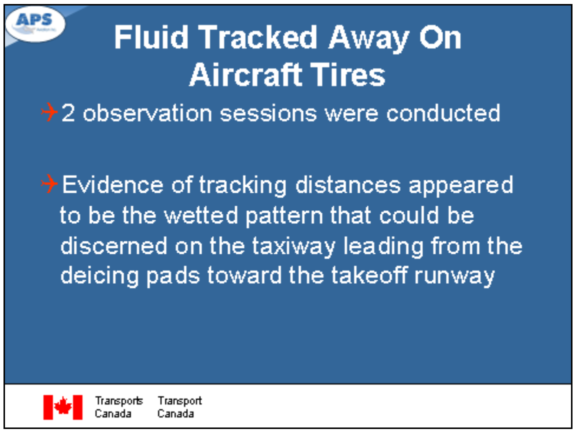
Fluid Tracked Away by Aircraft Tires



Fluid Tracked Away On Aircraft Tires

- 2 observation sessions were conducted
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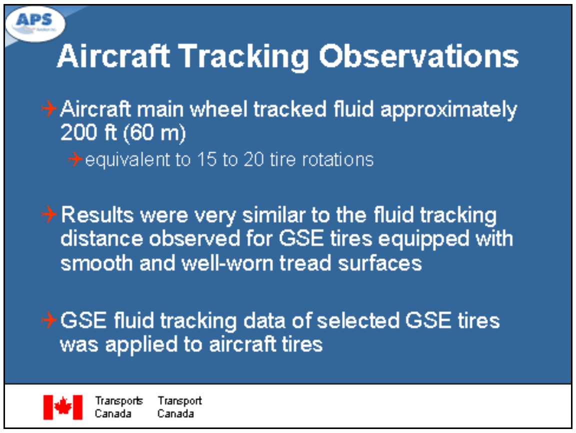

Aircraft Tracking Observations

- Aircraft main wheel tracked fluid approximately 200 ft (60 m)
  - equivalent to 15 to 20 tire rotations
- Results were very similar to the fluid tracking distance observed for GSE tires equipped with smooth and well-worn tread surfaces
- GSE fluid tracking data of selected GSE tires was applied to aircraft tires

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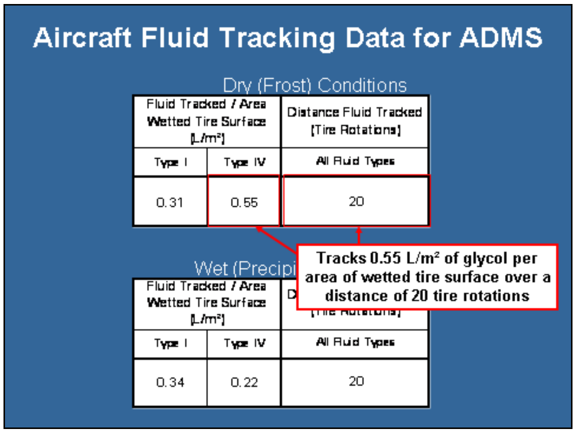


Aircraft Fluid Tracking Data for ADMS

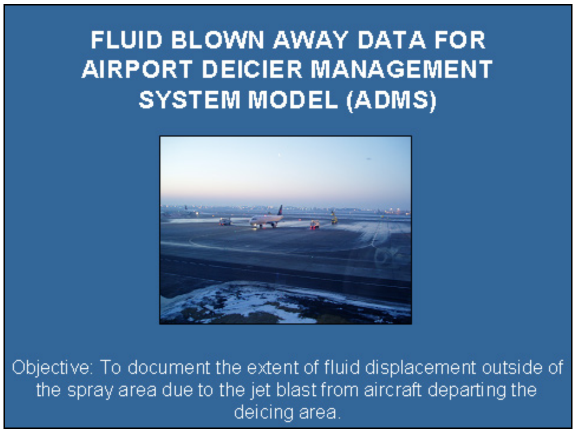
Dry (Frost) Conditions

Fluid Tracked / Area Wetted Tire Surface (L/m²)		Distance Fluid Tracked (Tire Rotations)
Type I	Type IV	All Fluid Types
0.31	0.55	20

Tracks 0.55 L/m² of glycol per area of wetted tire surface over a distance of 20 tire rotations

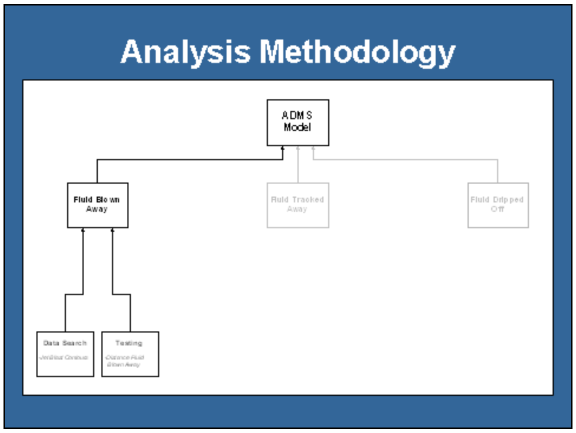
Wet (Precipi

Fluid Tracked / Area Wetted Tire Surface (L/m²)		D
Type I	Type IV	All Fluid Types
0.34	0.22	20

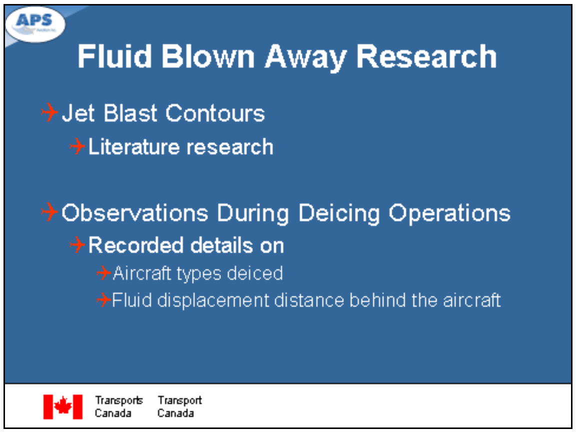


FLUID BLOWN AWAY DATA FOR AIRPORT DEICIER MANAGEMENT SYSTEM MODEL (ADMS)

Objective: To document the extent of fluid displacement outside of the spray area due to the jet blast from aircraft departing the deicing area.



Analysis Methodology



Fluid Blown Away Research

- Jet Blast Contours
  - Literature research
- Observations During Deicing Operations
  - Recorded details on
    - Aircraft types deiced
    - Fluid displacement distance behind the aircraft

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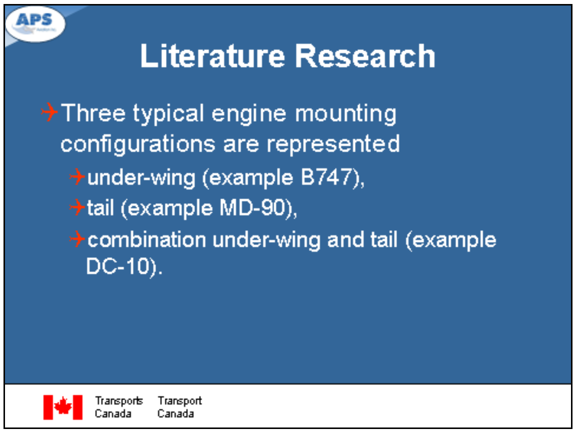

Literature Research

- Three typical engine mounting configurations are represented
  - under-wing (example B747),
  - tail (example MD-90),
  - combination under-wing and tail (example DC-10).

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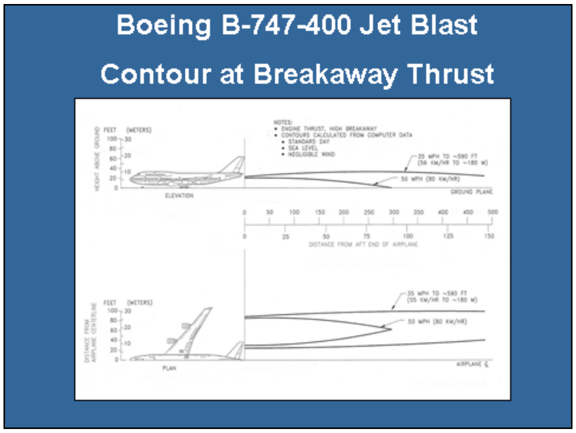
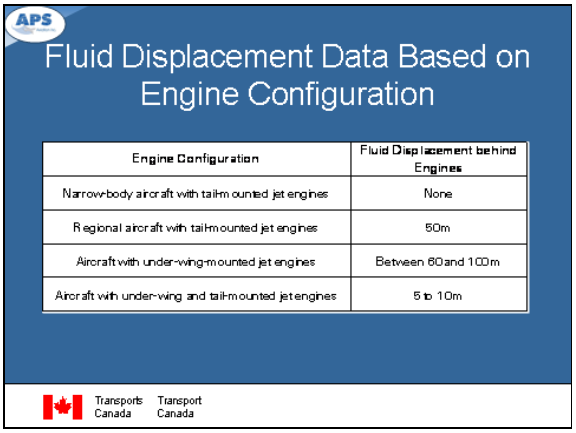


Boeing B-747-400 Jet Blast Contour at Breakaway Thrust

NOTES:
• ENGINE THRUST, HIGH BREAKAWAY
• CONTOURS CALCULATED FROM COMPUTER DATA
• STANDARD DAY
• SEA LEVEL
• NEGLIGIBLE WIND
HEIGHT ABOVE GROUND
FEET (METERS)
100 30
80
60 20
40
20 10
0
ELEVATION
35 MPH TO ~590 FT (56 KM/HR TO ~180 M)
50 MPH (80 KM/HR)
GROUND PLANE
0 50 100 150 200 250 300 350 400 450 500
0 25 50 75 100 125 150
DISTANCE FROM AFT END OF AIRPLANE
DISTANCE FROM AIRPLANE CENTERLINE
FEET (METERS)
PLAN
35 MPH TO ~590 FT (55 KM/HR TO ~180 M)
50 MPH (80 KM/HR)
AIRPLANE ℄



Fluid Displacement Data Based on Engine Configuration

Engine Configuration	Fluid Displacement behind Engines
Narrow-body aircraft with tail-mounted jet engines	None
Regional aircraft with tail-mounted jet engines	50m
Aircraft with under-wing-mounted jet engines	Between 60 and 100m
Aircraft with under-wing and tail-mounted jet engines	5 to 10m

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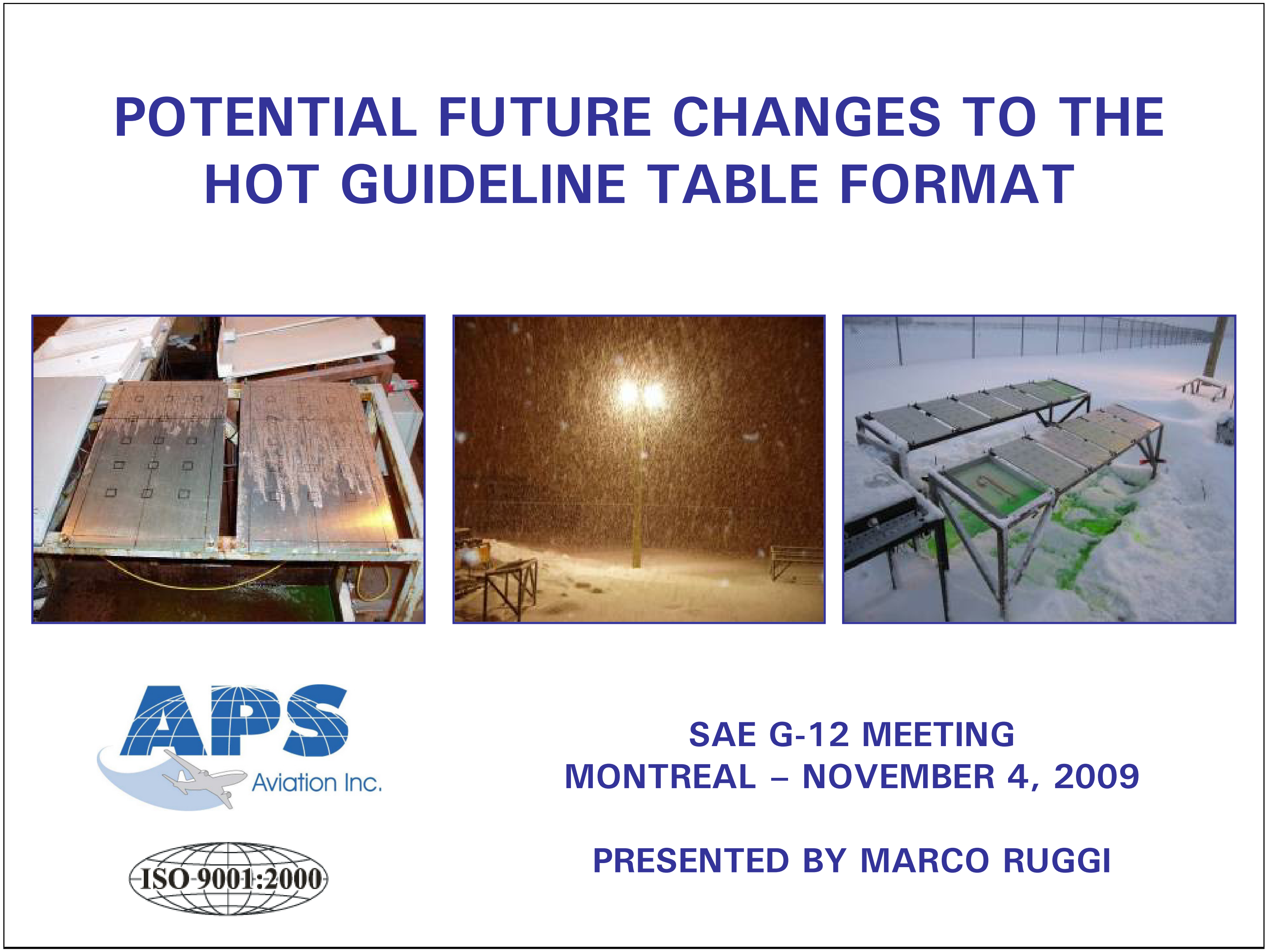
APS Aviation Inc.

Marco Ruggi
mruggi@adga.ca



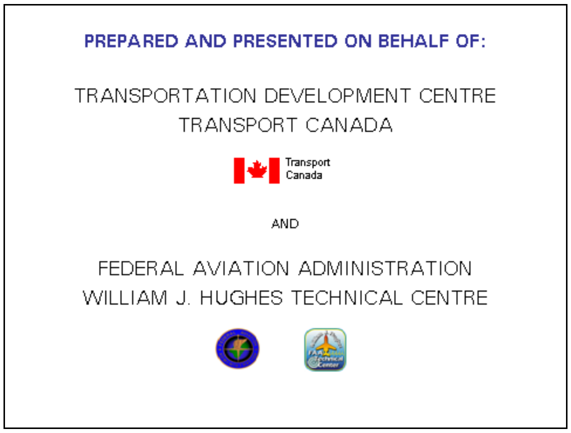
POTENTIAL FUTURE CHANGES TO THE HOT GUIDELINE TABLE FORMAT

APS Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING
MONTREAL – NOVEMBER 4, 2009

PRESENTED BY MARCO RUGGI



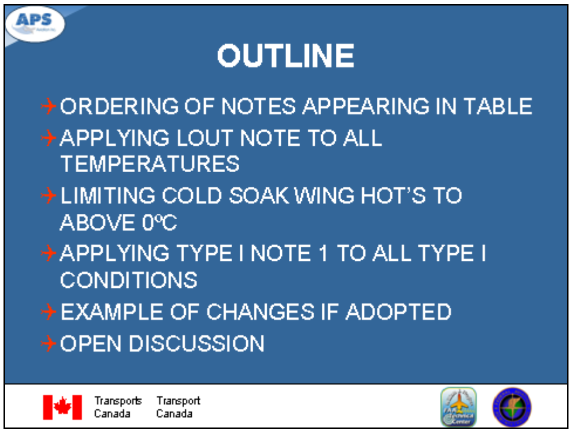
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

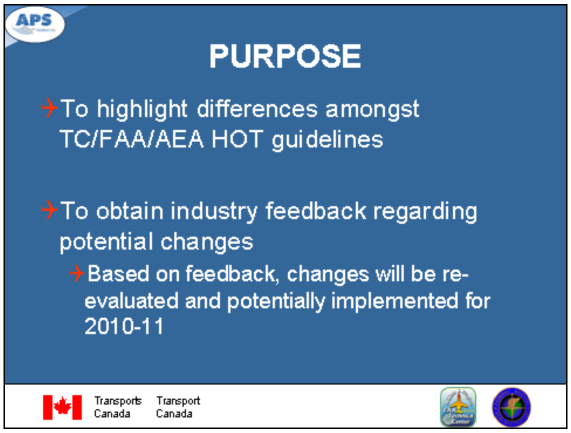
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

Transports Canada Transport Canada



PURPOSE

- To highlight differences amongst TC/FAA/AEA HOT guidelines
- To obtain industry feedback regarding potential changes
  - Based on feedback, changes will be re-evaluated and potentially implemented for 2010-11

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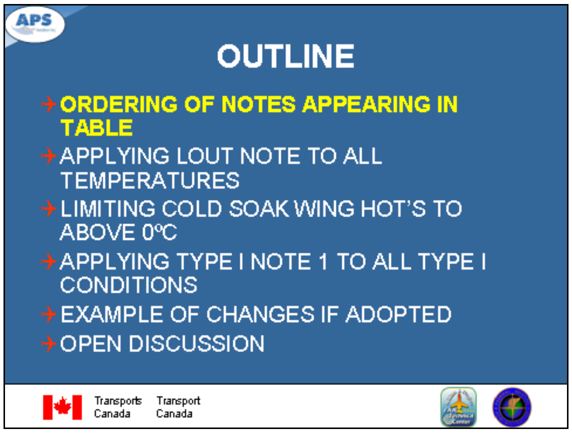

OUTLINE

- **ORDERING OF NOTES APPEARING IN TABLE**
- APPLYING LOUT NOTE TO ALL TEMPERATURES
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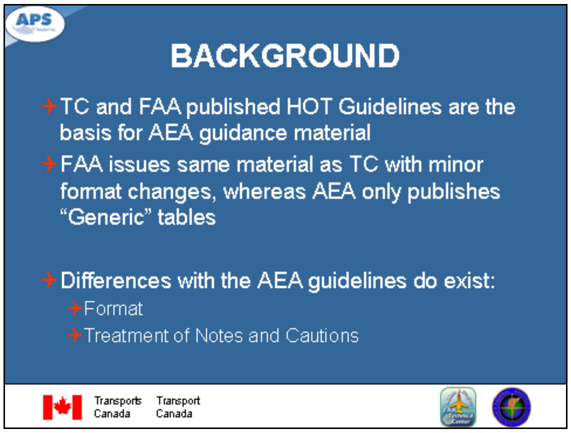

BACKGROUND

- TC and FAA published HOT Guidelines are the basis for AEA guidance material
- FAA issues same material as TC with minor format changes, whereas AEA only publishes "Generic" tables
- Differences with the AEA guidelines do exist:
  - Format
  - Treatment of Notes and Cautions

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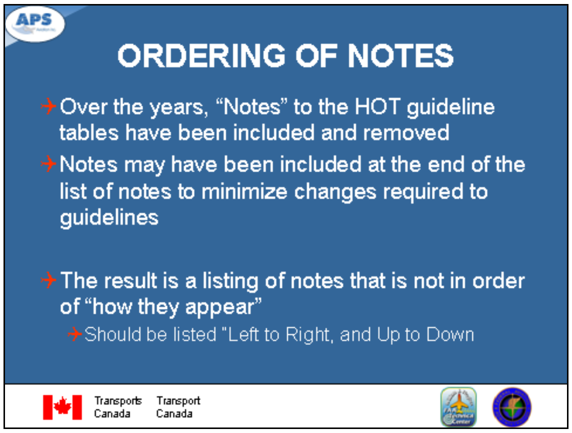

ORDERING OF NOTES

- Over the years, "Notes" to the HOT guideline tables have been included and removed
- Notes may have been included at the end of the list of notes to minimize changes required to guidelines
- The result is a listing of notes that is not in order of "how they appear"
  - Should be listed "Left to Right, and Up to Down

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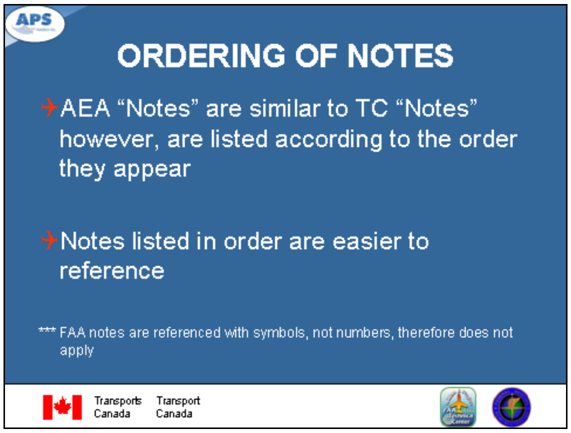

ORDERING OF NOTES

- AEA "Notes" are similar to TC "Notes" however, are listed according to the order they appear
- Notes listed in order are easier to reference

*** FAA notes are referenced with symbols, not numbers, therefore does not apply

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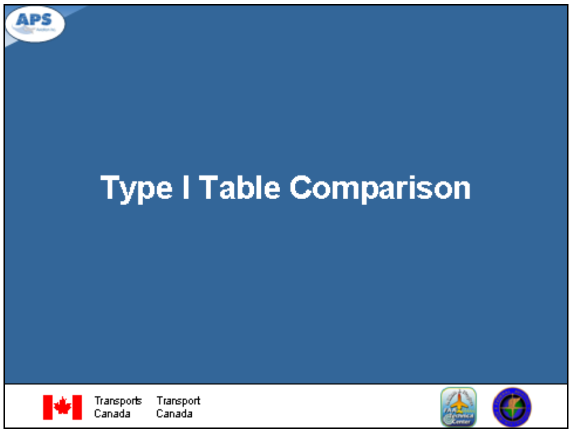

Type I Table Comparison

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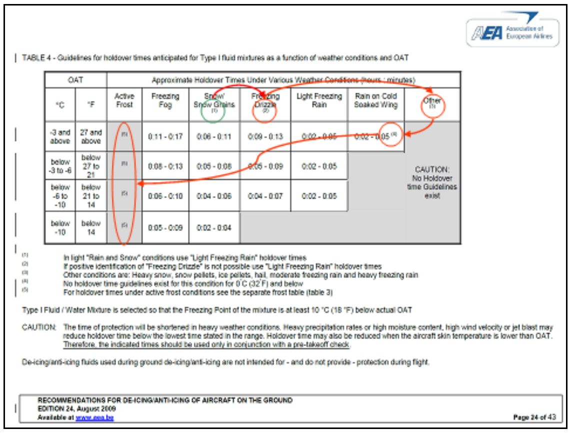

TABLE 4 - Guidelines for holdover times anticipated for Type I fluid mixtures as a function of weather conditions and OAT

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	(5)	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05 (4)	CAUTION: No Holdover time Guidelines exist
below -3 to -6	below 27 to 21	(5)	0:08 - 0:13	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05		
below -6 to -10	below 21 to 14	(5)	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05		
below -10	below 14	(5)	0:05 - 0:09	0:02 - 0:04				

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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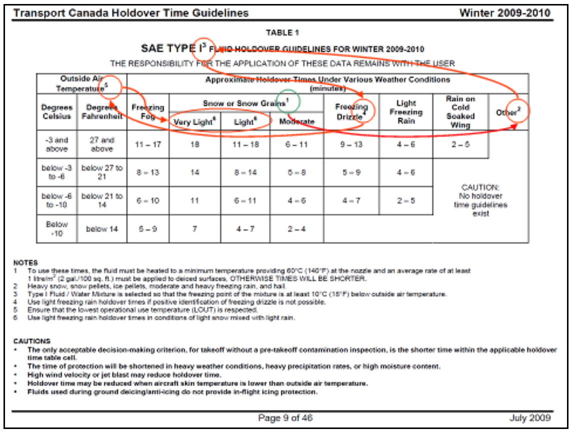

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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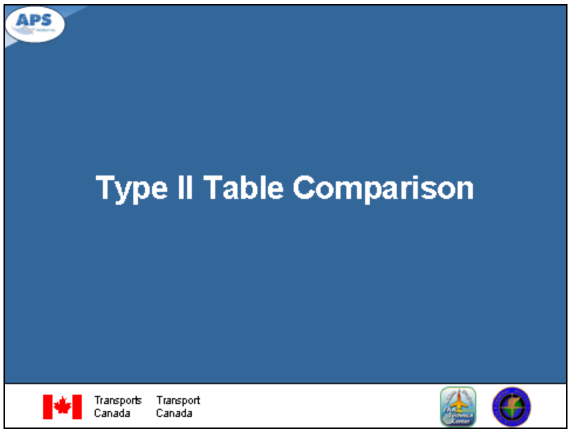

Type II Table Comparison

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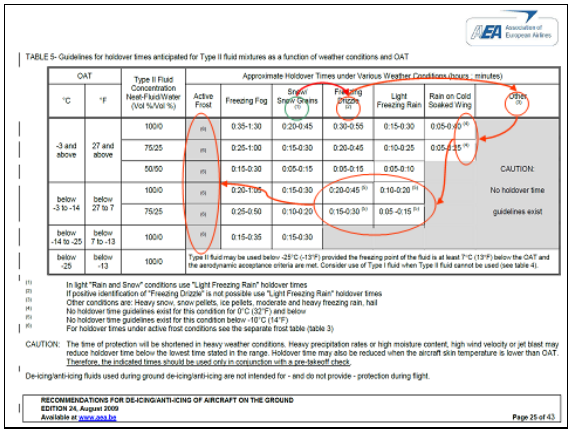

TABLE 5- Guidelines for holdover times anticipated for Type II fluid mixtures as a function of weather conditions and OAT

OAT		Type II Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	(6)	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40 (4)	CAUTION: No holdover time guidelines exist
		75/25	(6)	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25 (4)	
		50/50	(6)	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	(6)	0:20-1:05	0:15-0:30	0:20-0:45 (5)	0:10-0:20 (5)		
		75/25	(6)	0:25-0:50	0:10-0:20	0:15-0:30 (5)	0:05 -0:15 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:35	0:15-0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type II fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) No holdover time guidelines exist for this condition below -10°C (14°F)
(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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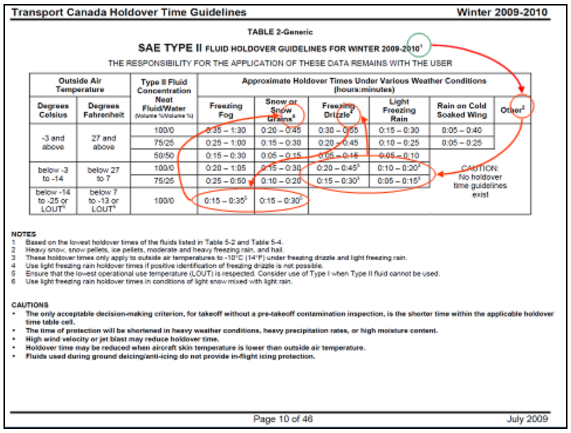

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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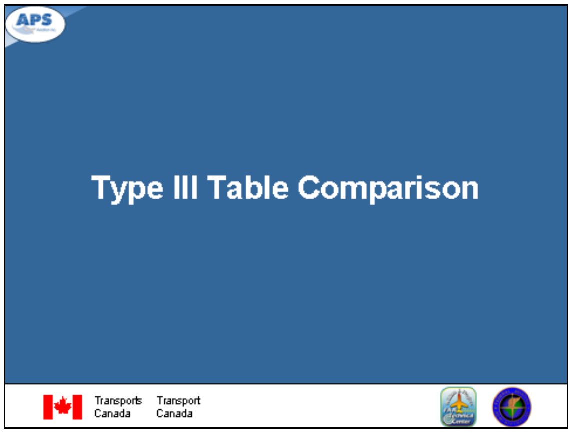

Type III Table Comparison

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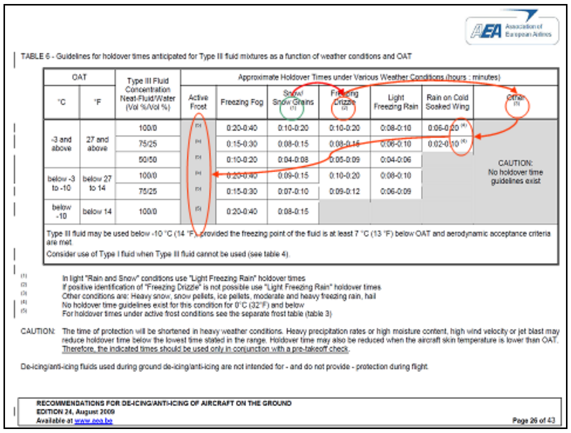

Association of European Airlines

TABLE 6 - Guidelines for holdover times anticipated for Type III fluid mixtures as a function of weather conditions and OAT

OAT		Type III Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	(5)	0:20-0:40	0:10-0:20	0:10-0:20	0:08-0:10	0:06-0:20 (4)	CAUTION: No holdover time guidelines exist
		75/25	(5)	0:15-0:30	0:08-0:15	0:08-0:15	0:06-0:10	0:02-0:10 (4)	
		50/50	(5)	0:10-0:20	0:04-0:08	0:05-0:09	0:04-0:06		
below -3 to -10	below 27 to 14	100/0	(5)	0:20-0:40	0:09-0:15	0:10-0:20	0:08-0:10		
		75/25	(5)	0:15-0:30	0:07-0:10	0:09-0:12	0:06-0:09		
below -10	below 14	100/0	(5)	0:20-0:40	0:08-0:15				
Type III fluid may be used below -10 °C (14 °F), provided the freezing point of the fluid is at least 7 °C (13 °F) below OAT and aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type III fluid cannot be used (see table 4).									

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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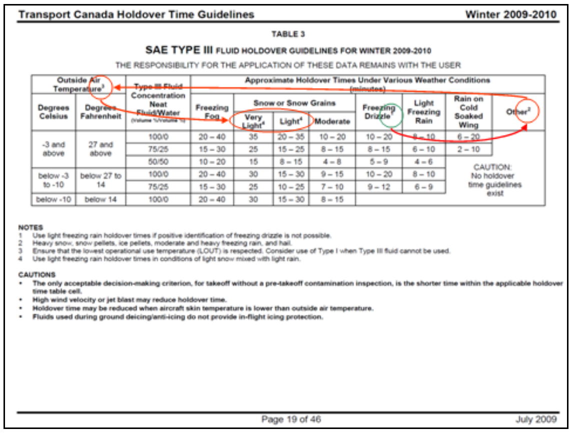

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains			Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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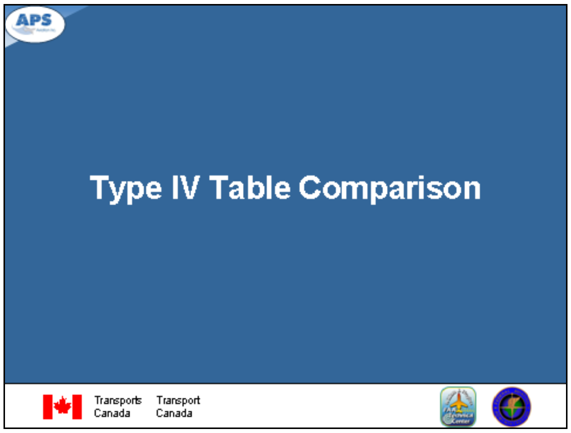
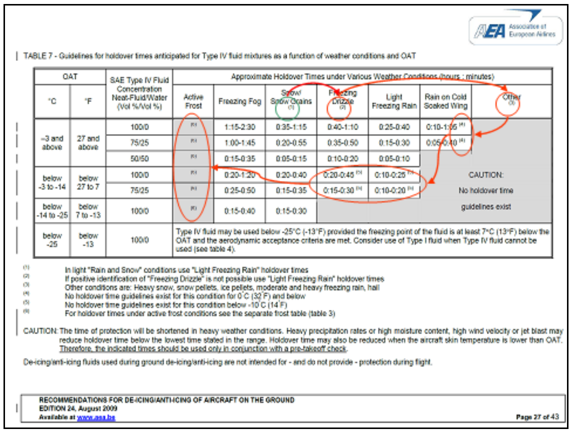


Type IV Table Comparison

Transports Canada
Transport Canada



Association of European Airlines

TABLE 7 - Guidelines for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	(6)	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	CAUTION: No holdover time guidelines exist
		75/25	(6)	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	(6)	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	(6)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)		
		75/25	(6)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type IV fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) No holdover time guidelines exist for this condition below -10°C (14°F)
(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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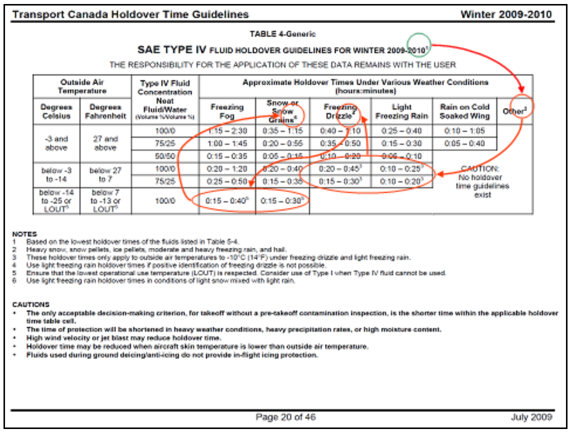

Transport Canada Holdover Time Guidelines | Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:06 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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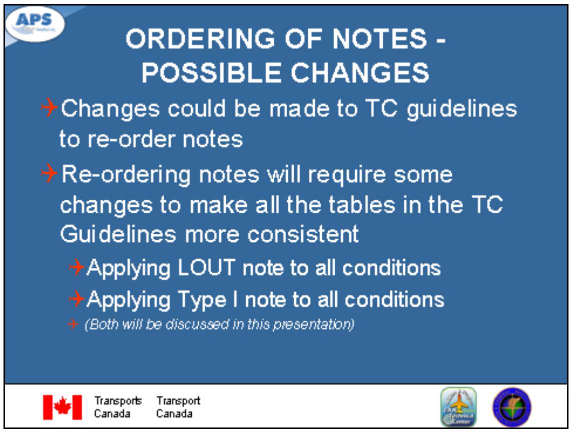

ORDERING OF NOTES - POSSIBLE CHANGES

- Changes could be made to TC guidelines to re-order notes
- Re-ordering notes will require some changes to make all the tables in the TC Guidelines more consistent
  - Applying LOUT note to all conditions
  - Applying Type I note to all conditions
  - *(Both will be discussed in this presentation)*

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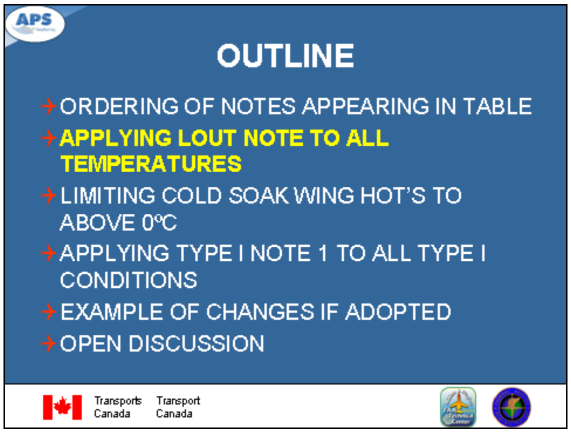

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- **APPLYING LOUT NOTE TO ALL TEMPERATURES**
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

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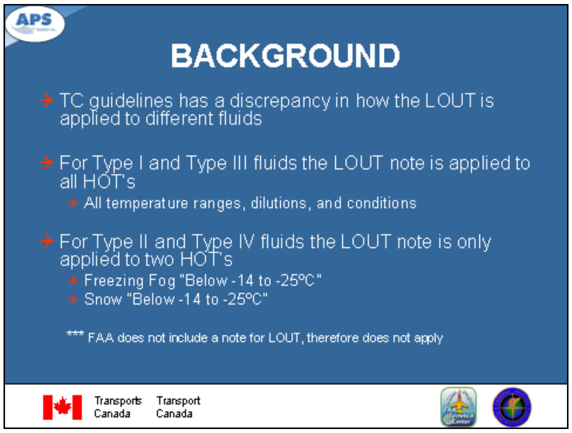

BACKGROUND

- TC guidelines has a discrepancy in how the LOUT is applied to different fluids
- For Type I and Type III fluids the LOUT note is applied to all HOT's
  - All temperature ranges, dilutions, and conditions
- For Type II and Type IV fluids the LOUT note is only applied to two HOT's
  - Freezing Fog "Below -14 to -25ºC"
  - Snow "Below -14 to -25ºC"

*** FAA does not include a note for LOUT, therefore does not apply

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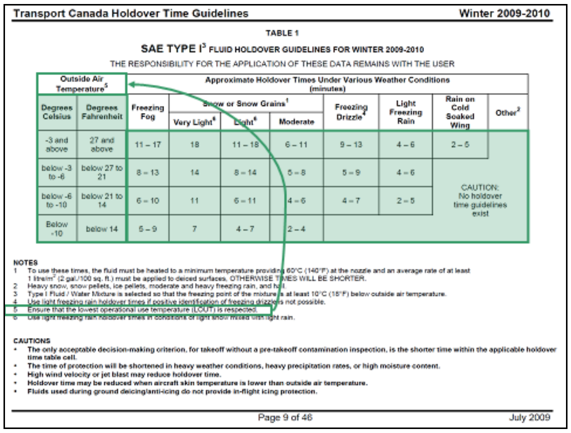

Transport Canada Holdover Time Guidelines | Winter 2009-2010

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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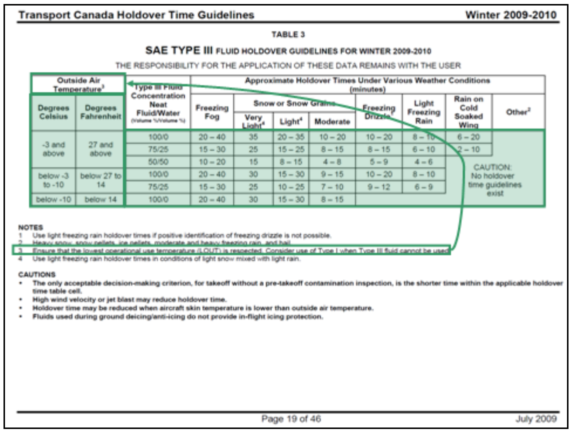

Transport Canada Holdover Time Guidelines | Winter 2009-2010

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[4]	Light[4]	Moderate	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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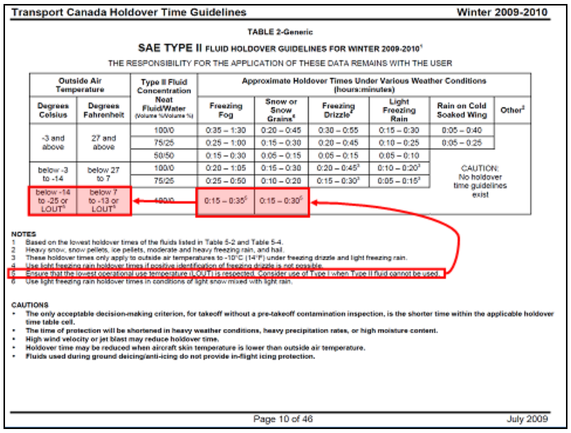

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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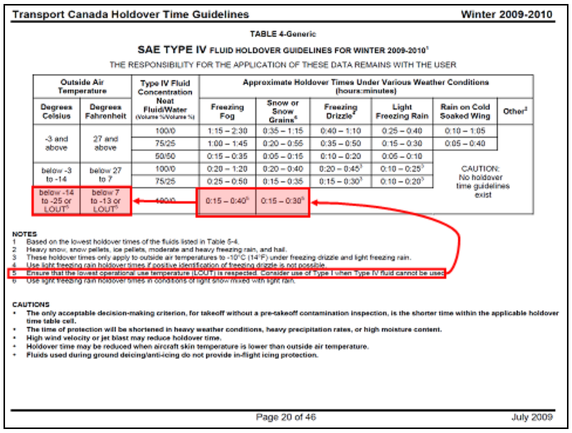

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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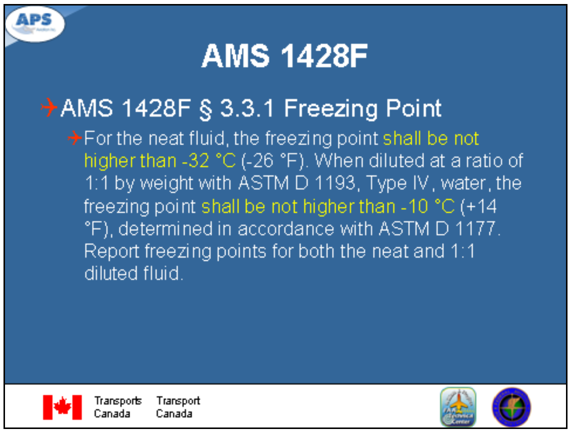

AMS 1428F

- AMS 1428F § 3.3.1 Freezing Point
  - For the neat fluid, the freezing point shall be not higher than -32 °C (-26 °F). When diluted at a ratio of 1:1 by weight with ASTM D 1193, Type IV, water, the freezing point shall be not higher than -10 °C (+14 °F), determined in accordance with ASTM D 1177. Report freezing points for both the neat and 1:1 diluted fluid.

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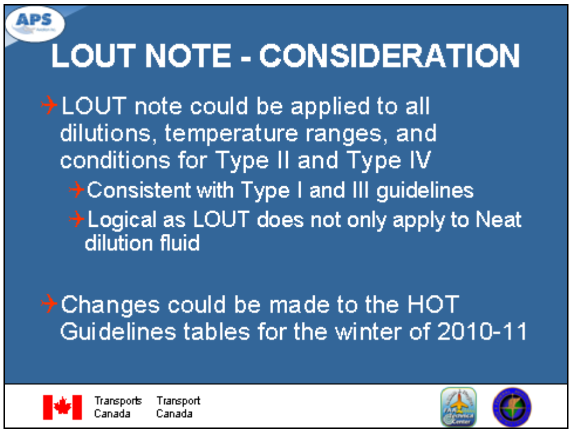

LOUT NOTE - CONSIDERATION

- LOUT note could be applied to all dilutions, temperature ranges, and conditions for Type II and Type IV
  - Consistent with Type I and III guidelines
  - Logical as LOUT does not only apply to Neat dilution fluid
- Changes could be made to the HOT Guidelines tables for the winter of 2010-11

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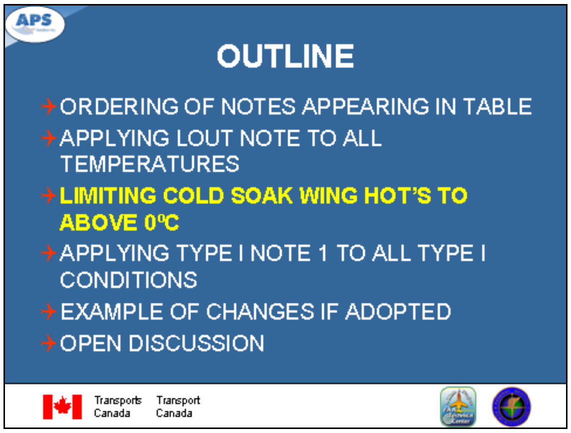

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- **LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC**
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

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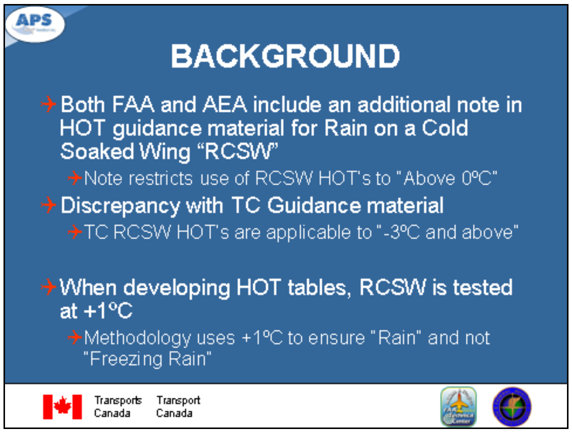

BACKGROUND

- Both FAA and AEA include an additional note in HOT guidance material for Rain on a Cold Soaked Wing "RCSW"
  - Note restricts use of RCSW HOT's to "Above 0ºC"
- Discrepancy with TC Guidance material
  - TC RCSW HOT's are applicable to "-3ºC and above"
- When developing HOT tables, RCSW is tested at +1ºC
  - Methodology uses +1ºC to ensure "Rain" and not "Freezing Rain"

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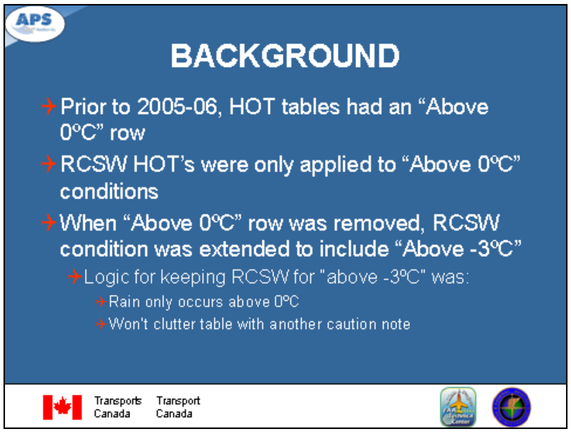

BACKGROUND

- Prior to 2005-06, HOT tables had an "Above 0ºC" row
- RCSW HOT's were only applied to "Above 0ºC" conditions
- When "Above 0ºC" row was removed, RCSW condition was extended to include "Above -3ºC"
  - Logic for keeping RCSW for "above -3ºC" was:
    - Rain only occurs above 0ºC
    - Won't clutter table with another caution note

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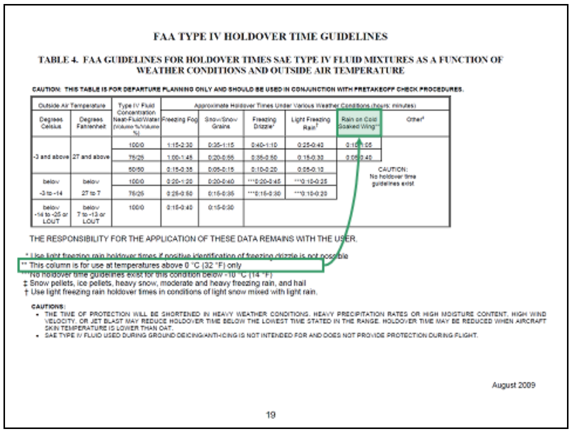

FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

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

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

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

*** No holdover time guidelines exist for this condition below -10 °C (14 °F)

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

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

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

August 2009

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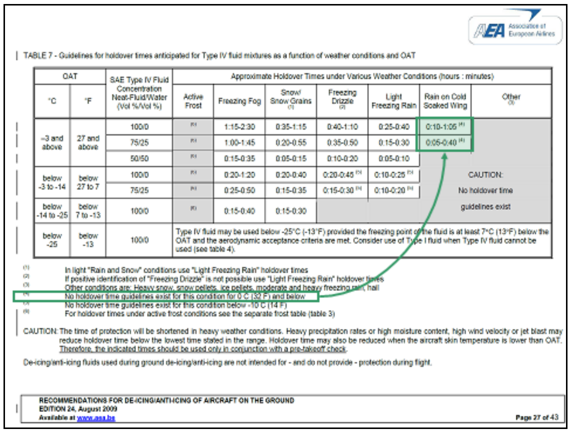

AEA Association of European Airlines

TABLE 7 - Guidelines for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	(6)	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	
		75/25	(6)	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	(6)	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	(6)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)		
		75/25	(6)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type IV fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times

(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times

(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail

(4) No holdover time guidelines exist for this condition for 0 C (32 F) and below

(5) No holdover time guidelines exist for this condition below -10 C (14 F)

(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
EDITION 24, August 2009
Available at www.aea.be

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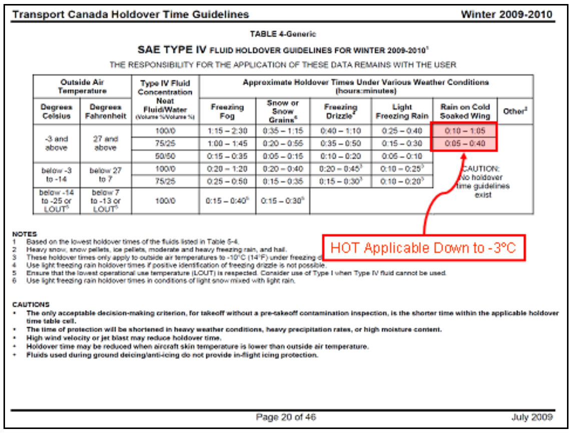

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

HOT Applicable Down to -3°C

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing d
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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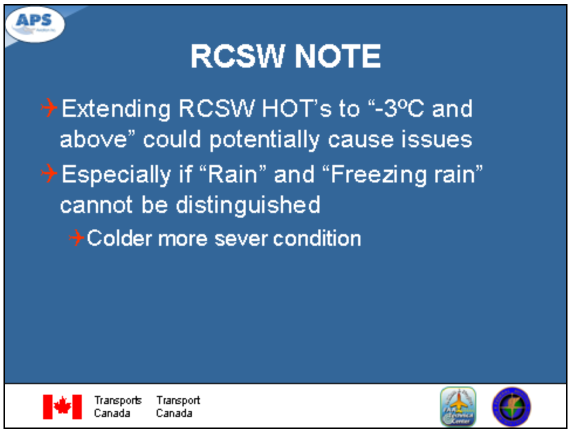

RCSW NOTE

- Extending RCSW HOT's to "-3ºC and above" could potentially cause issues
- Especially if "Rain" and "Freezing rain" cannot be distinguished
  - Colder more sever condition

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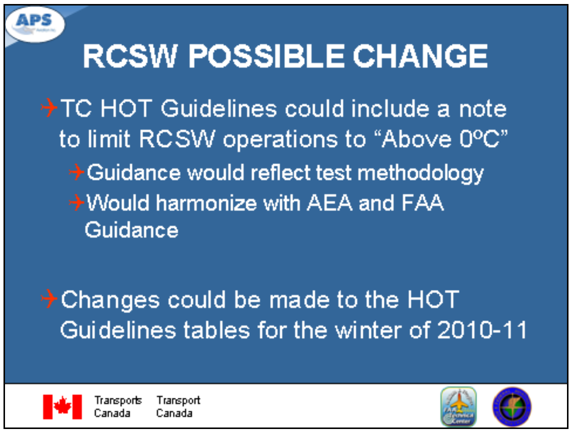

RCSW POSSIBLE CHANGE

- TC HOT Guidelines could include a note to limit RCSW operations to "Above 0ºC"
  - Guidance would reflect test methodology
  - Would harmonize with AEA and FAA Guidance
- Changes could be made to the HOT Guidelines tables for the winter of 2010-11

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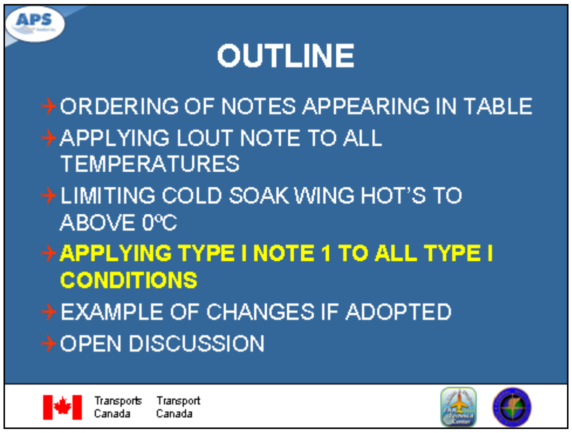
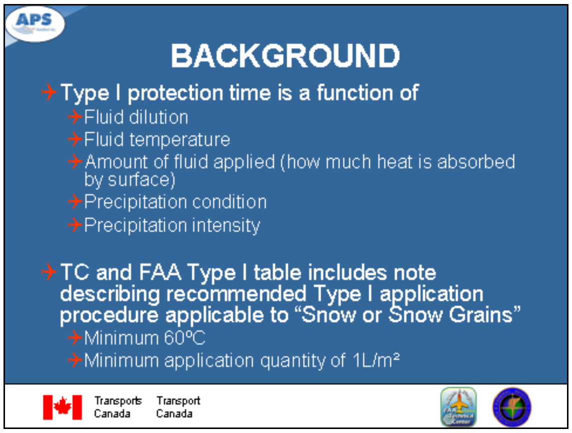


OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- **APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS**
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

Transports Canada Transport Canada



BACKGROUND

- Type I protection time is a function of
  - Fluid dilution
  - Fluid temperature
  - Amount of fluid applied (how much heat is absorbed by surface)
  - Precipitation condition
  - Precipitation intensity
- TC and FAA Type I table includes note describing recommended Type I application procedure applicable to "Snow or Snow Grains"
  - Minimum 60ºC
  - Minimum application quantity of 1L/m²

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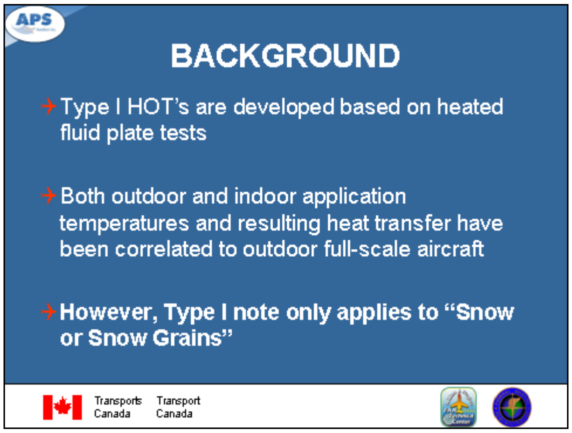

BACKGROUND

- Type I HOT's are developed based on heated fluid plate tests
- Both outdoor and indoor application temperatures and resulting heat transfer have been correlated to outdoor full-scale aircraft
- **However, Type I note only applies to "Snow or Snow Grains"**

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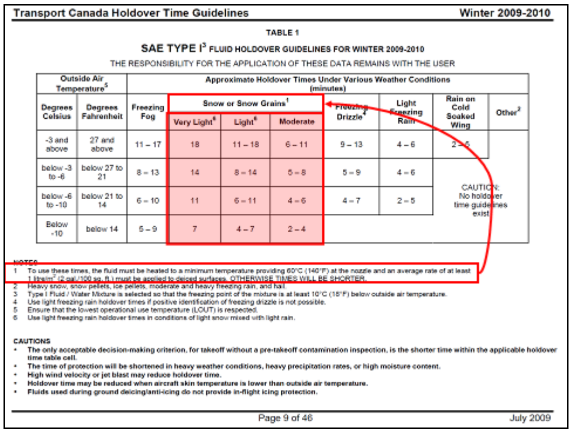

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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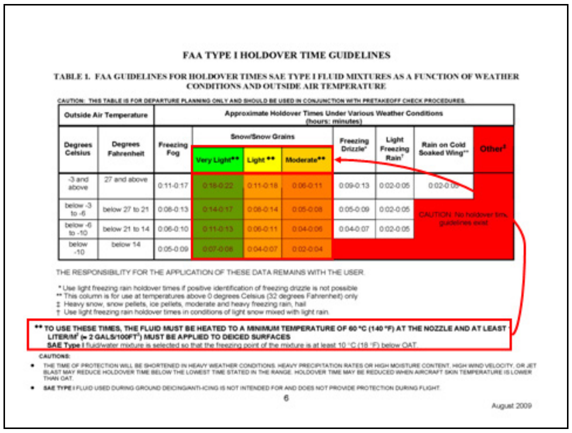

FAA TYPE I HOLDOVER TIME GUIDELINES

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
			Very Light**	Light **	Moderate**				
-3 and above	27 and above	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
below -10	below 14	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

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

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

**** TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M² (≈ 2 GALS/100FT²) MUST BE APPLIED TO DEICED SURFACES**
SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE** I FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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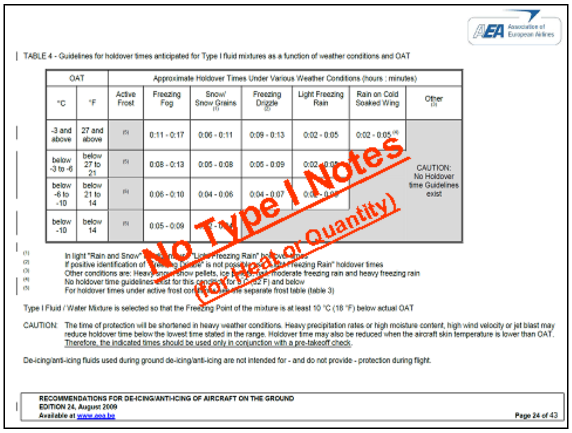

AEA Association of European Airlines

TABLE 4 - Guidelines for holdover times anticipated for Type I fluid mixtures as a function of weather conditions and OAT

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	(5)	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05 (4)	
below -3 to -6	below 27 to 21	(5)	0:08 - 0:13	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05	CAUTION: No Holdover time Guidelines exist	
below -6 to -10	below 21 to 14	(5)	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05		
below -10	below 14	(5)	0:05 - 0:09	0:02 - 0:04				

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain
(4) No holdover time guidelines exist for this condition for 0 °C (32 F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

No Type I Notes
(for Heat or Quantity)

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
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Available at www.aea.be
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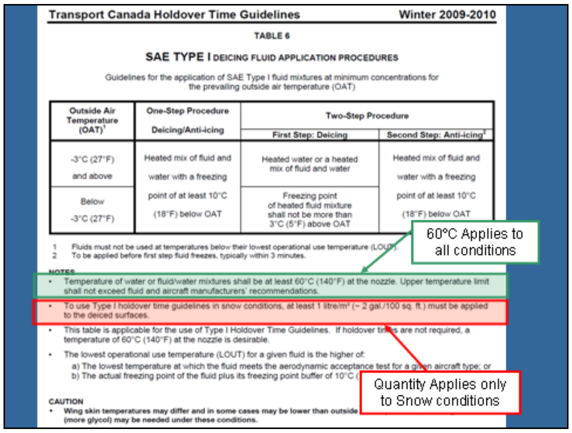


Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
2 To be applied before first step fluid freezes, typically within 3 minutes.

NOTES

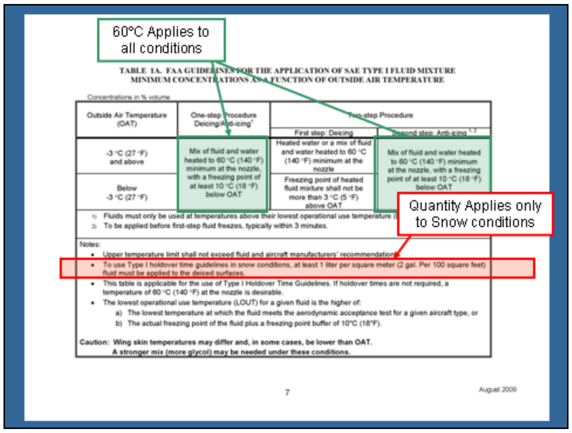
- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in snow conditions, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside**
  (more glycol) may be needed under these conditions.

60°C Applies to all conditions

Quantity Applies only to Snow conditions



60°C Applies to all conditions

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

Concentrations in % volume

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing [1, 2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

1) Fluids must only be used at temperatures above their lowest operational use temperature (
2) To be applied before first-step fluid freezes, typically within 3 minutes.

Notes:

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in snow conditions, at least 1 liter per square meter (2 gal. Per 100 square feet) fluid must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  b) The actual freezing point of the fluid plus a freezing point buffer of 10°C (18°F).

Caution: Wing skin temperatures may differ and, in some cases, be lower than OAT.
A stronger mix (more glycol) may be needed under these conditions.

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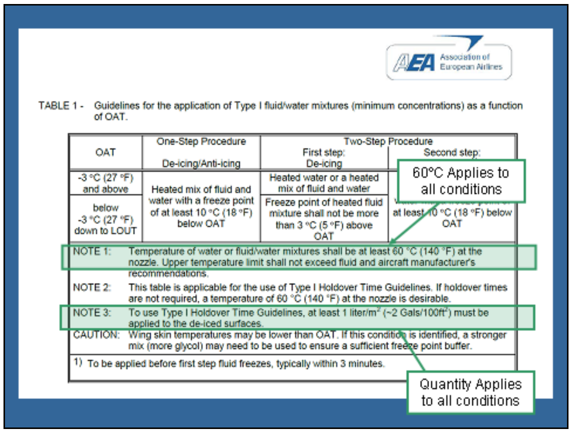
Quantity Applies only to Snow conditions



AEA Association of European Airlines

TABLE 1 - Guidelines for the application of Type I fluid/water mixtures (minimum concentrations) as a function of OAT.

OAT	One-Step Procedure De-icing/Anti-icing	Two-Step Procedure	
		First step: De-icing	Second step:
-3 °C (27 °F) and above	Heated mix of fluid and water with a freeze point of at least 10 °C (18 °F) below OAT	Heated water or a heated mix of fluid and water	at least 10 °C (18 °F) below OAT
below -3 °C (27 °F) down to LOUT		Freeze point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

NOTE 1: 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 manufacturer's recommendations.

NOTE 2: 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.

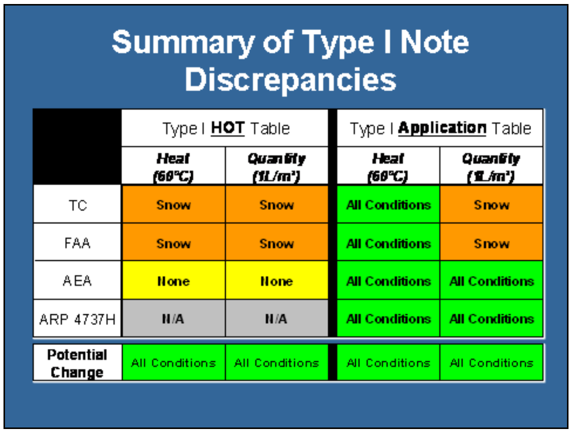
NOTE 3: To use Type I Holdover Time Guidelines, at least 1 liter/m² (~2 Gals/100ft²) must be applied to the de-iced surfaces.

CAUTION: Wing skin temperatures may be lower than OAT. If this condition is identified, a stronger mix (more glycol) may need to be used to ensure a sufficient freeze point buffer.

1) To be applied before first step fluid freezes, typically within 3 minutes.

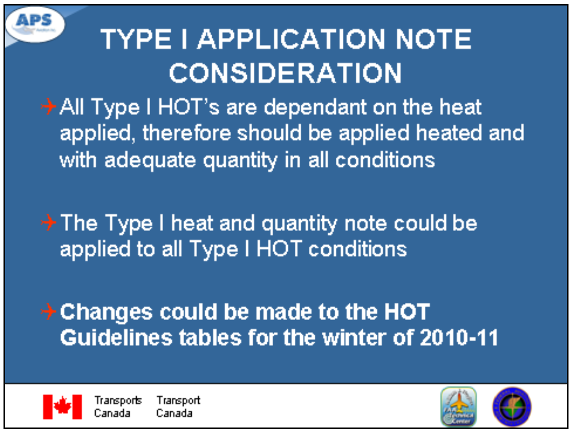
60°C Applies to all conditions

Quantity Applies to all conditions



Summary of Type I Note Discrepancies

	Type I **HOT** Table		Type I **Application** Table	
	Heat (60°C)	***Quantity (1L/m²)***	***Heat (60°C)***	***Quantity (1L/m²)***
TC	Snow	Snow	All Conditions	Snow
FAA	Snow	Snow	All Conditions	Snow
AEA	None	None	All Conditions	All Conditions
ARP 4737H	N/A	N/A	All Conditions	All Conditions
Potential Change	All Conditions	All Conditions	All Conditions	All Conditions



TYPE I APPLICATION NOTE CONSIDERATION

- All Type I HOT's are dependant on the heat applied, therefore should be applied heated and with adequate quantity in all conditions
- The Type I heat and quantity note could be applied to all Type I HOT conditions
- **Changes could be made to the HOT Guidelines tables for the winter of 2010-11**

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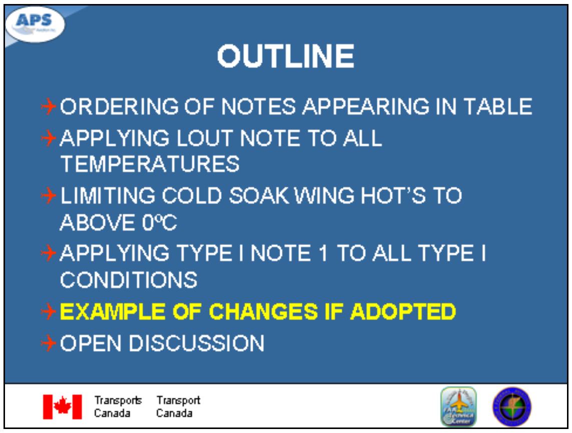

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- **EXAMPLE OF CHANGES IF ADOPTED**
- OPEN DISCUSSION

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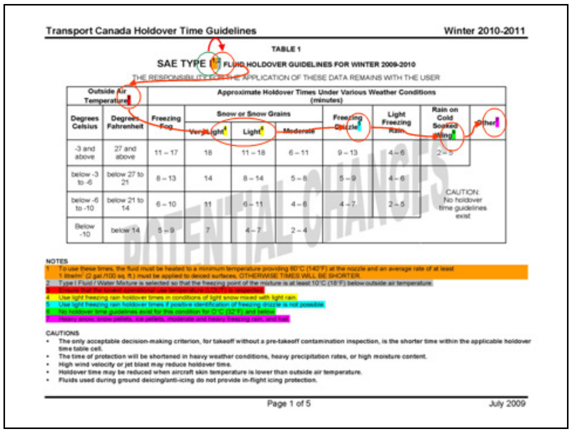

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 1

SAE TYPE I[1,2] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

POTENTIAL CHANGES

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 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.
3 Ensure that the lowest operational use temperature (LOUT) is respected.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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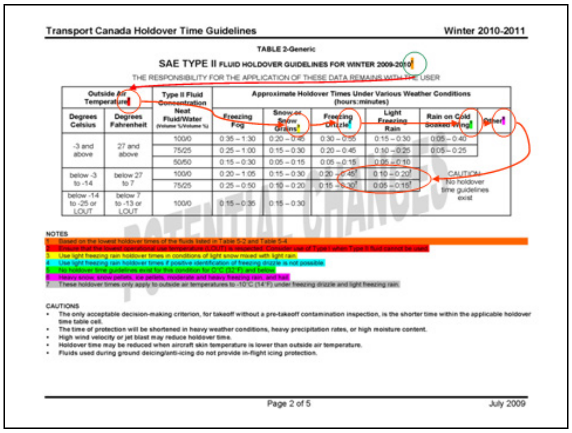

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature[2]		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[7]	0:10 – 0:20[7]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[7]	0:05 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

POTENTIAL CHANGES

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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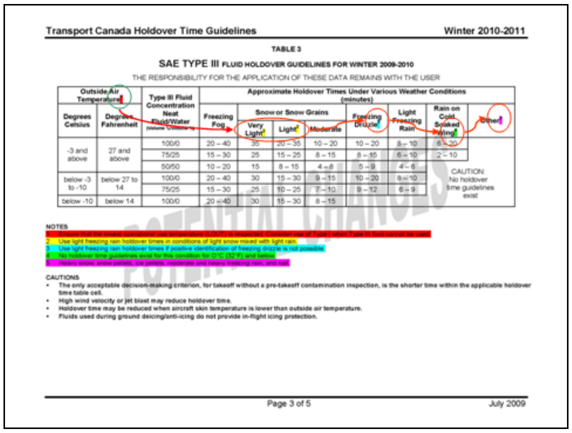

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[1]		Type III Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Freezing Fog	Very Light[2]	Light[2]	Moderate	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

POTENTIAL CHANGES

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
2 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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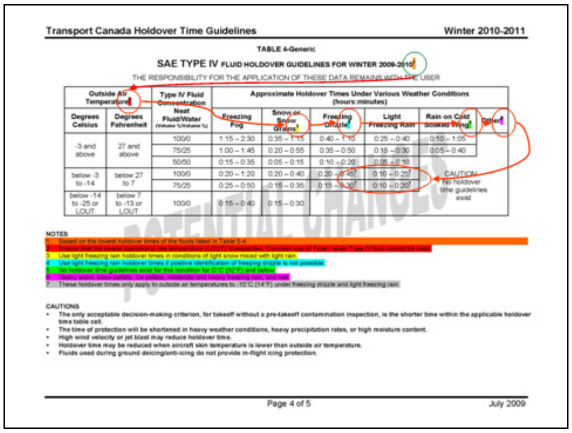

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

POTENTIAL CHANGES

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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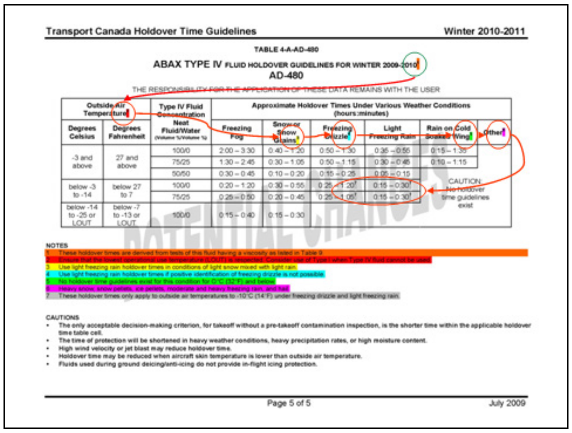

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-A-AD-480

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
AD-480

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

Outside Air Temperature[2]		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below -7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

POTENTIAL CHANGES

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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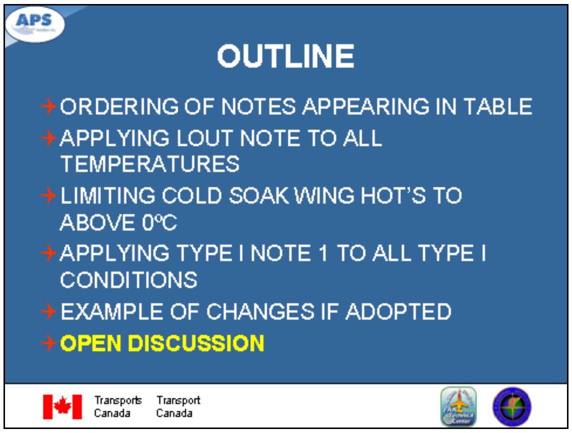

APS

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- **OPEN DISCUSSION**

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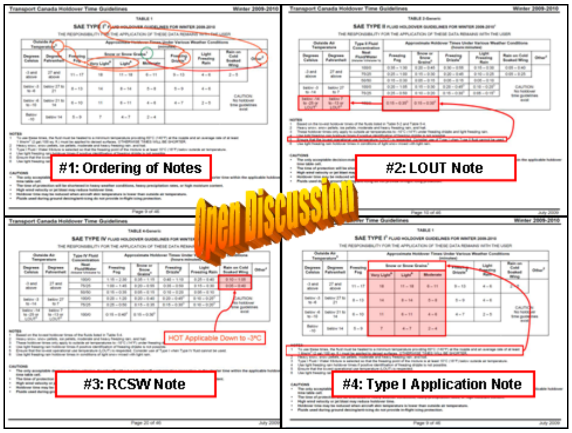

Open Discussion

#1: Ordering of Notes

#2: LOUT Note

#3: RCSW Note

HOT Applicable Down to -3°C

#4: Type I Application Note

APS
Aviation Inc.

Marco Ruggi
mruggi@adga.ca

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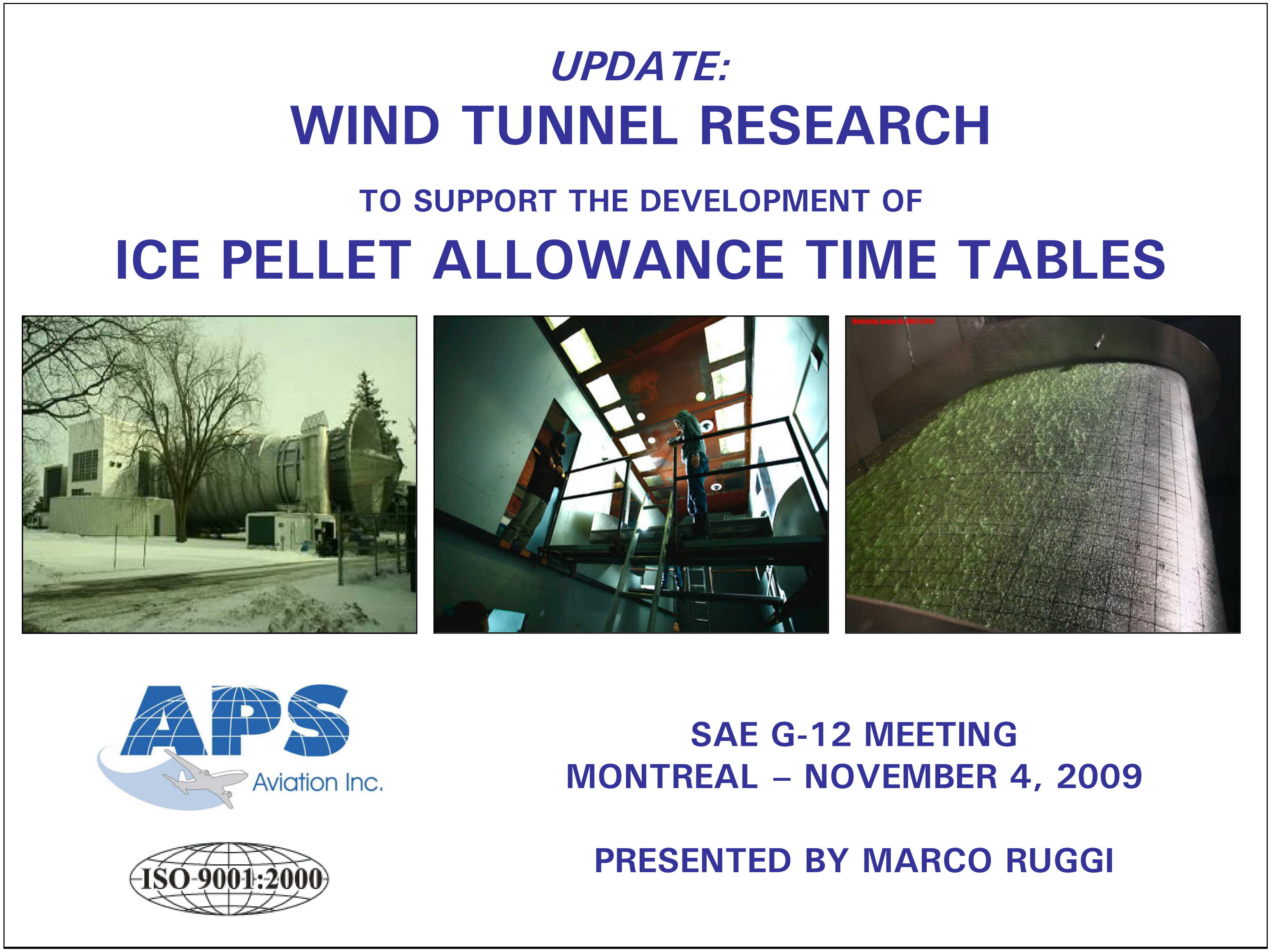


UPDATE:

WIND TUNNEL RESEARCH

TO SUPPORT THE DEVELOPMENT OF

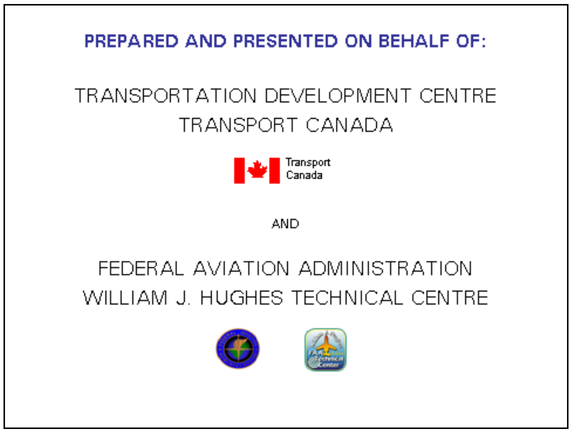
ICE PELLET ALLOWANCE TIME TABLES

APS Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING
MONTREAL – NOVEMBER 4, 2009

PRESENTED BY MARCO RUGGI



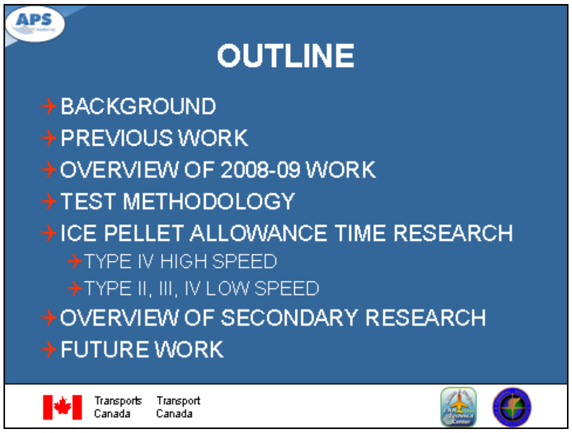
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE II, III, IV LOW SPEED
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

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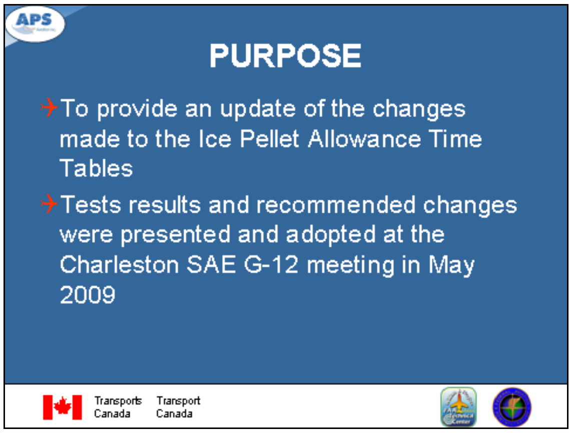

PURPOSE

- To provide an update of the changes made to the Ice Pellet Allowance Time Tables
- Tests results and recommended changes were presented and adopted at the Charleston SAE G-12 meeting in May 2009

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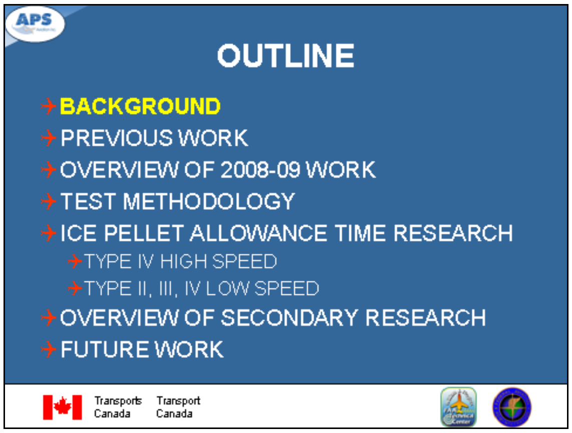

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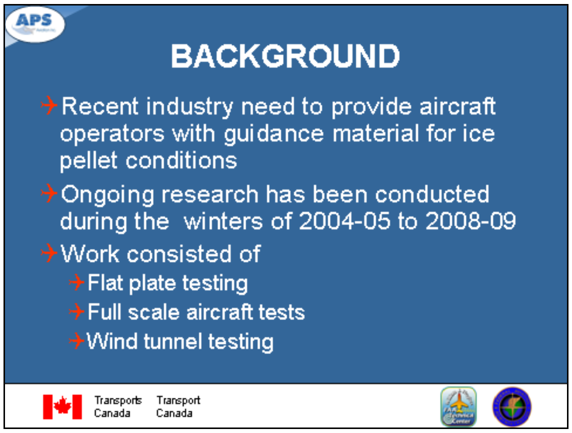

BACKGROUND

- Recent industry need to provide aircraft operators with guidance material for ice pellet conditions
- Ongoing research has been conducted during the winters of 2004-05 to 2008-09
- Work consisted of
  - Flat plate testing
  - Full scale aircraft tests
  - Wind tunnel testing

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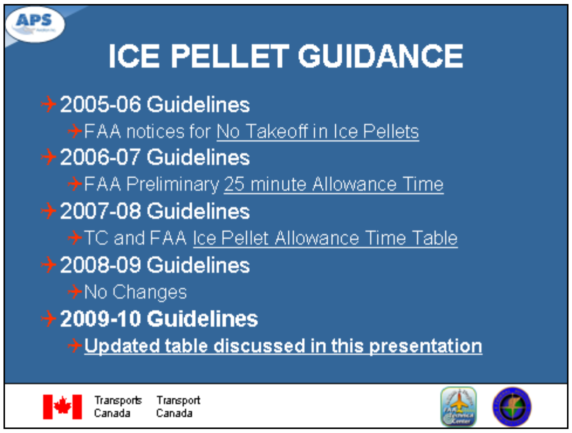

ICE PELLET GUIDANCE

- 2005-06 Guidelines
  - FAA notices for No Takeoff in Ice Pellets
- 2006-07 Guidelines
  - FAA Preliminary 25 minute Allowance Time
- 2007-08 Guidelines
  - TC and FAA Ice Pellet Allowance Time Table
- 2008-09 Guidelines
  - No Changes
- **2009-10 Guidelines**
  - **Updated table discussed in this presentation**

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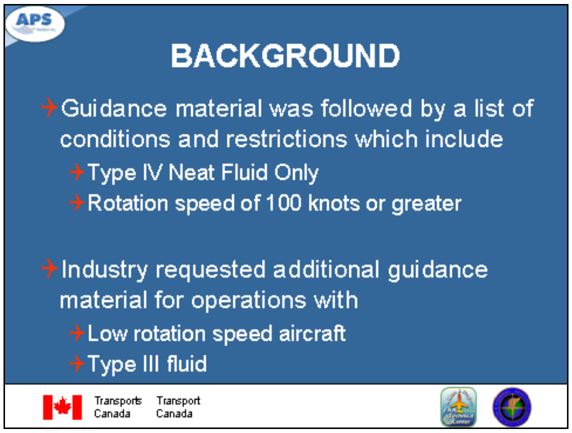

BACKGROUND

- Guidance material was followed by a list of conditions and restrictions which include
  - Type IV Neat Fluid Only
  - Rotation speed of 100 knots or greater
- Industry requested additional guidance material for operations with
  - Low rotation speed aircraft
  - Type III fluid

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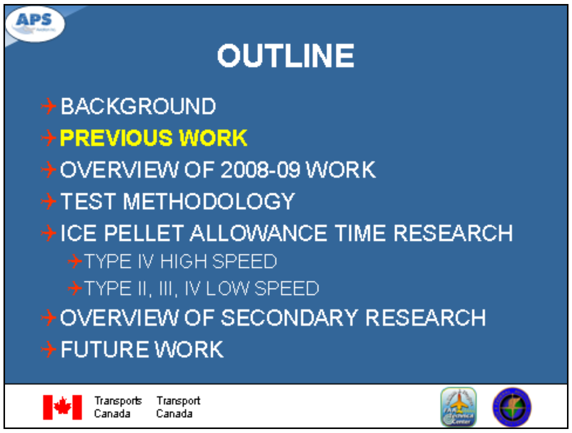

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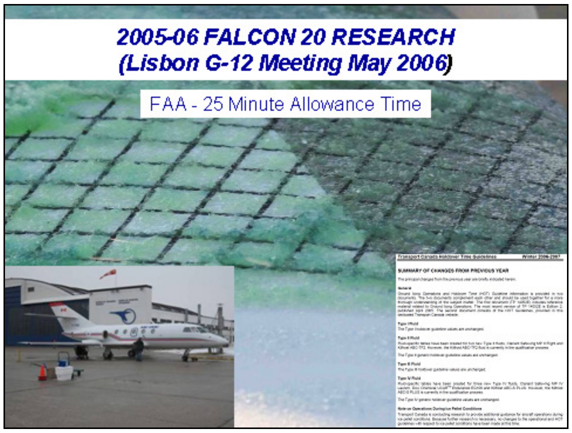
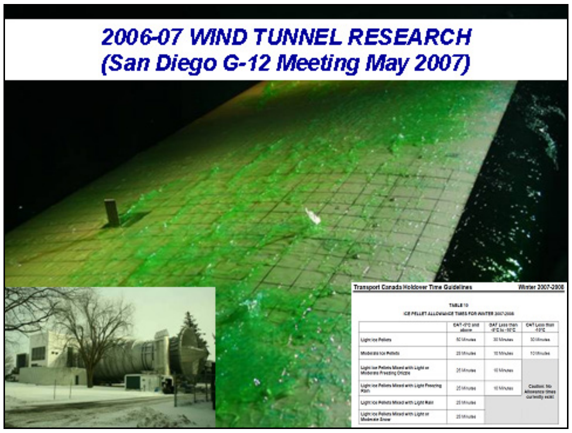


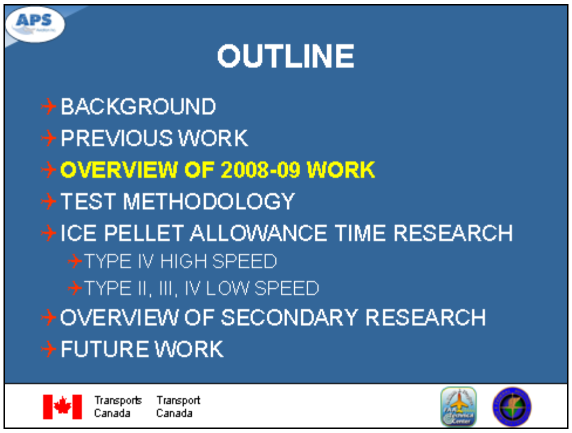
2005-06 FALCON 20 RESEARCH (Lisbon G-12 Meeting May 2006)

FAA - 25 Minute Allowance Time



2006-07 WIND TUNNEL RESEARCH (San Diego G-12 Meeting May 2007)

2007-08 F20 AND T-33 RESEARCH (Warsaw G-12 Meeting May 2008)



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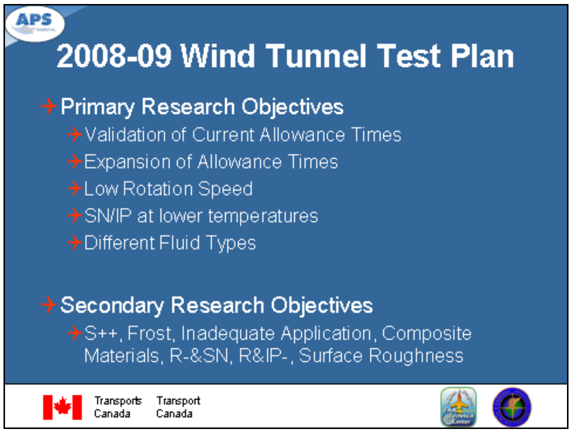

2008-09 Wind Tunnel Test Plan

- Primary Research Objectives
  - Validation of Current Allowance Times
  - Expansion of Allowance Times
  - Low Rotation Speed
  - SN/IP at lower temperatures
  - Different Fluid Types
- Secondary Research Objectives
  - S++, Frost, Inadequate Application, Composite Materials, R-&SN, R&IP-, Surface Roughness

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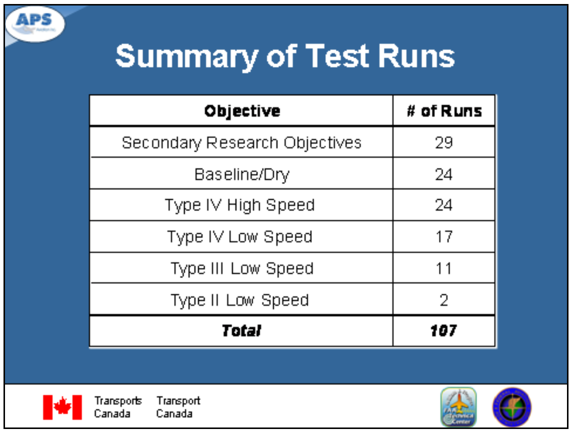

Summary of Test Runs

Objective	**# of Runs**
Secondary Research Objectives	29
Baseline/Dry	24
Type IV High Speed	24
Type IV Low Speed	17
Type III Low Speed	11
Type II Low Speed	2
Total	***107***

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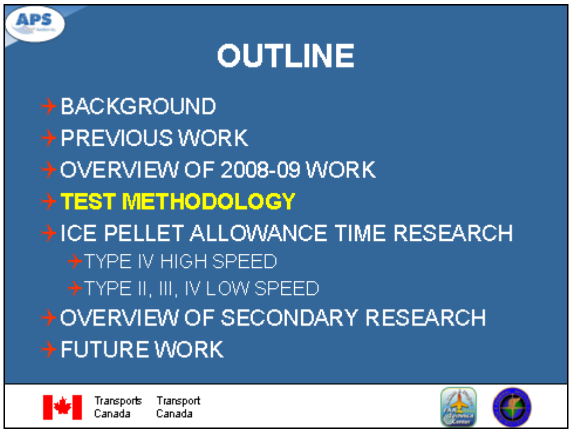
2008-09 RESEARCH TEAM



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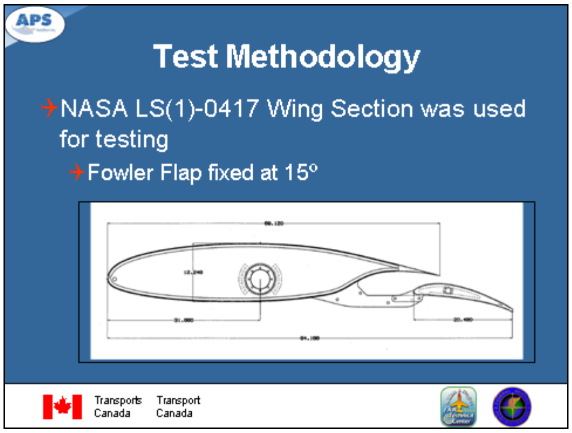

Test Methodology

- NASA LS(1)-0417 Wing Section was used for testing
  - Fowler Flap fixed at 15°

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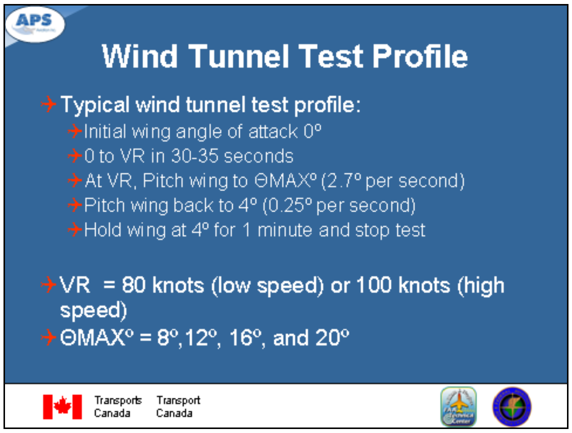

Wind Tunnel Test Profile

- Typical wind tunnel test profile:
  - Initial wing angle of attack 0°
  - 0 to VR in 30-35 seconds
  - At VR, Pitch wing to ΘMAX° (2.7° per second)
  - Pitch wing back to 4° (0.25° per second)
  - Hold wing at 4° for 1 minute and stop test
- VR = 80 knots (low speed) or 100 knots (high speed)
- ΘMAX° = 8°,12°, 16°, and 20°

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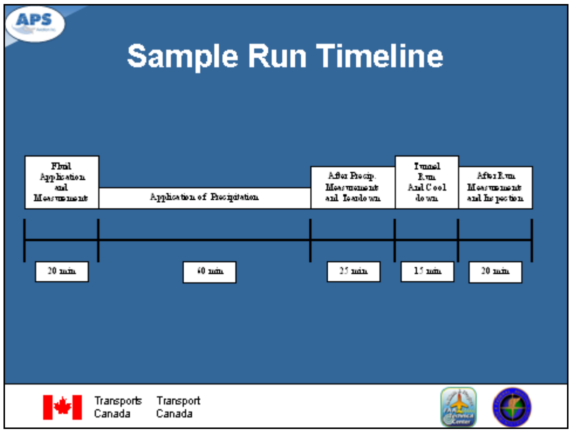

Sample Run Timeline

Fluid Application and Measurement — 20 min

Application of Precipitation — 60 min

After Precip. Measurement and Teardown — 25 min

Tunnel Run And Cool down — 15 min

After Run Measurement and Inspection — 20 min

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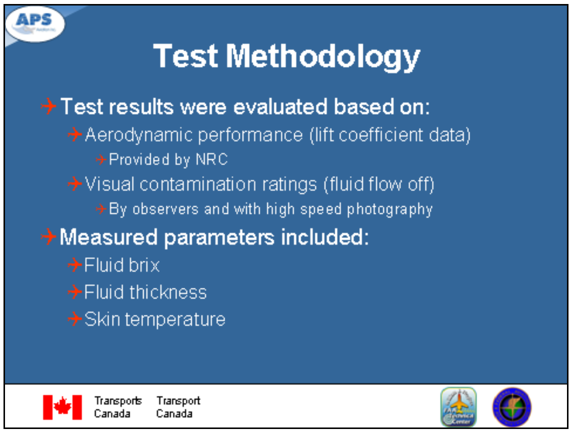

Test Methodology

- Test results were evaluated based on:
  - Aerodynamic performance (lift coefficient data)
    - Provided by NRC
  - Visual contamination ratings (fluid flow off)
    - By observers and with high speed photography
- Measured parameters included:
  - Fluid brix
  - Fluid thickness
  - Skin temperature

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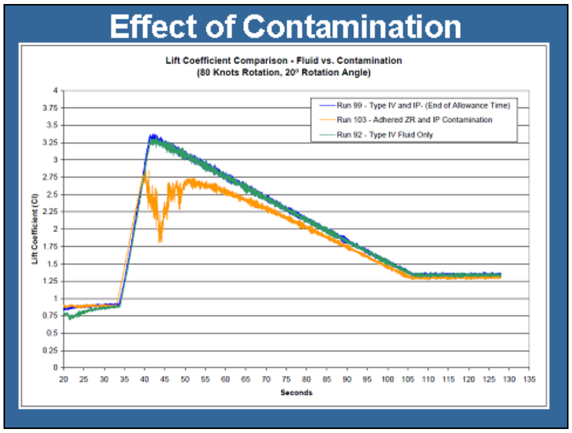
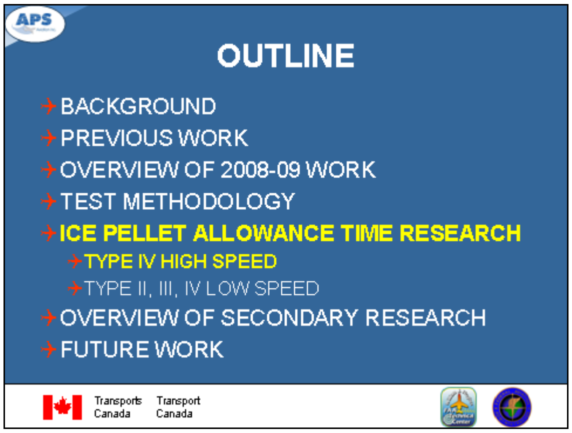


Effect of Contamination

Lift Coefficient Comparison - Fluid vs. Contamination
(80 Knots Rotation, 20° Rotation Angle)



OUTLINE

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  - TYPE IV HIGH SPEED
  - TYPE II, III, IV LOW SPEED
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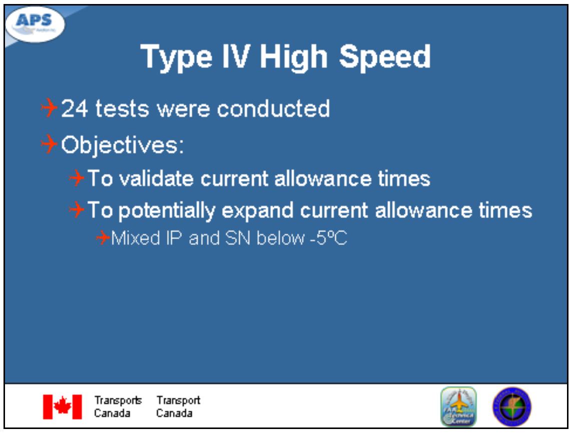

Type IV High Speed

- 24 tests were conducted
- Objectives:
  - To validate current allowance times
  - To potentially expand current allowance times
    - Mixed IP and SN below -5ºC

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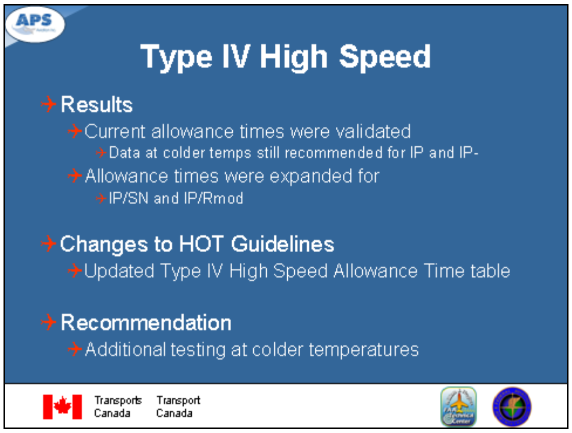

Type IV High Speed

- Results
  - Current allowance times were validated
    - Data at colder temps still recommended for IP and IP-
  - Allowance times were expanded for
    - IP/SN and IP/Rmod
- Changes to HOT Guidelines
  - Updated Type IV High Speed Allowance Time table
- Recommendation
  - Additional testing at colder temperatures

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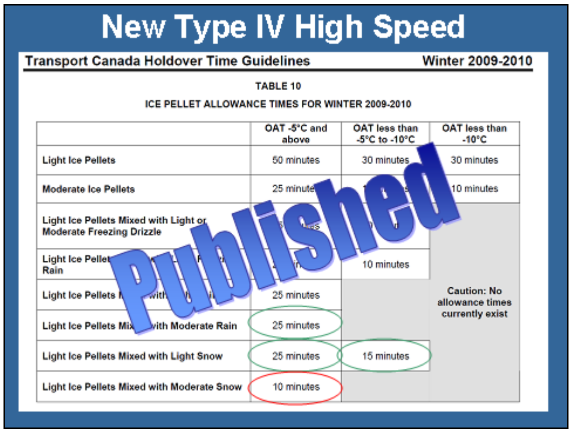


New Type IV High Speed

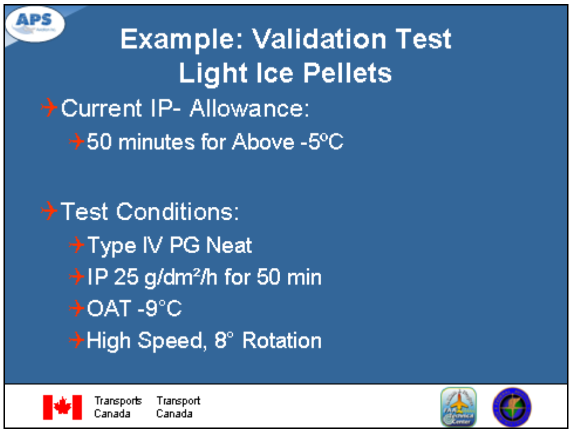
Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minute[illegible]	[illegible]	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	[illegible]	[illegible]	**Caution: No allowance times currently exist**
Light Ice Pellet[illegible] Rain	[illegible]	10 minutes	
Light Ice Pellets [illegible] with [illegible]	25 minutes		
Light Ice Pellets Mix[illegible] with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

Published



Example: Validation Test Light Ice Pellets

- Current IP- Allowance:
  - 50 minutes for Above -5ºC
- Test Conditions:
  - Type IV PG Neat
  - IP 25 g/dm²/h for 50 min
  - OAT -9°C
  - High Speed, 8° Rotation

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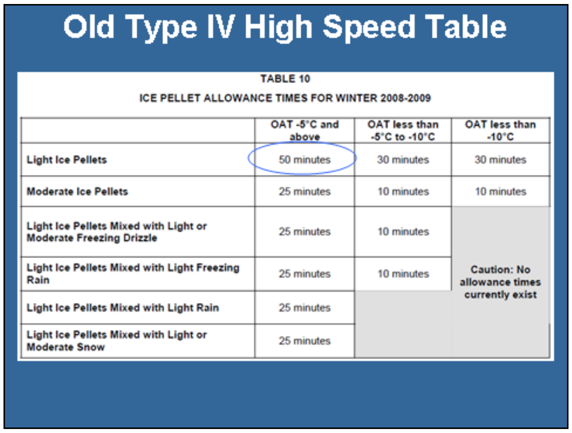
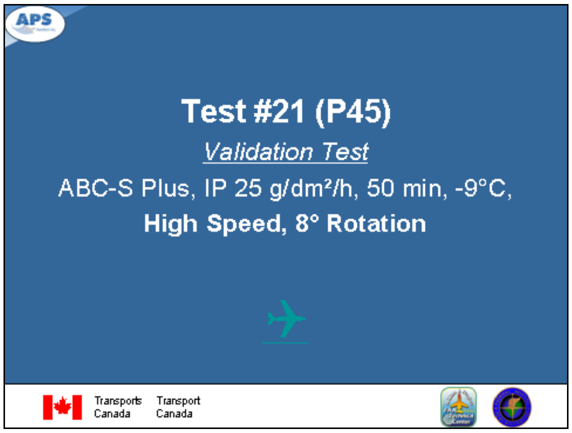


Old Type IV High Speed Table

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		



Test #21 (P45)

Validation Test

ABC-S Plus, IP 25 g/dm²/h, 50 min, -9°C,

High Speed, 8° Rotation

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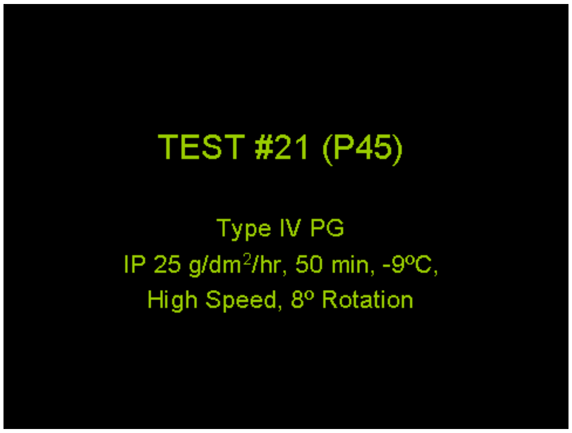
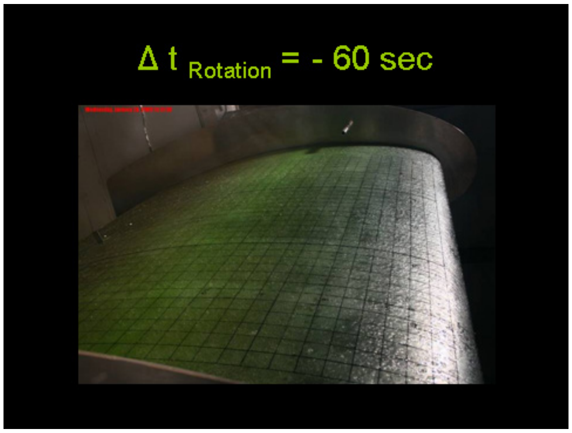


TEST #21 (P45)

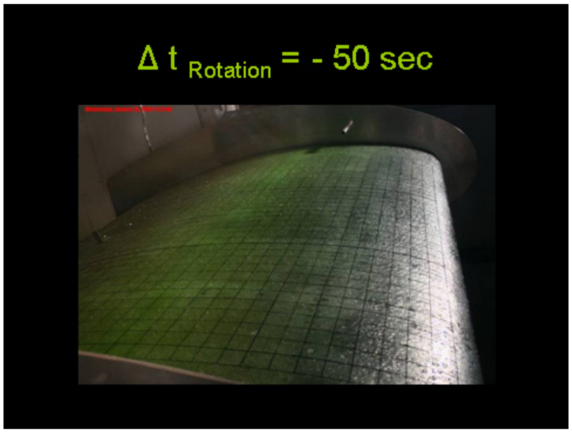
Type IV PG

IP 25 g/dm^2/hr, 50 min, -9ºC,

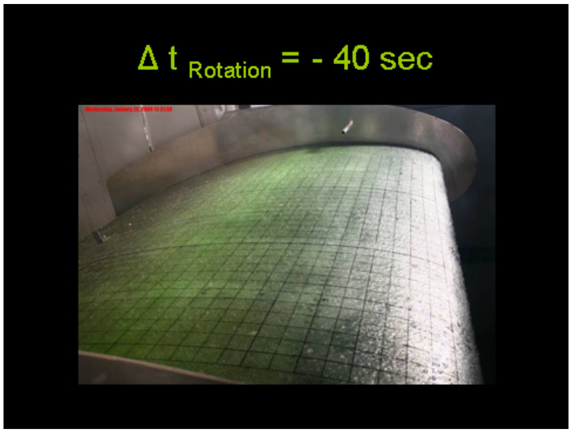
High Speed, 8º Rotation



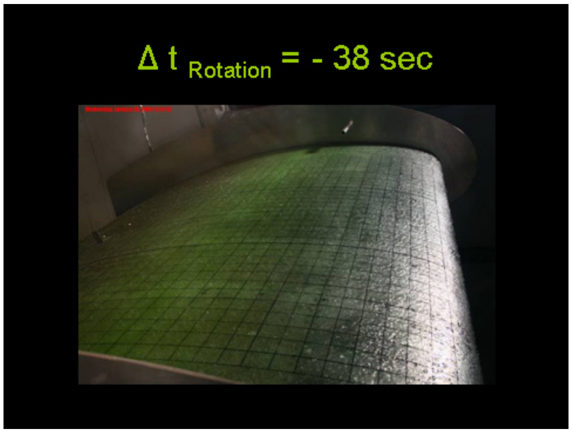
$\Delta t_{\text{Rotation}}$ = - 60 sec



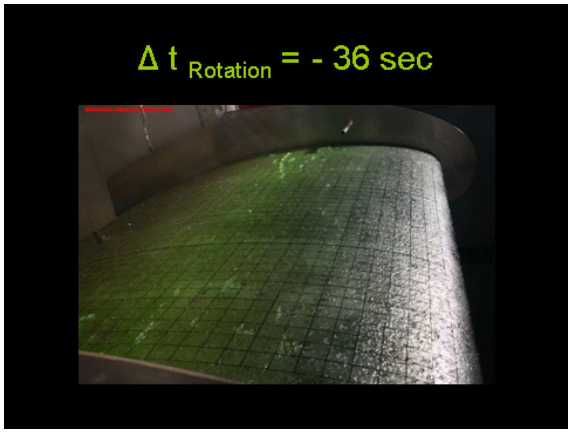
$\Delta t_{\text{Rotation}} = -50$ sec



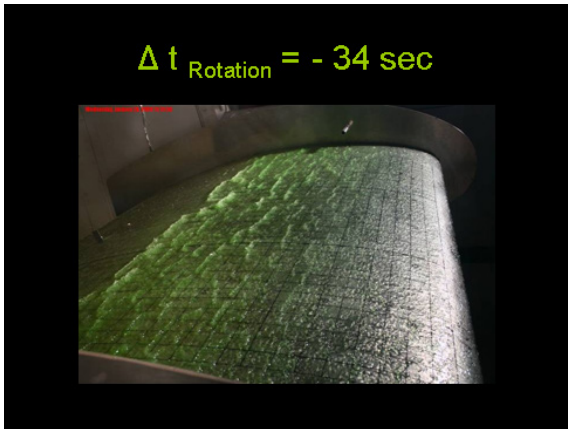
$\Delta t_{\text{Rotation}} = -40$ sec



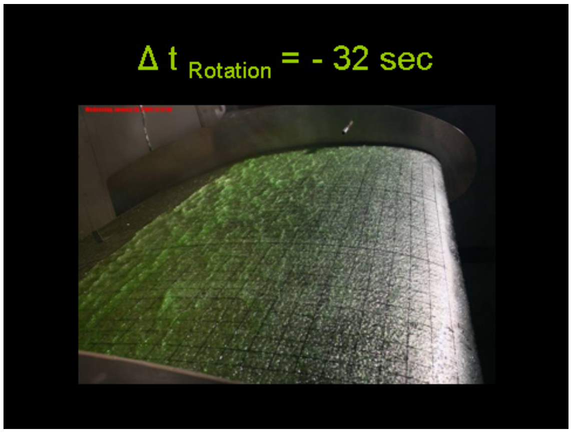
$\Delta t_{\text{Rotation}} = -38$ sec



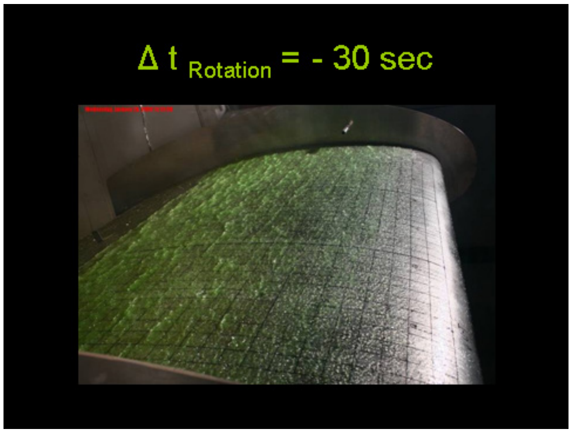
$\Delta t_{\text{Rotation}} = -36$ sec



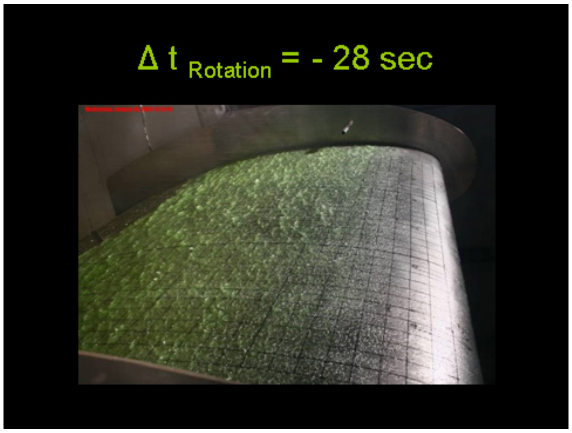
$\Delta t_{\text{Rotation}} = -34$ sec



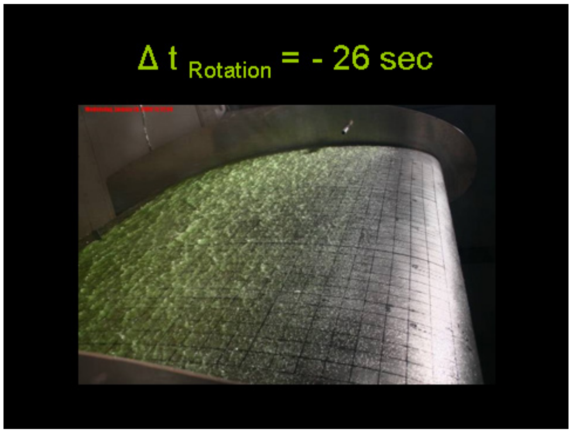
$\Delta t_{\text{Rotation}} = -32$ sec



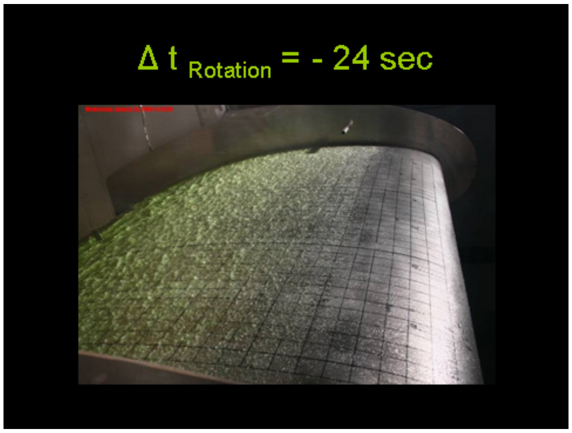
$\Delta t_{Rotation}$ = - 30 sec



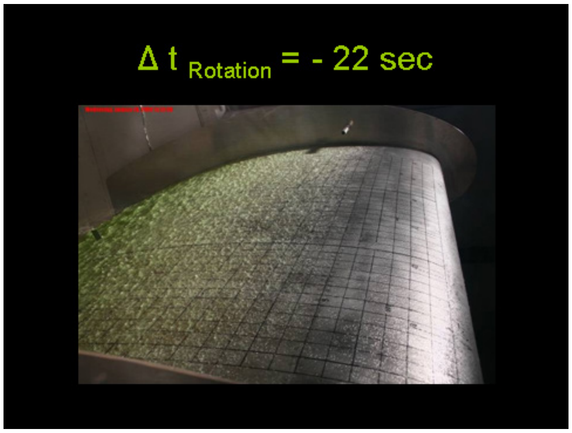
$\Delta t_{Rotation}$ = - 28 sec



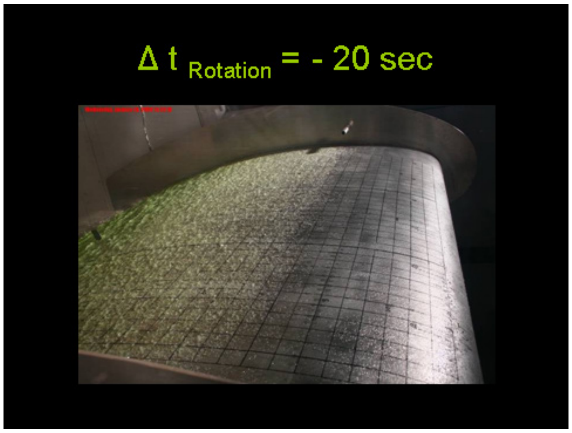
$\Delta t_{Rotation}$ = - 26 sec



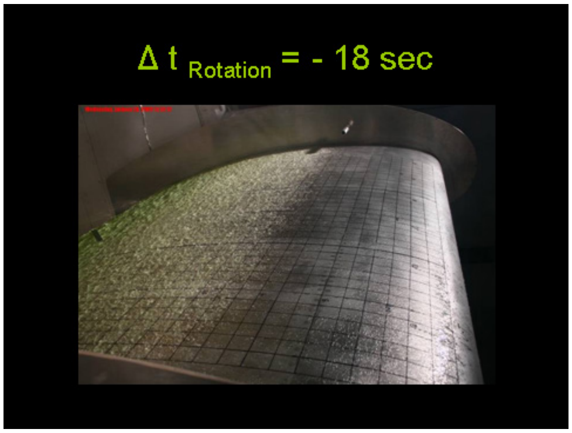
$\Delta t_{Rotation}$ = - 24 sec



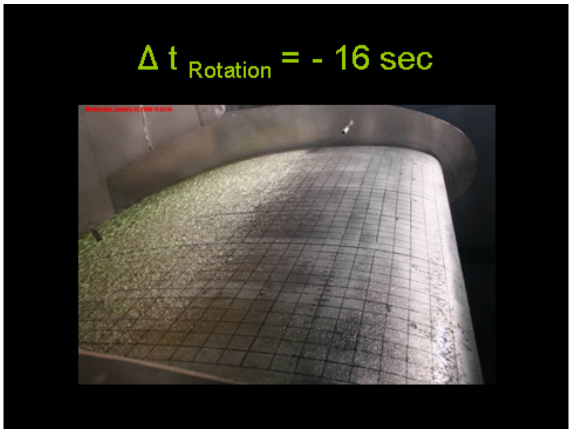
$\Delta t_{Rotation}$ = - 22 sec



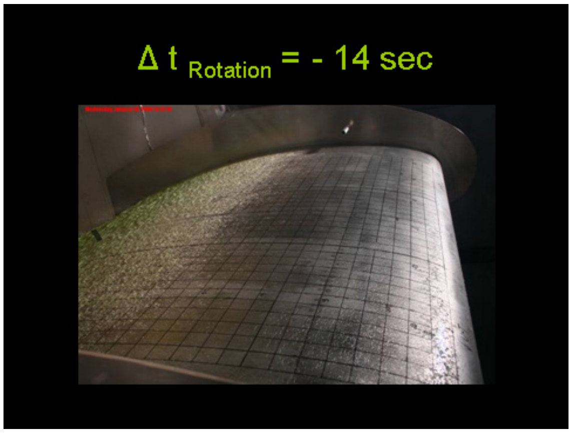
$\Delta t_{Rotation}$ = - 20 sec



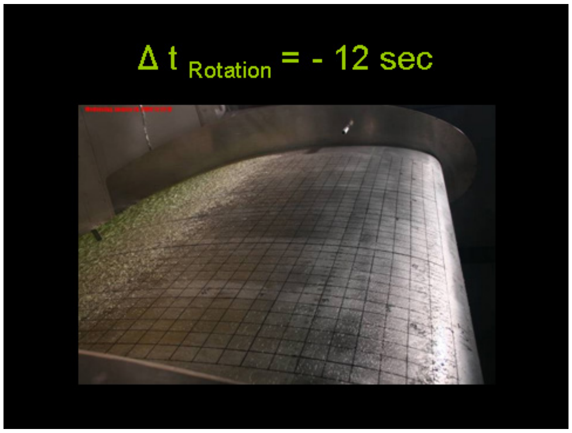
$\Delta t_{Rotation} = -18$ sec



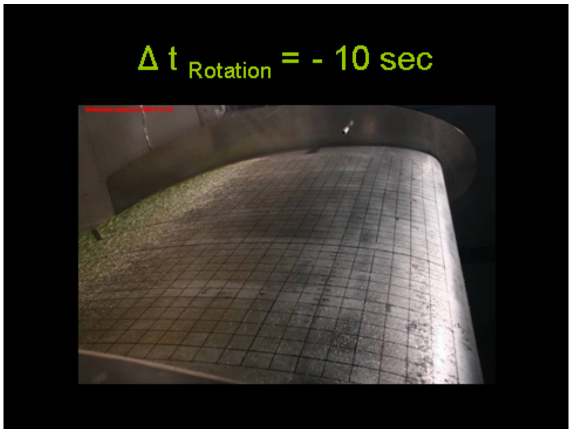
$\Delta t_{Rotation} = -16$ sec



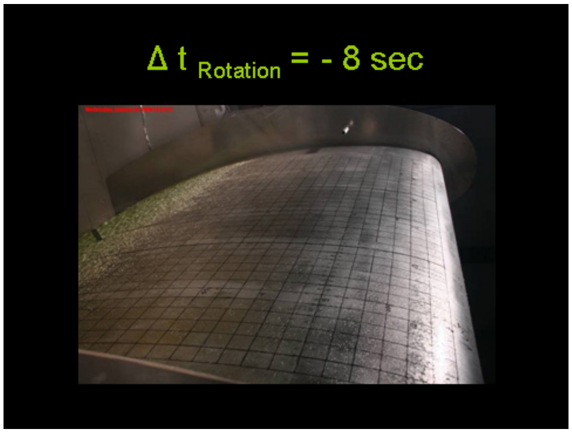
$\Delta t_{Rotation} = -14$ sec



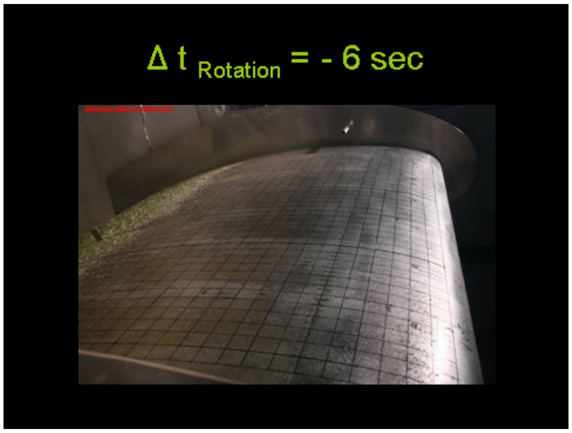
$\Delta t_{Rotation} = -12$ sec

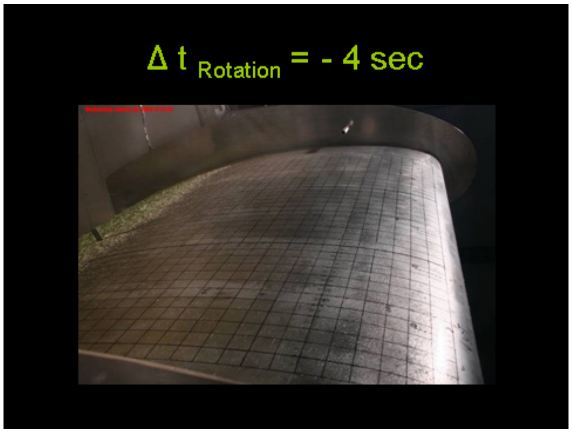


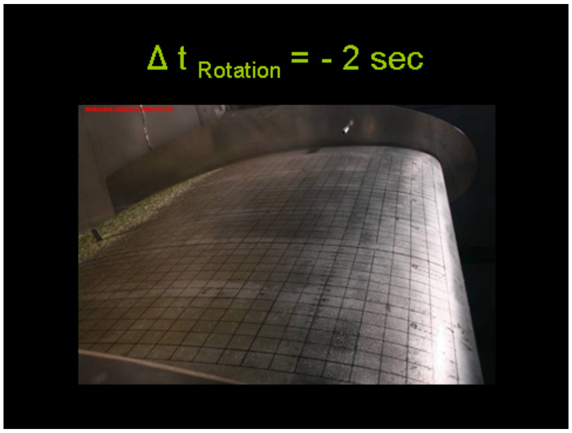
$\Delta t_{Rotation} = -10$ sec

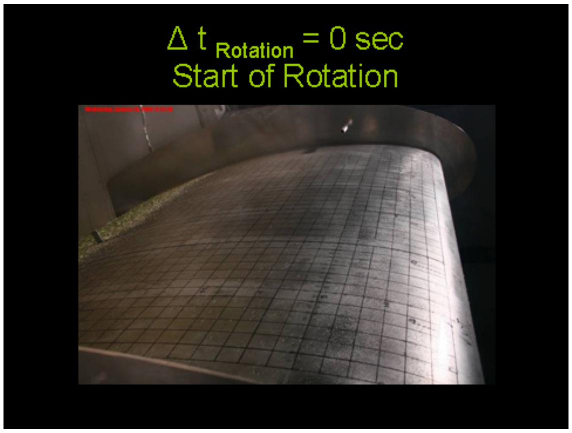


$\Delta t_{Rotation} = -8$ sec

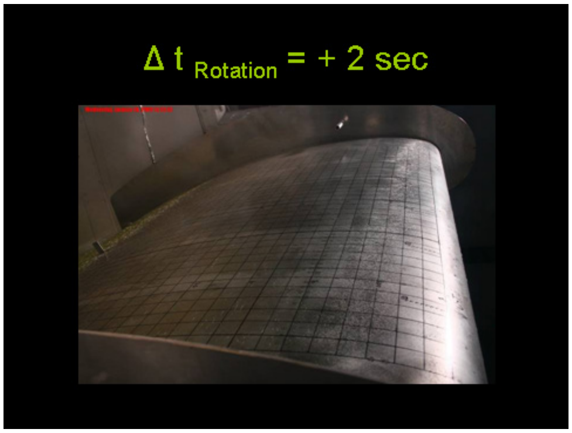

$\Delta t_{\text{Rotation}} = -6$ sec

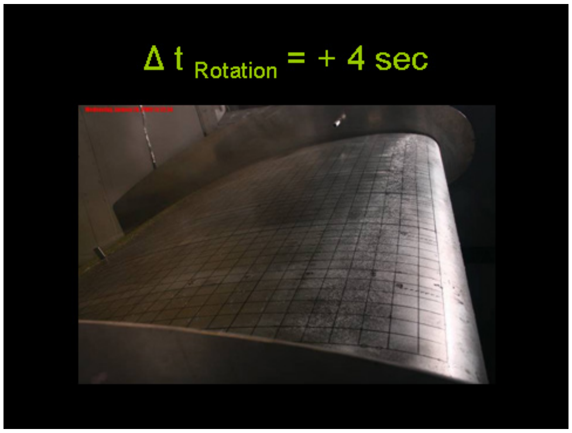

$\Delta t_{\text{Rotation}} = -4$ sec

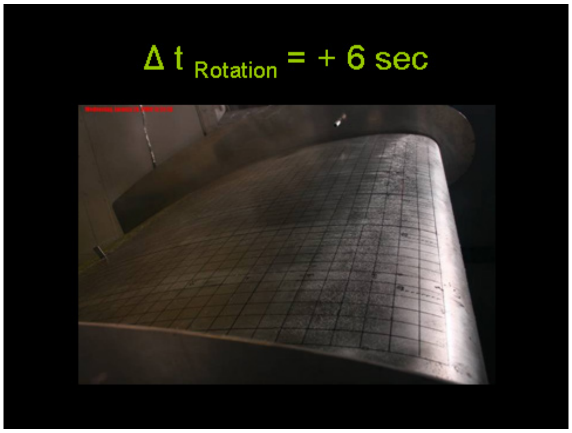

$\Delta t_{\text{Rotation}} = -2$ sec


$\Delta t_{\text{Rotation}} = 0$ sec

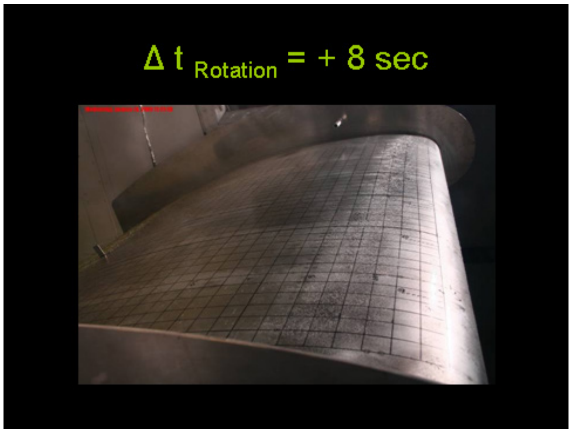
Start of Rotation


$\Delta t_{\text{Rotation}} = +2$ sec

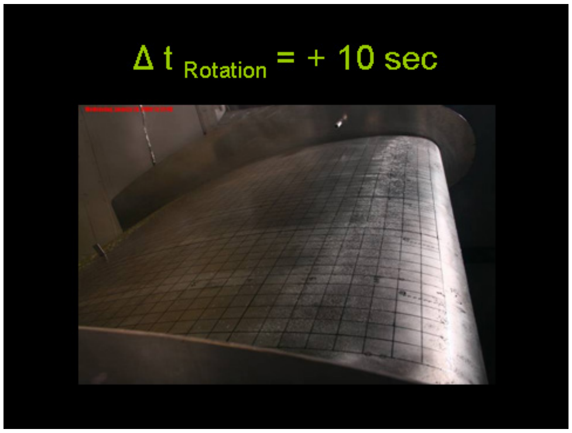

$\Delta t_{\text{Rotation}} = +4$ sec



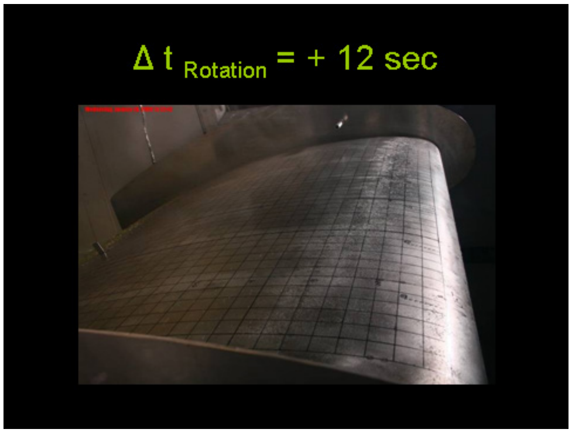
$\Delta t_{\text{Rotation}} = + 6$ sec



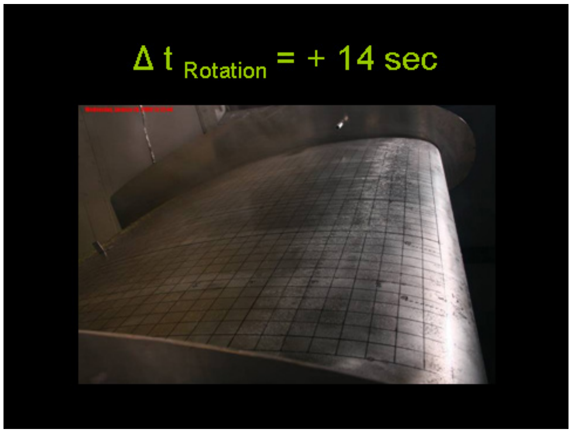
$\Delta t_{\text{Rotation}} = + 8$ sec



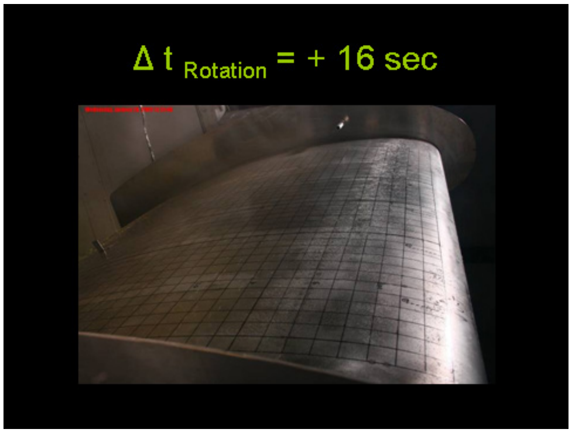
$\Delta t_{\text{Rotation}} = + 10$ sec



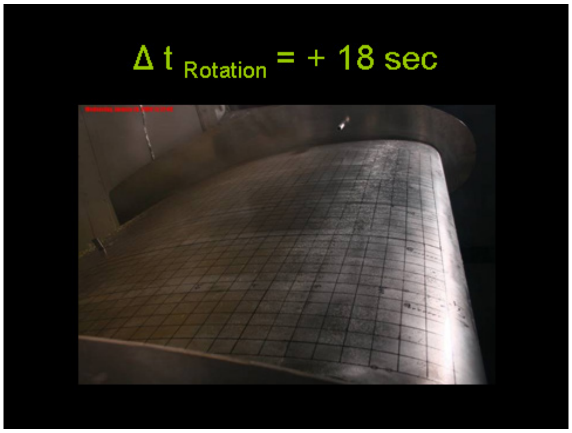
$\Delta t_{\text{Rotation}} = + 12$ sec



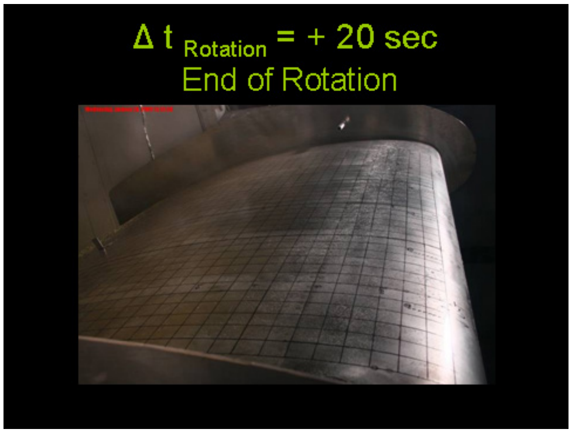
$\Delta t_{\text{Rotation}} = + 14$ sec



$\Delta t_{\text{Rotation}} = + 16$ sec

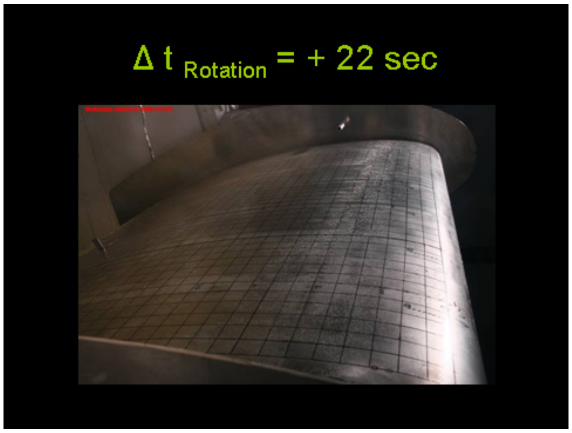


$\Delta t_{\text{Rotation}} = + 18$ sec

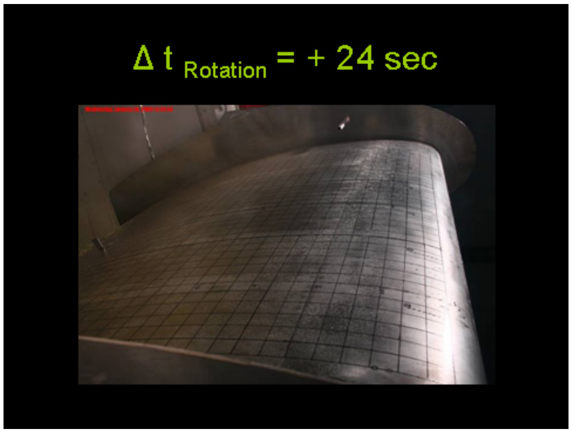


$\Delta t_{\text{Rotation}} = + 20$ sec

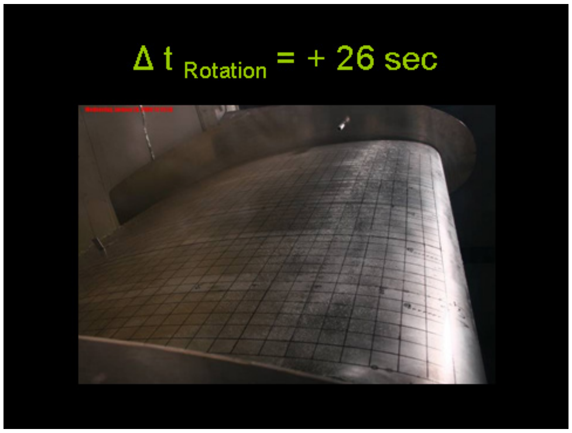
End of Rotation



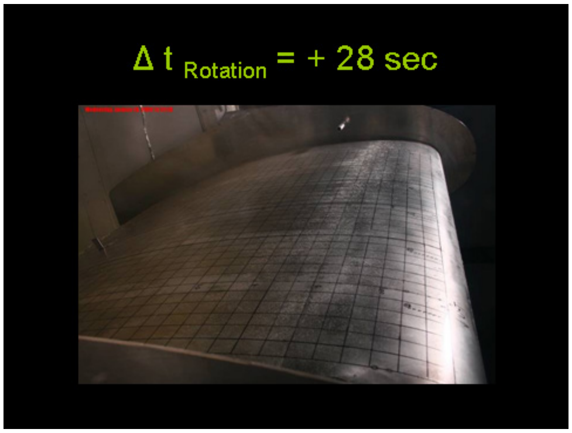
$\Delta t_{\text{Rotation}} = + 22$ sec



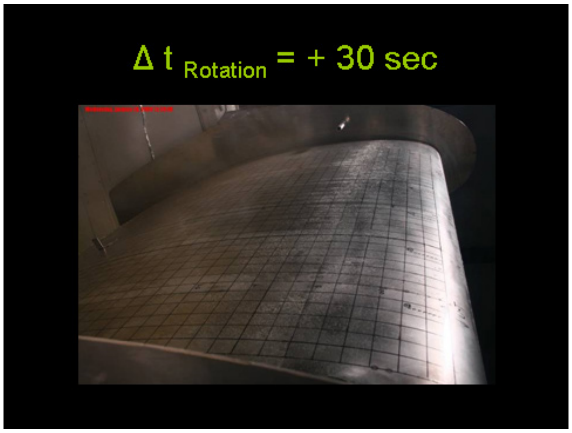
$\Delta t_{\text{Rotation}} = + 24$ sec



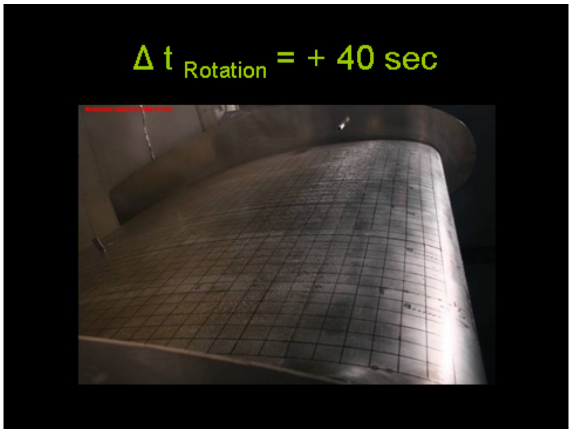
$\Delta t_{\text{Rotation}} = + 26$ sec



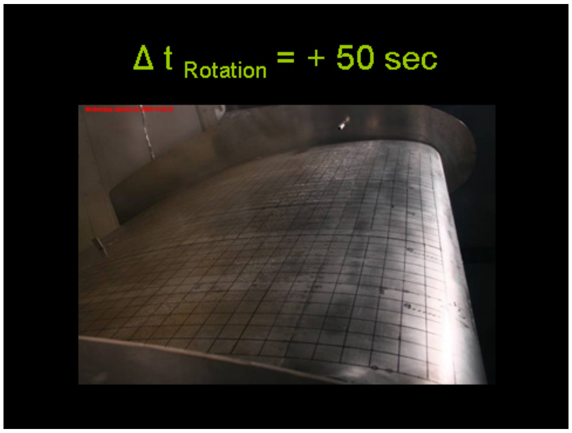
$\Delta t_{\text{Rotation}} = + 28$ sec



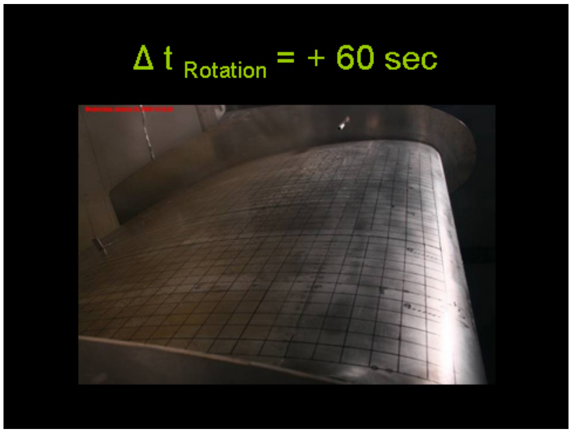
$\Delta t_{\text{Rotation}}$ = + 30 sec



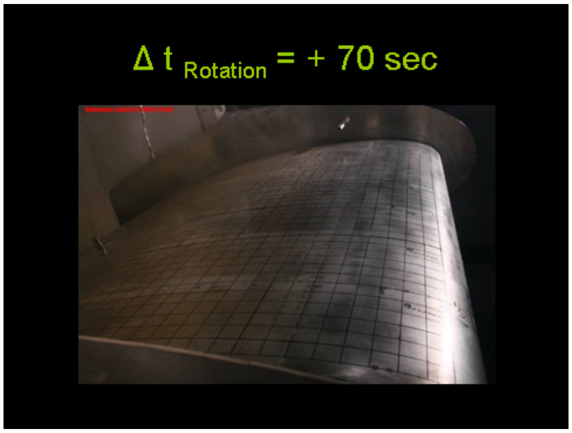
$\Delta t_{\text{Rotation}}$ = + 40 sec



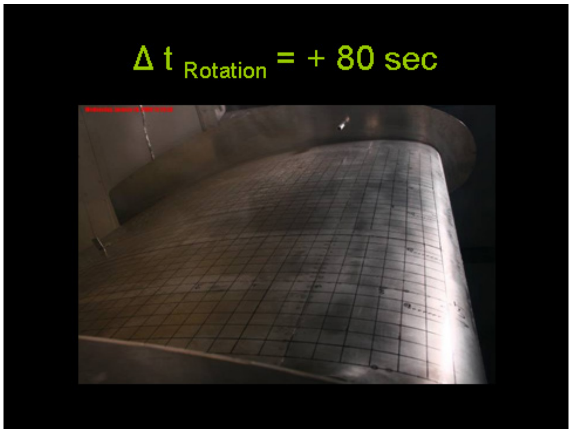
$\Delta t_{\text{Rotation}}$ = + 50 sec



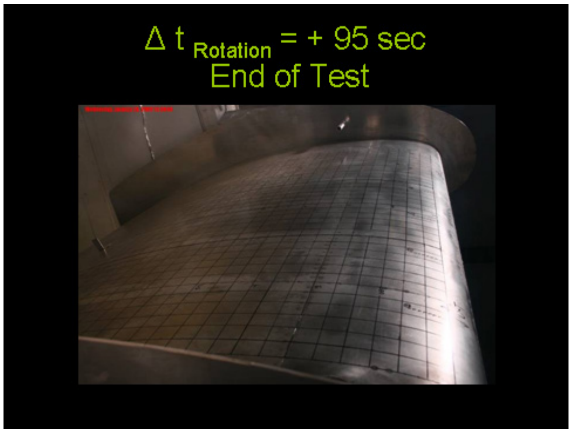
$\Delta t_{\text{Rotation}}$ = + 60 sec



$\Delta t_{\text{Rotation}}$ = + 70 sec

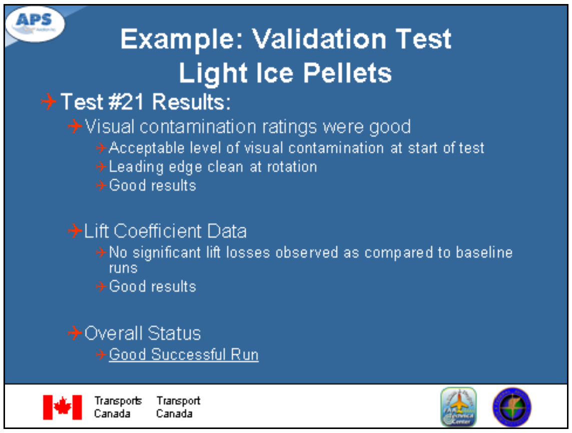


$\Delta t_{\text{Rotation}}$ = + 80 sec



$\Delta t_{Rotation}$ = + 95 sec

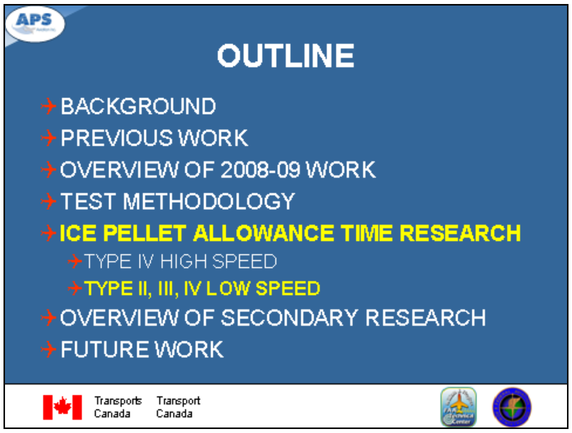
End of Test



Example: Validation Test Light Ice Pellets

- Test #21 Results:
  - Visual contamination ratings were good
    - Acceptable level of visual contamination at start of test
    - Leading edge clean at rotation
    - Good results
  - Lift Coefficient Data
    - No significant lift losses observed as compared to baseline runs
    - Good results
  - Overall Status
    - Good Successful Run

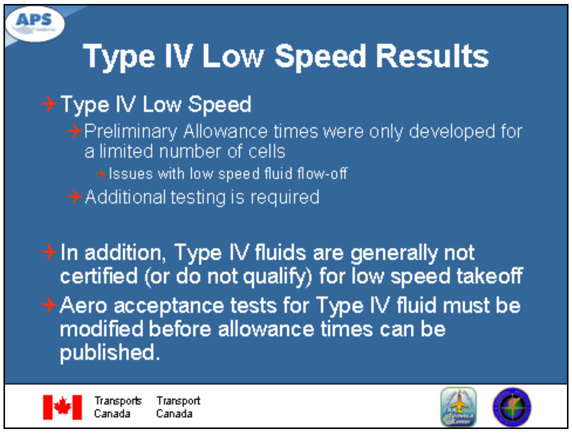
Transports Canada Transport Canada



OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- **ICE PELLET ALLOWANCE TIME RESEARCH**
  - TYPE IV HIGH SPEED
  - **TYPE II, III, IV LOW SPEED**
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

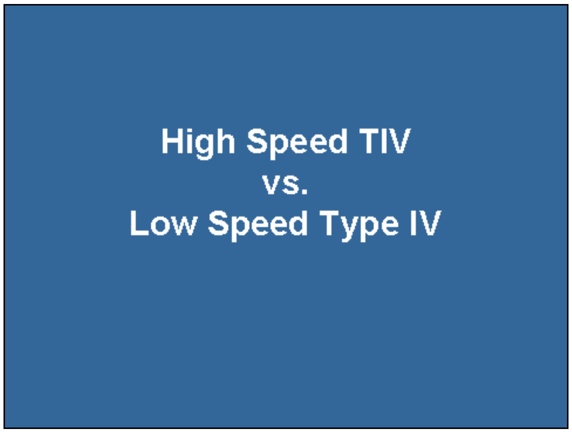
Transports Canada Transport Canada



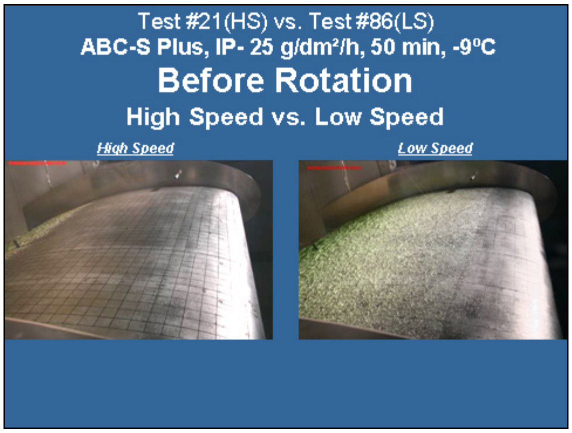
Type IV Low Speed Results

- Type IV Low Speed
  - Preliminary Allowance times were only developed for a limited number of cells
    - Issues with low speed fluid flow-off
  - Additional testing is required
- In addition, Type IV fluids are generally not certified (or do not qualify) for low speed takeoff
- Aero acceptance tests for Type IV fluid must be modified before allowance times can be published.

Transports Canada Transport Canada



High Speed TIV vs. Low Speed Type IV



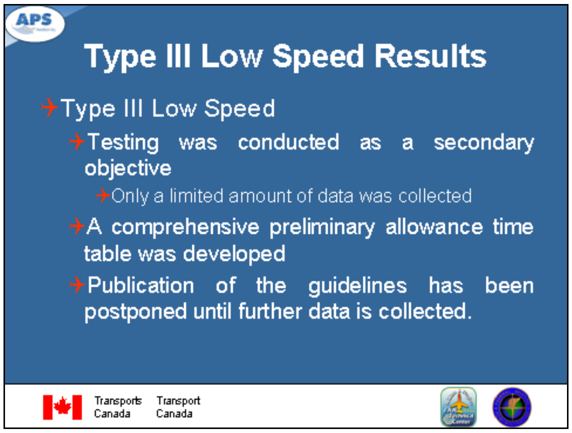
Test #21(HS) vs. Test #86(LS)

ABC-S Plus, IP- 25 g/dm²/h, 50 min, -9°C

Before Rotation

High Speed vs. Low Speed

High Speed ***Low Speed***



Type III Low Speed Results

- Type III Low Speed
  - Testing was conducted as a secondary objective
    - Only a limited amount of data was collected
  - A comprehensive preliminary allowance time table was developed
  - Publication of the guidelines has been postponed until further data is collected.

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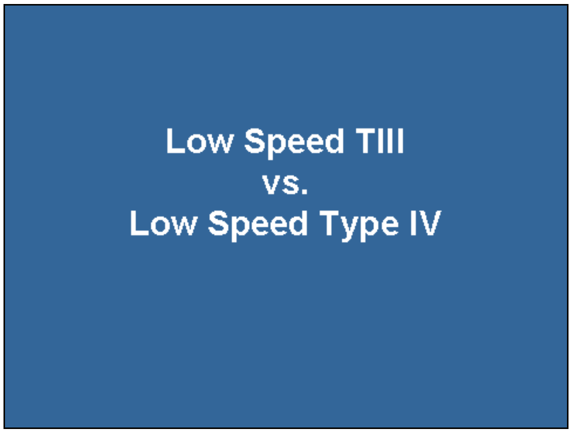
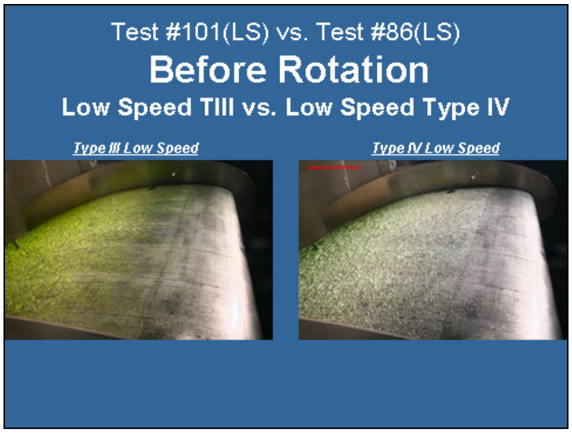


Low Speed TIII
vs.
Low Speed Type IV

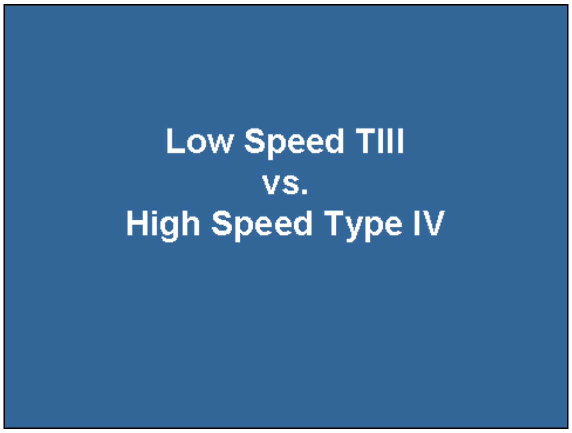


Test #101(LS) vs. Test #86(LS)

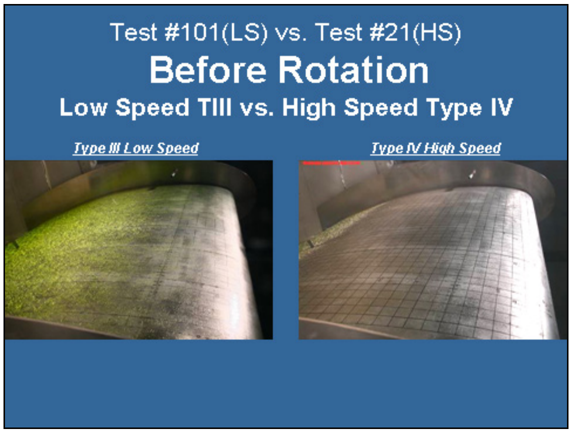
Before Rotation

Low Speed TIII vs. Low Speed Type IV

Type III Low Speed *Type IV Low Speed*



Low Speed TIII
vs.
High Speed Type IV

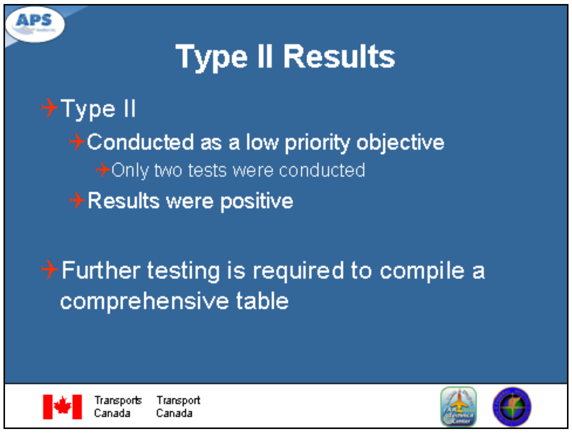


Test #101(LS) vs. Test #21(HS)

Before Rotation

Low Speed TIII vs. High Speed Type IV

Type III Low Speed *Type IV High Speed*



Type II Results

- Type II
  - Conducted as a low priority objective
    - Only two tests were conducted
  - Results were positive
- Further testing is required to compile a comprehensive table

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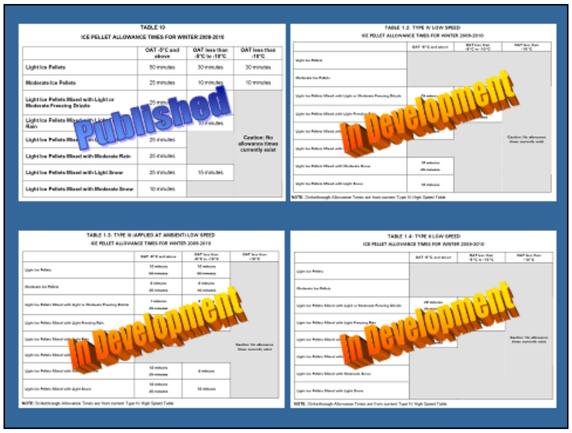
Published
In Development
In Development
In Development

TABLE 10
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light [illegible] Rain		10 minutes	
Light Ice Pellets Mixed [illegible]	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

TABLE 1.2: TYPE IV LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

TABLE 1.3: TYPE III (APPLIED AT AMBIENT) LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

TABLE 1.4: TYPE II LOW SPEED
ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

NOTE: Strikethrough Allowance Times are from current Type IV High Speed Table

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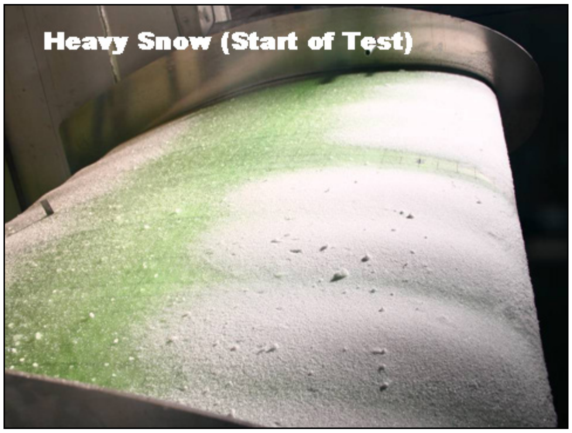
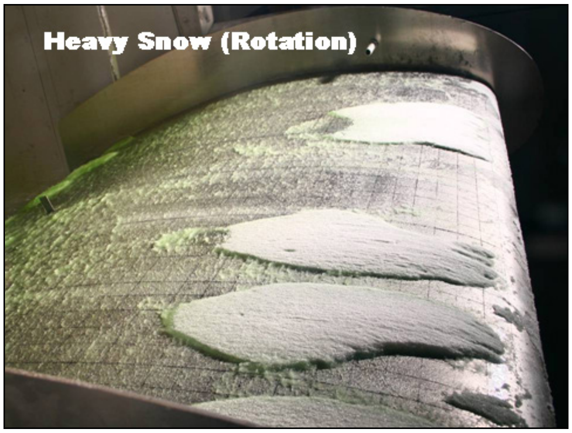
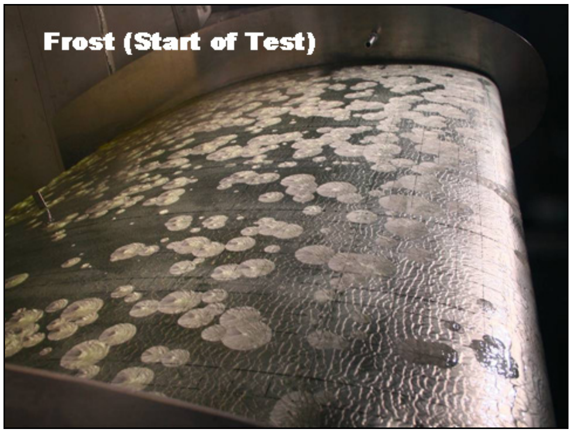
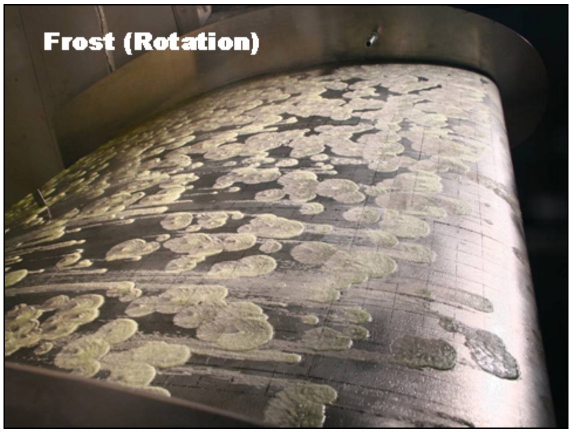
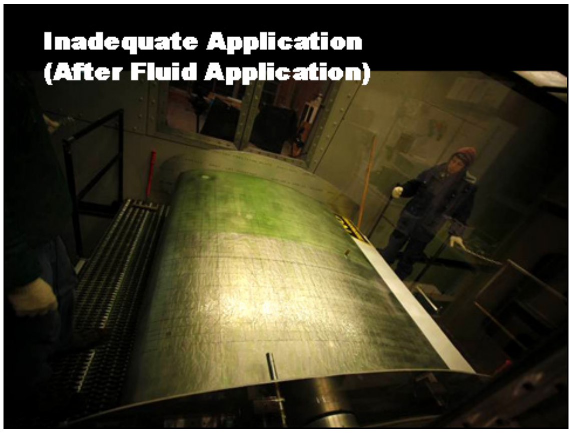
Transports Canada Transport Canada


Heavy Snow (Start of Test)

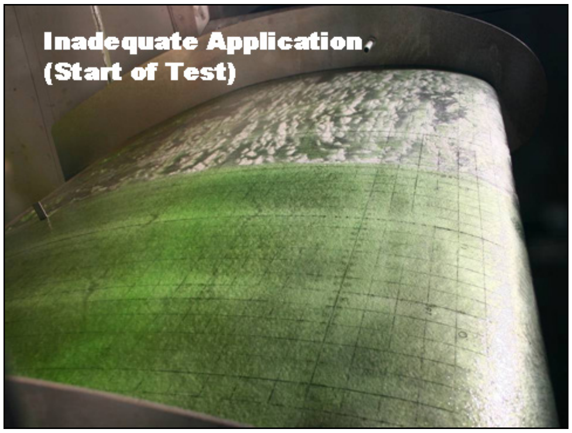

Heavy Snow (Rotation)


Frost (Start of Test)

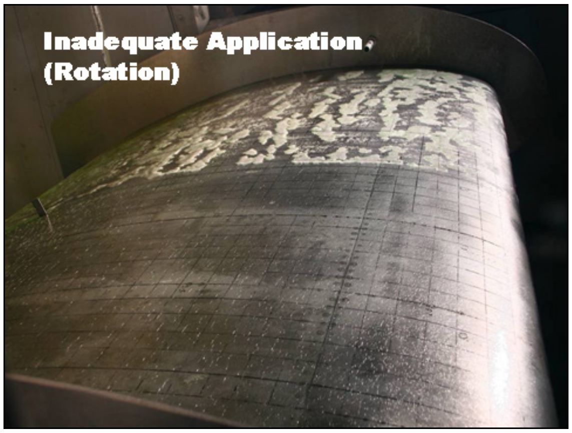

Frost (Rotation)



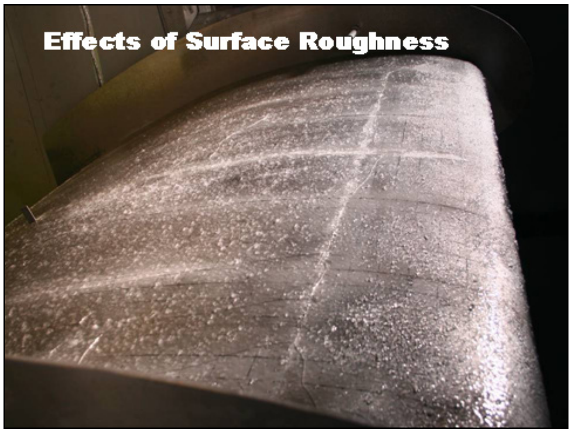
Inadequate Application (After Fluid Application)



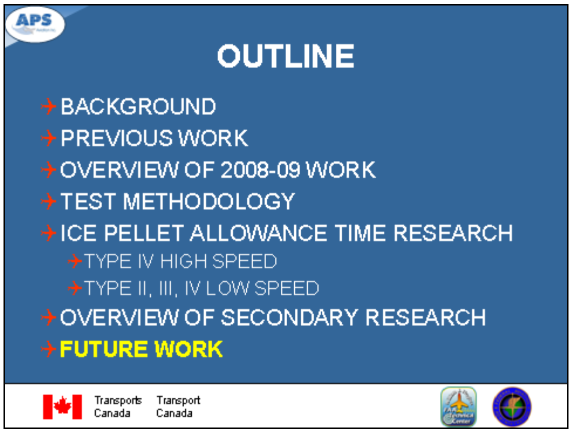
Inadequate Application (Start of Test)



Inadequate Application (Rotation)



Effects of Surface Roughness



OUTLINE

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- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
  - TYPE IV HIGH SPEED
  - TYPE II, III, IV LOW SPEED
- OVERVIEW OF SECONDARY RESEARCH
- **FUTURE WORK**

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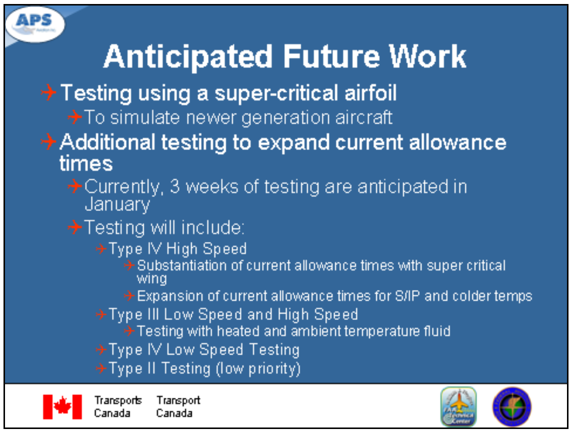

Anticipated Future Work

- Testing using a super-critical airfoil
  - To simulate newer generation aircraft
- Additional testing to expand current allowance times
  - Currently, 3 weeks of testing are anticipated in January
  - Testing will include:
    - Type IV High Speed
      - Substantiation of current allowance times with super critical wing
      - Expansion of current allowance times for S/IP and colder temps
    - Type III Low Speed and High Speed
      - Testing with heated and ambient temperature fluid
    - Type IV Low Speed Testing
    - Type II Testing (low priority)

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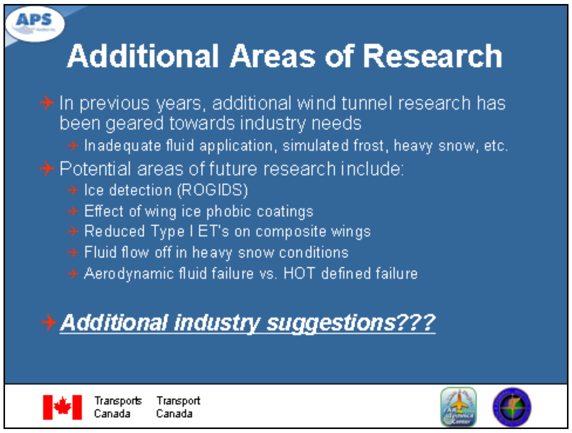


Additional Areas of Research

- In previous years, additional wind tunnel research has been geared towards industry needs
  - Inadequate fluid application, simulated frost, heavy snow, etc.
- Potential areas of future research include:
  - Ice detection (ROGIDS)
  - Effect of wing ice phobic coatings
  - Reduced Type I ET's on composite wings
  - Fluid flow off in heavy snow conditions
  - Aerodynamic fluid failure vs. HOT defined failure
- ***Additional industry suggestions???***

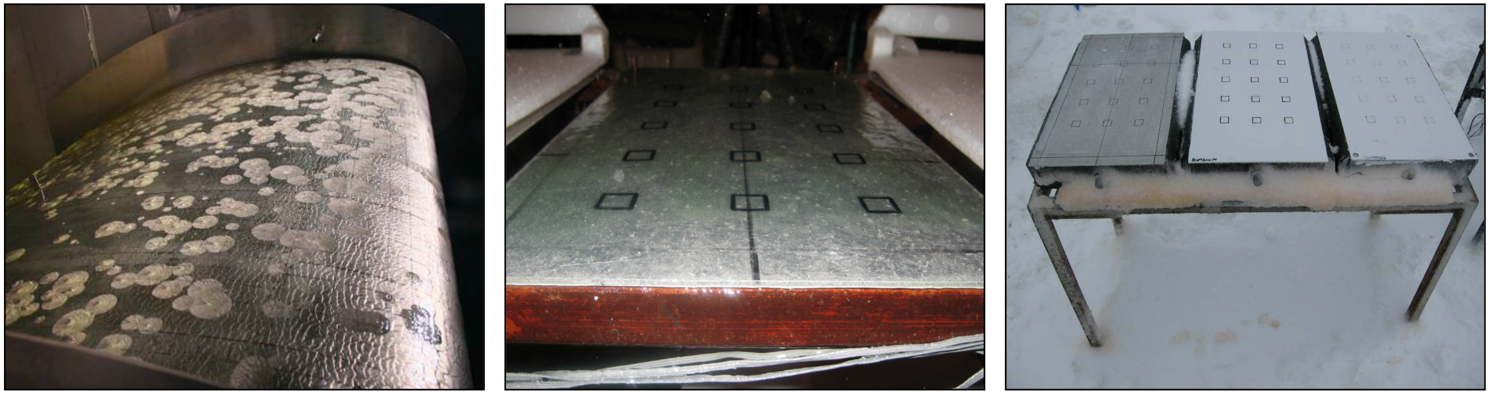
APS
Transports Canada
Transport Canada

C-FIGO
APS
Aviation Inc.

Marco Ruggi
mruggi@adga.ca

OPERATIONAL CHANGES TO HOT GUIDELINES

RELATED TO 2008-09 R&D ACTIVITIES



SAE G-12 SUBCOMITEE MEETING
MONTREAL – NOVEMBER 4, 2009

PRESENTED BY MARCO RUGGI

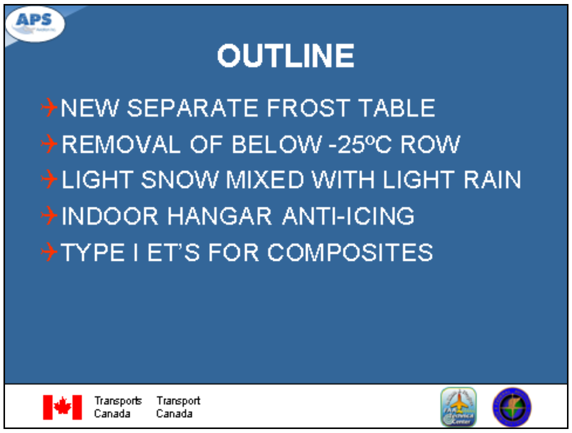
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- NEW SEPARATE FROST TABLE
- REMOVAL OF BELOW -25ºC ROW
- LIGHT SNOW MIXED WITH LIGHT RAIN
- INDOOR HANGAR ANTI-ICING
- TYPE I ET'S FOR COMPOSITES

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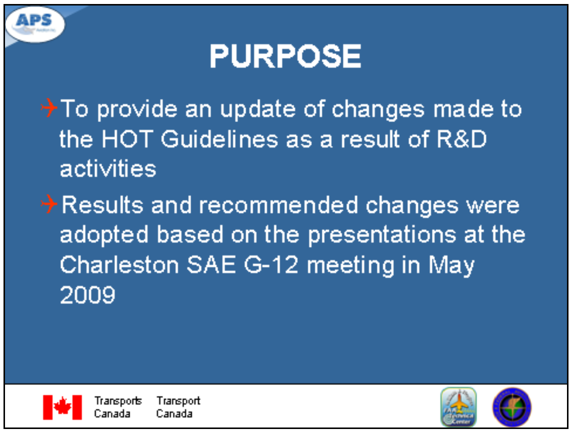

PURPOSE

- To provide an update of changes made to the HOT Guidelines as a result of R&D activities
- Results and recommended changes were adopted based on the presentations at the Charleston SAE G-12 meeting in May 2009

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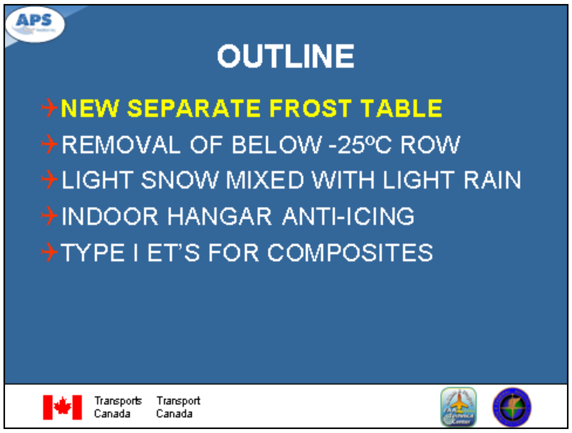

OUTLINE

- **NEW SEPARATE FROST TABLE**
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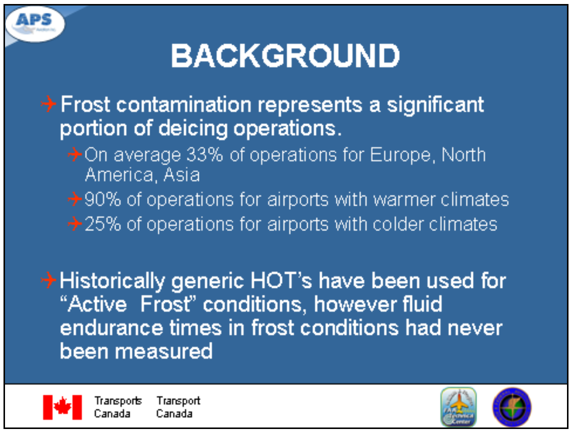

BACKGROUND

- Frost contamination represents a significant portion of deicing operations.
  - On average 33% of operations for Europe, North America, Asia
  - 90% of operations for airports with warmer climates
  - 25% of operations for airports with colder climates
- Historically generic HOT's have been used for "Active Frost" conditions, however fluid endurance times in frost conditions had never been measured

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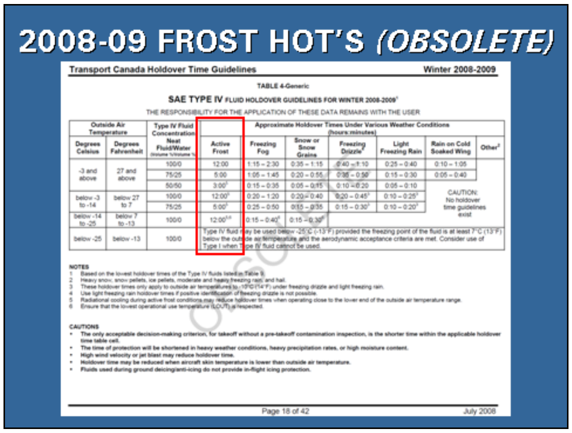

2008-09 FROST HOT'S *(OBSOLETE)*

Transport Canada Holdover Time Guidelines — Winter 2008-2009

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]

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

Outside Air Temperature		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit	Neat Fluid/Water (Volume %/Volume %)	Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00[5]	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00[5]	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	5:00[5]	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[5,6]	0:15 – 0:40[6]	0:15 – 0:30[6]				
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.

OBSOLETE

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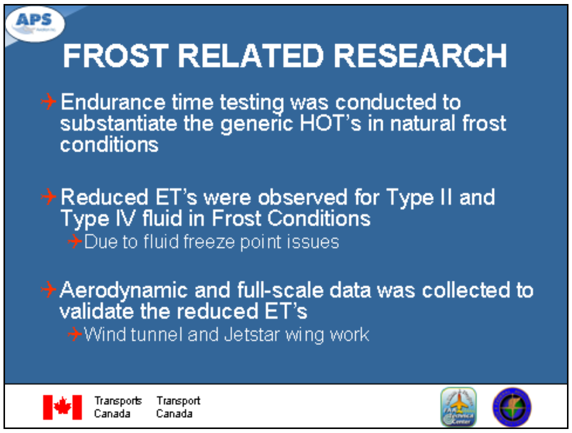

FROST RELATED RESEARCH

- Endurance time testing was conducted to substantiate the generic HOT's in natural frost conditions
- Reduced ET's were observed for Type II and Type IV fluid in Frost Conditions
  - Due to fluid freeze point issues
- Aerodynamic and full-scale data was collected to validate the reduced ET's
  - Wind tunnel and Jetstar wing work

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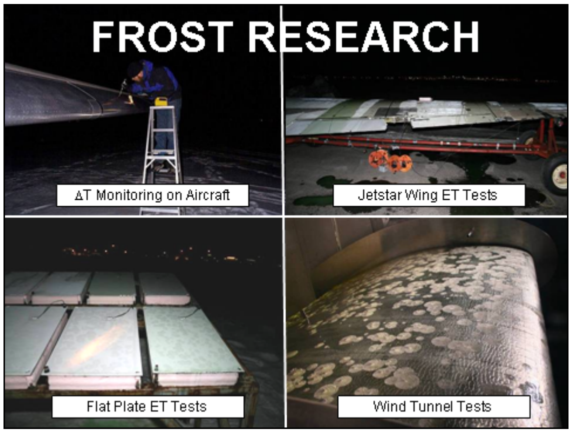
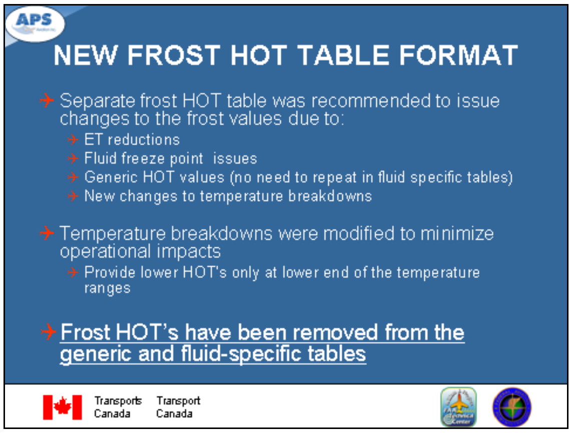


FROST RESEARCH



NEW FROST HOT TABLE FORMAT

- Separate frost HOT table was recommended to issue changes to the frost values due to:
  - ET reductions
  - Fluid freeze point issues
  - Generic HOT values (no need to repeat in fluid specific tables)
  - New changes to temperature breakdowns
- Temperature breakdowns were modified to minimize operational impacts
  - Provide lower HOT's only at lower end of the temperature ranges
- Frost HOT's have been removed from the generic and fluid-specific tables

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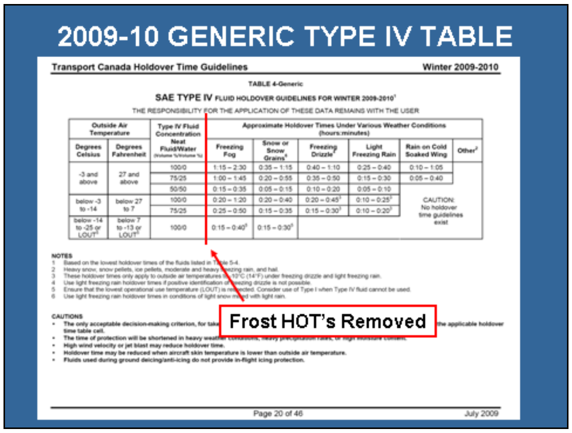

2009-10 GENERIC TYPE IV TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[4]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- The only acceptable decision-making criterion, for take… the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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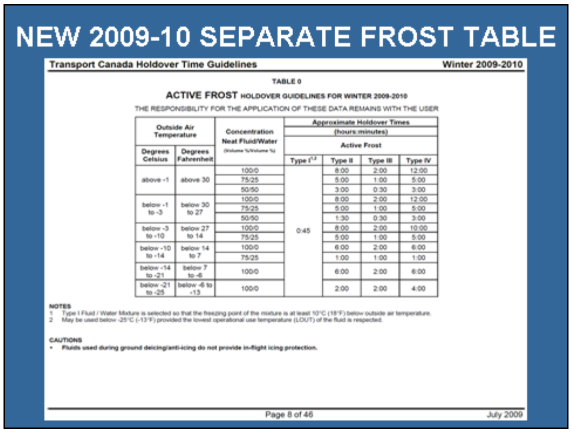
Frost HOT's Removed



NEW 2009-10 SEPARATE FROST TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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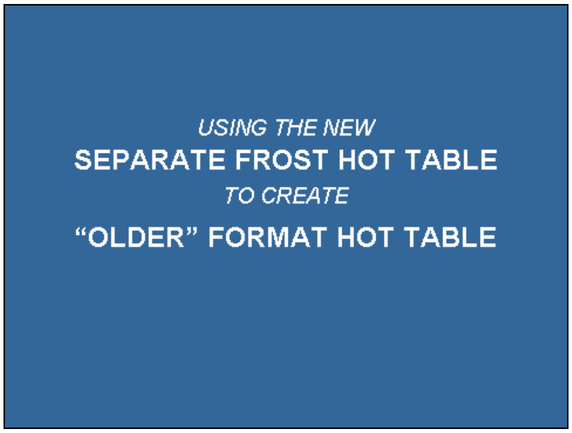
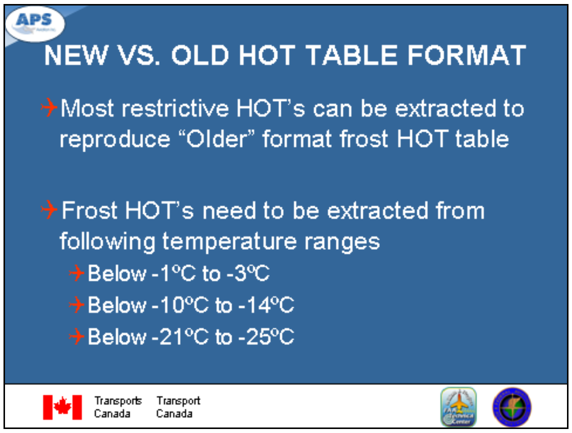


USING THE NEW

SEPARATE FROST HOT TABLE

TO CREATE

"OLDER" FORMAT HOT TABLE



NEW VS. OLD HOT TABLE FORMAT

- Most restrictive HOT's can be extracted to reproduce "Older" format frost HOT table
- Frost HOT's need to be extracted from following temperature ranges
  - Below -1°C to -3°C
  - Below -10°C to -14°C
  - Below -21°C to -25°C

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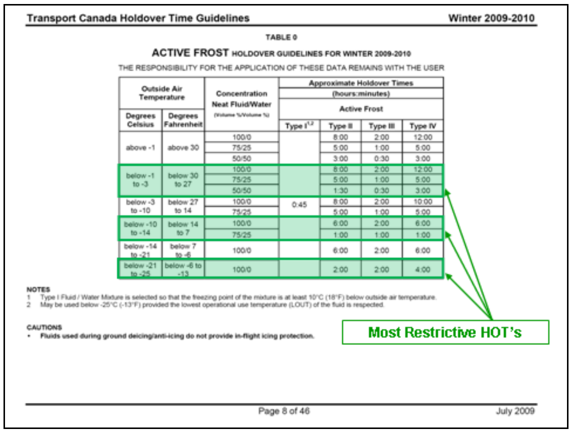

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

Most Restrictive HOT's

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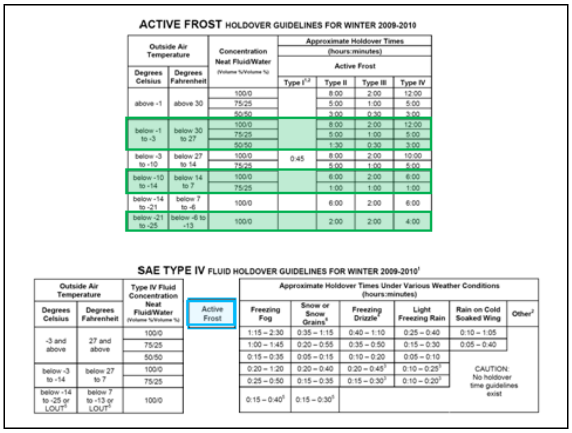
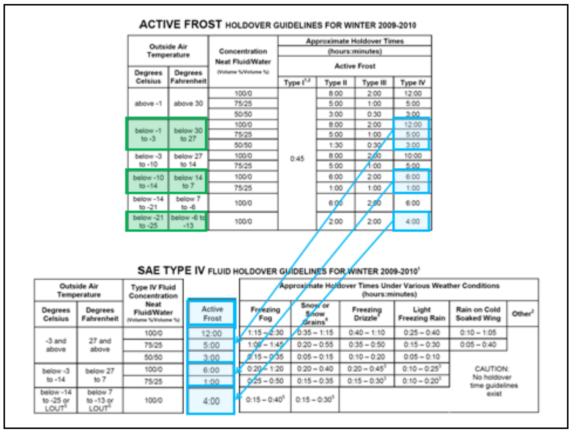


ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Active Frost	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit			Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0		1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25		1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50		0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0		0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25		0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0		0:15 – 0:40[5]	0:15 – 0:30[5]				

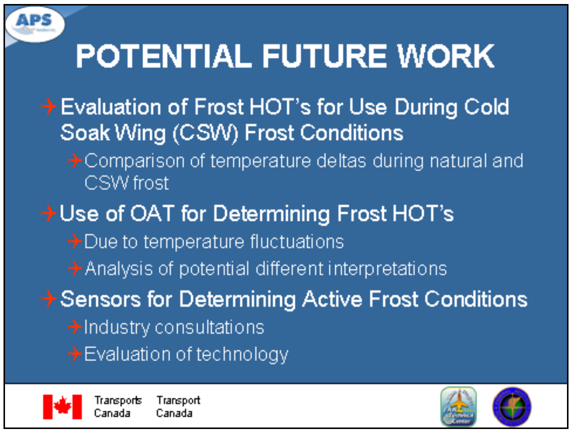


ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Active Frost	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit			Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	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	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	6:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	1:00	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	4:00	0:15 – 0:40[5]	0:15 – 0:30[5]				



POTENTIAL FUTURE WORK

- Evaluation of Frost HOT's for Use During Cold Soak Wing (CSW) Frost Conditions
  - Comparison of temperature deltas during natural and CSW frost
- Use of OAT for Determining Frost HOT's
  - Due to temperature fluctuations
  - Analysis of potential different interpretations
- Sensors for Determining Active Frost Conditions
  - Industry consultations
  - Evaluation of technology

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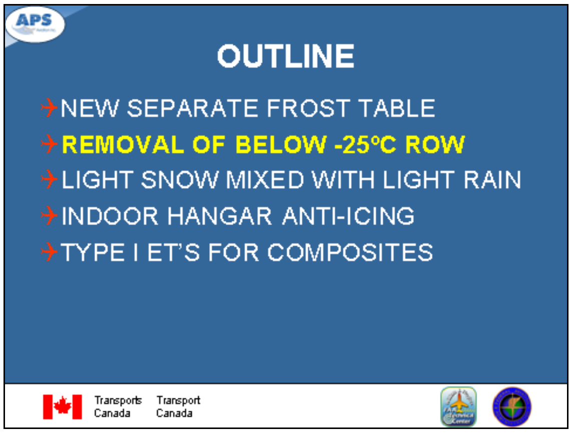
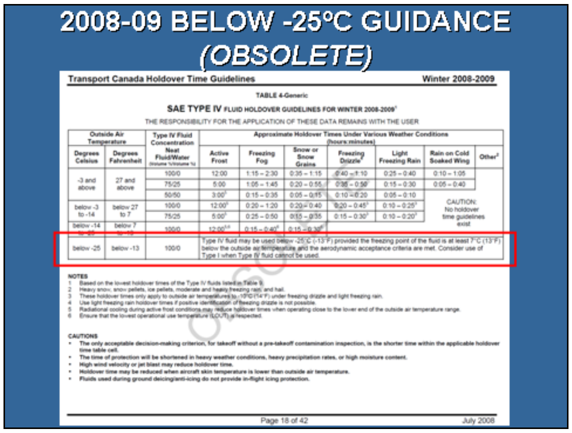


OUTLINE

- NEW SEPARATE FROST TABLE
- **REMOVAL OF BELOW -25°C ROW**
- LIGHT SNOW MIXED WITH LIGHT RAIN
- INDOOR HANGAR ANTI-ICING
- TYPE I ET'S FOR COMPOSITES

Transports Canada Transport Canada



2008-09 BELOW -25°C GUIDANCE (OBSOLETE)

Transport Canada Holdover Time Guidelines **Winter 2008-2009**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00[5]	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00[5]	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	5:00[5]	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[5,6]	0:15 – 0:40[6]	0:15 – 0:30[6]				
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.

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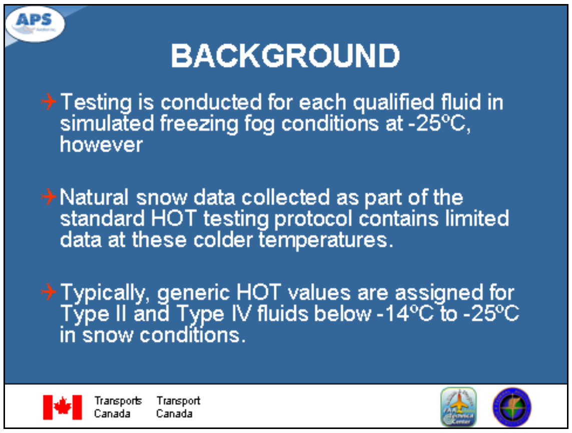

BACKGROUND

- 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.
- Typically, generic HOT values are assigned for Type II and Type IV fluids below -14°C to -25°C in snow conditions.

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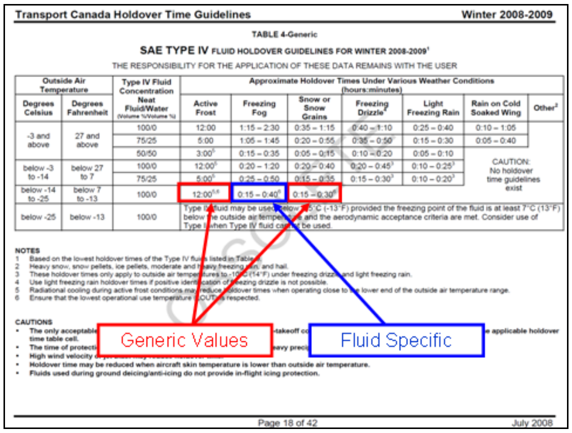

Transport Canada Holdover Time Guidelines **Winter 2008-2009**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2008-2009[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	12:00	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	5:00	1:05 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	3:00[5]	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00[5]	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	5:00[5]	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00[5,6]	0:15 – 0:40[6]	0:15 – 0:30[6]				
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 … time table cell.
- The time of protecti… …avy preci…
- High wind velocity …
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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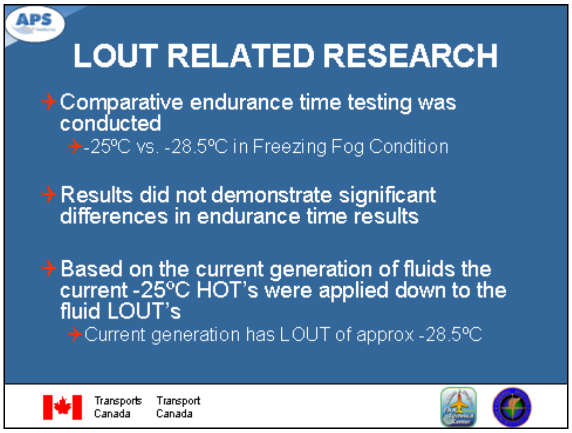
Generic Values

Fluid Specific



LOUT RELATED RESEARCH

- Comparative endurance time testing was conducted
  - -25°C vs. -28.5°C in Freezing Fog Condition
- Results did not demonstrate significant differences in endurance time results
- Based on the current generation of fluids the current -25°C HOT's were applied down to the fluid LOUT's
  - Current generation has LOUT of approx -28.5°C

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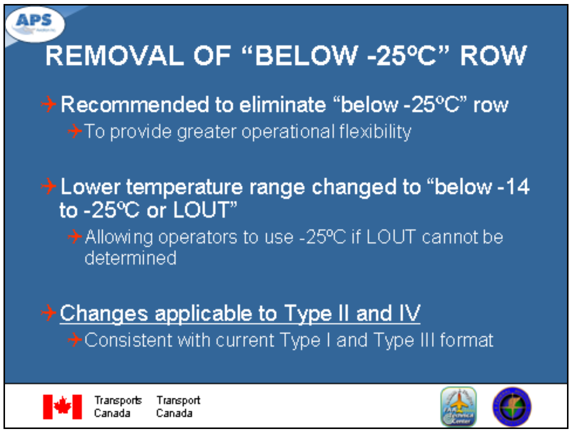

REMOVAL OF "BELOW -25°C" ROW

- Recommended to eliminate "below -25°C" row
  - To provide greater operational flexibility
- Lower temperature range changed to "below -14 to -25°C or LOUT"
  - Allowing operators to use -25°C if LOUT cannot be determined
- Changes applicable to Type II and IV
  - Consistent with current Type I and Type III format

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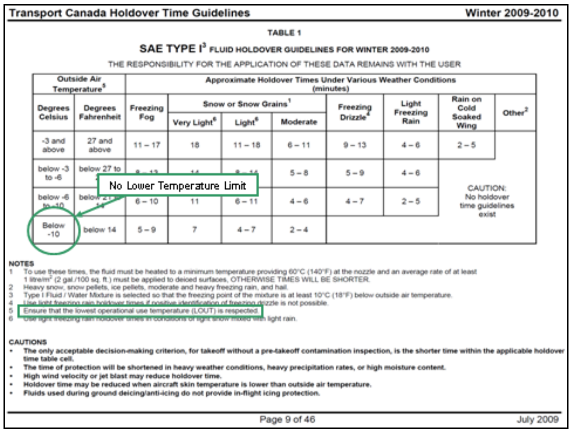

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

No Lower Temperature Limit

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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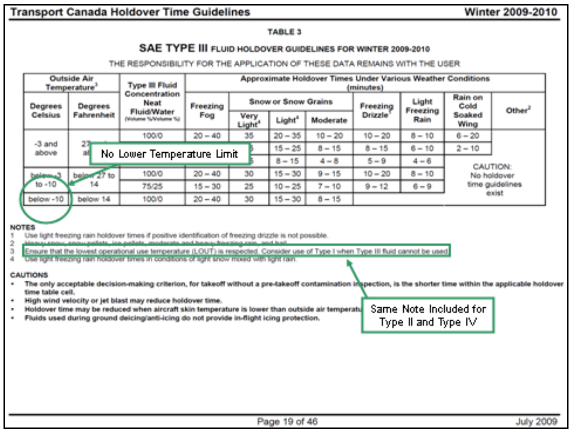

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains			Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 [illegible]	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	
		[illegible]	[illegible]	[illegible]	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		[illegible]	[illegible]	[illegible]	8 – 15	4 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

No Lower Temperature Limit

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 ~~Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.~~
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 ~~Use light freezing rain holdover times in conditions of light snow mixed with light rain.~~

Same Note Included for Type II and Type IV

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 temperatu[illegible]**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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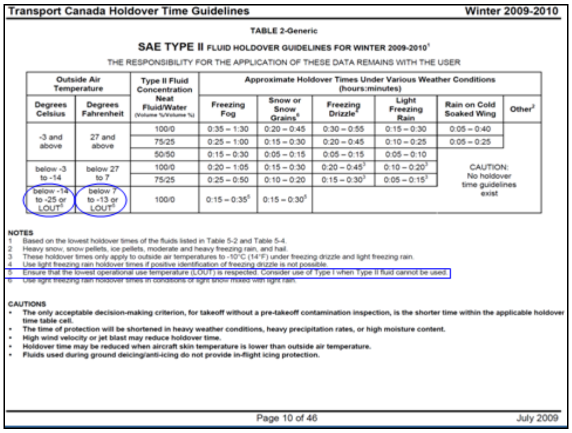

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 ~~Use light freezing rain holdover times in conditions of light snow mixed with light rain.~~

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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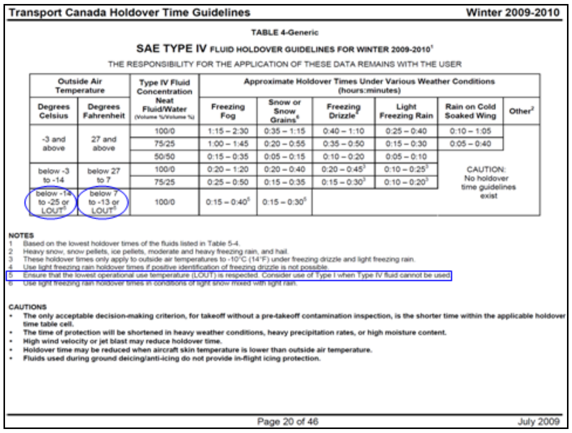

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 ~~Use light freezing rain holdover times in conditions of light snow mixed with light rain.~~

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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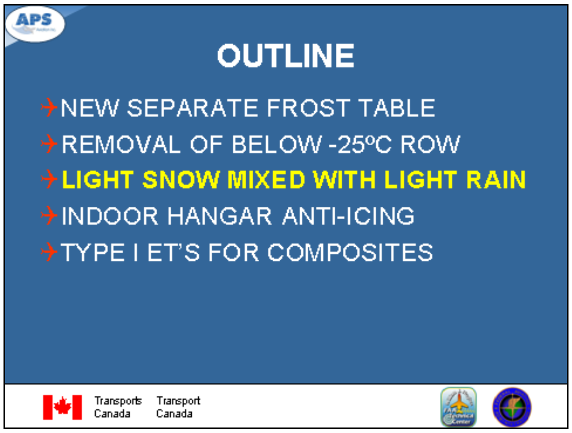

OUTLINE

- NEW SEPARATE FROST TABLE
- REMOVAL OF BELOW -25ºC ROW
- LIGHT SNOW MIXED WITH LIGHT RAIN
- INDOOR HANGAR ANTI-ICING
- TYPE I ET'S FOR COMPOSITES

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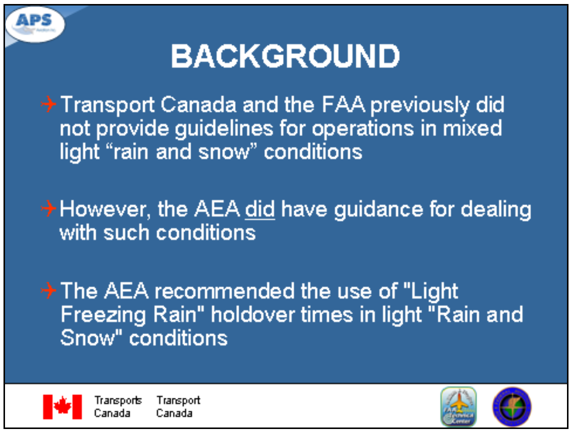
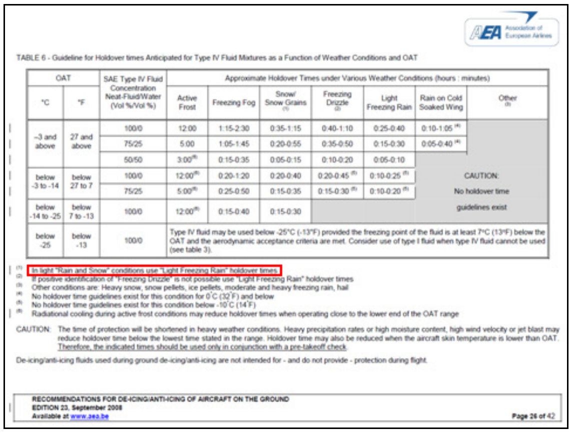


BACKGROUND

- Transport Canada and the FAA previously did not provide guidelines for operations in mixed light "rain and snow" conditions
- However, the AEA did have guidance for dealing with such conditions
- The AEA recommended the use of "Light Freezing Rain" holdover times in light "Rain and Snow" conditions

Transports Canada Transport Canada



AEA Association of European Airlines

TABLE 6 - Guideline for Holdover times Anticipated for Type IV Fluid Mixtures as a Function of Weather Conditions and OAT

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
–3 and above	27 and above	100/0	12:00	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	
		75/25	5:00	1:05-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	3:00(6)	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12:00(6)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)		
		75/25	5:00(6)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)		
below -14 to -25	below 7 to -13	100/0	12:00(6)	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of type I fluid when type IV fluid cannot be used (see table 3).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times.
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) No holdover time guidelines exist for this condition below -10°C (14°F)
(6) Radiational cooling during active frost conditions may reduce holdover times when operating close to the lower end of the OAT range

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

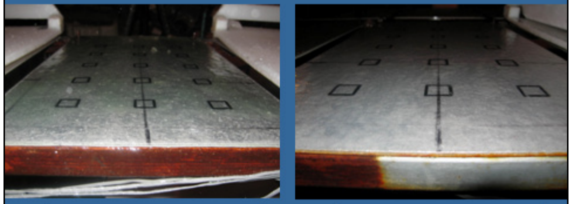
De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
EDITION 23, September 2008
Available at www.aea.be **Page 26 of 42**

S-/R- RELATED RESEARCH

- Comparative endurance time testing was conducted
  - S-/R- (+1°C) vs. ZR- (-3°C)
- ET's for "light snow mixed with light rain" was always slightly longer compared to "light freezing rain"
- Both conditions showed similar failure characteristics
  - i.e. adherence and erosion of the fluid layer

FAILURE COMPARISON TYPE IV PG

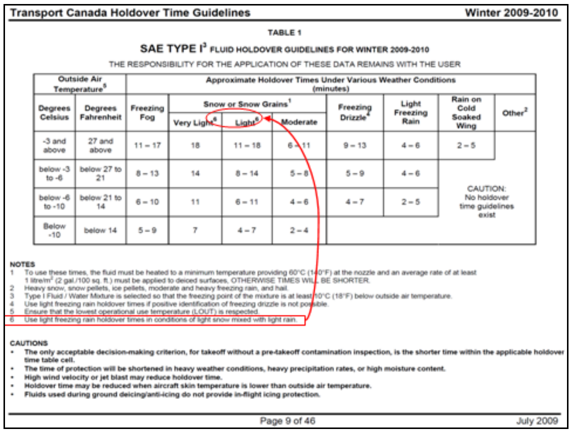


Light Rain and Snow

Light Freezing Rain

S-/R- GUIDANCE MATERIAL

- "Light freezing rain" holdover times were deemed to be a good conservative approach for "light snow mixed with light rain"
  - In accordance with AEA recommendation
- A footnote has been included in all tables



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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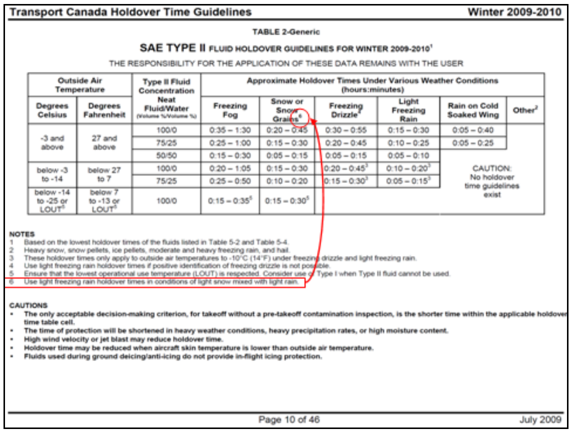

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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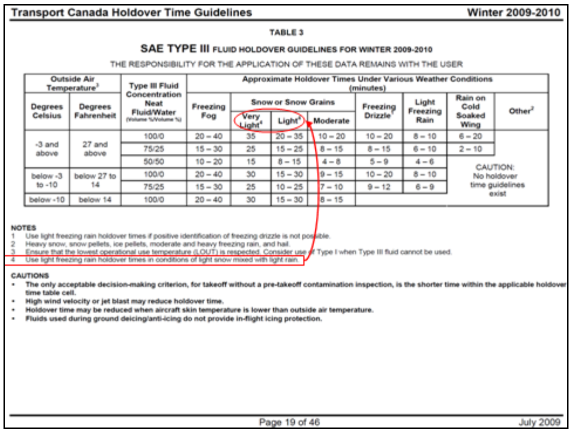

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains			Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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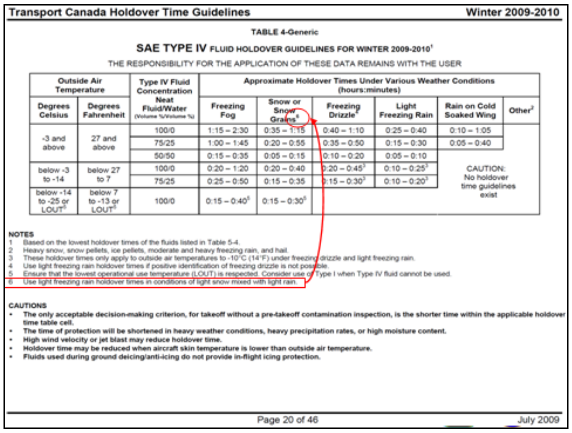

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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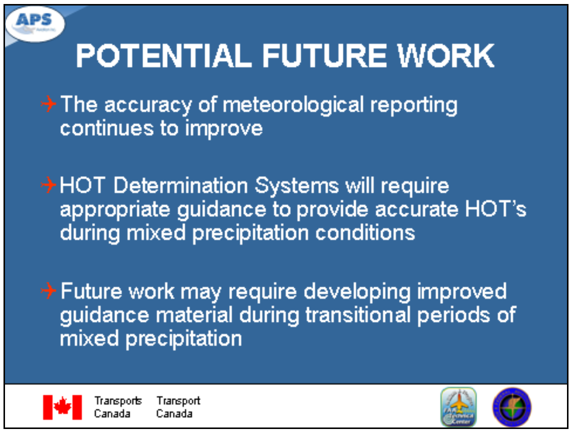

POTENTIAL FUTURE WORK

- The accuracy of meteorological reporting continues to improve
- HOT Determination Systems will require appropriate guidance to provide accurate HOT's during mixed precipitation conditions
- Future work may require developing improved guidance material during transitional periods of mixed precipitation

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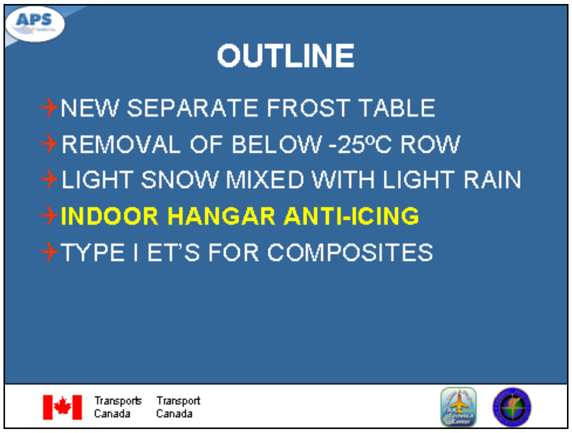

OUTLINE

- NEW SEPARATE FROST TABLE
- REMOVAL OF BELOW -25ºC ROW
- LIGHT SNOW MIXED WITH LIGHT RAIN
- INDOOR HANGAR ANTI-ICING
- TYPE I ET'S FOR COMPOSITES

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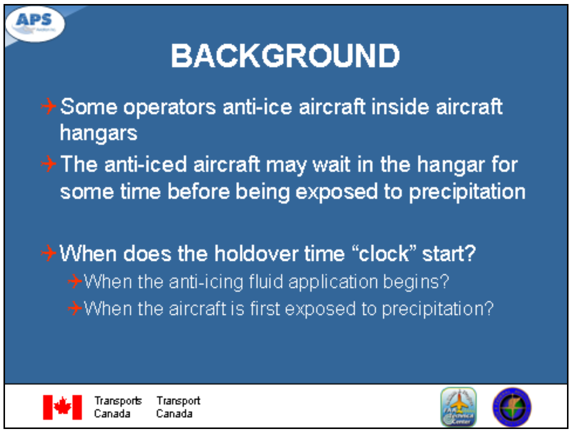

BACKGROUND

- Some operators anti-ice aircraft inside aircraft hangars
- The anti-iced aircraft may wait in the hangar for some time before being exposed to precipitation
- When does the holdover time "clock" start?
  - When the anti-icing fluid application begins?
  - When the aircraft is first exposed to precipitation?

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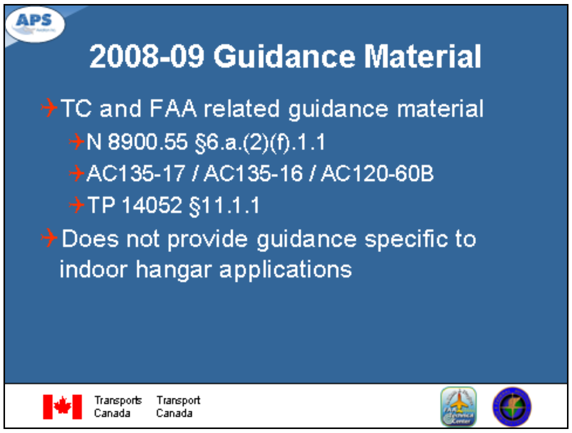

2008-09 Guidance Material

- TC and FAA related guidance material
  - N 8900.55 §6.a.(2)(f).1.1
  - AC135-17 / AC135-16 / AC120-60B
  - TP 14052 §11.1.1
- Does not provide guidance specific to indoor hangar applications

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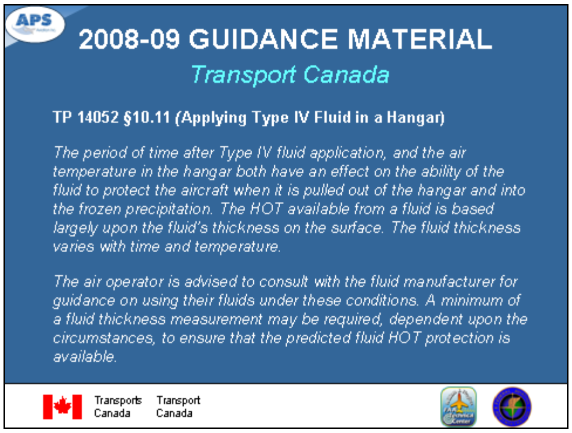

2008-09 GUIDANCE MATERIAL

Transport Canada

TP 14052 §10.11 (Applying Type IV Fluid in a Hangar)

The period of time after Type IV fluid application, and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into the frozen precipitation. The HOT available from a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature.

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

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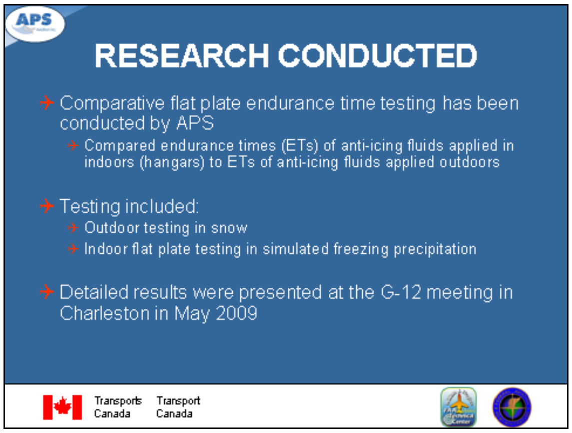

RESEARCH CONDUCTED

- Comparative flat plate endurance time testing has been conducted by APS
  - Compared endurance times (ETs) of anti-icing fluids applied in indoors (hangars) to ETs of anti-icing fluids applied outdoors
- Testing included:
  - Outdoor testing in snow
  - Indoor flat plate testing in simulated freezing precipitation
- Detailed results were presented at the G-12 meeting in Charleston in May 2009

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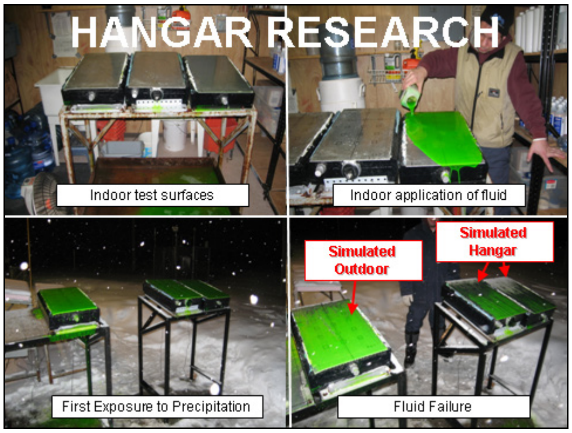
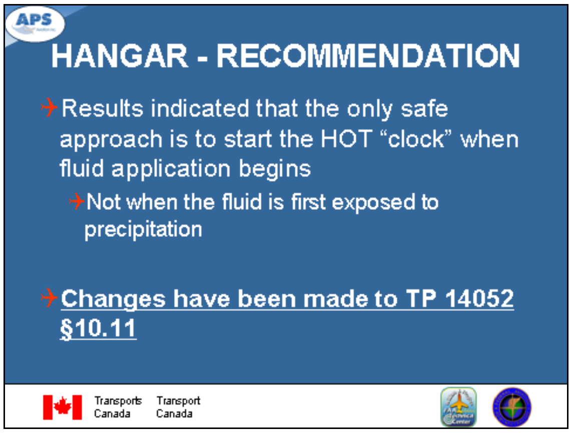


HANGAR RESEARCH



HANGAR - RECOMMENDATION

- Results indicated that the only safe approach is to start the HOT "clock" when fluid application begins
  - Not when the fluid is first exposed to precipitation
- **Changes have been made to TP 14052 §10.11**

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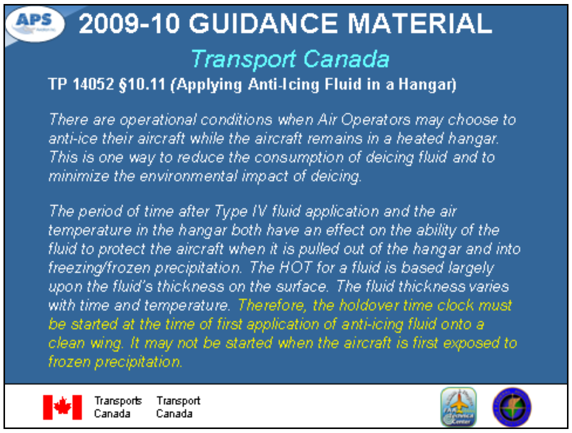

2009-10 GUIDANCE MATERIAL

Transport Canada

TP 14052 §10.11 (Applying Anti-Icing Fluid in a Hangar)

There are operational conditions when Air Operators may choose to anti-ice their aircraft while the aircraft remains in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after Type IV fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to frozen precipitation.

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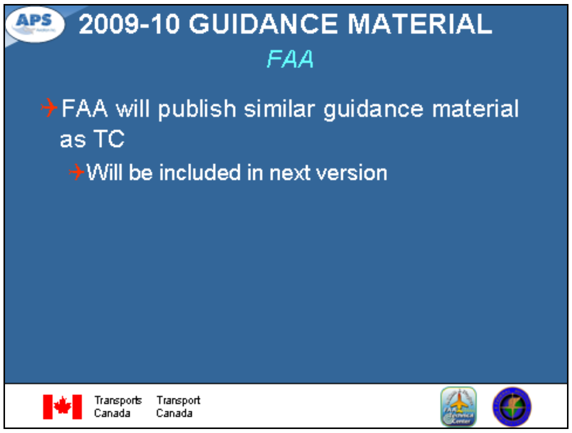

2009-10 GUIDANCE MATERIAL

FAA

- FAA will publish similar guidance material as TC
  - Will be included in next version

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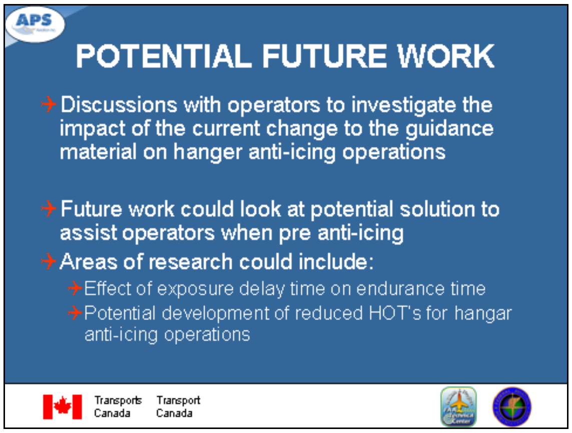

POTENTIAL FUTURE WORK

- Discussions with operators to investigate the impact of the current change to the guidance material on hanger anti-icing operations
- Future work could look at potential solution to assist operators when pre anti-icing
- Areas of research could include:
  - Effect of exposure delay time on endurance time
  - Potential development of reduced HOT's for hangar anti-icing operations

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OUTLINE

- NEW SEPARATE FROST TABLE
- REMOVAL OF BELOW -25ºC ROW
- LIGHT SNOW MIXED WITH LIGHT RAIN
- INDOOR HANGAR ANTI-ICING
- **TYPE I ET'S FOR COMPOSITES**

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BACKGROUND

- Recent increase in manufacturing of aircraft wings with non-aluminum materials
  - Airbus A380, Boeing 787, etc
- Benefits of composite material aircraft construction include:
  - reduced aircraft weight
  - increased fuel efficiency
  - improved maintainability
- A validation of the current holdover time values is required

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BACKGROUND

- Comparative endurance time testing has been conducted by APS
- Testing included:
  - Outdoor testing in snow
    - Plates and Leading Edge Thermal Equivalent boxes
  - Outdoor flat plate testing in frost
  - Indoor flat plate testing in simulated freezing precipitation
- Detailed results were presented at the G-12 meeting in Warsaw and Charleston

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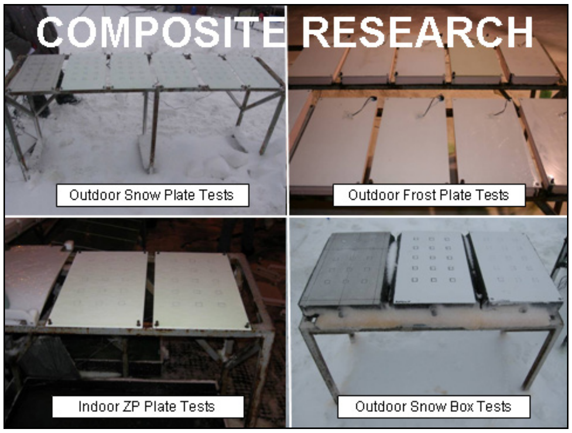

COMPOSITE RESEARCH

GENERAL OBSERVATIONS

- Type II,III,IV composite endurance times were comparable to aluminum endurance times
- Type I fluid demonstrated reduced endurance times when applied to composite surfaces
  - 20-36% reduction depending on condition
- Results in accordance with industry feedback
  - Composite spoiler panels observed to fail first

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CHANGES TO HOT GUIDELINES

- Guidance material is needed for new generation aircraft with critical surfaces made of composite materials
- Additional comprehensive testing is required to develop HOT guidance for use with composite surfaces
- **No changes have been made the 2009-10 HOT Guidelines**
  - NOTE: FAA included interim advisory material regarding composite surfaces

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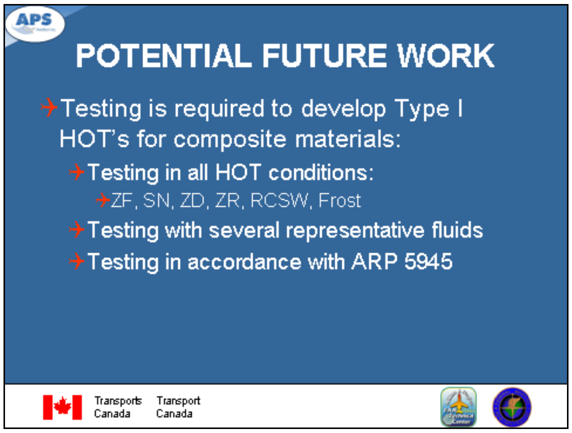

POTENTIAL FUTURE WORK

- Testing is required to develop Type I HOT's for composite materials:
  - Testing in all HOT conditions:
    - ZF, SN, ZD, ZR, RCSW, Frost
  - Testing with several representative fluids
  - Testing in accordance with ARP 5945

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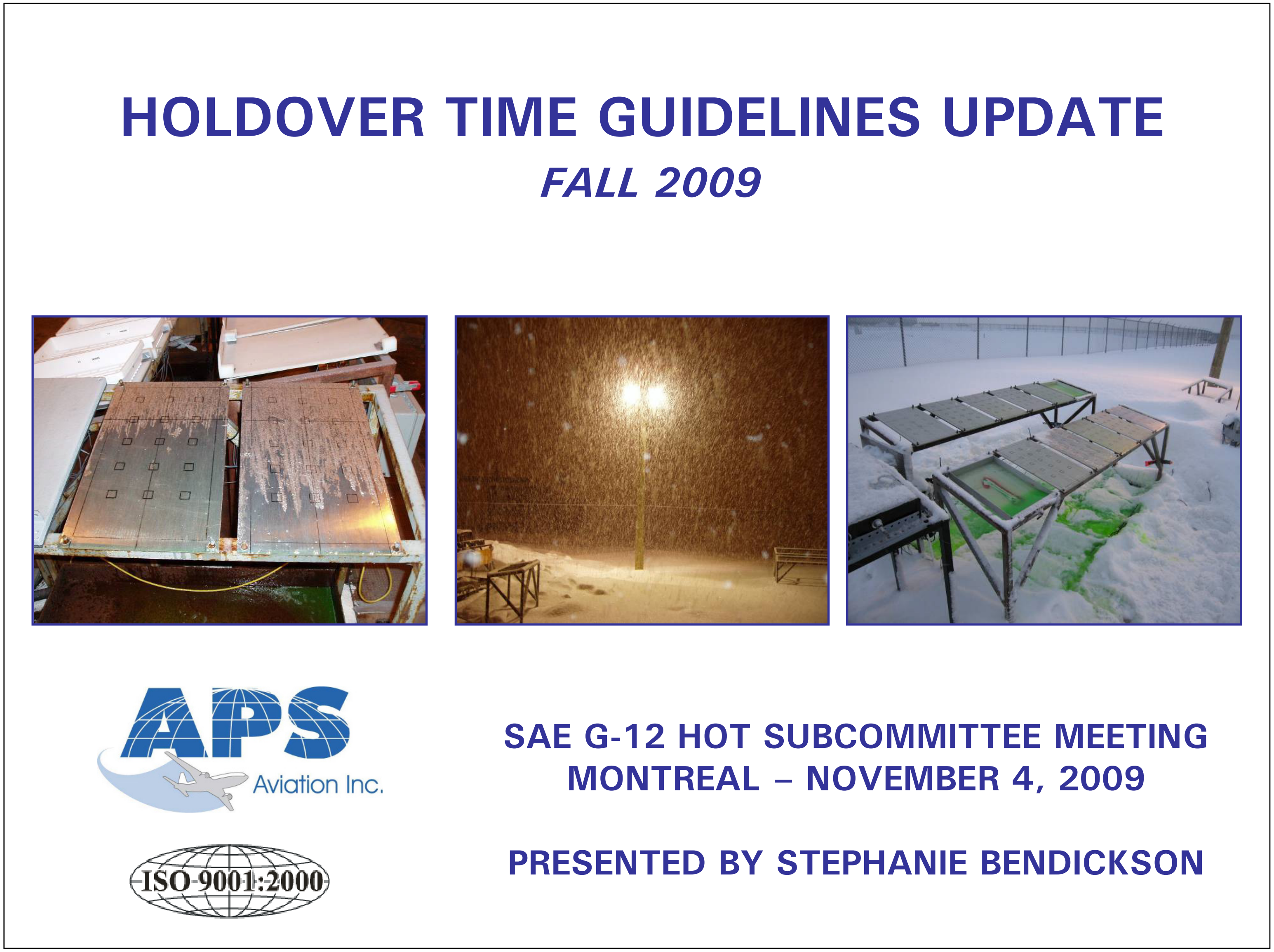


HOLDOVER TIME GUIDELINES UPDATE

FALL 2009

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE MEETING
MONTREAL – NOVEMBER 4, 2009

PRESENTED BY STEPHANIE BENDICKSON

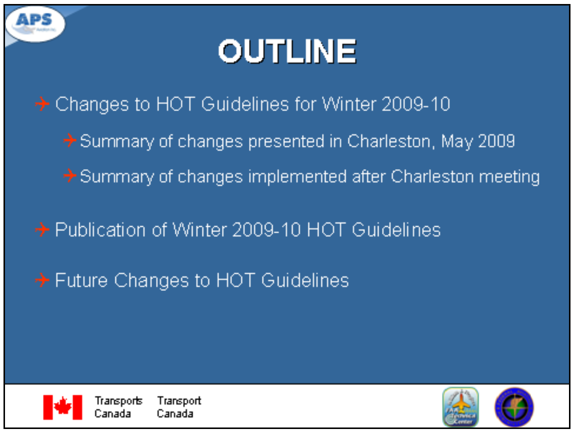
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- Changes to HOT Guidelines for Winter 2009-10
  - Summary of changes presented in Charleston, May 2009
  - Summary of changes implemented after Charleston meeting
- Publication of Winter 2009-10 HOT Guidelines
- Future Changes to HOT Guidelines

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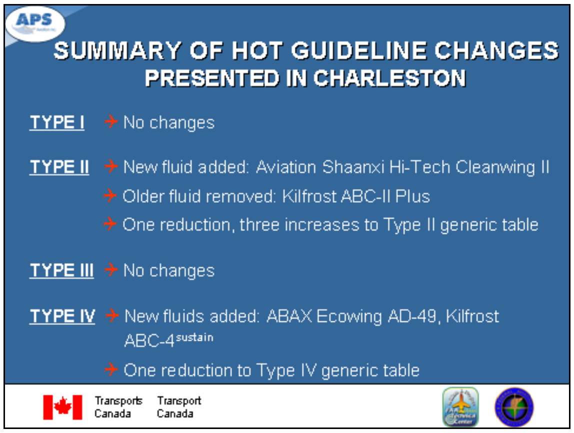

SUMMARY OF HOT GUIDELINE CHANGES PRESENTED IN CHARLESTON

TYPE I
- No changes

TYPE II
- New fluid added: Aviation Shaanxi Hi-Tech Cleanwing II
- Older fluid removed: Kilfrost ABC-II Plus
- One reduction, three increases to Type II generic table

TYPE III
- No changes

TYPE IV
- New fluids added: ABAX Ecowing AD-49, Kilfrost ABC-4^{sustain}
- One reduction to Type IV generic table

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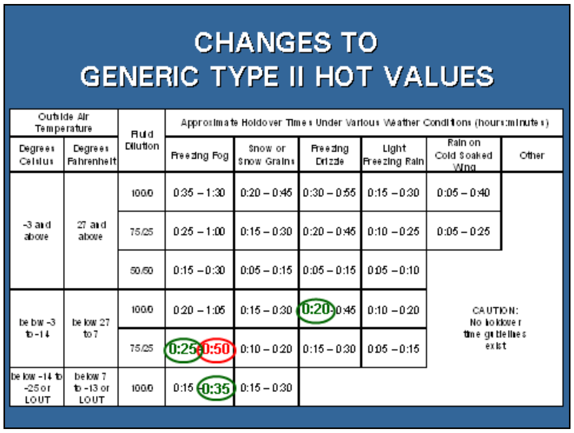
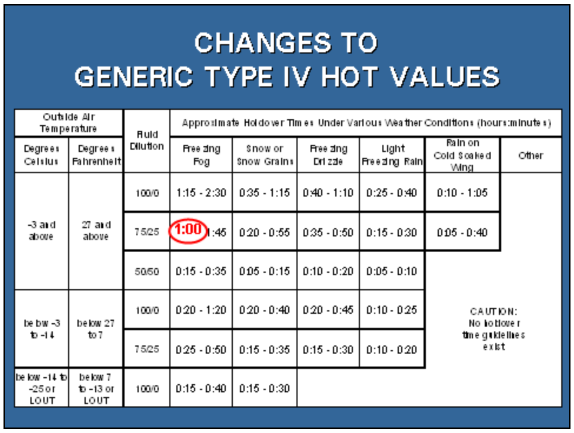


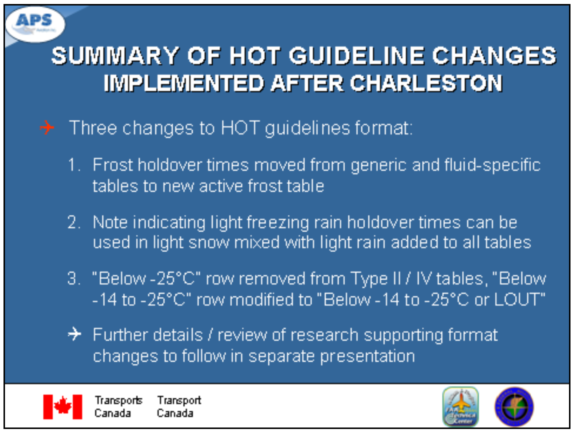
CHANGES TO GENERIC TYPE II HOT VALUES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45	0:10 – 0:20		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30	0:05 – 0:15		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				



CHANGES TO GENERIC TYPE IV HOT VALUES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:15 - 2:30	0:35 - 1:15	0:40 - 1:10	0:25 - 0:40	0:10 - 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 - 1:45	0:20 - 0:55	0:35 - 0:50	0:15 - 0:30	0:05 - 0:40	
		50/50	0:15 - 0:35	0:05 - 0:15	0:10 - 0:20	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 - 1:20	0:20 - 0:40	0:20 - 0:45	0:10 - 0:25		
		75/25	0:25 - 0:50	0:15 - 0:35	0:15 - 0:30	0:10 - 0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 - 0:40	0:15 - 0:30				



SUMMARY OF HOT GUIDELINE CHANGES IMPLEMENTED AFTER CHARLESTON

- Three changes to HOT guidelines format:
  1. Frost holdover times moved from generic and fluid-specific tables to new active frost table
  2. Note indicating light freezing rain holdover times can be used in light snow mixed with light rain added to all tables
  3. "Below -25°C" row removed from Type II / IV tables, "Below -14 to -25°C" row modified to "Below -14 to -25°C or LOUT"
  - Further details / review of research supporting format changes to follow in separate presentation

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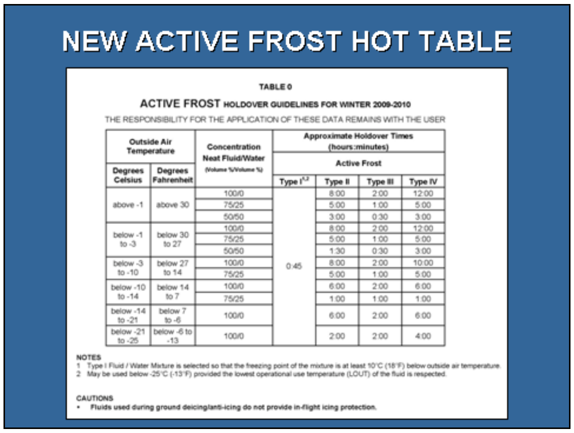


NEW ACTIVE FROST HOT TABLE

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

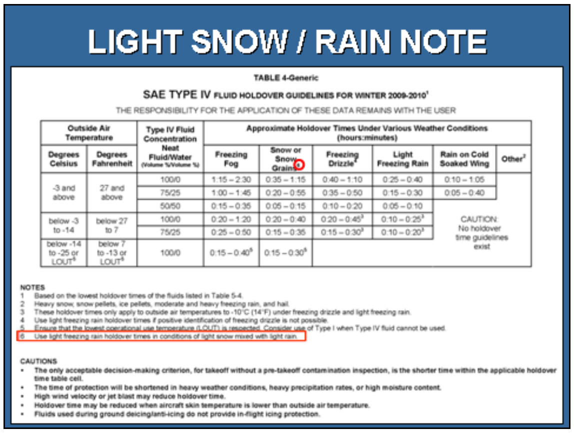
NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.

2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS

- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.



LIGHT SNOW / RAIN NOTE

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.

2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

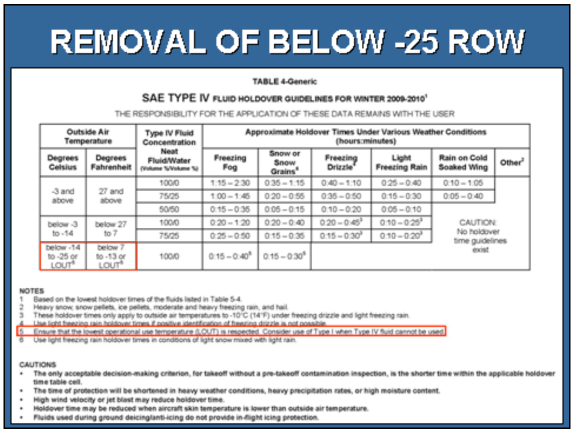
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.

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

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.



REMOVAL OF BELOW -25 ROW

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[7]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.

2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

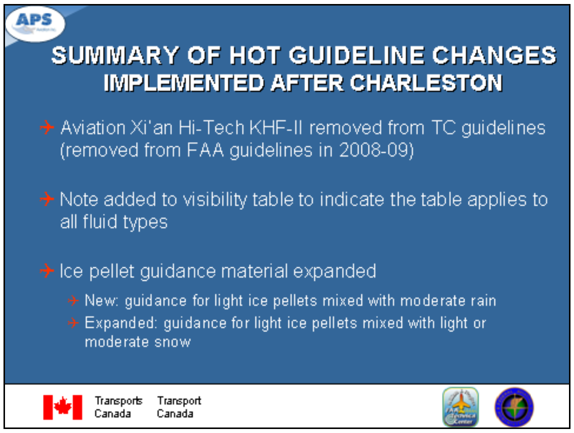
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.

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

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.



SUMMARY OF HOT GUIDELINE CHANGES IMPLEMENTED AFTER CHARLESTON

- Aviation Xi'an Hi-Tech KHF-II removed from TC guidelines (removed from FAA guidelines in 2008-09)
- Note added to visibility table to indicate the table applies to all fluid types
- Ice pellet guidance material expanded
  - New: guidance for light ice pellets mixed with moderate rain
  - Expanded: guidance for light ice pellets mixed with light or moderate snow

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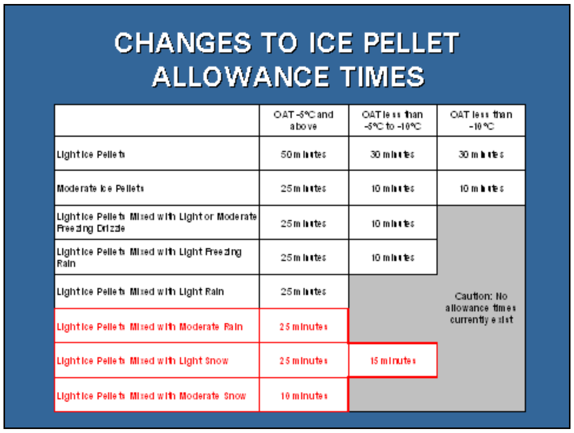
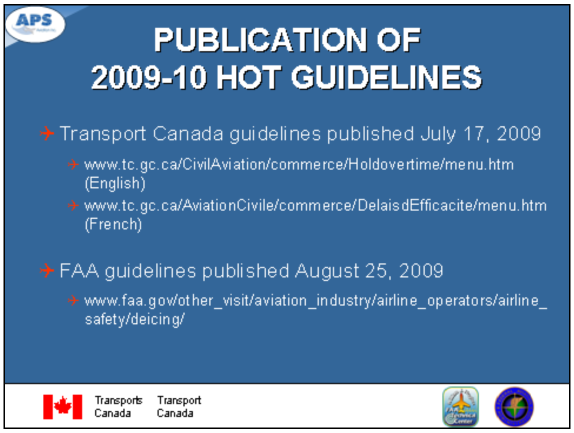


CHANGES TO ICE PELLET ALLOWANCE TIMES

	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 Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		



PUBLICATION OF 2009-10 HOT GUIDELINES

- Transport Canada guidelines published July 17, 2009
  - www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm (English)
  - www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/menu.htm (French)
- FAA guidelines published August 25, 2009
  - www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/

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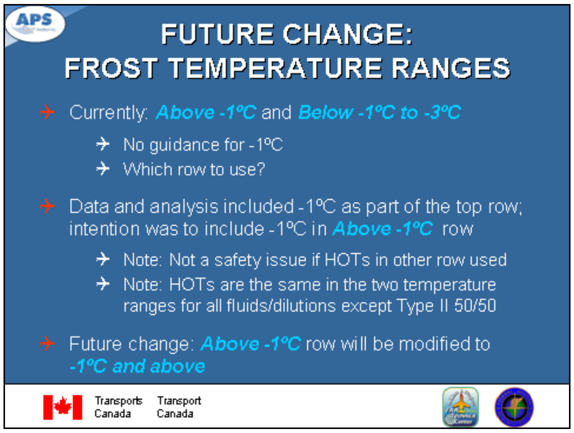

FUTURE CHANGE: FROST TEMPERATURE RANGES

- Currently: ***Above -1°C*** and ***Below -1°C to -3°C***
  - No guidance for -1°C
  - Which row to use?
- Data and analysis included -1°C as part of the top row; intention was to include -1°C in ***Above -1°C*** row
  - Note: Not a safety issue if HOTs in other row used
  - Note: HOTs are the same in the two temperature ranges for all fluids/dilutions except Type II 50/50
- Future change: ***Above -1°C*** row will be modified to ***-1°C and above***

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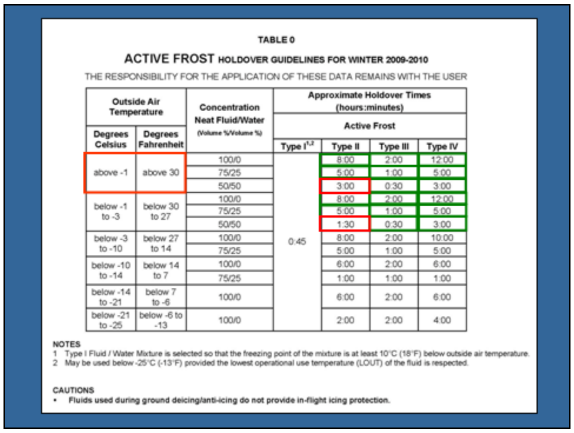

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

POTENTIAL FUTURE CHANGES

- To be discussed in separate presentation this afternoon

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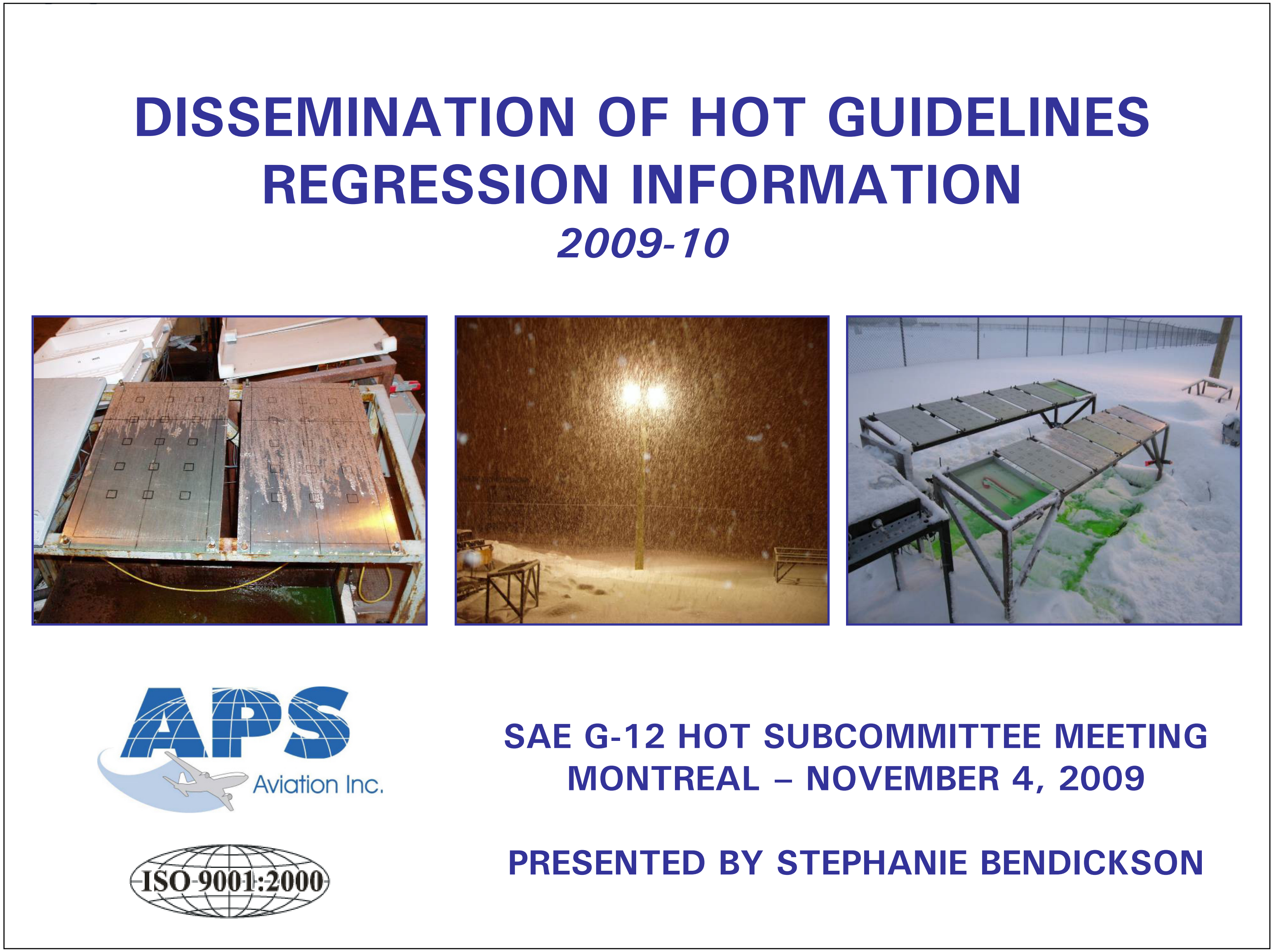

DISSEMINATION OF HOT GUIDELINES REGRESSION INFORMATION

2009-10

Aviation Inc.

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE MEETING
MONTREAL – NOVEMBER 4, 2009

PRESENTED BY STEPHANIE BENDICKSON

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

PURPOSE

- To publicize how Transport Canada intends to disseminate regression information for the 2009-10 and future HOT guidelines

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BACKGROUND

- Development of Holdover Time Determination Systems (HOTDS) has necessitated the regression information underlying the HOT tables be published
- Information needs to be updated and republished each year due to annual changes to HOT guidelines

Transports Canada Transport Canada

BACKGROUND

- Presentation given at November 2008 HOT meeting detailed the specific information that needs to be published
    - Regression coefficients and equations underlying all of the HOT guideline tables
- Example:
    - Fluid: ABAX Ecowing 26 100/0
    - Temperature: -3°C
    - Precipitation type: Snow
    - Precipitation rate: 10 g/dm^2/h

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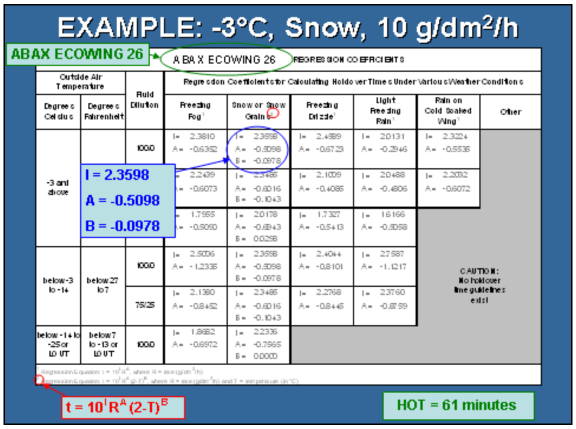
EXAMPLE: -3°C, Snow, 10 g/dm^2/h



ABAX ECOWING 26

ABAX ECOWING 26 REGRESSION COEFFICIENTS

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above		100/0	I= 2.3810 A= -0.6352	I= 2.3598 A= -0.5098 B= -0.0978	I= 2.4589 A= -0.6723	I= 2.0131 A= -0.2946	I= 2.3224 A= -0.5535	
			I= 2.2439 A= -0.6073	I= 2.3486 A= -0.6016 B= -0.1043	I= 2.1009 A= -0.4086	I= 2.0488 A= -0.4806	I= 2.2032 A= -0.6072	
			I= 1.7955 A= -0.5090	I= 2.0178 A= -0.6943 B= 0.0298	I= 1.7327 A= -0.5413	I= 1.6166 A= -0.5058		
below -3 to -14	below 27 to 7	100/0	I= 2.5006 A= -1.2335	I= 2.3598 A= -0.5098 B= -0.0978	I= 2.4044 A= -0.8101	I= 2.7587 A= -1.1217	CAUTION: No holdover time guidelines exist	
		75/25	I= 2.1380 A= -0.8452	I= 2.3486 A= -0.6016 B= -0.1043	I= 2.2768 A= -0.8446	I= 2.3760 A= -0.8759		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	I= 1.8682 A= -0.6972	I= 2.2336 A= -0.7565 B= 0.0000				

[1] Regression Equation: $t = 10^I R^A$, where R = rate (g/dm^2/h)

[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = rate (g/dm^2/h) and T = temperature (in °C)

I = 2.3598
A = -0.5098
B = -0.0978

$t = 10^I R^A (2-T)^B$

HOT = 61 minutes

BACKGROUND

- Last year Transport Canada published regression information in a TP report, TP 14873:
    - *Regression Coefficients Used to Develop Aircraft Ground Deicing Holdover Time Tables for the Winter of 2008-09*
- However, the report was not officially published until recently, so information not available during the winter when it was needed
- Using a TP report to publish information does not allow timely dissemination of the information

Transports Canada Transport Canada

NEW APPROACH FOR 2009-10

- New approach will include two publications:
  1. Online Document
  2. Transport Canada TP Report
- Both publications will be updated annually

Transports Canada Transport Canada

ONLINE DOCUMENT

- Purpose: Will provide regression information and guidance on its usage
- Target Audience: Users (i.e. HOTDS manufacturers)
- Location: Published online with the HOT guidelines
- Availability: Several months prior to the winter operating season (i.e. summer)

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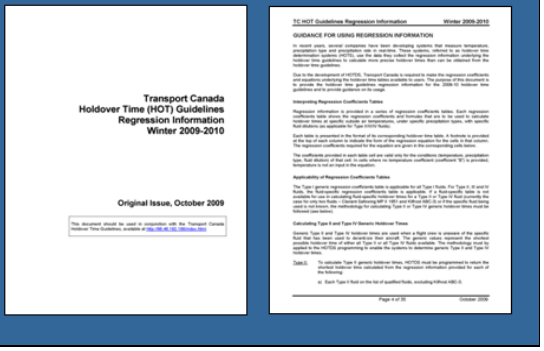
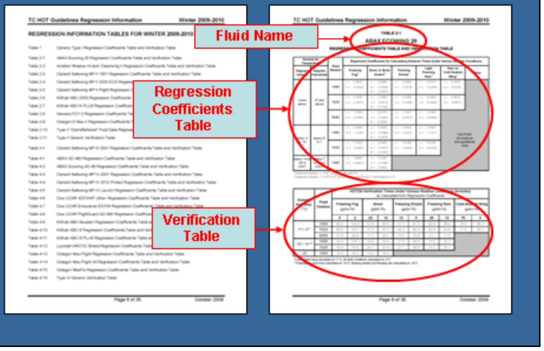
ONLINE DOCUMENT


Transport Canada
Holdover Time (HOT) Guidelines
Regression Information
Winter 2009-2010

Original Issue, October 2009

ONLINE DOCUMENT



TP REPORT

- Purpose: Will document how and from where the information in the current online document was obtained
- Target Audience: Reference document for regulators
- Location: Published as TP report, available from TDC
- Availability: 1 to 2 years following a winter operating season

Transports Canada Transport Canada

WINTER 2009-10 PUBLICATIONS

- Hope to have Winter 2009-10 online document published online in the next several months
- Draft TP report has been written; final draft will be submitted to TDC by the end of the year

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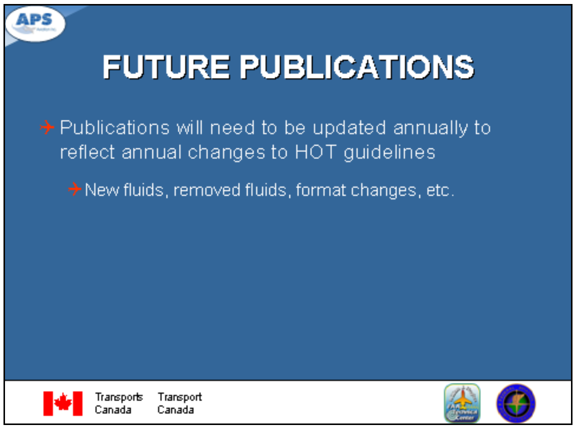

FUTURE PUBLICATIONS

- Publications will need to be updated annually to reflect annual changes to HOT guidelines
  - New fluids, removed fluids, format changes, etc.

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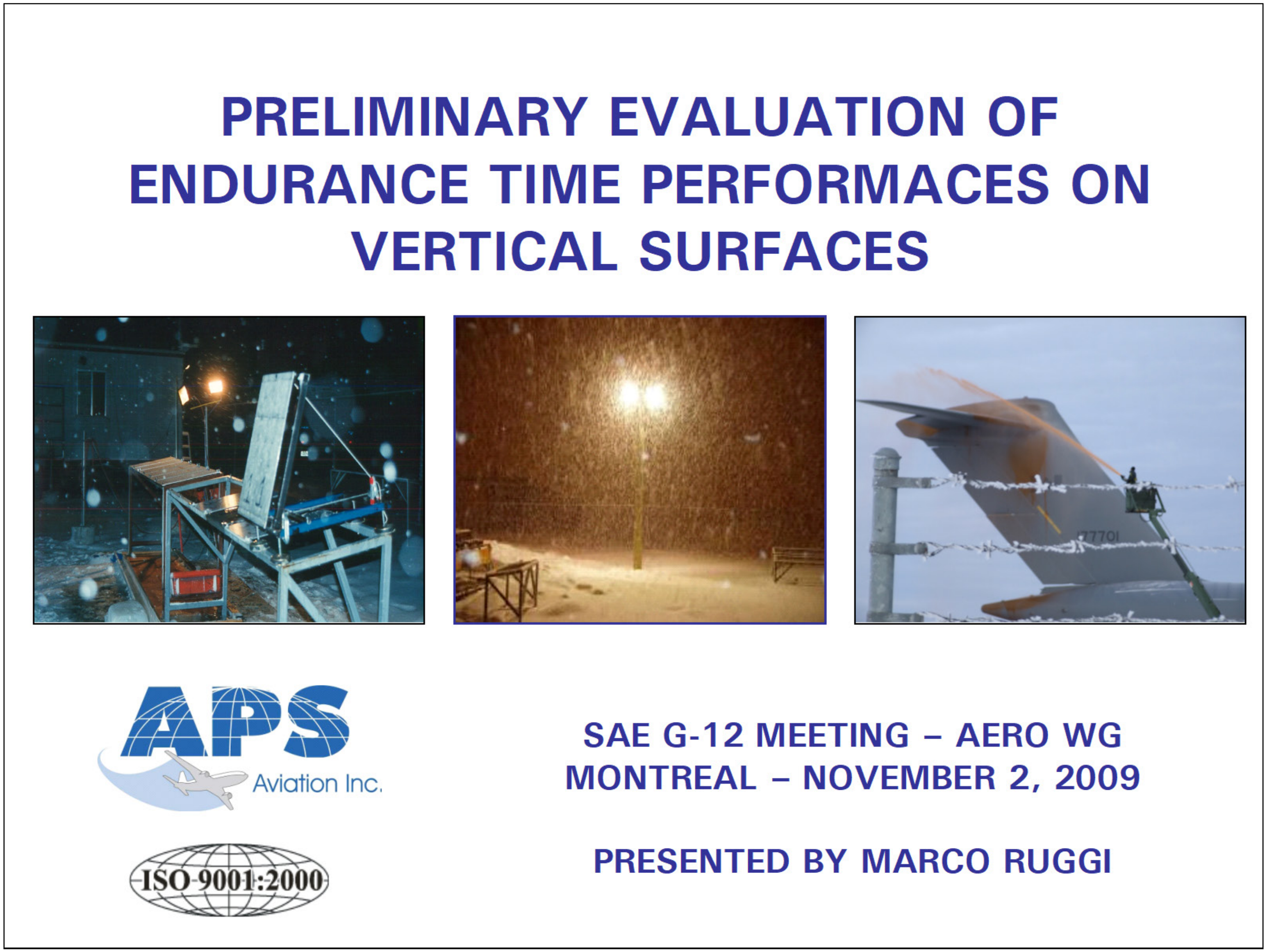


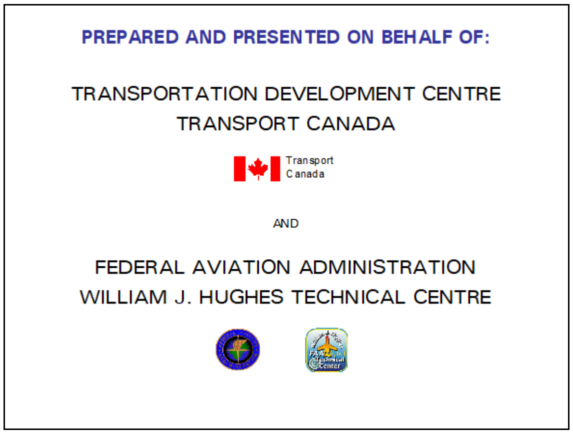
PRELIMINARY EVALUATION OF ENDURANCE TIME PERFORMACES ON VERTICAL SURFACES

APS Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING – AERO WG
MONTREAL – NOVEMBER 2, 2009

PRESENTED BY MARCO RUGGI

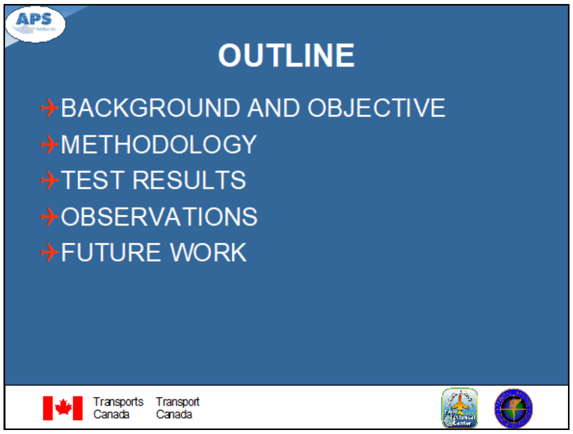


PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

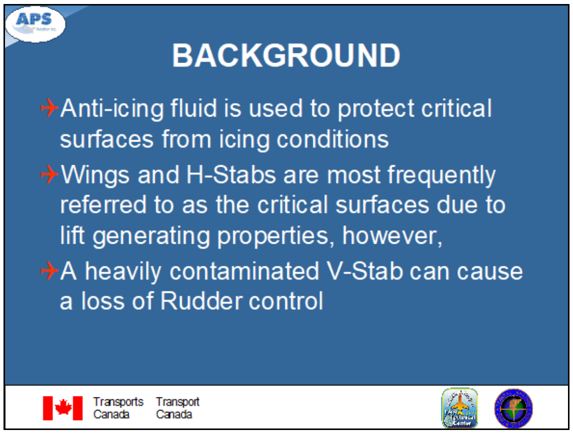
AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



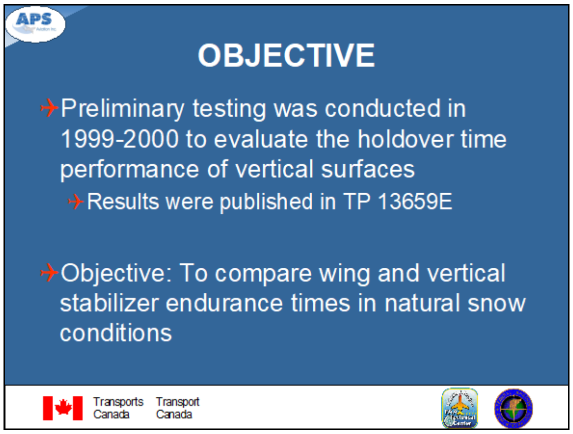
OUTLINE

- BACKGROUND AND OBJECTIVE
- METHODOLOGY
- TEST RESULTS
- OBSERVATIONS
- FUTURE WORK



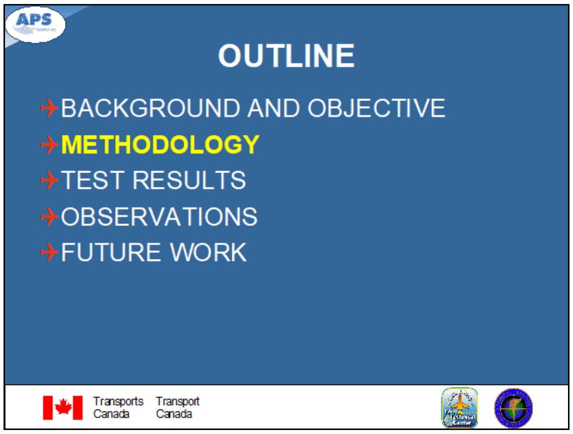
BACKGROUND

- Anti-icing fluid is used to protect critical surfaces from icing conditions
- Wings and H-Stabs are most frequently referred to as the critical surfaces due to lift generating properties, however,
- A heavily contaminated V-Stab can cause a loss of Rudder control



OBJECTIVE

- Preliminary testing was conducted in 1999-2000 to evaluate the holdover time performance of vertical surfaces
  - Results were published in TP 13659E
- Objective: To compare wing and vertical stabilizer endurance times in natural snow conditions



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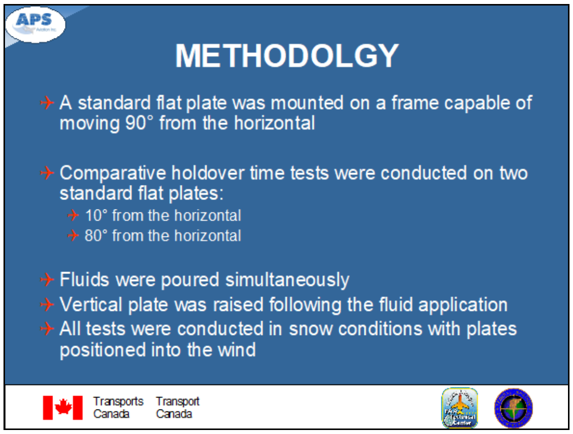
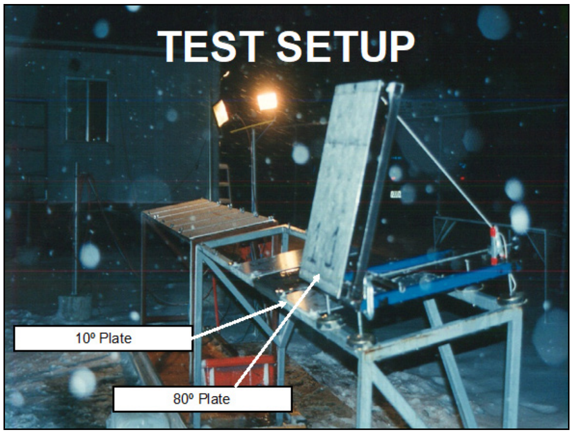
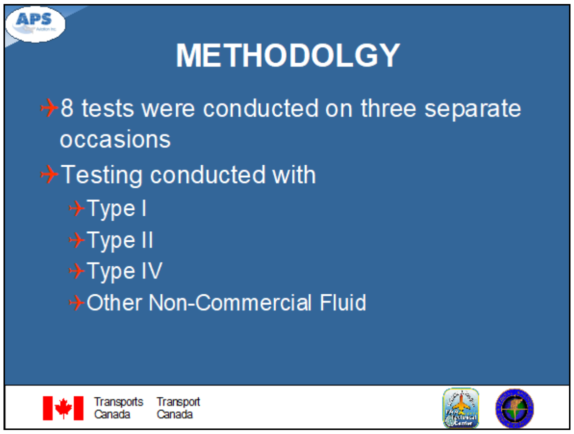


METHODOLGY

- A standard flat plate was mounted on a frame capable of moving 90° from the horizontal
- Comparative holdover time tests were conducted on two standard flat plates:
  - 10° from the horizontal
  - 80° from the horizontal
- Fluids were poured simultaneously
- Vertical plate was raised following the fluid application
- All tests were conducted in snow conditions with plates positioned into the wind



TEST SETUP



METHODOLGY

- 8 tests were conducted on three separate occasions
- Testing conducted with
  - Type I
  - Type II
  - Type IV
  - Other Non-Commercial Fluid

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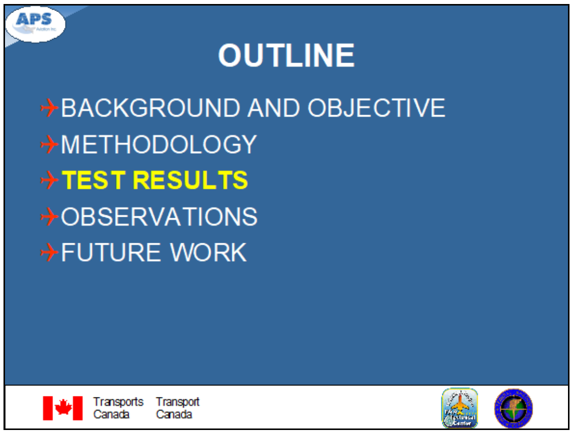

OUTLINE

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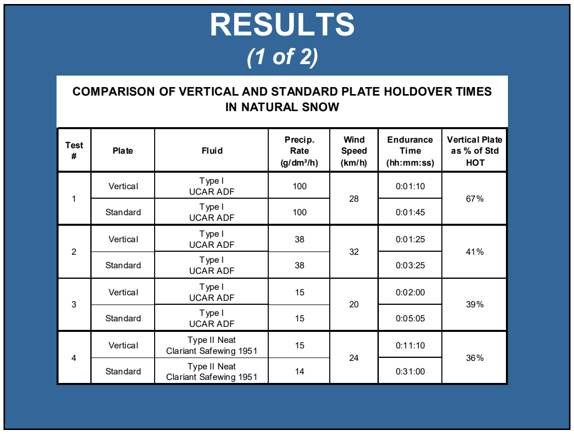
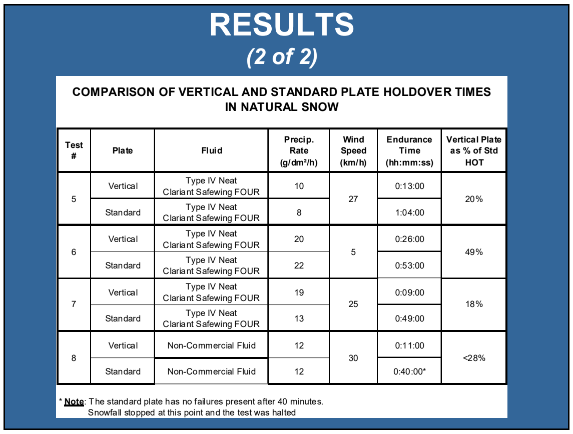


RESULTS

(1 of 2)

COMPARISON OF VERTICAL AND STANDARD PLATE HOLDOVER TIMES IN NATURAL SNOW

Test #	Plate	Fluid	Precip. Rate (g/dm²/h)	Wind Speed (km/h)	Endurance Time (hh:mm:ss)	Vertical Plate as % of Std HOT
1	Vertical	Type I UCAR ADF	100	28	0:01:10	67%
	Standard	Type I UCAR ADF	100		0:01:45	
2	Vertical	Type I UCAR ADF	38	32	0:01:25	41%
	Standard	Type I UCAR ADF	38		0:03:25	
3	Vertical	Type I UCAR ADF	15	20	0:02:00	39%
	Standard	Type I UCAR ADF	15		0:05:05	
4	Vertical	Type II Neat Clariant Safewing 1951	15	24	0:11:10	36%
	Standard	Type II Neat Clariant Safewing 1951	14		0:31:00	



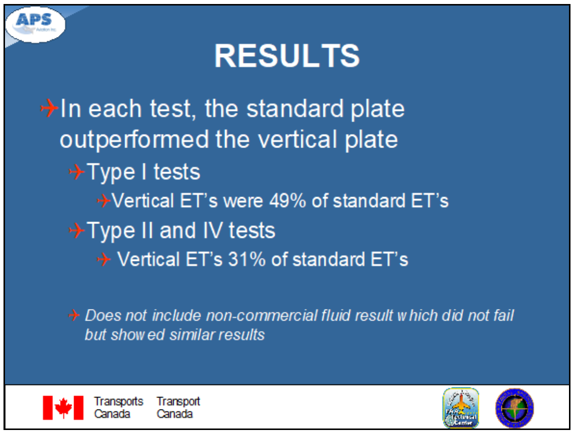
RESULTS

(2 of 2)

COMPARISON OF VERTICAL AND STANDARD PLATE HOLDOVER TIMES IN NATURAL SNOW

Test #	Plate	Fluid	Precip. Rate (g/dm²/h)	Wind Speed (km/h)	Endurance Time (hh:mm:ss)	Vertical Plate as % of Std HOT
5	Vertical	Type IV Neat Clariant Safewing FOUR	10	27	0:13:00	20%
	Standard	Type IV Neat Clariant Safewing FOUR	8		1:04:00	
6	Vertical	Type IV Neat Clariant Safewing FOUR	20	5	0:26:00	49%
	Standard	Type IV Neat Clariant Safewing FOUR	22		0:53:00	
7	Vertical	Type IV Neat Clariant Safewing FOUR	19	25	0:09:00	18%
	Standard	Type IV Neat Clariant Safewing FOUR	13		0:49:00	
8	Vertical	Non-Commercial Fluid	12	30	0:11:00	<28%
	Standard	Non-Commercial Fluid	12		0:40:00*	

* **Note**: The standard plate has no failures present after 40 minutes.
Snowfall stopped at this point and the test was halted



RESULTS

- In each test, the standard plate outperformed the vertical plate
  - Type I tests
    - Vertical ET's were 49% of standard ET's
  - Type II and IV tests
    - Vertical ET's 31% of standard ET's
  - *Does not include non-commercial fluid result which did not fail but showed similar results*

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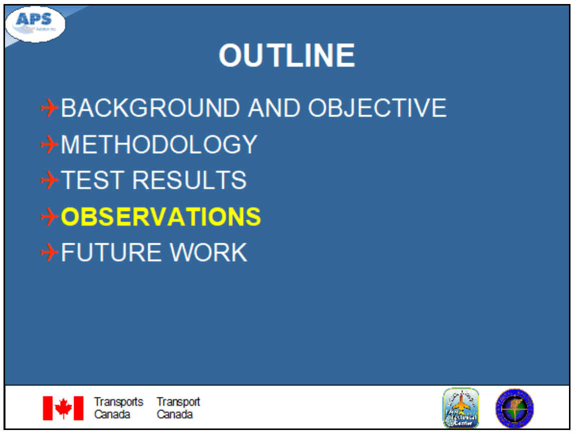

OUTLINE

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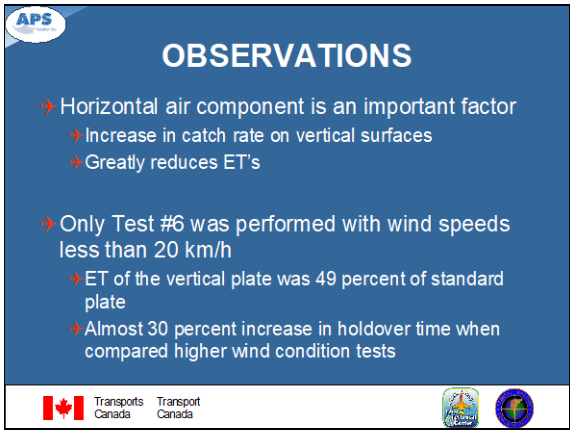

OBSERVATIONS

- Horizontal air component is an important factor
  - Increase in catch rate on vertical surfaces
  - Greatly reduces ET's
- Only Test #6 was performed with wind speeds less than 20 km/h
  - ET of the vertical plate was 49 percent of standard plate
  - Almost 30 percent increase in holdover time when compared higher wind condition tests

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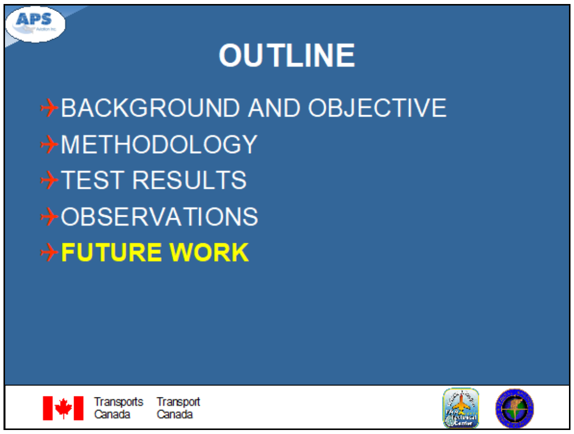

OUTLINE

- BACKGROUND AND OBJECTIVE
- METHODOLOGY
- TEST RESULTS
- OBSERVATIONS
- **FUTURE WORK**

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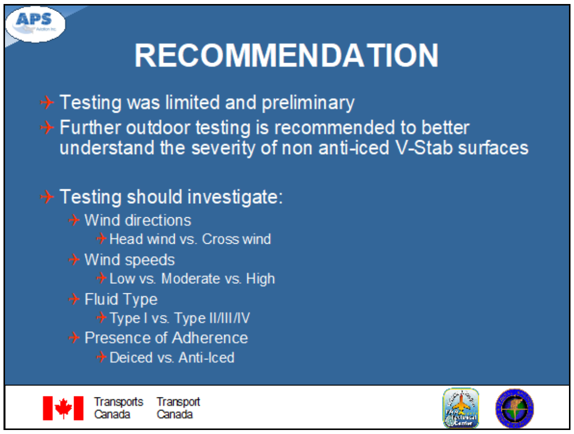

RECOMMENDATION

- Testing was limited and preliminary
- Further outdoor testing is recommended to better understand the severity of non anti-iced V-Stab surfaces
- Testing should investigate:
  - Wind directions
    - Head wind vs. Cross wind
  - Wind speeds
    - Low vs. Moderate vs. High
  - Fluid Type
    - Type I vs. Type II/III/IV
  - Presence of Adherence
    - Deiced vs. Anti-Iced

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APS Aviation Inc.

Marco Ruggi
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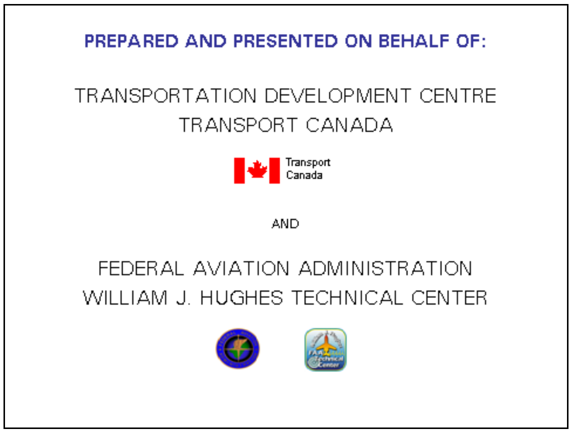
ANTI-ICING ENDURANCE TIMES FOR AIRCRAFT HANGAR OPERATIONS

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT COMMITTEE MEETING
BERLIN – MAY 11, 2010

PRESENTED BY STEPHANIE BENDICKSON



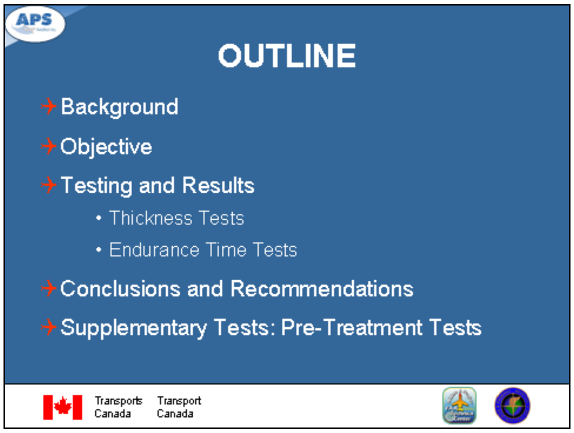
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Objective
- Testing and Results
  - Thickness Tests
  - Endurance Time Tests
- Conclusions and Recommendations
- Supplementary Tests: Pre-Treatment Tests

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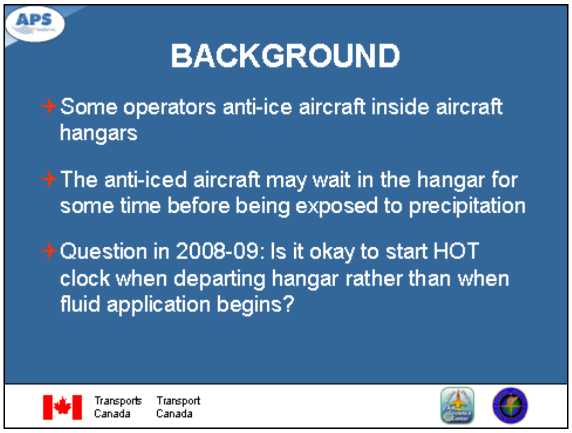

BACKGROUND

- Some operators anti-ice aircraft inside aircraft hangars
- The anti-iced aircraft may wait in the hangar for some time before being exposed to precipitation
- Question in 2008-09: Is it okay to start HOT clock when departing hangar rather than when fluid application begins?

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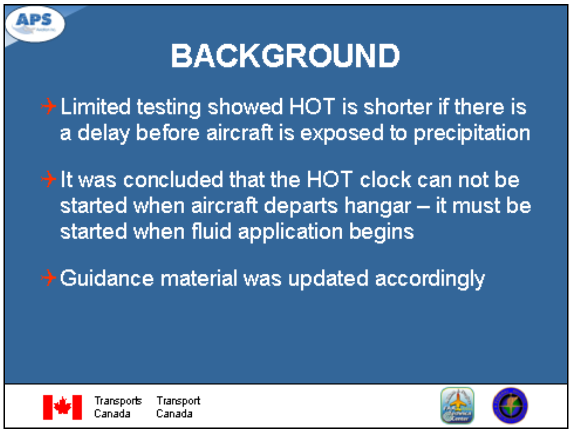

BACKGROUND

- Limited testing showed HOT is shorter if there is a delay before aircraft is exposed to precipitation
- It was concluded that the HOT clock can not be started when aircraft departs hangar – it must be started when fluid application begins
- Guidance material was updated accordingly

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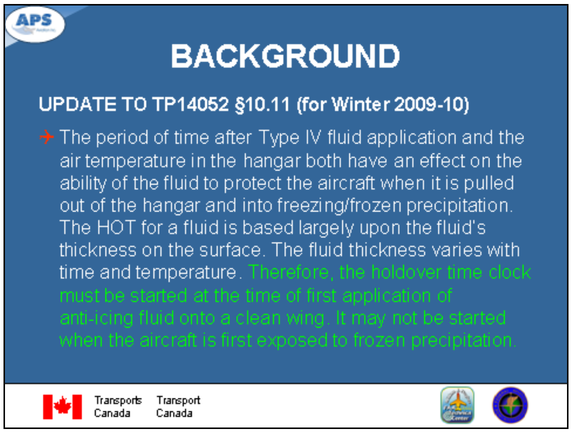

BACKGROUND

UPDATE TO TP14052 §10.11 (for Winter 2009-10)

- The period of time after Type IV fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to frozen precipitation.

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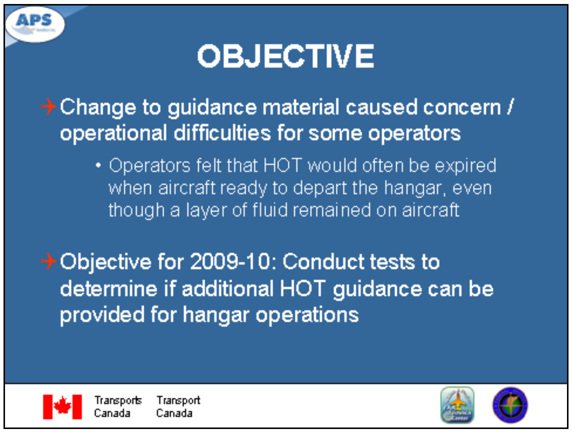

OBJECTIVE

- Change to guidance material caused concern / operational difficulties for some operators
  - Operators felt that HOT would often be expired when aircraft ready to depart the hangar, even though a layer of fluid remained on aircraft
- Objective for 2009-10: Conduct tests to determine if additional HOT guidance can be provided for hangar operations

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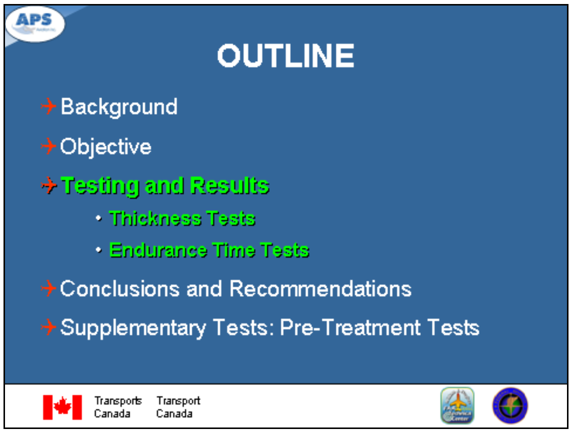

OUTLINE

- Background
- Objective
- **Testing and Results**
  - **Thickness Tests**
  - **Endurance Time Tests**
- Conclusions and Recommendations
- Supplementary Tests: Pre-Treatment Tests

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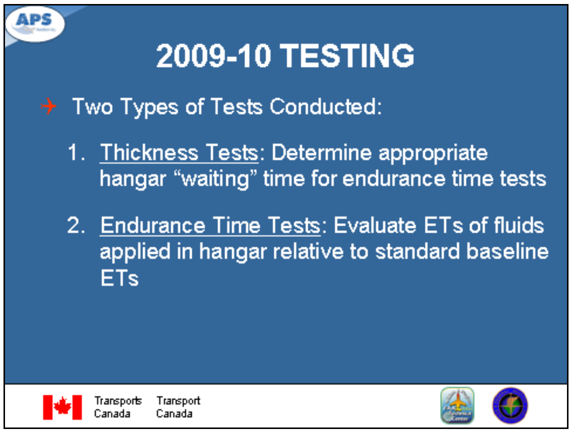

2009-10 TESTING

- Two Types of Tests Conducted:

1. Thickness Tests: Determine appropriate hangar "waiting" time for endurance time tests
2. Endurance Time Tests: Evaluate ETs of fluids applied in hangar relative to standard baseline ETs

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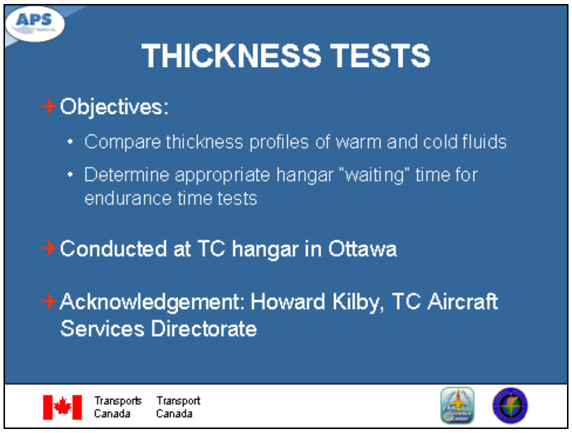
THICKNESS TESTS



THICKNESS TESTS

- Objectives:
  - Compare thickness profiles of warm and cold fluids
  - Determine appropriate hangar "waiting" time for endurance time tests
- Conducted at TC hangar in Ottawa
- Acknowledgement: Howard Kilby, TC Aircraft Services Directorate

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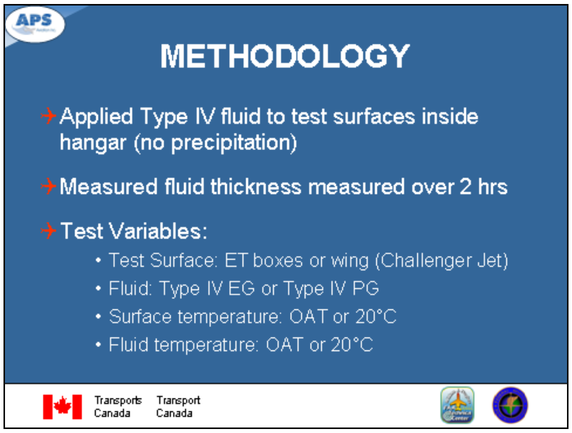

METHODOLOGY

- Applied Type IV fluid to test surfaces inside hangar (no precipitation)
- Measured fluid thickness measured over 2 hrs
- Test Variables:
  - Test Surface: ET boxes or wing (Challenger Jet)
  - Fluid: Type IV EG or Type IV PG
  - Surface temperature: OAT or 20°C
  - Fluid temperature: OAT or 20°C

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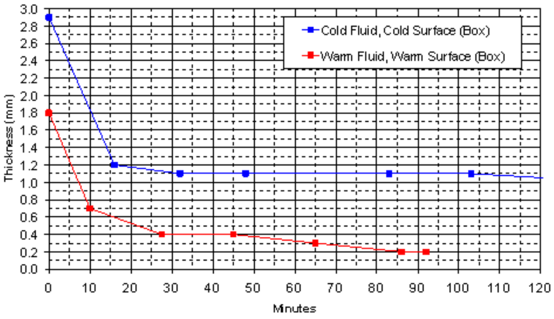
CHALLENGER WING

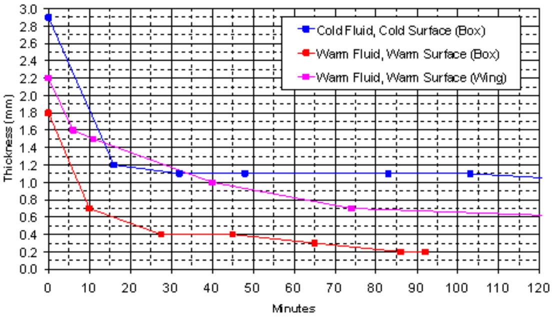
CHALLENGER WING

ET BOXES

COLD FLUID/SURFACE VS. WARM FLUID/SURFACE
EG Fluid



COLD FLUID/SURFACE VS. WARM FLUID/SURFACE
EG Fluid



Note: Wing measurement taken on top of wing, 15 cm beyond LE joint

OBSERVATIONS

- Thickness of cold fluid on cold surface > warm fluid applied on warm surface
- The most significant reduction in thickness occurs immediately following application, but there is still a significant amount of decay thereafter

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CONCLUSIONS

- Thickness data was reviewed to help select appropriate hangar "waiting" time to use for ET tests
- Goal: select a time that allows the longest amount of time inside the hanger, while retaining a reasonable amount of HOT
- 30 minutes selected

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ENDURANCE TIME TESTS

ENDURANCE TIME TESTS

- Objective: Evaluate ETs of fluids applied in hangar relative to standard baseline ETs
  - Natural snow tests:
    - Conducted at APS test site in Montreal
    - No control over precipitation rate or OAT
    - Tests conducted at various rates and OATs
  - Freezing precipitation tests:
    - Conducted at NRC cold chamber in Ottawa
    - Controlled precipitation rates and OATs
    - Tests conducted in most Type IV table rates/OATs

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FLUIDS TESTED

- Testing limited to two fluids due to financial limitations:
  - Dow UCAR EG106 Neat (Type IV EG)
  - Clariant Launch Neat (Type IV PG)
- Selection based on concerns brought forward by a specific Canadian operator; attempt to provide guidance for the operator

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METHODOLOGY

- Comparative ET tests: baseline vs. hangar
  - Baseline: Fluid @ OAT, Surface @ OAT, fluid applied and immediately exposed to precip
  - Hangar: Fluid @ 20°C, Surface @ 20°C, fluid applied 30 mins before exposure to precip, kept at 20°C during "waiting" period
  - Test start time at time of exposure to precipitation for both test types

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TEST VARIABLES

TEST VARIABLES	Baseline	Hangar
Fluid Temp	OAT	20°C
Test Surface Temp	OAT	20°C
Time between Fluid App and Exposure to Precipitation	0 mins	30 mins (kept at 20°C)

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INDOOR FLUID APPLICATION

WAITING TIME

EXPOSURE TO PRECIPITATION

TESTS CONDUCTED

FLUID	Snow	Freezing Fog	Freezing Drizzle	Freezing Rain	ALL PRECIP.
Clariant Launch	9	5	4	4	22
Dow UCAR EG106	6	4	4	4	18
ALL FLUIDS	15	9	8	8	**40**

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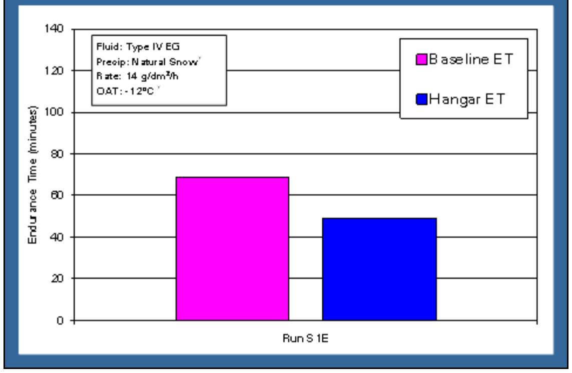
SAMPLE RESULTS: RUN S1E



LOG OF TESTS: SNOW EG FLUID

Run #	Fluid Type	Precip Type	Precip Rate (g/dm²/h)	OAT (°C)	Endurance Times		
					Baseline	Hangar	Hangar ET as % of Baseline ET
S1E	Type IV EG	Snow	14	-12	69	49	71%
S2E	Type IV EG	Snow	5	-1	179	143	80%
S4E	Type IV EG	Snow	6	0	151	130	86%
S5E	Type IV EG	Snow	8	1	156	104	67%
S6E	Type IV EG	Snow	7	1	172	150	87%
S7E	Type IV EG	Snow	9	1	129	113	88%
S8E	Type IV EG	Snow	7	1	131	96	73%
S10E	Type IV EG	Snow	10	1	130	82	63%
S11E	Type IV EG	Snow	10	1	136	84	62%
						Average	75%
						Min Value	62%

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LOG OF TESTS: SNOW PG FLUID

Run #	Fluid Type	Precip Type	Precip Rate (g/dm²/h)	OAT (°C)	Endurance Times		
					Baseline	Hangar	Hangar ET as % of Baseline ET
S1P	Type IV PG	Snow	14	-12	80	68	85%
S5P	Type IV PG	Snow	9	0	151	160	106%
S6P	Type IV PG	Snow	7	-1	149	213	143%
S8P	Type IV PG	Snow	6	1	259	213	82%
S9P	Type IV PG	Snow	7	0	216	162	75%
S10P	Type IV PG	Snow	9	1	167	110	66%
						Average	93%
						Min Value	66%

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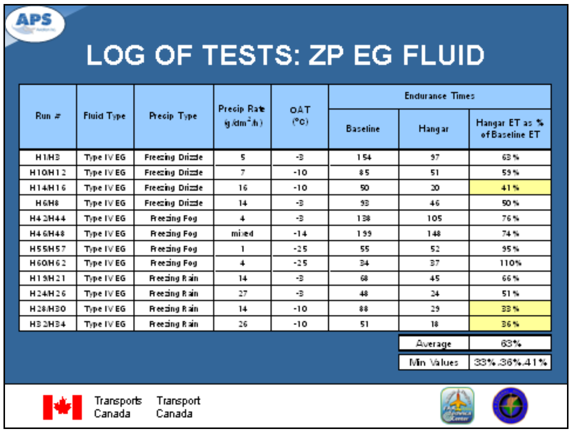

LOG OF TESTS: ZP EG FLUID

Run #	Fluid Type	Precip Type	Precip Rate (g/dm²/h)	OAT (°C)	Endurance Times		
					Baseline	Hangar	Hangar ET as % of Baseline ET
H1/H3	Type IV EG	Freezing Drizzle	5	-3	154	97	63 %
H10/H12	Type IV EG	Freezing Drizzle	7	-10	85	51	59 %
H14/H16	Type IV EG	Freezing Drizzle	16	-10	50	20	41 %
H6/H8	Type IV EG	Freezing Drizzle	14	-3	93	46	50 %
H42/H44	Type IV EG	Freezing Fog	4	-3	138	105	76 %
H46/H48	Type IV EG	Freezing Fog	mixed	-14	199	148	74 %
H55/H57	Type IV EG	Freezing Fog	1	-25	55	52	95 %
H60/H62	Type IV EG	Freezing Fog	4	-25	34	37	110%
H19/H21	Type IV EG	Freezing Rain	14	-3	68	45	66 %
H24/H26	Type IV EG	Freezing Rain	27	-3	48	24	51 %
H28/H30	Type IV EG	Freezing Rain	14	-10	88	29	33 %
H32/H34	Type IV EG	Freezing Rain	26	-10	51	18	36 %
						Average	63%
						Min Values	33%,36%,41%

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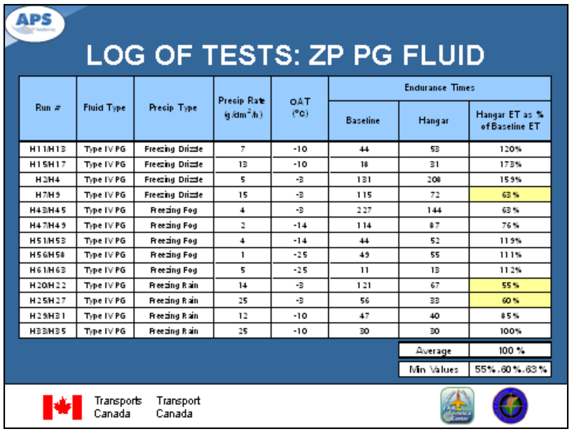

LOG OF TESTS: ZP PG FLUID

Run #	Fluid Type	Precip Type	Precip Rate (g/dm²/h)	OAT (°C)	Endurance Times		
					Baseline	Hangar	Hangar ET as % of Baseline ET
H11/H13	Type IV PG	Freezing Drizzle	7	-10	44	53	120%
H15/H17	Type IV PG	Freezing Drizzle	13	-10	18	31	173%
H2/H4	Type IV PG	Freezing Drizzle	5	-3	131	208	159%
H7/H9	Type IV PG	Freezing Drizzle	15	-3	115	72	63 %
H43/H45	Type IV PG	Freezing Fog	4	-3	227	144	63 %
H47/H49	Type IV PG	Freezing Fog	2	-14	114	87	76 %
H51/H53	Type IV PG	Freezing Fog	4	-14	44	52	119%
H56/H58	Type IV PG	Freezing Fog	1	-25	49	55	111%
H61/H63	Type IV PG	Freezing Fog	5	-25	11	13	112%
H20/H22	Type IV PG	Freezing Rain	14	-3	121	67	55 %
H25/H27	Type IV PG	Freezing Rain	25	-3	56	33	60 %
H29/H31	Type IV PG	Freezing Rain	12	-10	47	40	85 %
H33/H35	Type IV PG	Freezing Rain	25	-10	30	30	100%
						Average	100 %
						Min Values	55%,60%,63%

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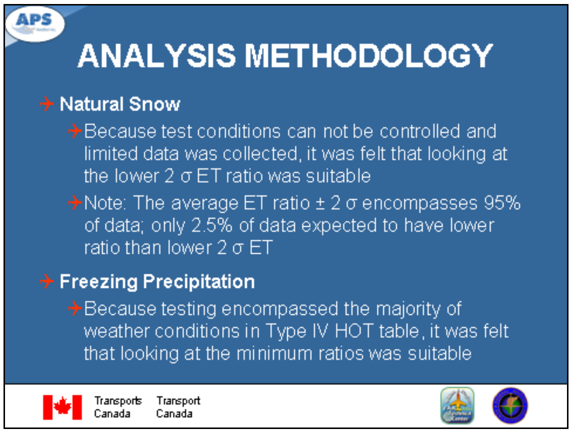

ANALYSIS METHODOLOGY

- Natural Snow
  - Because test conditions can not be controlled and limited data was collected, it was felt that looking at the lower 2 σ ET ratio was suitable
  - Note: The average ET ratio ± 2 σ encompasses 95% of data; only 2.5% of data expected to have lower ratio than lower 2 σ ET
- Freezing Precipitation
  - Because testing encompassed the majority of weather conditions in Type IV HOT table, it was felt that looking at the minimum ratios was suitable

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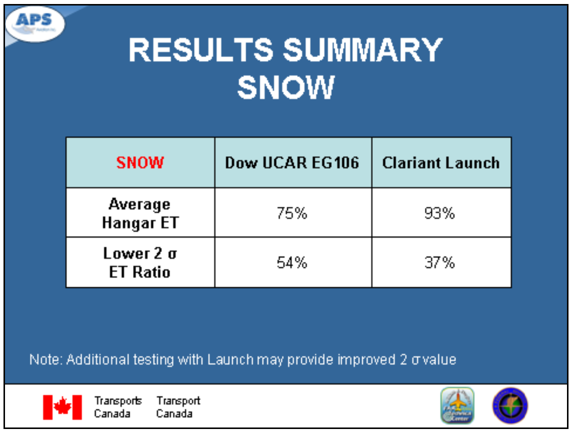

RESULTS SUMMARY SNOW

SNOW	Dow UCAR EG106	Clariant Launch
Average Hangar ET	75%	93%
Lower 2 σ ET Ratio	54%	37%

Note: Additional testing with Launch may provide improved 2 σ value

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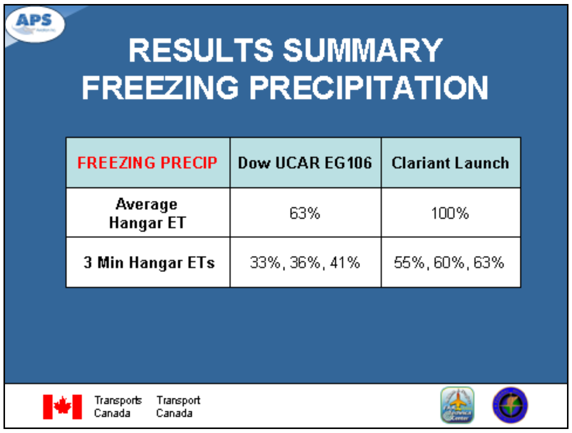

RESULTS SUMMARY FREEZING PRECIPITATION

FREEZING PRECIP	Dow UCAR EG106	Clariant Launch
Average Hangar ET	63%	100%
3 Min Hangar ETs	33%, 36%, 41%	55%, 60%, 63%

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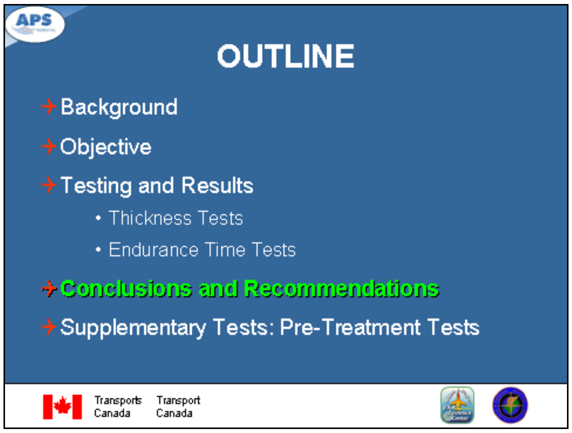

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- Supplementary Tests: Pre-Treatment Tests

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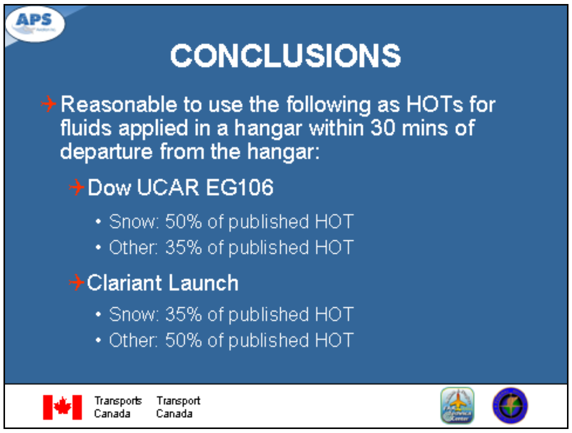

CONCLUSIONS

- Reasonable to use the following as HOTs for fluids applied in a hangar within 30 mins of departure from the hangar:
  - Dow UCAR EG106
    - Snow: 50% of published HOT
    - Other: 35% of published HOT
  - Clariant Launch
    - Snow: 35% of published HOT
    - Other: 50% of published HOT

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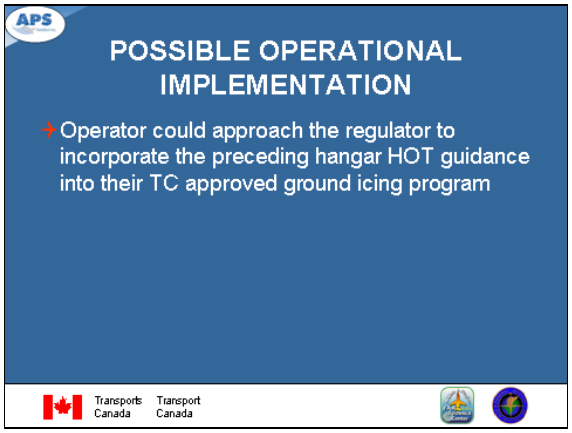

POSSIBLE OPERATIONAL IMPLEMENTATION

- Operator could approach the regulator to incorporate the preceding hangar HOT guidance into their TC approved ground icing program

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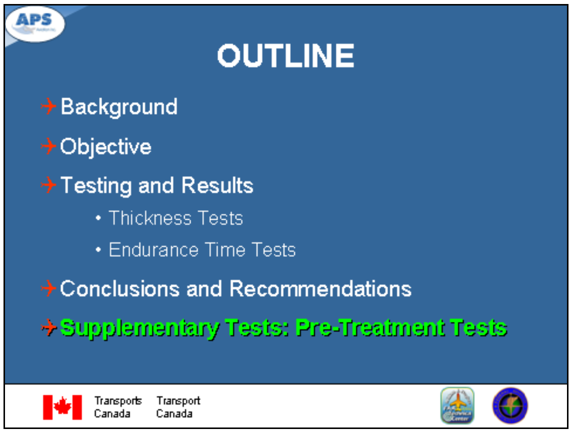

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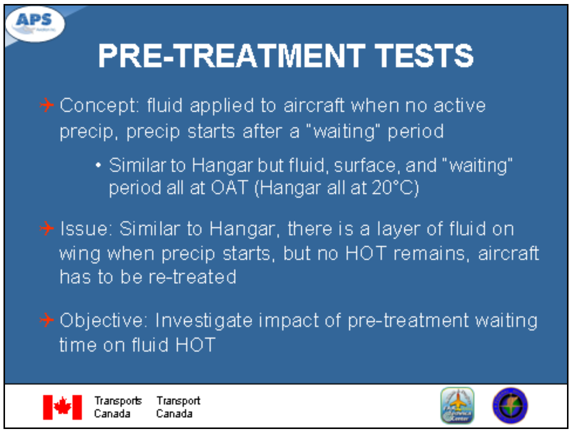

PRE-TREATMENT TESTS

- Concept: fluid applied to aircraft when no active precip, precip starts after a "waiting" period
  - Similar to Hangar but fluid, surface, and "waiting" period all at OAT (Hangar all at 20°C)
- Issue: Similar to Hangar, there is a layer of fluid on wing when precip starts, but no HOT remains, aircraft has to be re-treated
- Objective: Investigate impact of pre-treatment waiting time on fluid HOT

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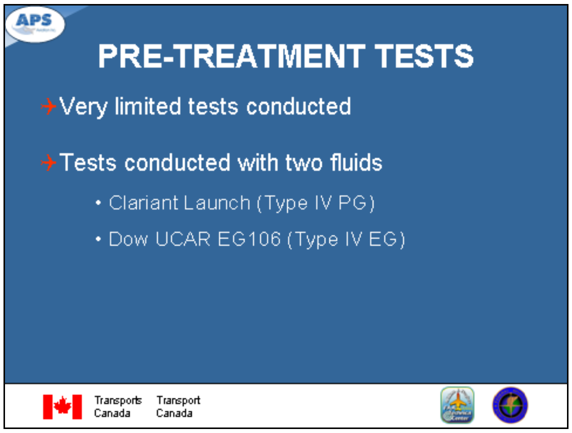

PRE-TREATMENT TESTS

- Very limited tests conducted
- Tests conducted with two fluids
  - Clariant Launch (Type IV PG)
  - Dow UCAR EG106 (Type IV EG)

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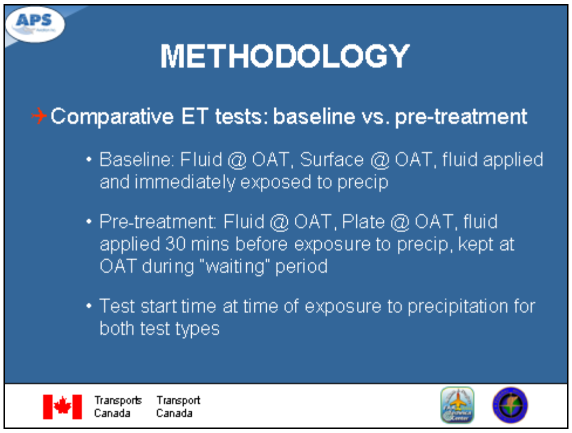

METHODOLOGY

- Comparative ET tests: baseline vs. pre-treatment
  - Baseline: Fluid @ OAT, Surface @ OAT, fluid applied and immediately exposed to precip
  - Pre-treatment: Fluid @ OAT, Plate @ OAT, fluid applied 30 mins before exposure to precip, kept at OAT during "waiting" period
  - Test start time at time of exposure to precipitation for both test types

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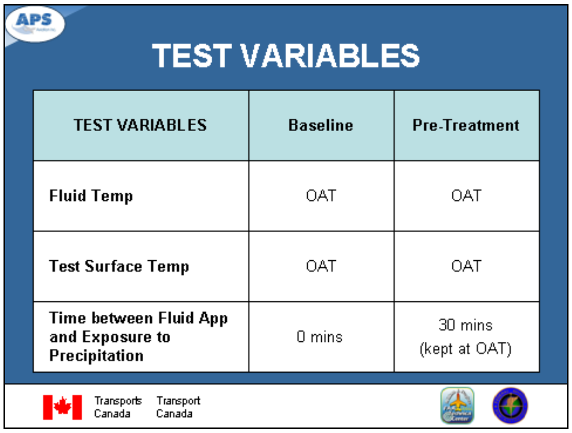

TEST VARIABLES

TEST VARIABLES	Baseline	Pre-Treatment
Fluid Temp	OAT	OAT
Test Surface Temp	OAT	OAT
Time between Fluid App and Exposure to Precipitation	0 mins	30 mins (kept at OAT)

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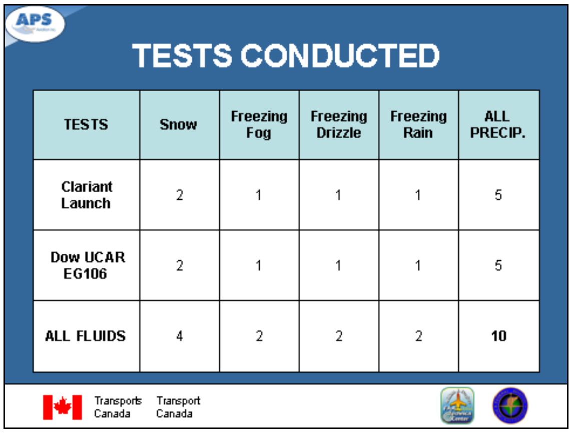

TESTS CONDUCTED

TESTS	Snow	Freezing Fog	Freezing Drizzle	Freezing Rain	ALL PRECIP.
Clariant Launch	2	1	1	1	5
Dow UCAR EG106	2	1	1	1	5
ALL FLUIDS	4	2	2	2	**10**

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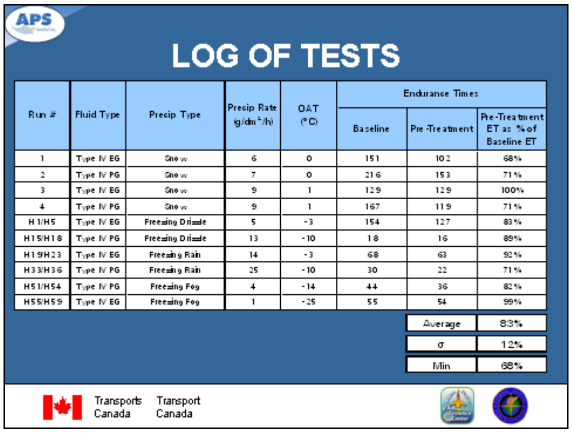

LOG OF TESTS

Run #	Fluid Type	Precip Type	Precip Rate (g/dm²/h)	OAT (°C)	Endurance Times		
					Baseline	Pre-Treatment	Pre-Treatment ET as % of Baseline ET
1	Type IV EG	Snow	6	0	151	102	68%
2	Type IV PG	Snow	7	0	216	153	71%
3	Type IV EG	Snow	9	1	129	129	100%
4	Type IV PG	Snow	9	1	167	119	71%
H1/H5	Type IV EG	Freezing Drizzle	5	-3	154	127	83%
H15/H18	Type IV PG	Freezing Drizzle	13	-10	18	16	89%
H19/H23	Type IV EG	Freezing Rain	14	-3	68	63	92%
H33/H36	Type IV PG	Freezing Rain	25	-10	30	22	71%
H51/H54	Type IV PG	Freezing Fog	4	-14	44	36	82%
H55/H59	Type IV EG	Freezing Fog	1	-25	55	54	99%
						Average	83%
						σ	12%
						Min	68%

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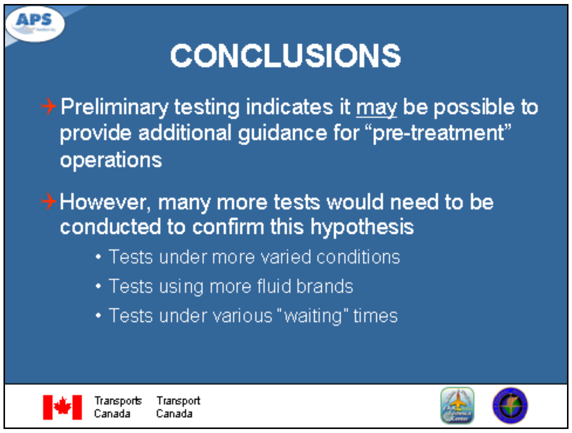

CONCLUSIONS

- Preliminary testing indicates it may be possible to provide additional guidance for "pre-treatment" operations
- However, many more tests would need to be conducted to confirm this hypothesis
  - Tests under more varied conditions
  - Tests using more fluid brands
  - Tests under various "waiting" times

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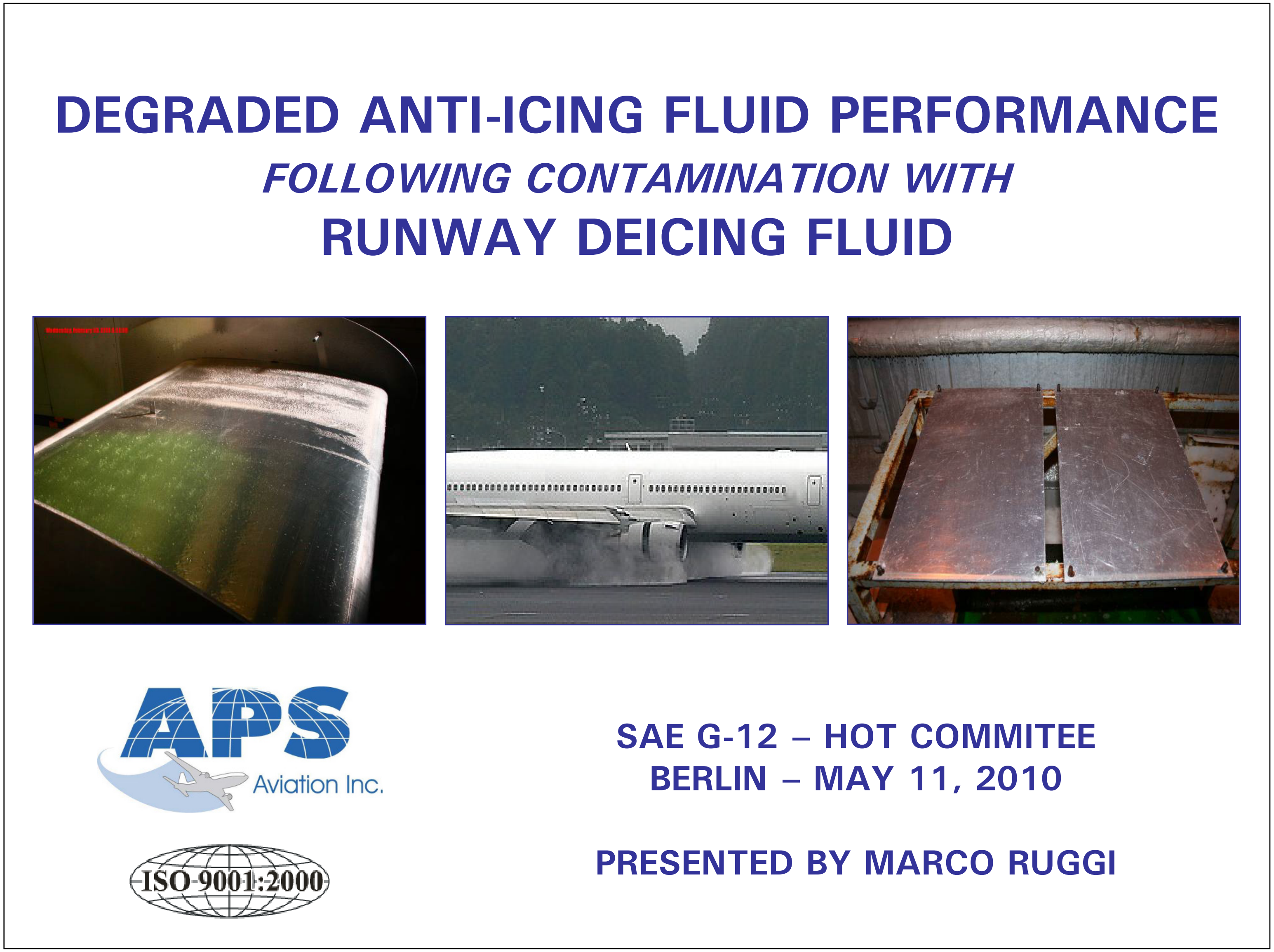
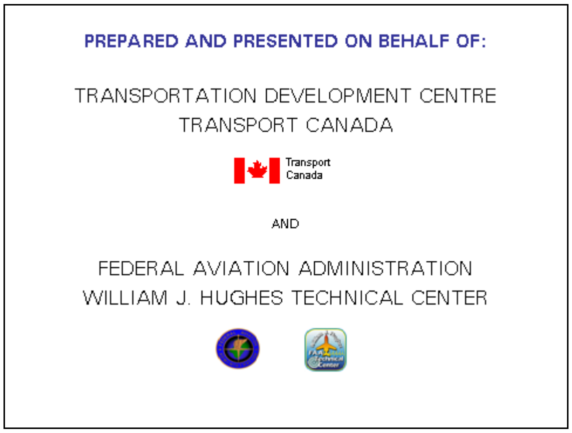


DEGRADED ANTI-ICING FLUID PERFORMANCE
FOLLOWING CONTAMINATION WITH
RUNWAY DEICING FLUID

SAE G-12 – HOT COMMITEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI



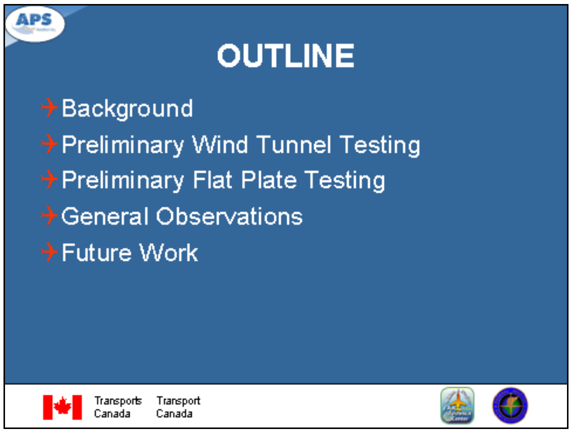
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

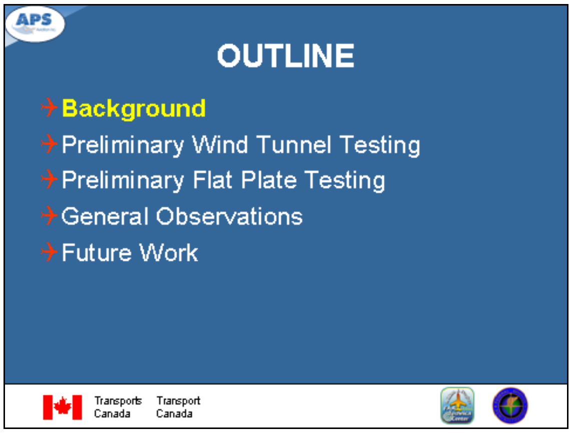
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Preliminary Wind Tunnel Testing
- Preliminary Flat Plate Testing
- General Observations
- Future Work

Transports Canada Transport Canada



OUTLINE

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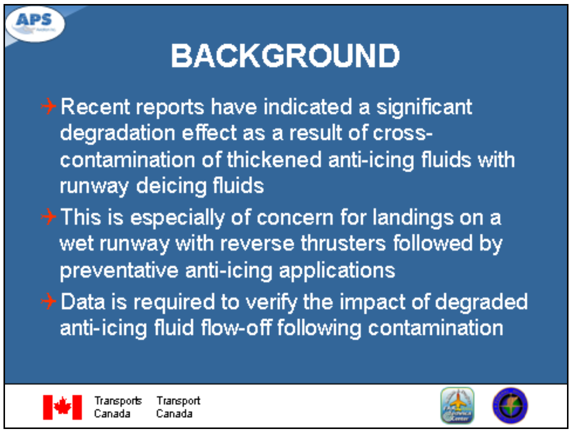
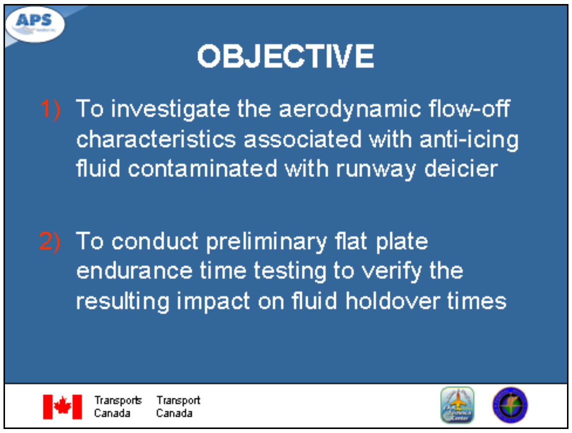
Transports Canada Transport Canada



BACKGROUND

- Recent reports have indicated a significant degradation effect as a result of cross-contamination of thickened anti-icing fluids with runway deicing fluids
- This is especially of concern for landings on a wet runway with reverse thrusters followed by preventative anti-icing applications
- Data is required to verify the impact of degraded anti-icing fluid flow-off following contamination

Transports Canada Transport Canada

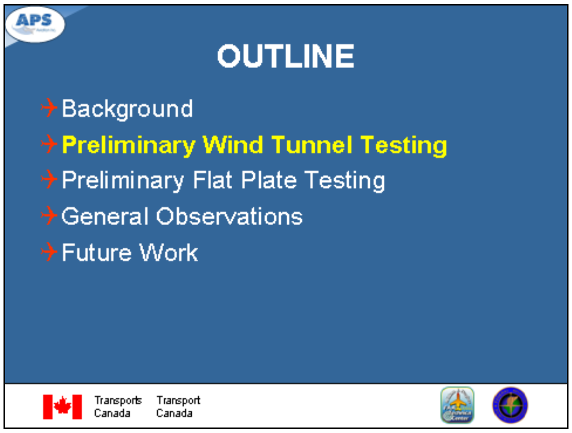


OBJECTIVE

1) To investigate the aerodynamic flow-off characteristics associated with anti-icing fluid contaminated with runway deicier

2) To conduct preliminary flat plate endurance time testing to verify the resulting impact on fluid holdover times

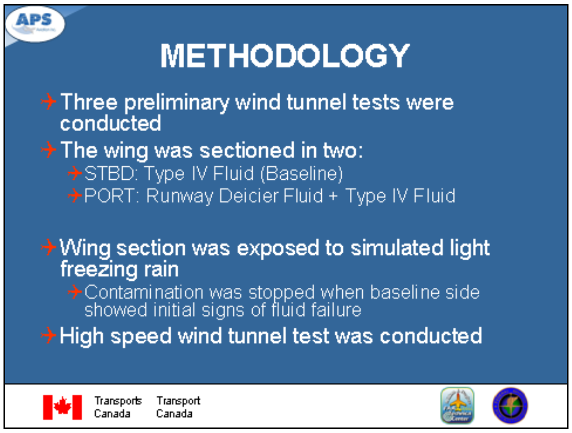
Transports Canada Transport Canada



OUTLINE

- Background
- **Preliminary Wind Tunnel Testing**
- Preliminary Flat Plate Testing
- General Observations
- Future Work

Transports Canada Transport Canada



METHODOLOGY

- Three preliminary wind tunnel tests were conducted
- The wing was sectioned in two:
  - STBD: Type IV Fluid (Baseline)
  - PORT: Runway Deicier Fluid + Type IV Fluid
- Wing section was exposed to simulated light freezing rain
  - Contamination was stopped when baseline side showed initial signs of fluid failure
- High speed wind tunnel test was conducted

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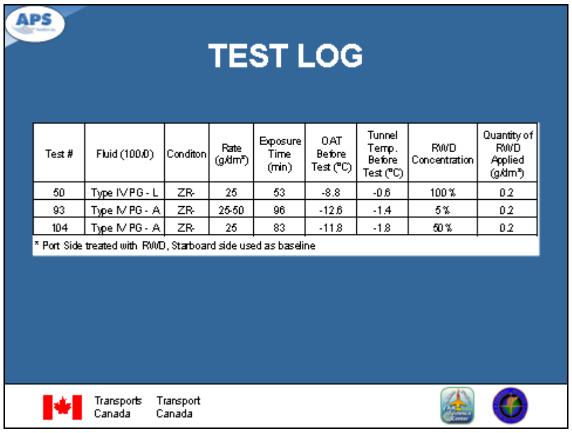

TEST LOG

Test #	Fluid (100/0)	Conditon	Rate (g/dm²)	Exposure Time (min)	OAT Before Test (°C)	Tunnel Temp. Before Test (°C)	RWD Concentration	Quantity of RWD Applied (g/dm²)
50	Type IV PG - L	ZR-	25	53	-8.8	-0.6	100 %	0.2
93	Type IV PG - A	ZR-	25-50	96	-12.6	-1.4	5 %	0.2
104	Type IV PG - A	ZR-	25	83	-11.8	-1.8	50 %	0.2

* Port Side treated with RWD, Starboard side used as baseline

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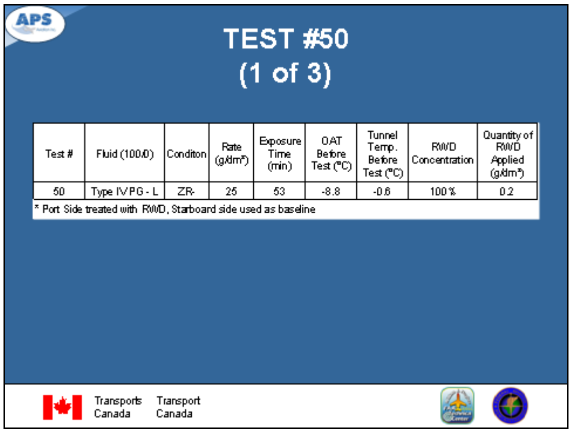
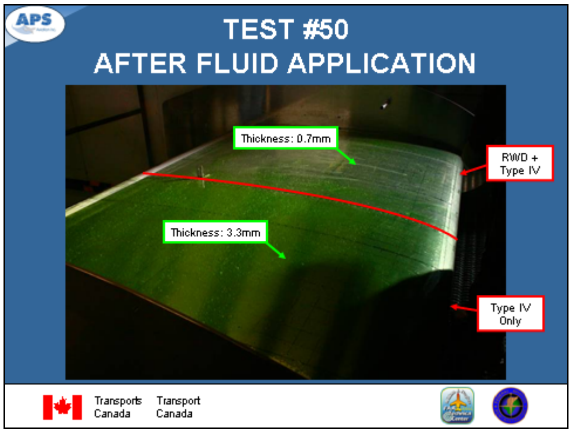


TEST #50
(1 of 3)

Test #	Fluid (100/0)	Conditon	Rate (g/dm²)	Exposure Time (min)	OAT Before Test (°C)	Tunnel Temp. Before Test (°C)	RWD Concentration	Quantity of RWD Applied (g/dm²)
50	Type IV PG - L	ZR-	25	53	-8.8	-0.6	100 %	0.2

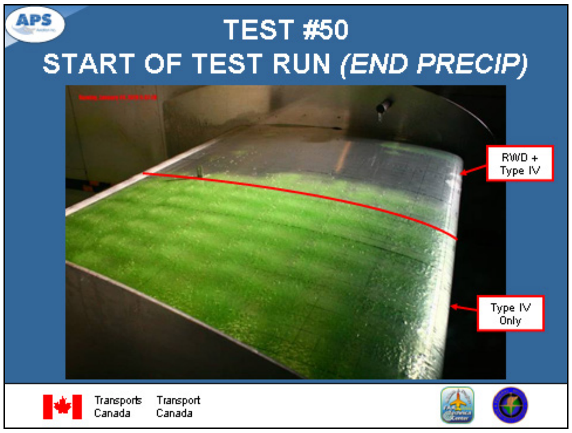
* Port Side treated with RWD, Starboard side used as baseline

Transports Canada Transport Canada



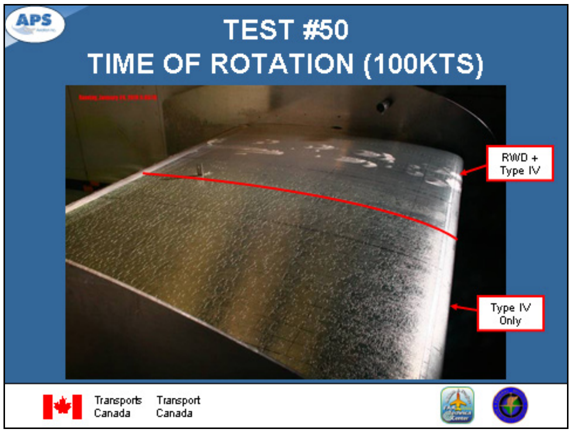
TEST #50
AFTER FLUID APPLICATION

Transports Canada Transport Canada



TEST #50
START OF TEST RUN *(END PRECIP)*

Transports Canada Transport Canada



TEST #50
TIME OF ROTATION (100KTS)

Transports Canada Transport Canada

RUN #50

Transports Canada Transport Canada

DEGRADED ANTI-ICING FLUID PERFORMANCE

FOLLOWING CONTAMINATION WITH

RUNWAY DEICING FLUID

APS Aviation Inc.

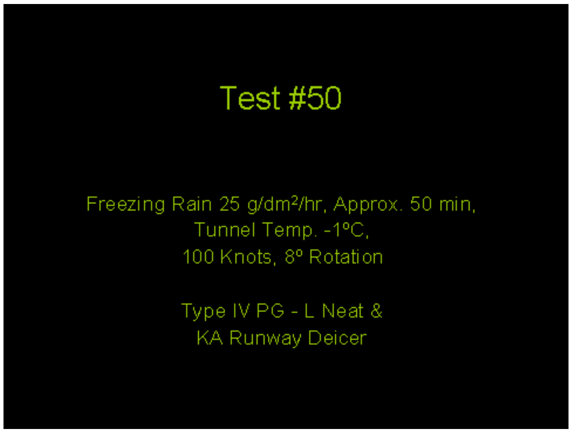
Prepared for

Transportation Development Centre

Transport Canada

and the

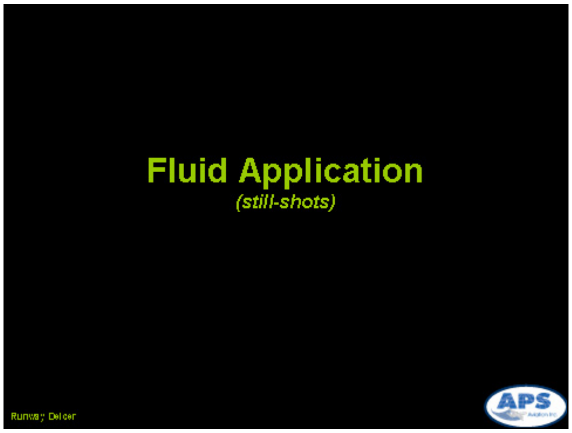
Federal Aviation Administration



Test #50

Freezing Rain 25 g/dm²/hr, Approx. 50 min,
Tunnel Temp. -1°C,
100 Knots, 8° Rotation

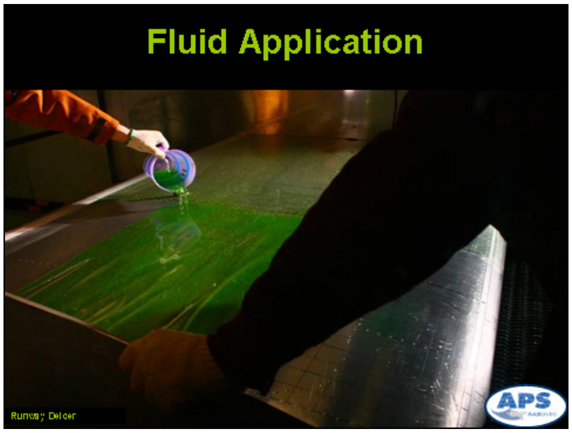
Type IV PG - L Neat &
KA Runway Deicer



Fluid Application

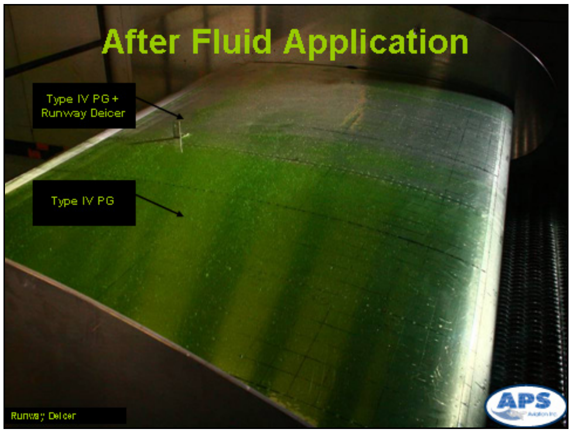
(still-shots)

Runway Deicer



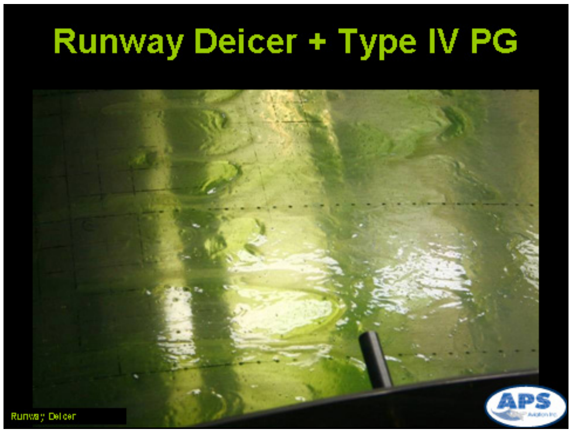
Fluid Application

Runway Deicer



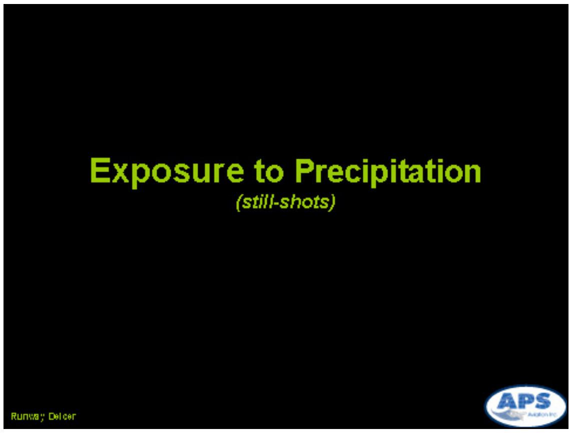
After Fluid Application

Runway Deicer



Runway Deicer + Type IV PG

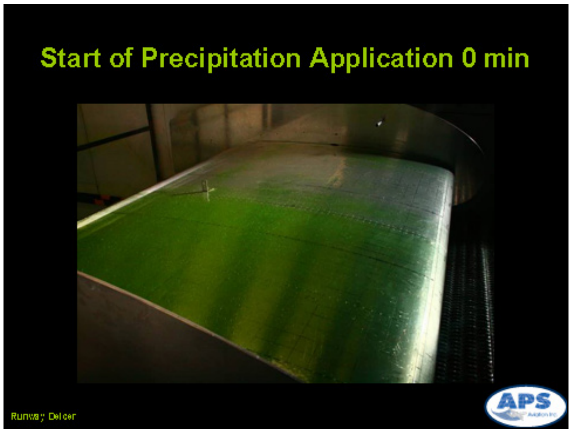
Runway Deicer



Exposure to Precipitation

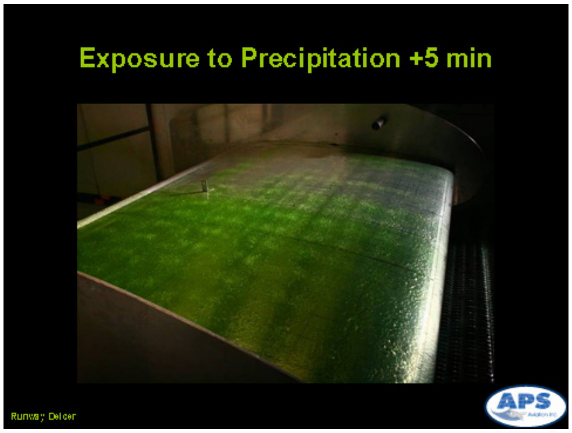
(still-shots)

Runway Deicer



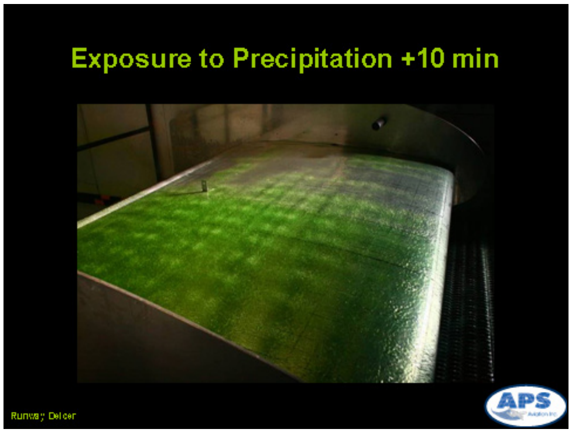
Start of Precipitation Application 0 min

Runway Deicer



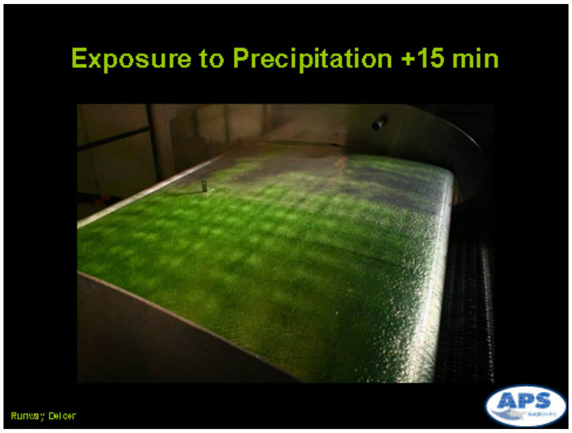
Exposure to Precipitation +5 min

Runway Deicer



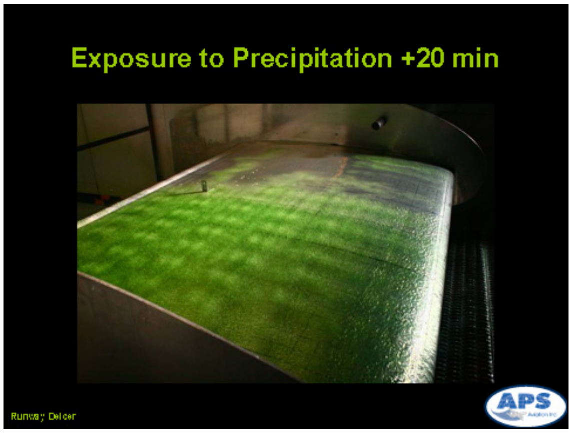
Exposure to Precipitation +10 min

Runway Deicer



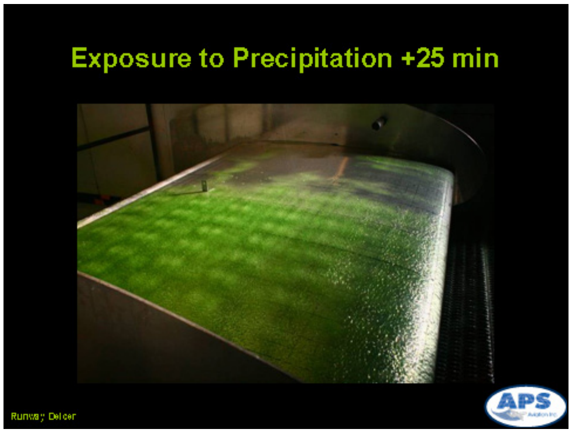
Exposure to Precipitation +15 min

Runway Deicer



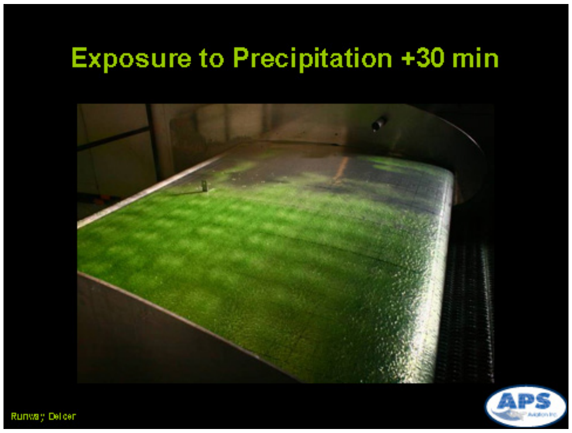
Exposure to Precipitation +20 min

Runway Deicer



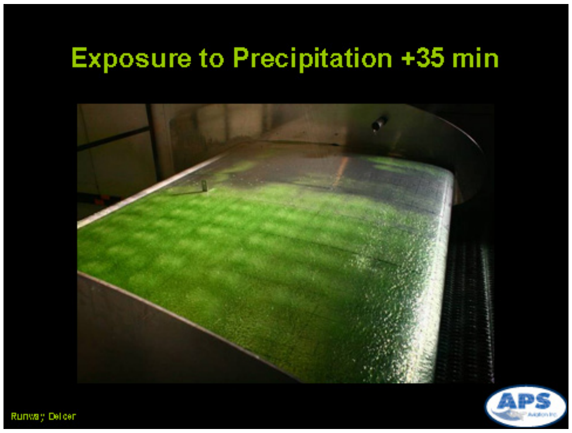
Exposure to Precipitation +25 min

Runway Deicer



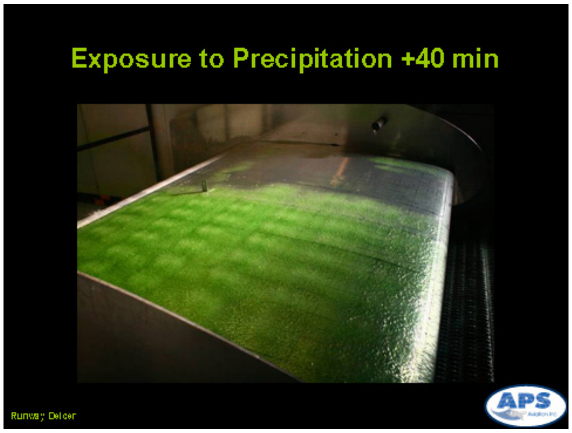
Exposure to Precipitation +30 min

Runway Deicer



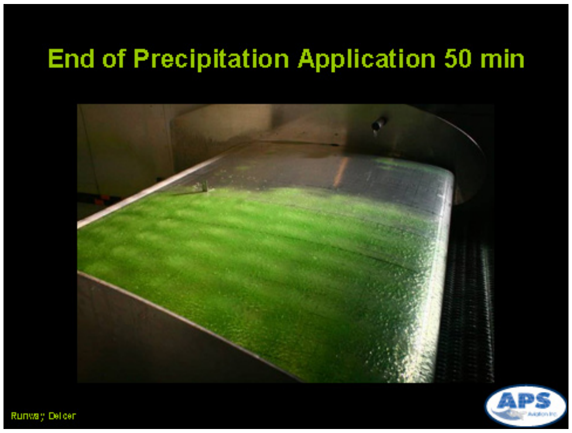
Exposure to Precipitation +35 min

Runway Deicer



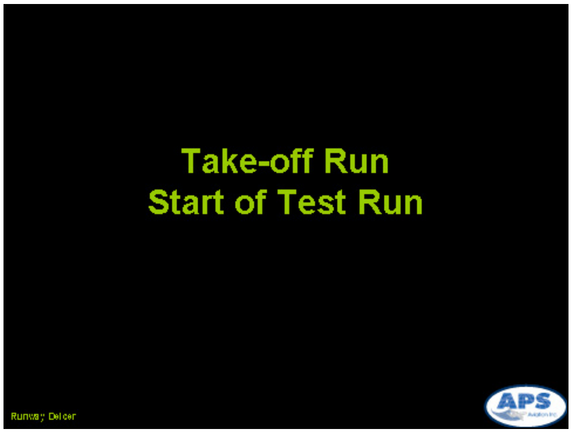
Exposure to Precipitation +40 min

Runway Deicer



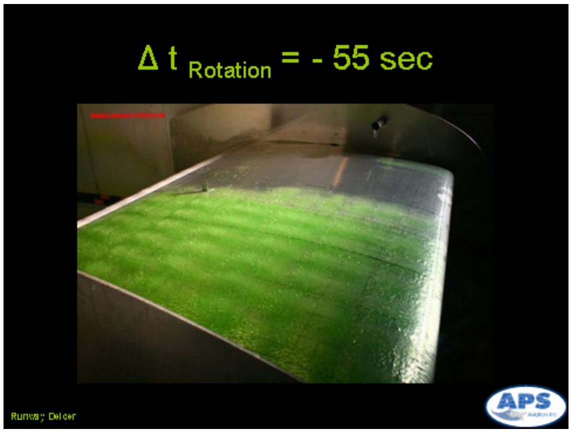
End of Precipitation Application 50 min

Runway Deicer



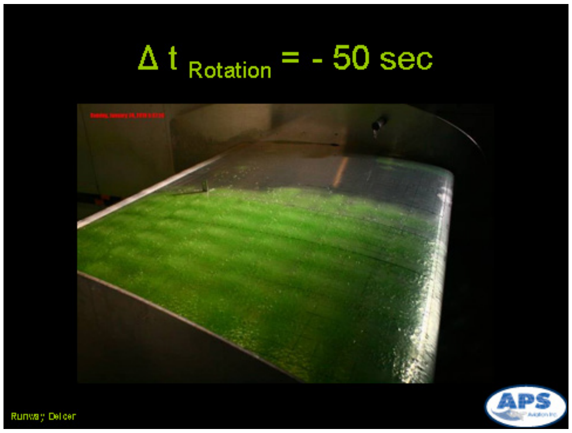
Take-off Run
Start of Test Run

Runway Deicer



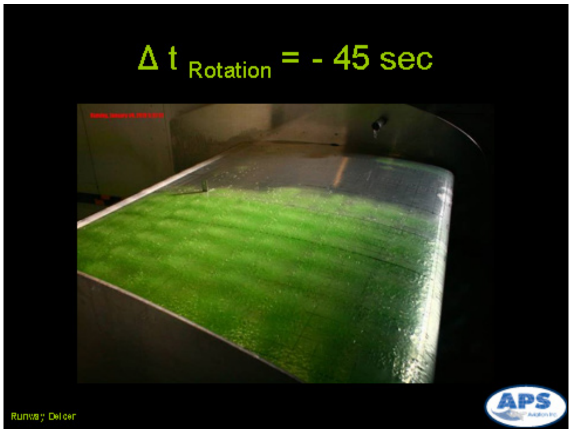
$\Delta t_{\text{Rotation}} = -55$ sec

Runway Deicer



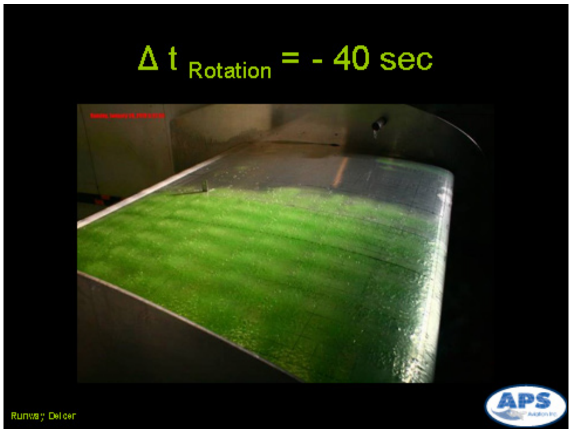
$\Delta t_{\text{Rotation}} = -50$ sec

Runway Deicer



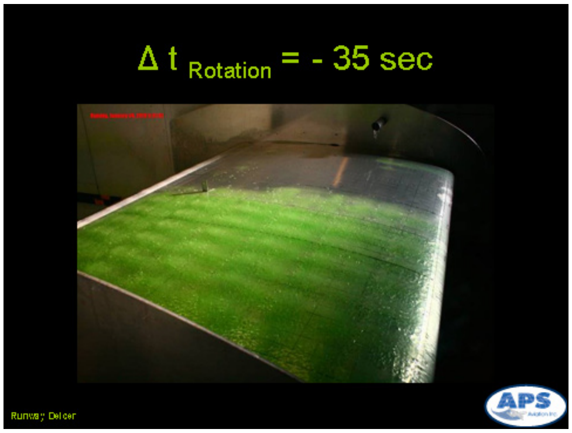
$\Delta t_{\text{Rotation}} = -45$ sec

Runway Deicer



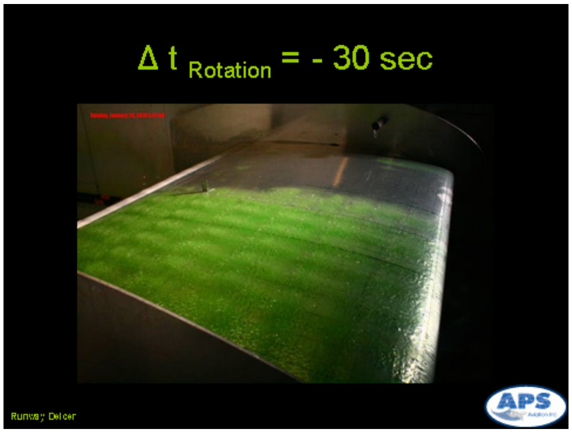
$\Delta t_{\text{Rotation}} = -40$ sec

Runway Deicer



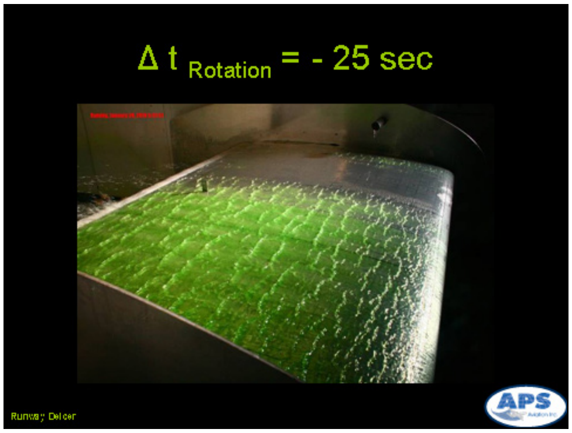
$\Delta t_{\text{Rotation}} = -35$ sec

Runway Deicer



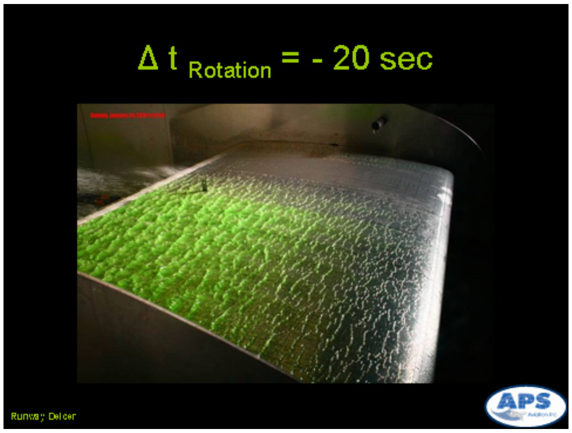
$\Delta t_{\text{Rotation}}$ = - 30 sec

Runway Deicer



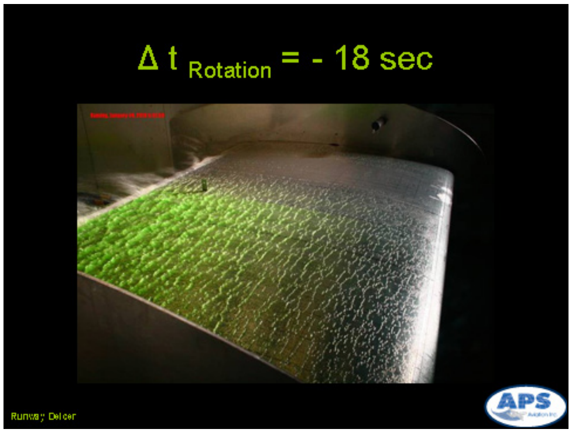
$\Delta t_{\text{Rotation}}$ = - 25 sec

Runway Deicer



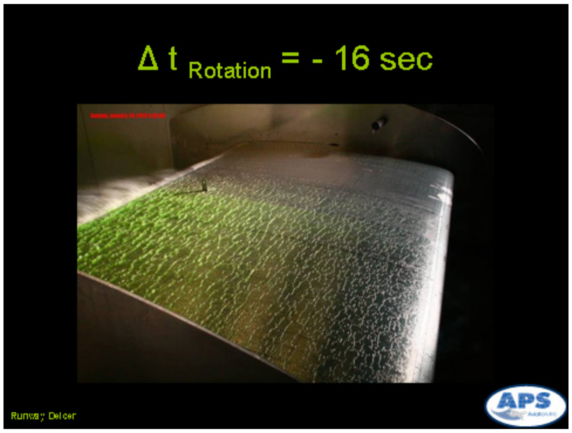
$\Delta t_{\text{Rotation}}$ = - 20 sec

Runway Deicer



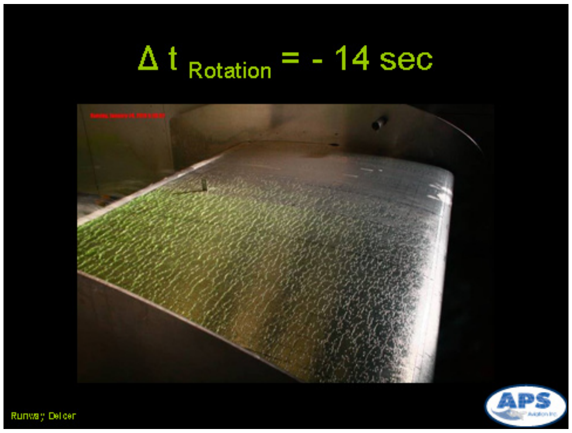
$\Delta t_{\text{Rotation}}$ = - 18 sec

Runway Deicer



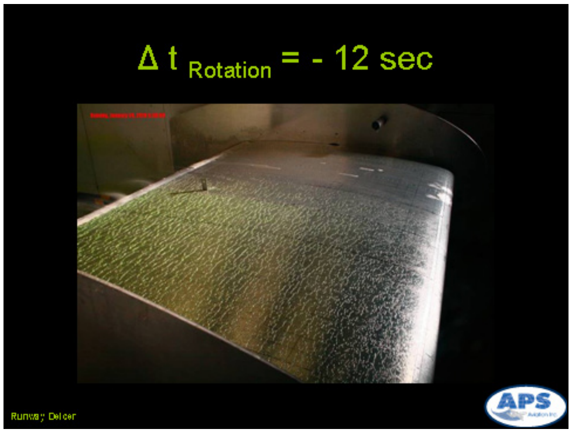
$\Delta t_{\text{Rotation}}$ = - 16 sec

Runway Deicer



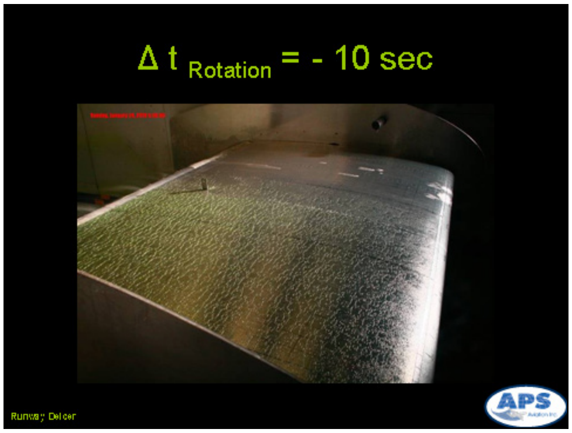
$\Delta t_{\text{Rotation}}$ = - 14 sec

Runway Deicer



$\Delta t_{\text{Rotation}} = -12$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = -10$ sec

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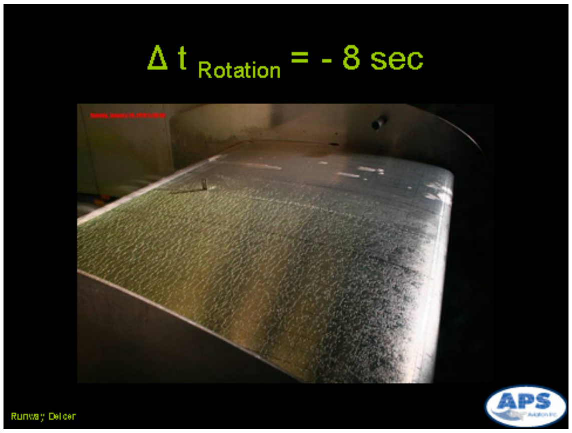
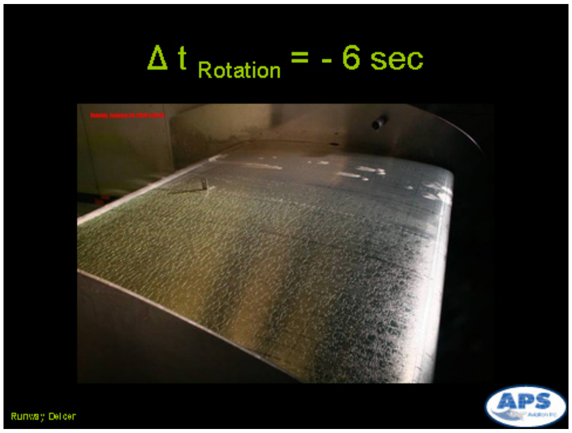


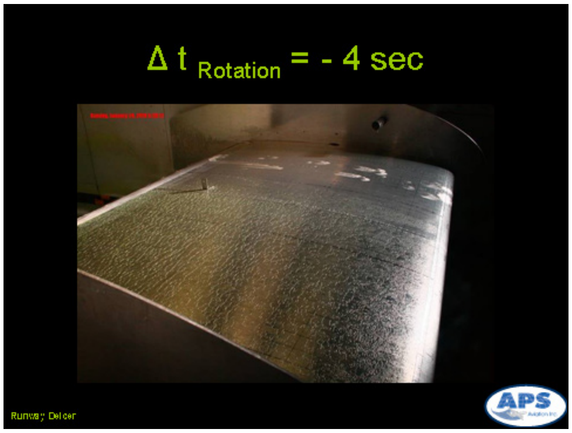
$\Delta t_{\text{Rotation}} = -8$ sec

Runway Deicer



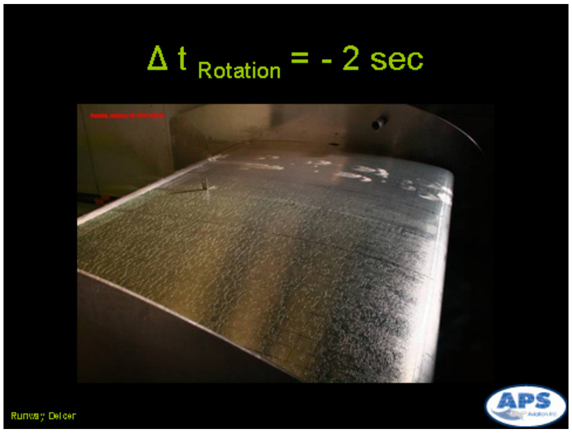
$\Delta t_{\text{Rotation}} = -6$ sec

Runway Deicer



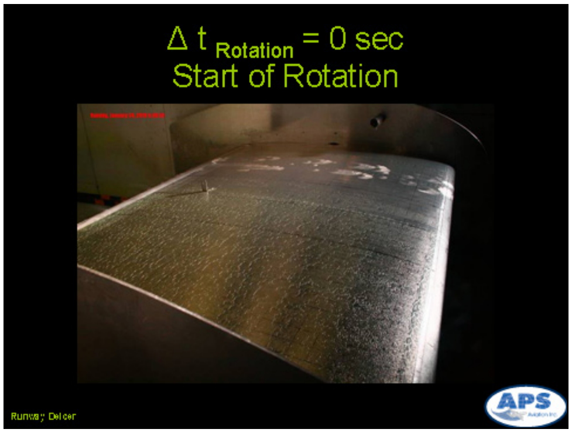
$\Delta t_{\text{Rotation}} = -4$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = -2$ sec

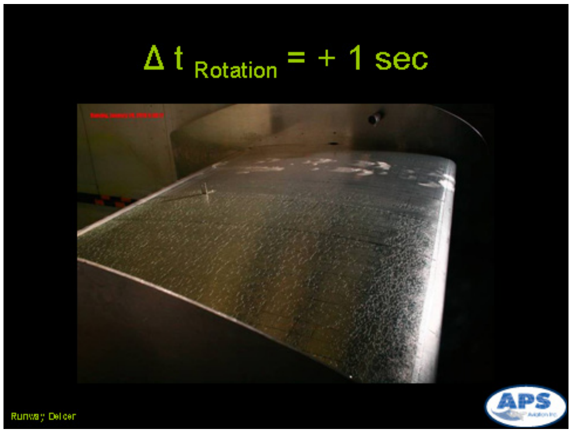
Runway Deicer



Δ t $_{\text{Rotation}}$ = 0 sec

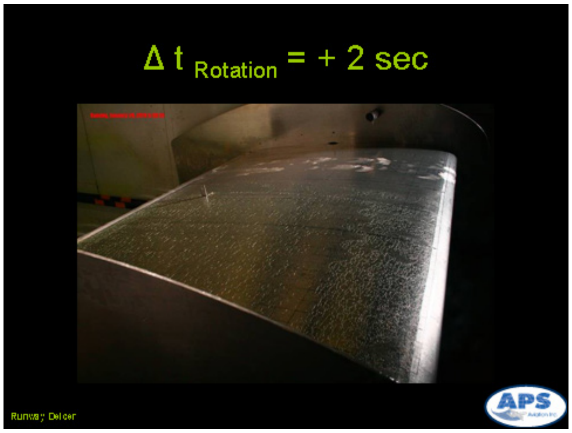
Start of Rotation

Runway Deicer



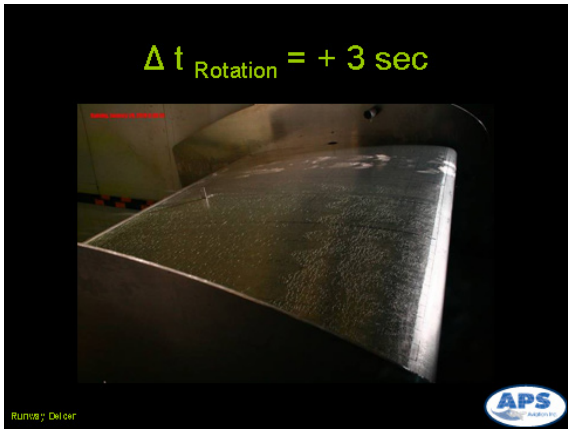
Δ t $_{\text{Rotation}}$ = + 1 sec

Runway Deicer



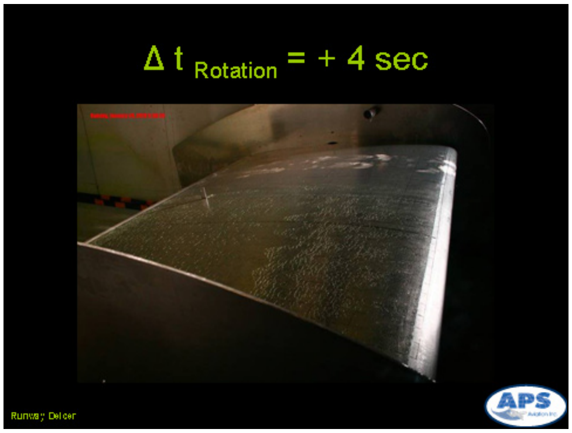
Δ t $_{\text{Rotation}}$ = + 2 sec

Runway Deicer



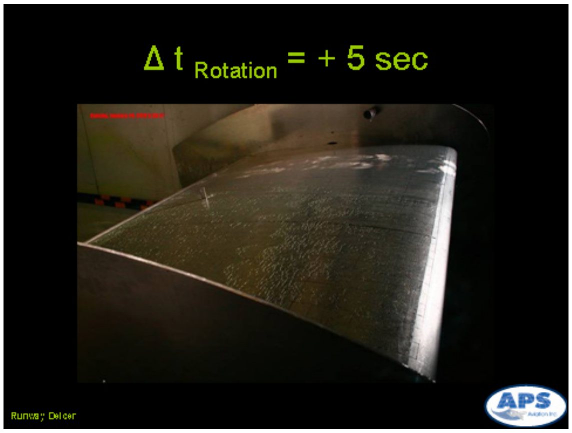
Δ t $_{\text{Rotation}}$ = + 3 sec

Runway Deicer



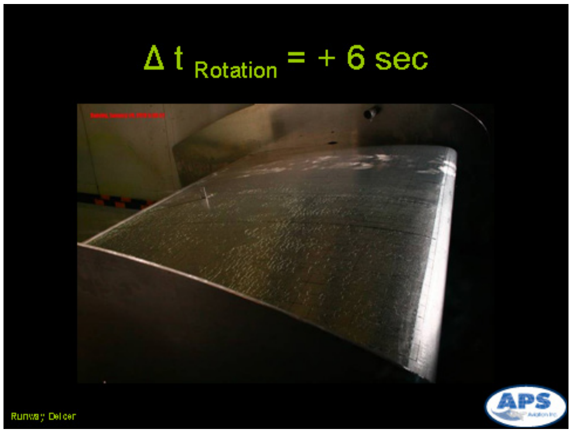
Δ t $_{\text{Rotation}}$ = + 4 sec

Runway Deicer



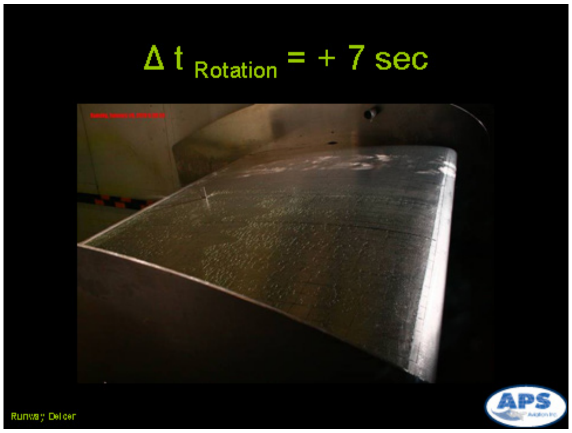
Δ t $_{\text{Rotation}}$ = + 5 sec

Runway Deicer



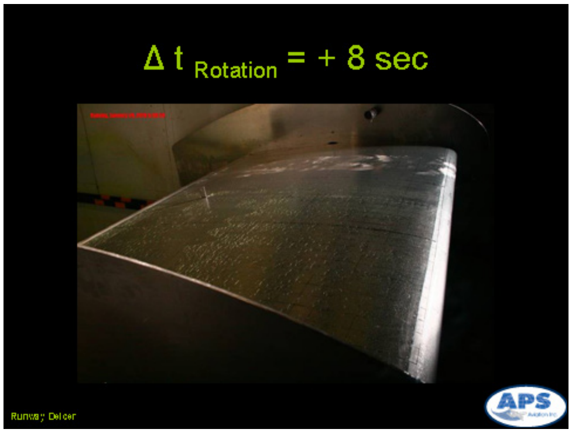
$\Delta t_{\text{Rotation}} = + 6$ sec

Runway Deicer



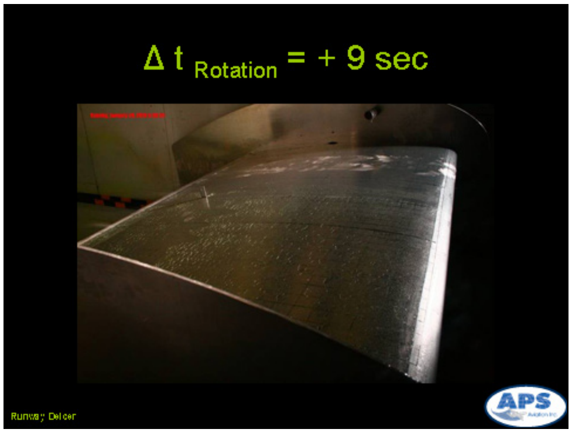
$\Delta t_{\text{Rotation}} = + 7$ sec

Runway Deicer



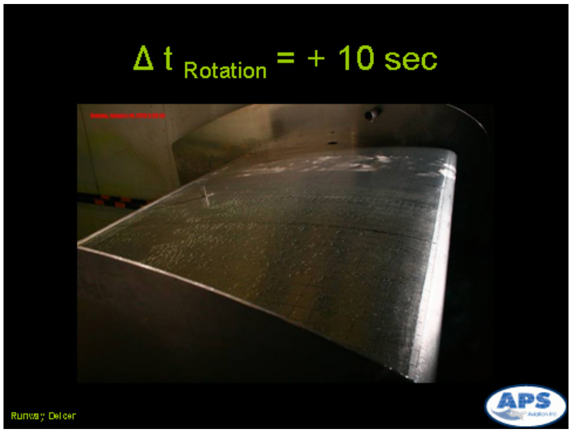
$\Delta t_{\text{Rotation}} = + 8$ sec

Runway Deicer



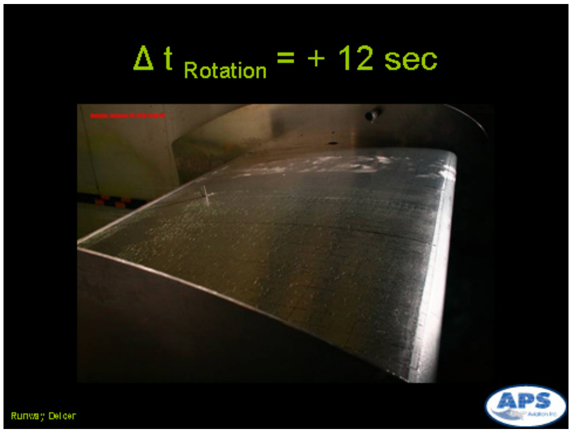
$\Delta t_{\text{Rotation}} = + 9$ sec

Runway Deicer



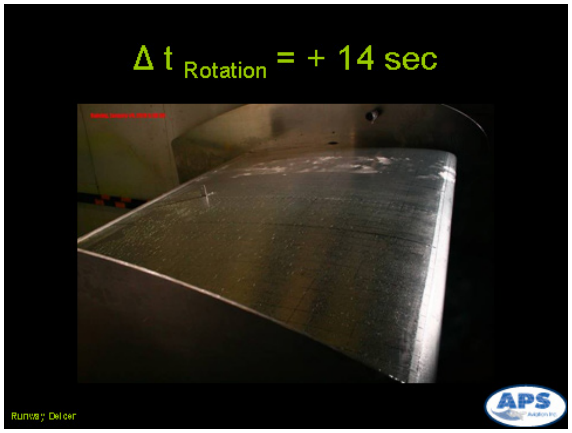
$\Delta t_{\text{Rotation}} = + 10$ sec

Runway Deicer



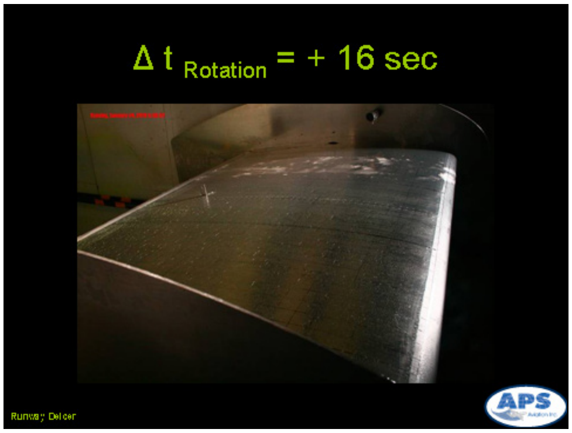
$\Delta t_{\text{Rotation}} = + 12$ sec

Runway Deicer



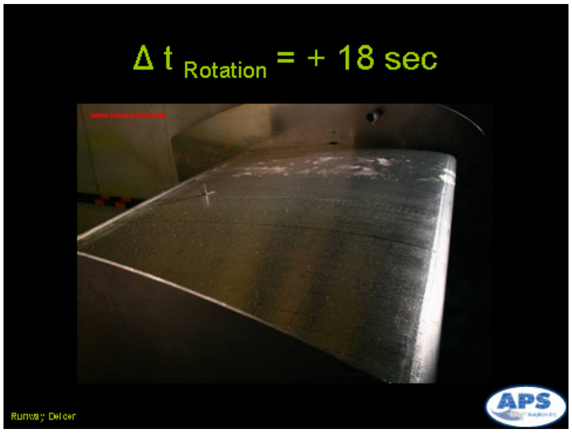
$\Delta t_{\text{Rotation}} = + 14$ sec

Runway Deicer



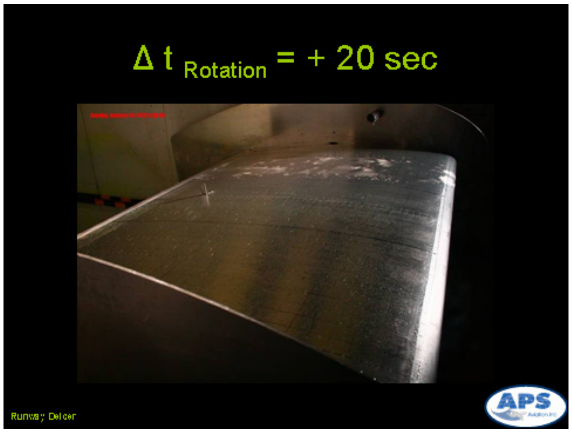
$\Delta t_{\text{Rotation}} = + 16$ sec

Runway Deicer



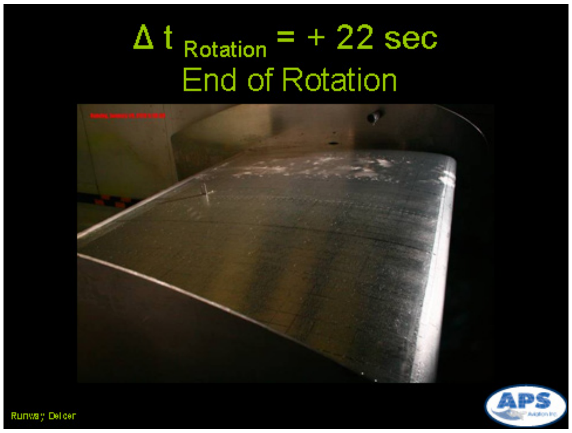
$\Delta t_{\text{Rotation}} = + 18$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = + 20$ sec

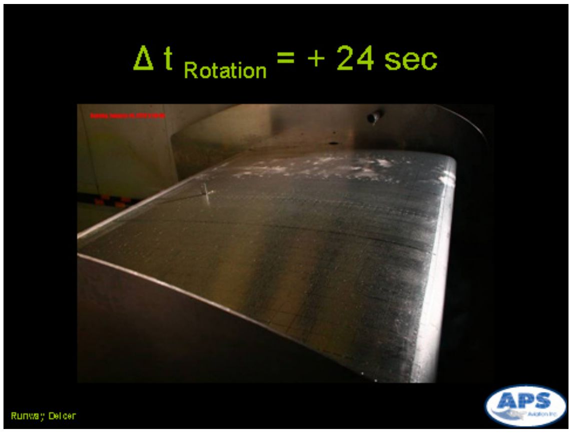
Runway Deicer



$\Delta t_{\text{Rotation}} = + 22$ sec

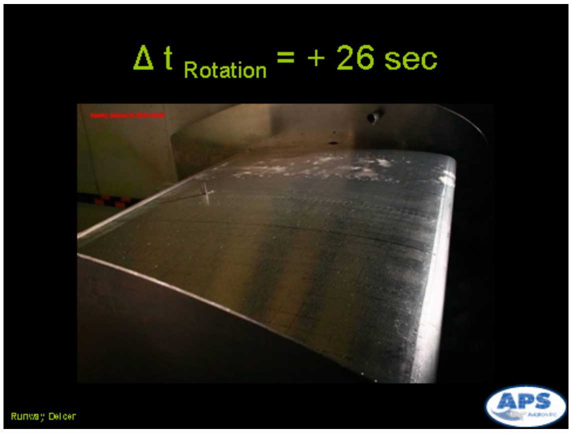
End of Rotation

Runway Deicer



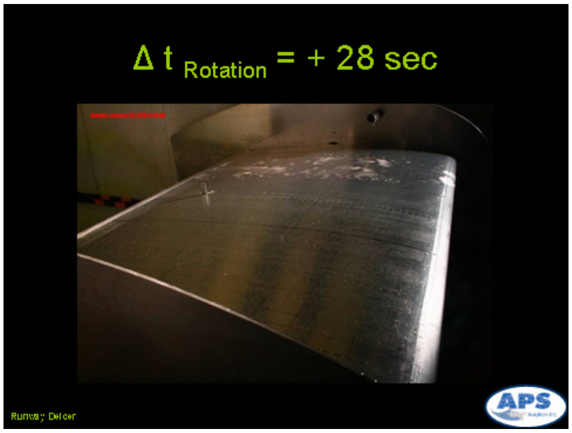
$\Delta t_{\text{Rotation}} = + 24$ sec

Runway Deicer



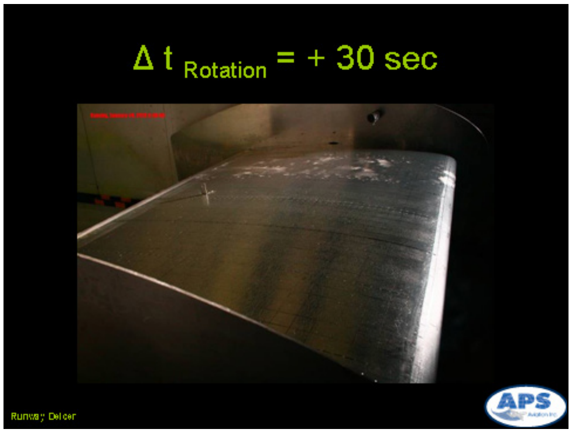
$\Delta t_{\text{Rotation}} = +26$ sec

Runway Deicer



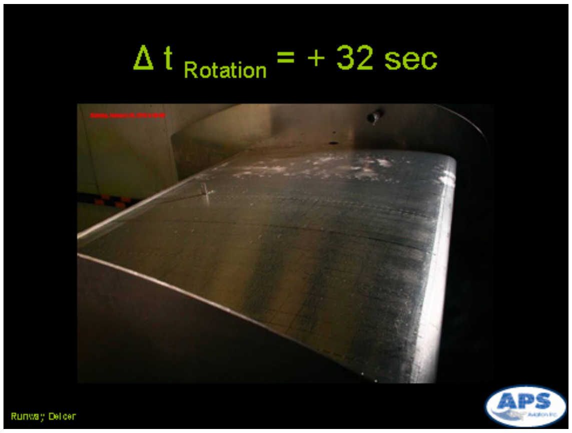
$\Delta t_{\text{Rotation}} = +28$ sec

Runway Deicer



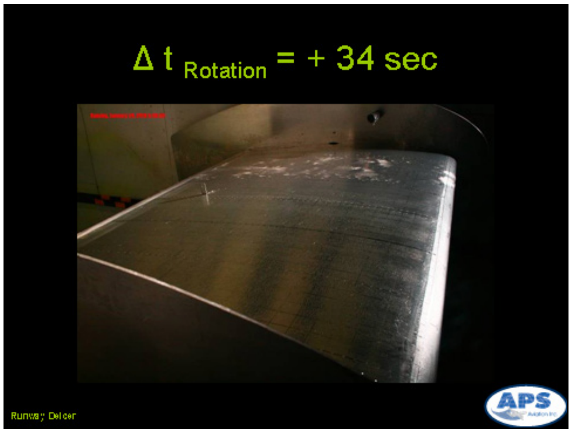
$\Delta t_{\text{Rotation}} = +30$ sec

Runway Deicer



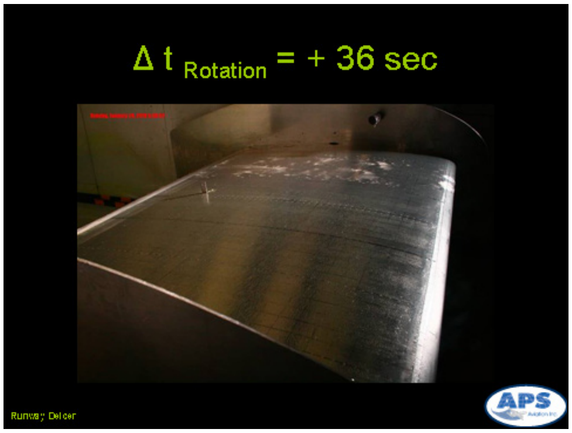
$\Delta t_{\text{Rotation}} = +32$ sec

Runway Deicer



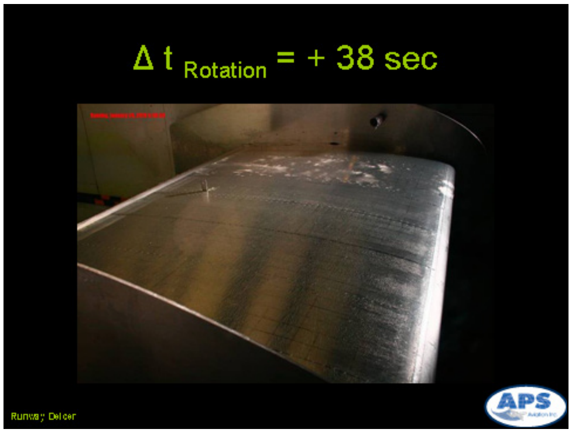
$\Delta t_{\text{Rotation}} = +34$ sec

Runway Deicer



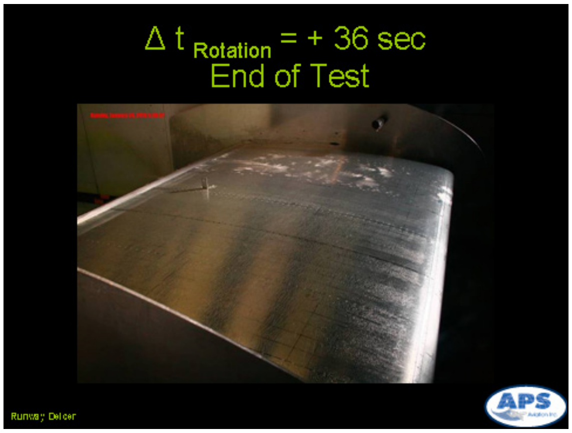
$\Delta t_{\text{Rotation}} = +36$ sec

Runway Deicer



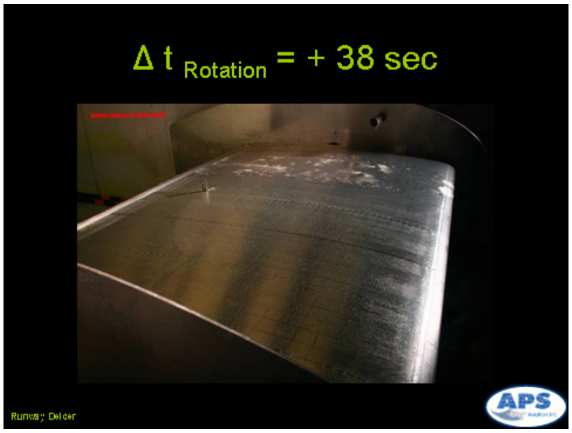
$\Delta t_{\text{Rotation}}$ = + 38 sec

Runway Deicer



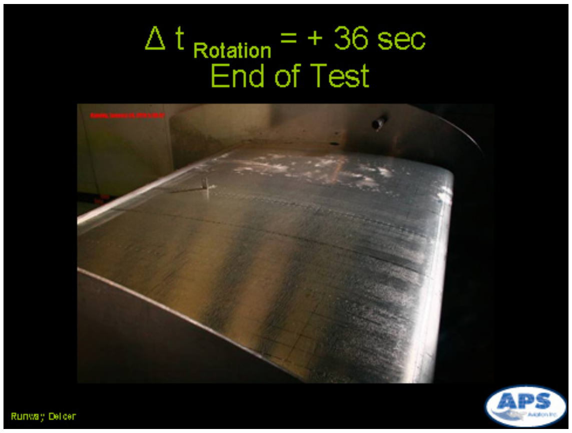
$\Delta t_{\text{Rotation}}$ = + 36 sec
End of Test

Runway Deicer



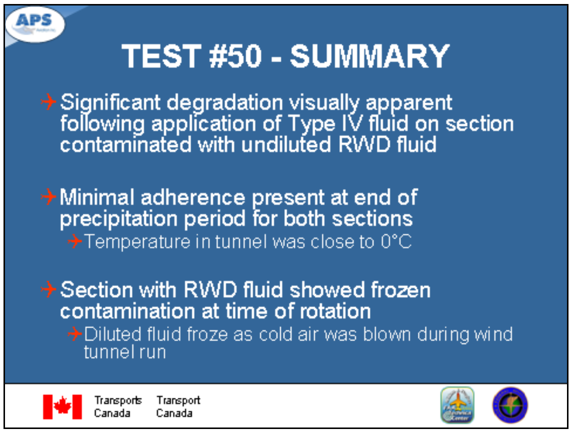
$\Delta t_{\text{Rotation}}$ = + 38 sec

Runway Deicer



$\Delta t_{\text{Rotation}}$ = + 36 sec
End of Test

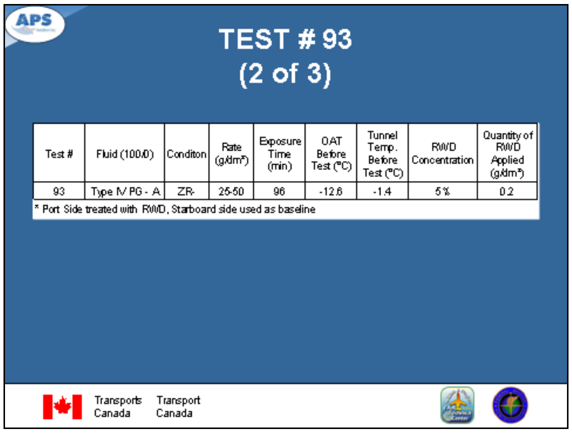
Runway Deicer



TEST #50 - SUMMARY

- Significant degradation visually apparent following application of Type IV fluid on section contaminated with undiluted RWD fluid
- Minimal adherence present at end of precipitation period for both sections
  - Temperature in tunnel was close to 0°C
- Section with RWD fluid showed frozen contamination at time of rotation
  - Diluted fluid froze as cold air was blown during wind tunnel run

Transports Canada Transport Canada

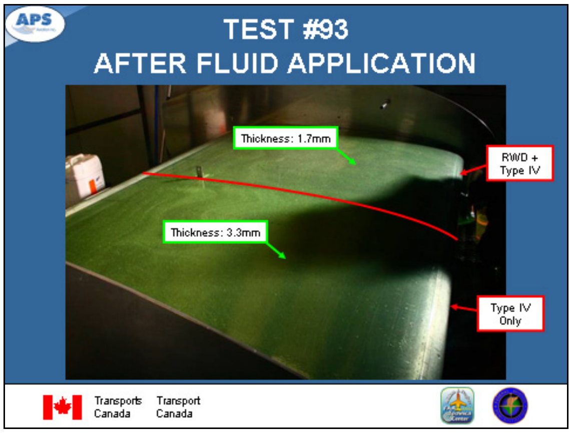


TEST # 93
(2 of 3)

Test #	Fluid (100/0)	Conditon	Rate (g/dm²)	Exposure Time (min)	OAT Before Test (°C)	Tunnel Temp. Before Test (°C)	RWD Concentration	Quantity of RWD Applied (g/dm²)
93	Type IV PG - A	ZR-	25-50	96	-12.6	-1.4	5 %	0.2

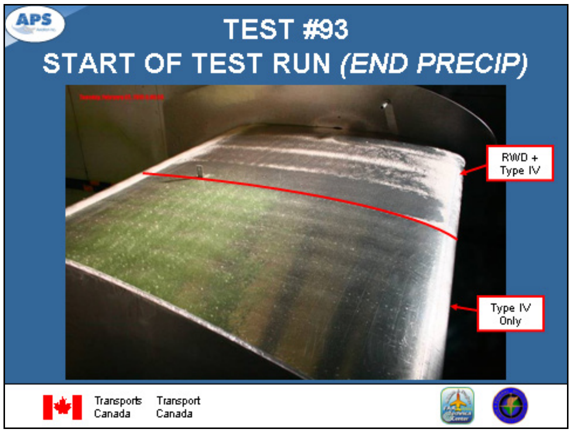
* Port Side treated with RWD, Starboard side used as baseline

Transports Canada Transport Canada



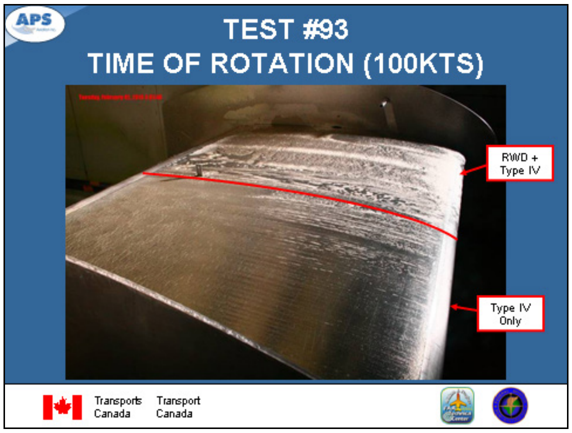
TEST #93
AFTER FLUID APPLICATION

Thickness: 1.7mm
Thickness: 3.3mm
RWD + Type IV
Type IV Only
Transports Canada
Transport Canada



TEST #93
START OF TEST RUN *(END PRECIP)*

RWD + Type IV
Type IV Only
Transports Canada
Transport Canada



TEST #93
TIME OF ROTATION (100KTS)

RWD + Type IV
Type IV Only
Transports Canada
Transport Canada

RUN #93

Transports Canada Transport Canada

DEGRADED ANTI-ICING FLUID PERFORMANCE

FOLLOWING CONTAMINATION WITH

RUNWAY DEICING FLUID

APS Aviation Inc.

Prepared for

Transportation Development Centre

Transport Canada

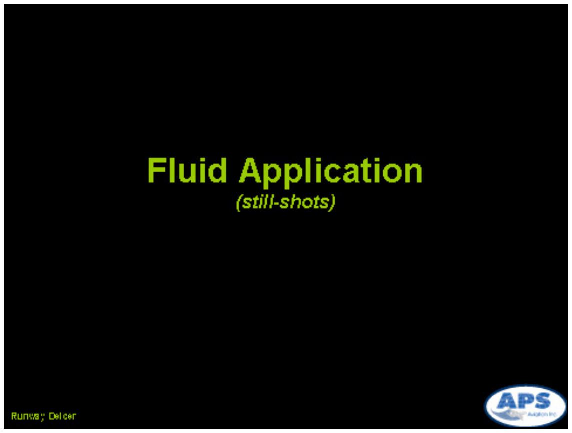
and the

Federal Aviation Administration

Test #93

Freezing Rain 25-50 g/dm²/hr, Approx. 95 min,
Tunnel Temp. -1°C,
100 Knots, 8° Rotation

Type IV PG A Neat &
KA Runway Deicer



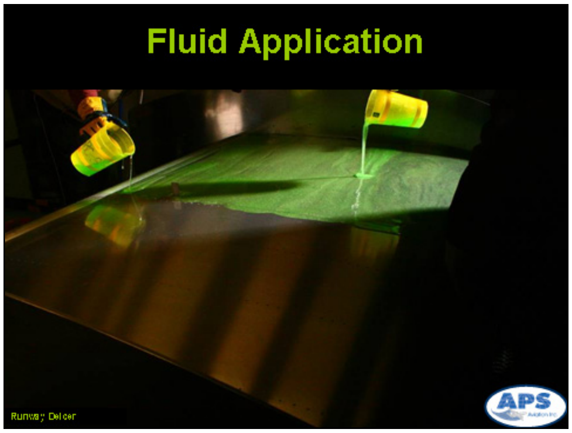
Fluid Application

(still-shots)

Runway Deicer

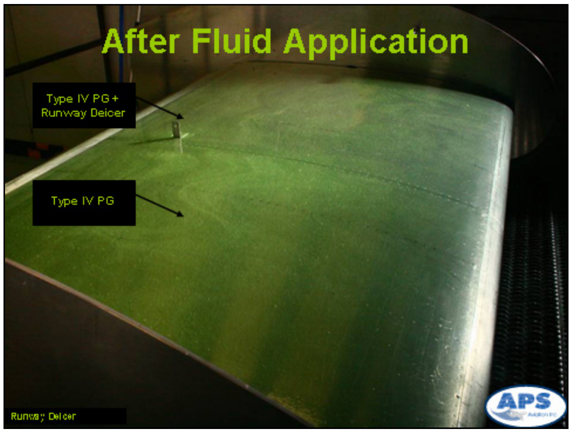
Runway Deicer Application

Runway Deicer



Fluid Application

Runway Deicer

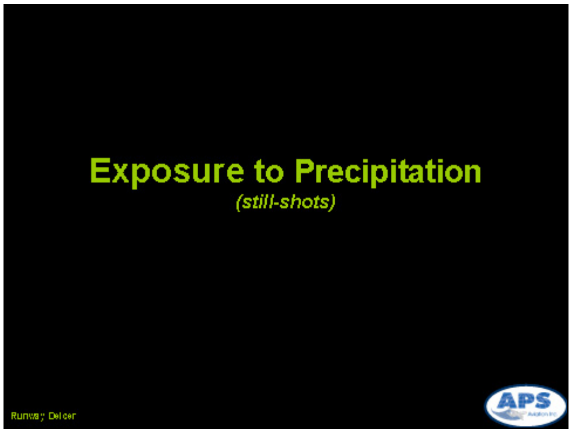


After Fluid Application

Type IV PG + Runway Deicer

Type IV PG

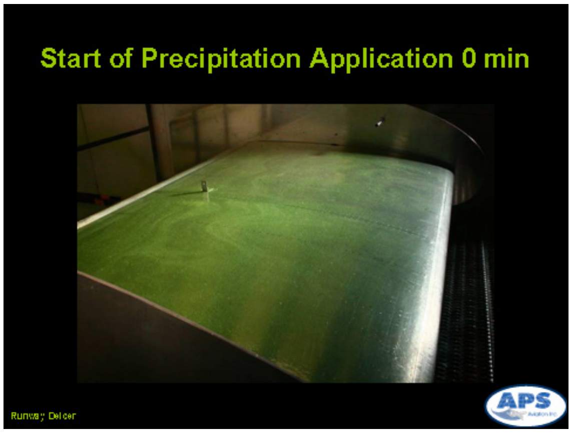
Runway Deicer



Exposure to Precipitation

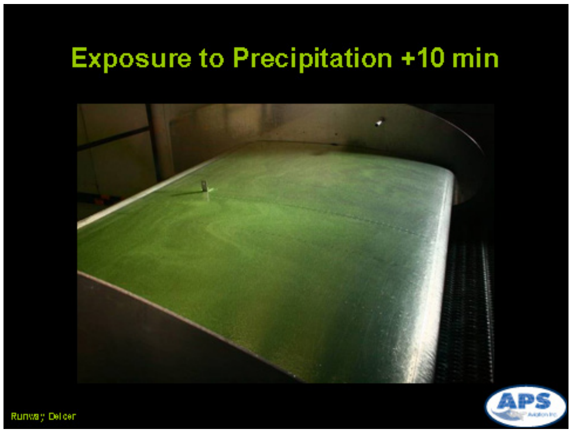
(still-shots)

Runway Deicer



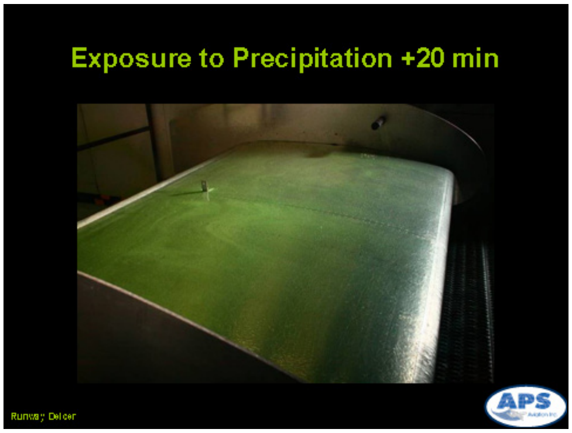
Start of Precipitation Application 0 min

Runway Deicer



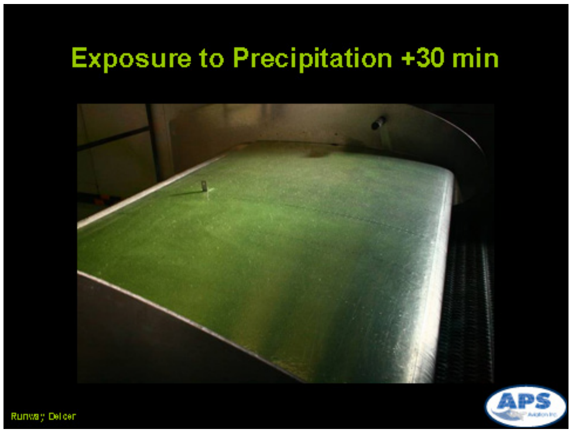
Exposure to Precipitation +10 min

Runway Deicer



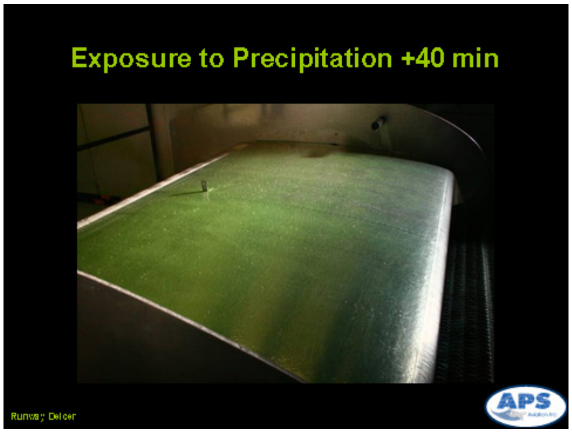
Exposure to Precipitation +20 min

Runway Deicer



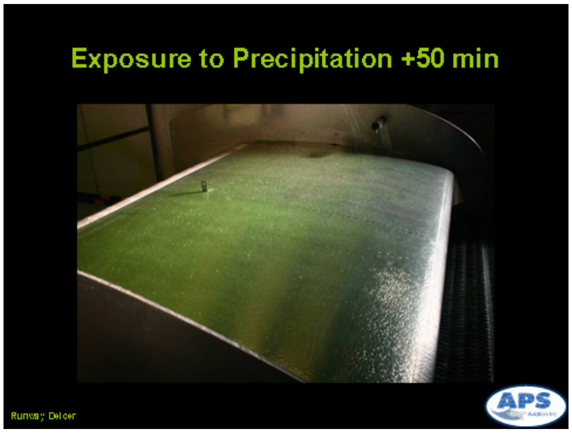
Exposure to Precipitation +30 min

Runway Deicer



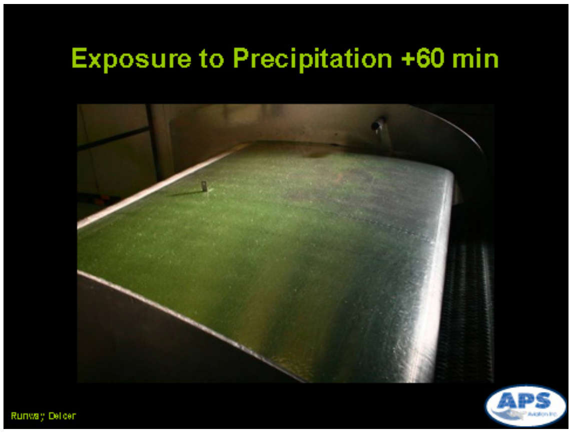
Exposure to Precipitation +40 min

Runway Deicer



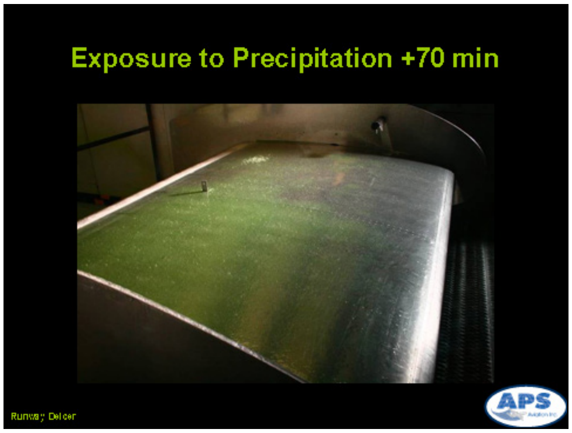
Exposure to Precipitation +50 min

Runway Deicer



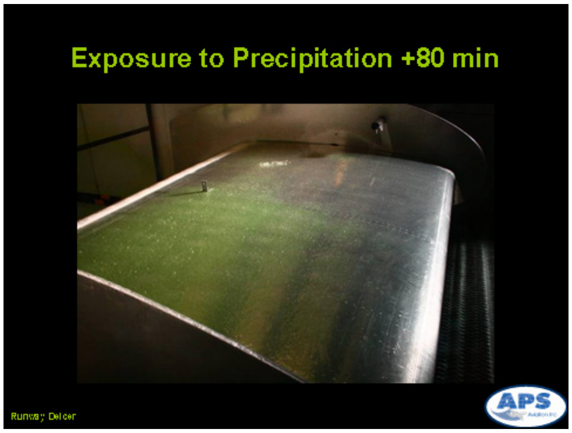
Exposure to Precipitation +60 min

Runway Deicer



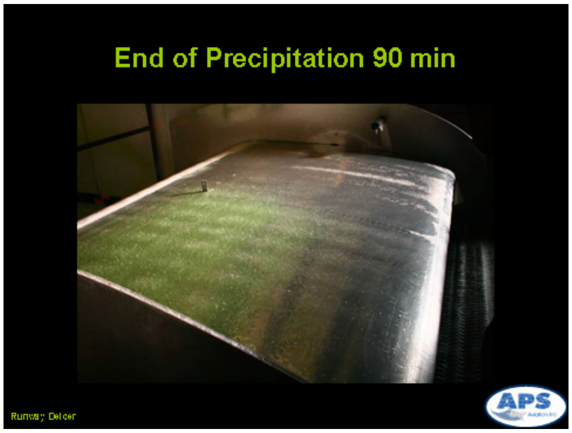
Exposure to Precipitation +70 min

Runway Deicer



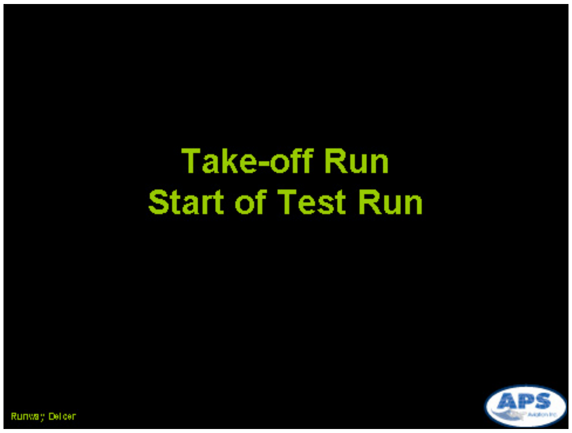
Exposure to Precipitation +80 min

Runway Deicer



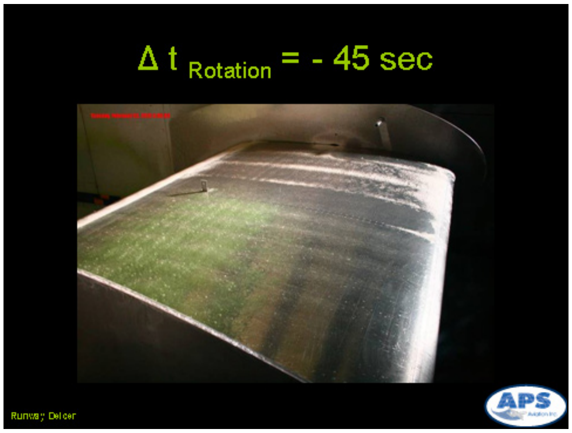
End of Precipitation 90 min

Runway Deicer



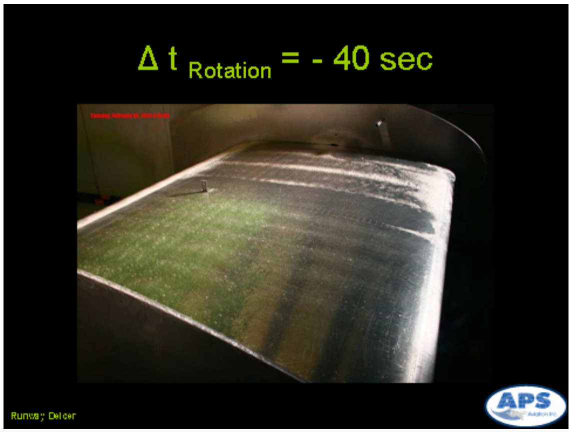
Take-off Run
Start of Test Run

Runway Deicer



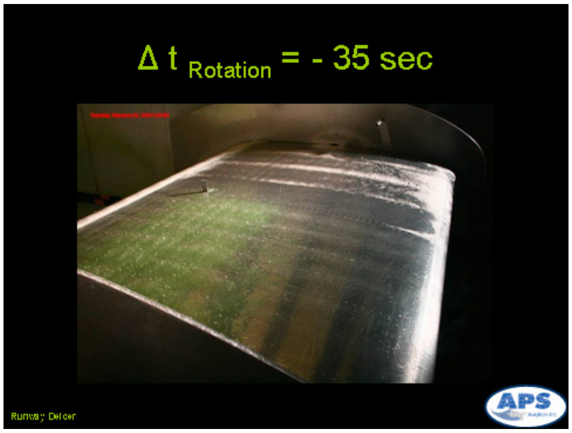
$\Delta t_{\text{Rotation}} = - 45$ sec

Runway Deicer



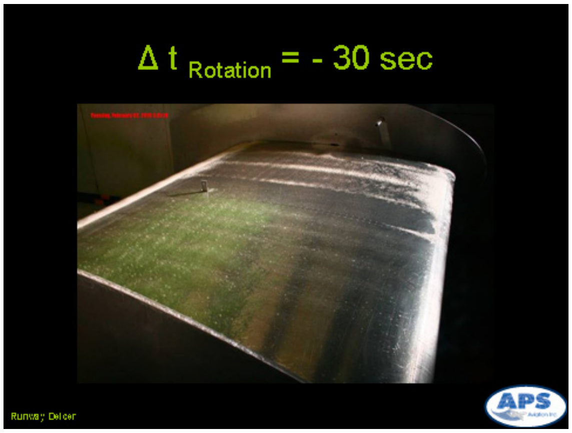
$\Delta t_{\text{Rotation}} = - 40$ sec

Runway Deicer



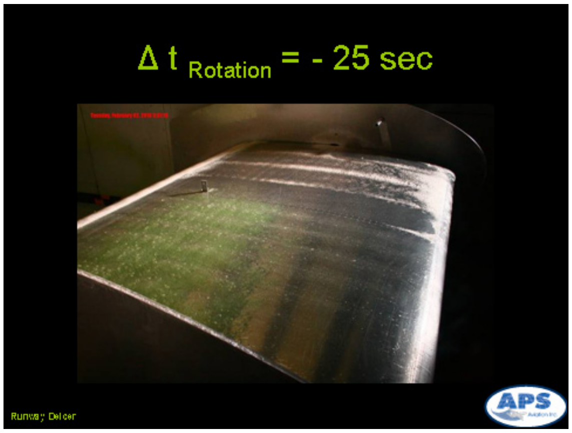
$\Delta t_{\text{Rotation}} = -\ 35\ \text{sec}$

Runway Deicer



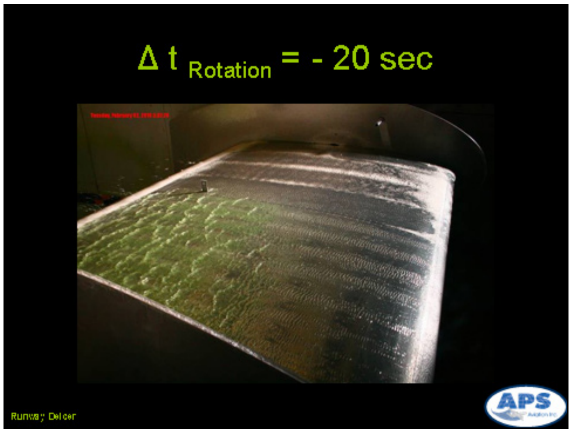
$\Delta t_{\text{Rotation}} = -\ 30\ \text{sec}$

Runway Deicer



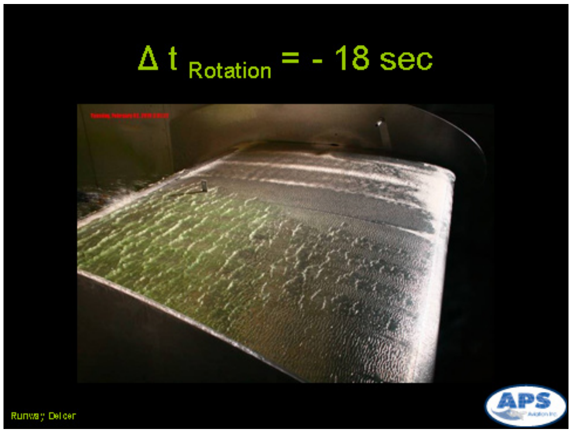
$\Delta t_{\text{Rotation}} = -\ 25\ \text{sec}$

Runway Deicer



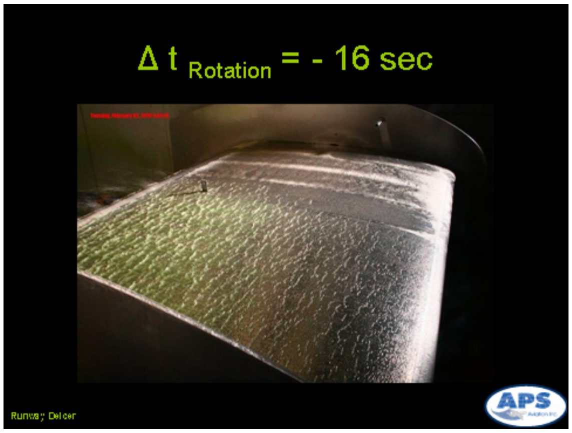
$\Delta t_{\text{Rotation}} = -\ 20\ \text{sec}$

Runway Deicer



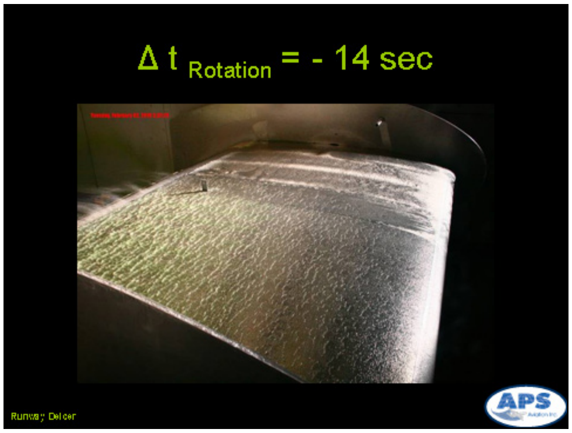
$\Delta t_{\text{Rotation}} = -\ 18\ \text{sec}$

Runway Deicer



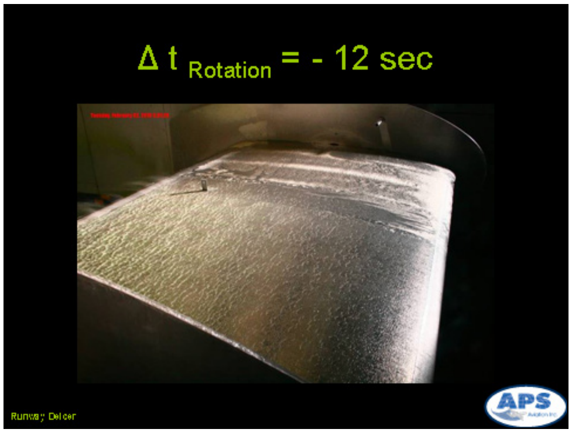
$\Delta t_{\text{Rotation}} = -\ 16\ \text{sec}$

Runway Deicer



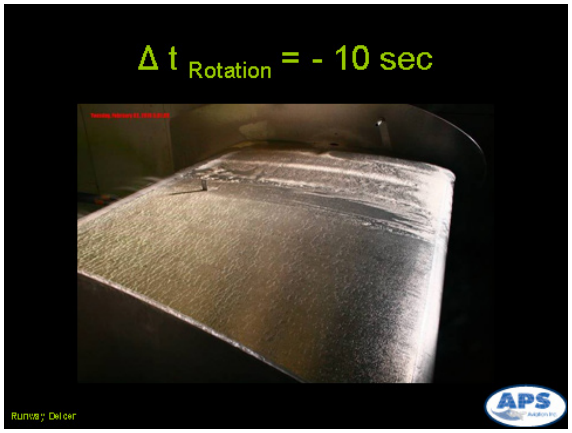
$\Delta t_{Rotation}$ = - 14 sec

Runway Deicer



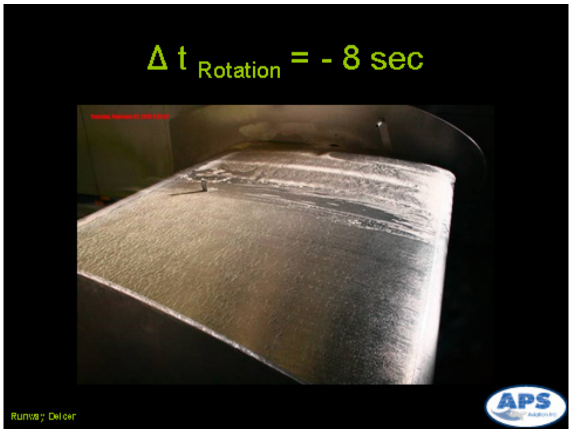
$\Delta t_{Rotation}$ = - 12 sec

Runway Deicer



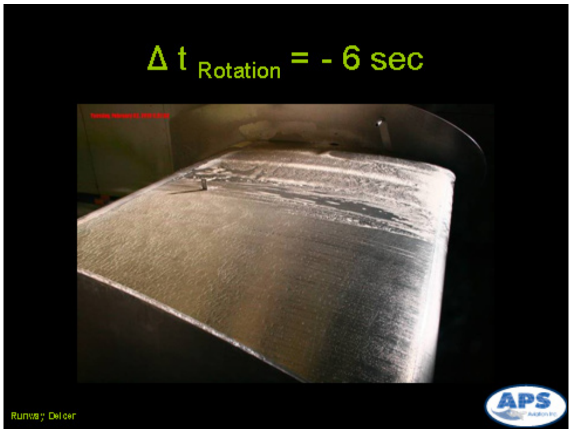
$\Delta t_{Rotation}$ = - 10 sec

Runway Deicer



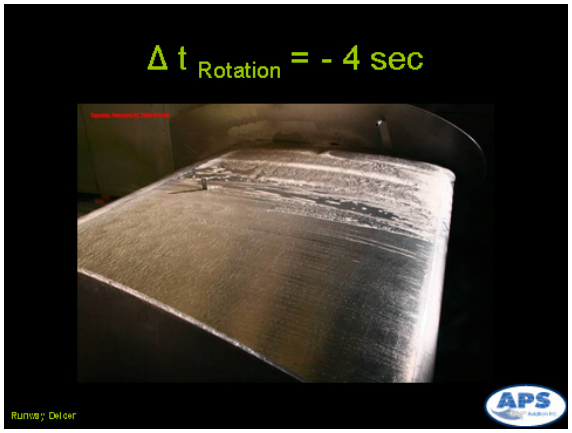
$\Delta t_{Rotation}$ = - 8 sec

Runway Deicer



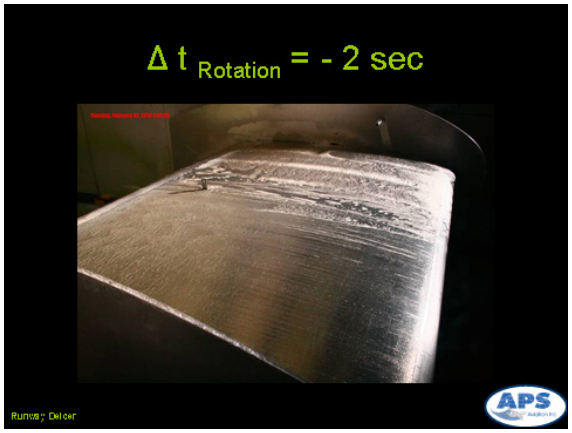
$\Delta t_{Rotation}$ = - 6 sec

Runway Deicer



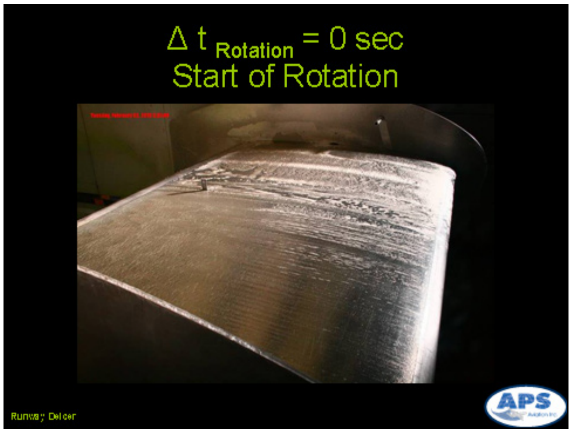
$\Delta t_{Rotation}$ = - 4 sec

Runway Deicer


$\Delta t_{\text{Rotation}} = -2$ sec

Runway Deicer

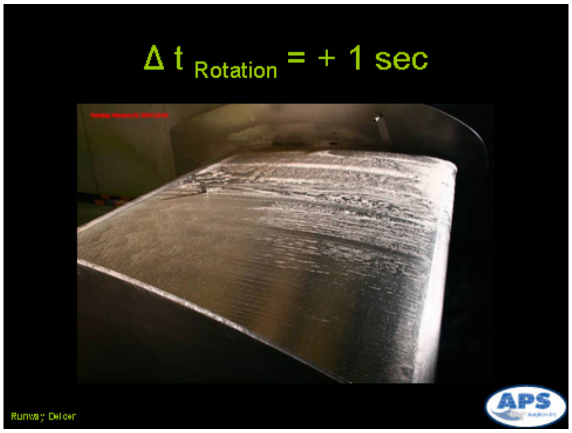
APS


$\Delta t_{\text{Rotation}} = 0$ sec

Start of Rotation

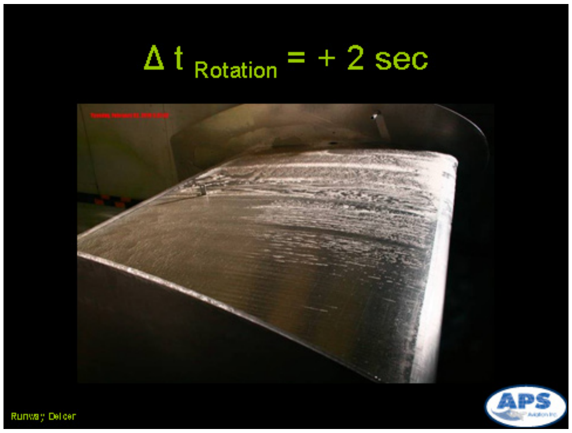
Runway Deicer

APS


$\Delta t_{\text{Rotation}} = +1$ sec

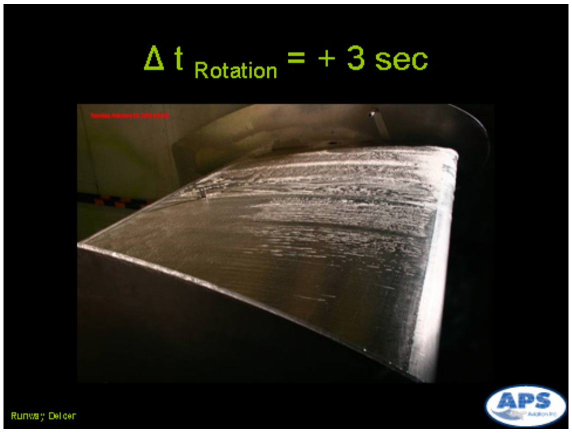
Runway Deicer

APS


$\Delta t_{\text{Rotation}} = +2$ sec

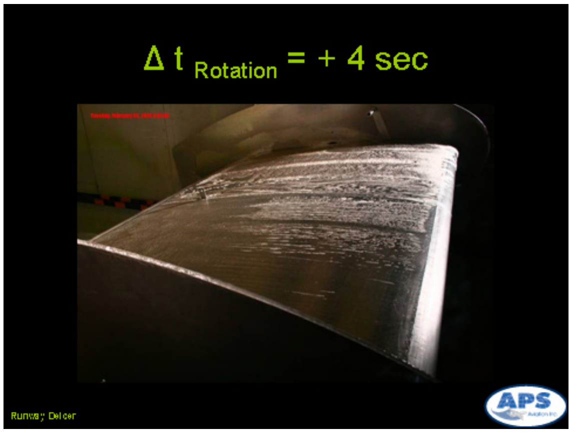
Runway Deicer

APS


$\Delta t_{\text{Rotation}} = +3$ sec

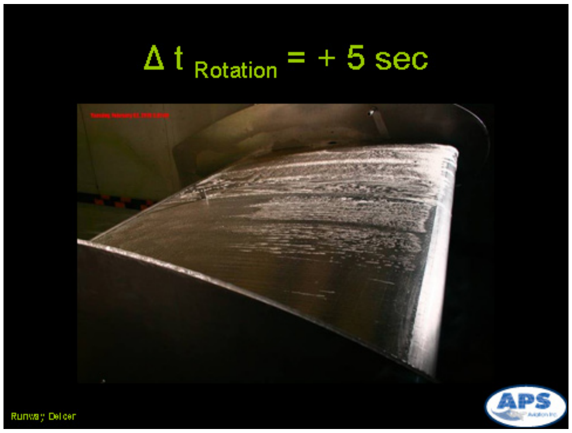
Runway Deicer

APS


$\Delta t_{\text{Rotation}} = +4$ sec

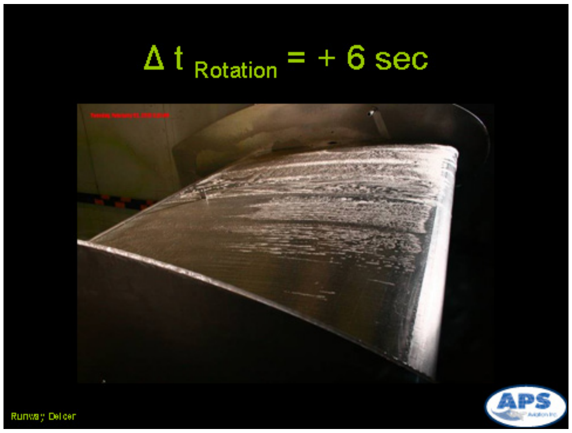
Runway Deicer

APS



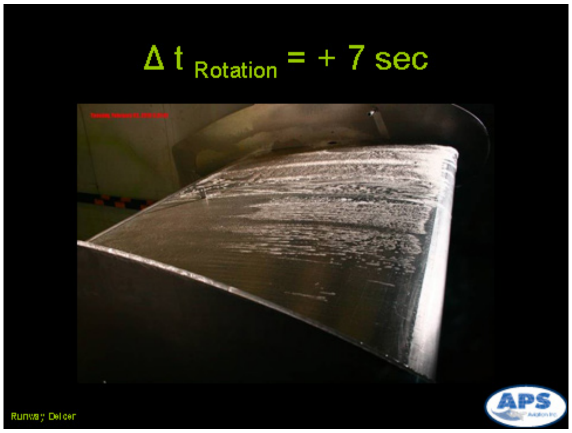
$\Delta t_{Rotation} = +5$ sec

Runway Deicer



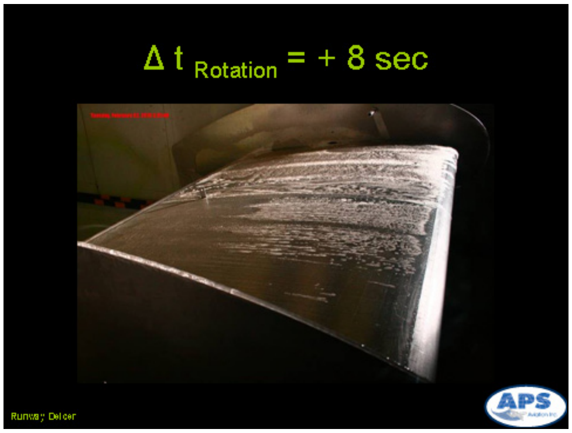
$\Delta t_{Rotation} = +6$ sec

Runway Deicer



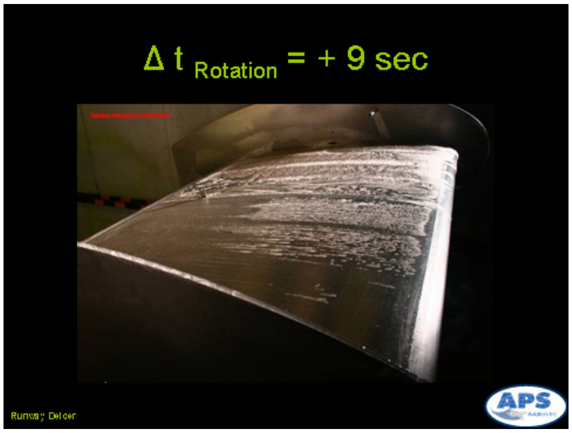
$\Delta t_{Rotation} = +7$ sec

Runway Deicer



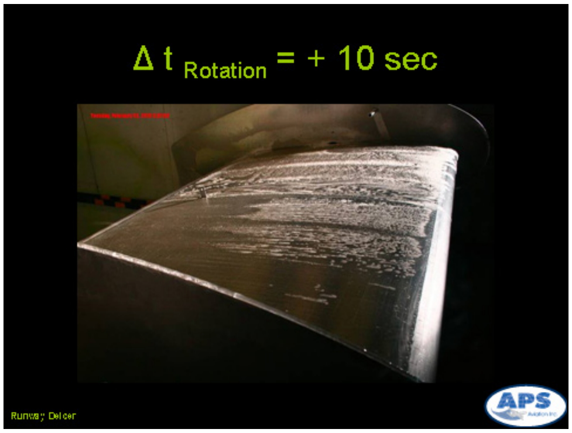
$\Delta t_{Rotation} = +8$ sec

Runway Deicer



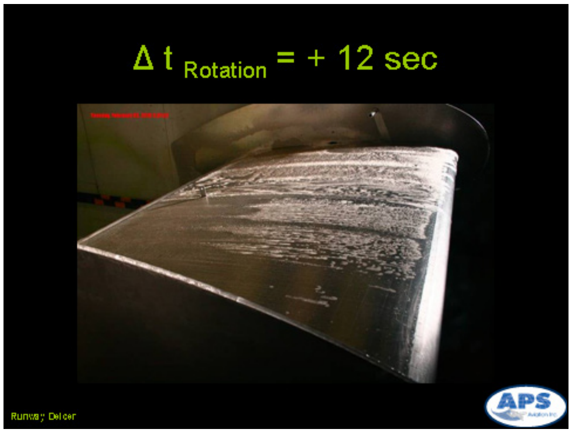
$\Delta t_{Rotation} = +9$ sec

Runway Deicer



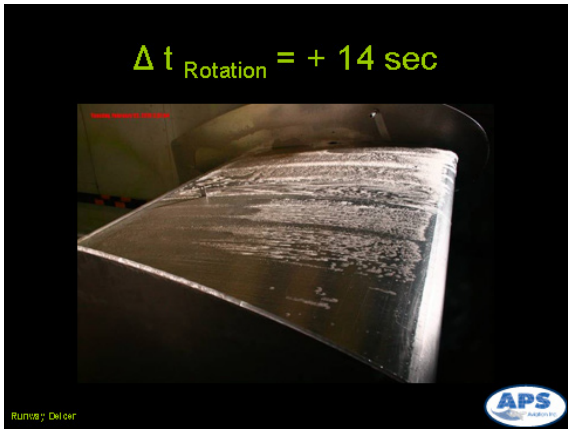
$\Delta t_{Rotation} = +10$ sec

Runway Deicer



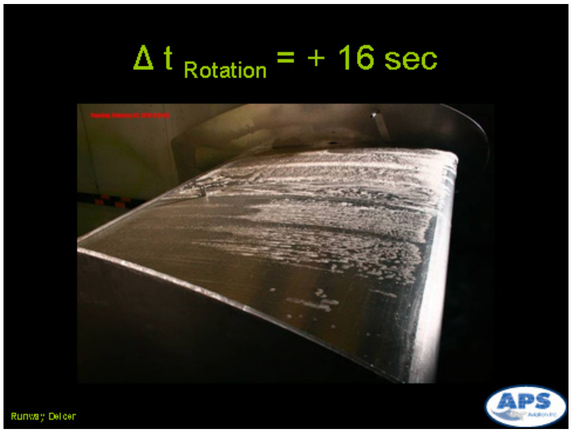
$\Delta t_{\text{Rotation}} = +\ 12$ sec

Runway Deicer



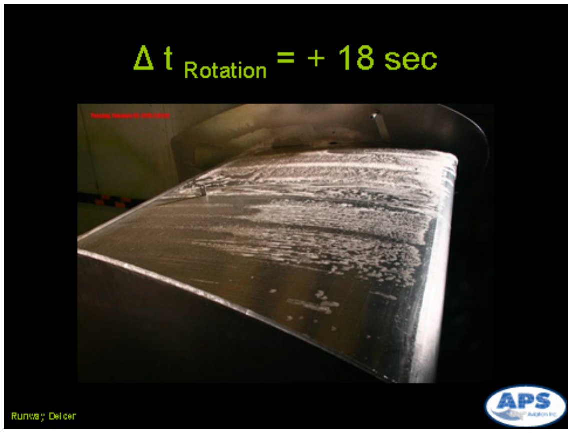
$\Delta t_{\text{Rotation}} = +\ 14$ sec

Runway Deicer



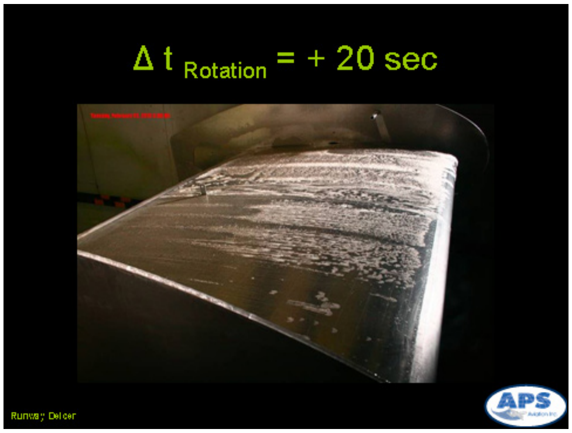
$\Delta t_{\text{Rotation}} = +\ 16$ sec

Runway Deicer



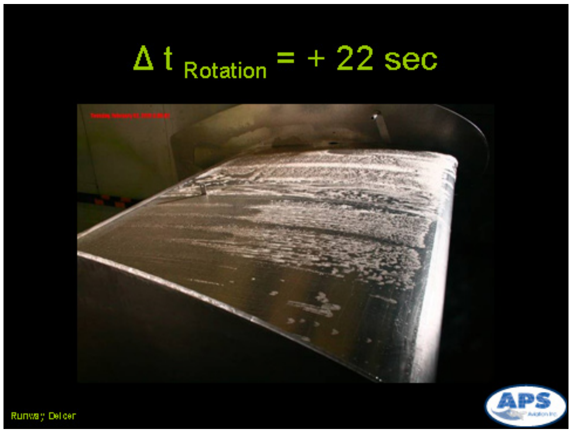
$\Delta t_{\text{Rotation}} = +\ 18$ sec

Runway Deicer



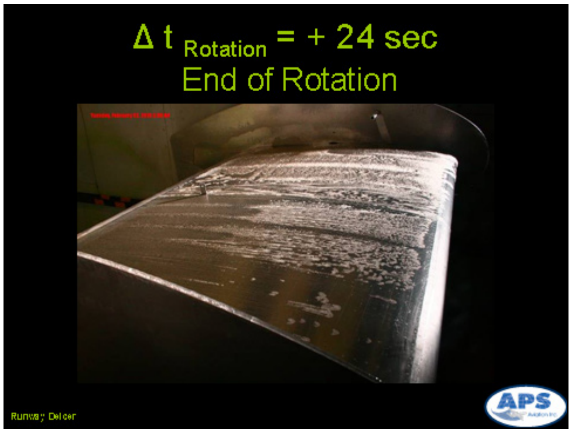
$\Delta t_{\text{Rotation}} = +\ 20$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = +\ 22$ sec

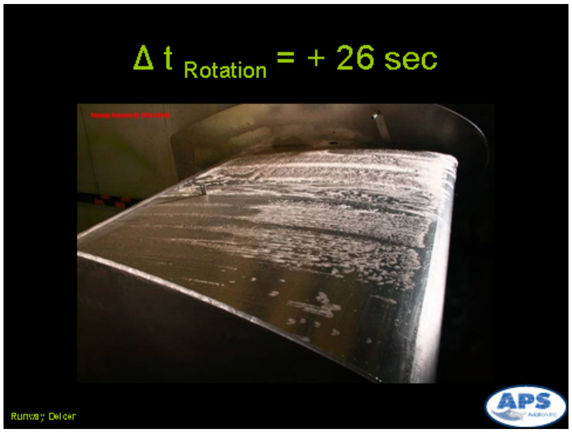
Runway Deicer



$\Delta t_{\text{Rotation}} = +24$ sec

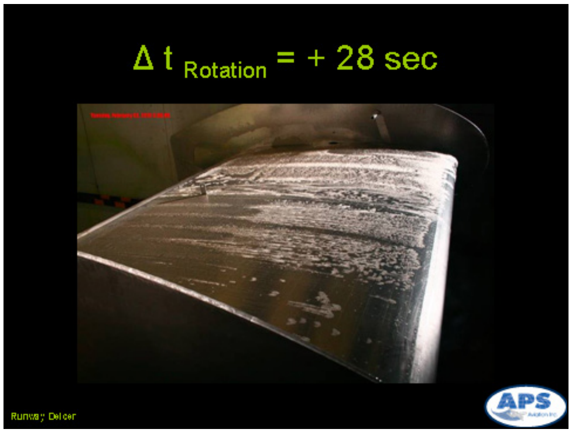
End of Rotation

Runway Deicer



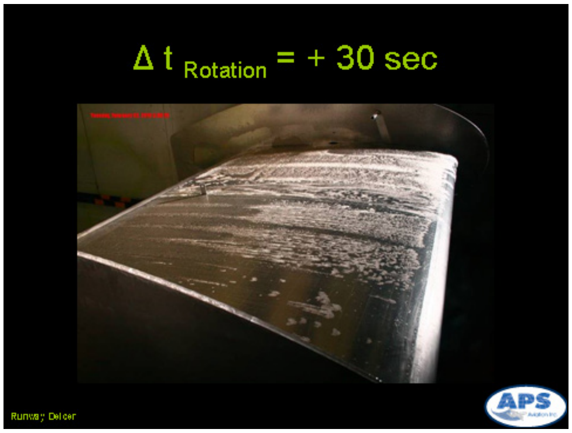
$\Delta t_{\text{Rotation}} = +26$ sec

Runway Deicer



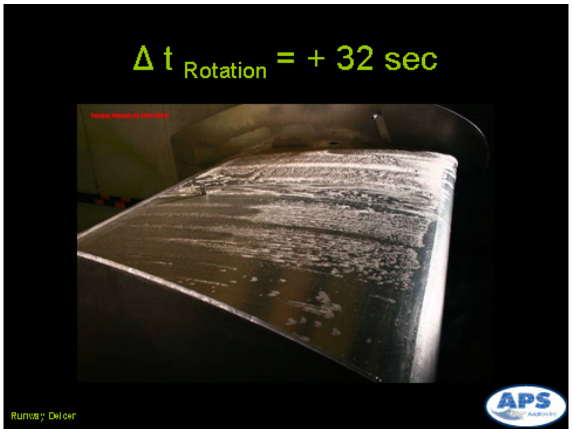
$\Delta t_{\text{Rotation}} = +28$ sec

Runway Deicer



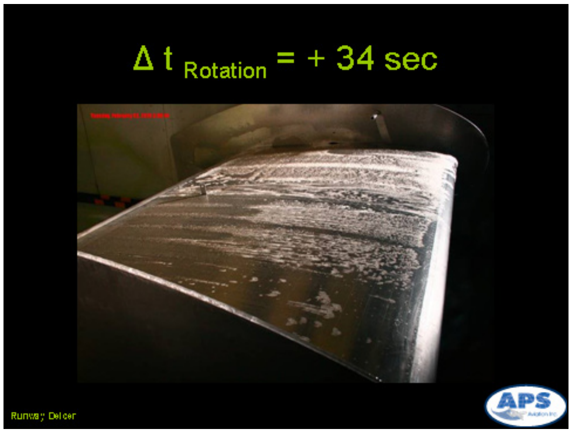
$\Delta t_{\text{Rotation}} = +30$ sec

Runway Deicer



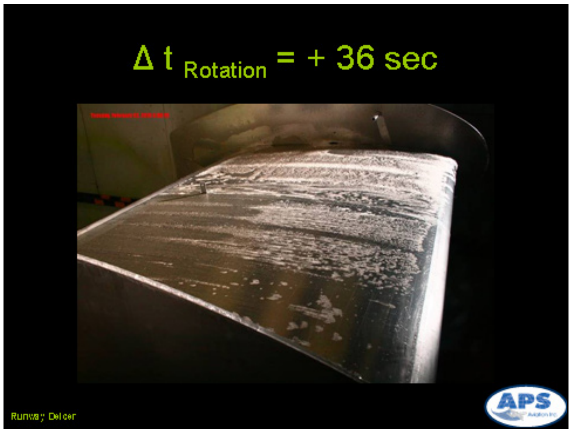
$\Delta t_{\text{Rotation}} = +32$ sec

Runway Deicer



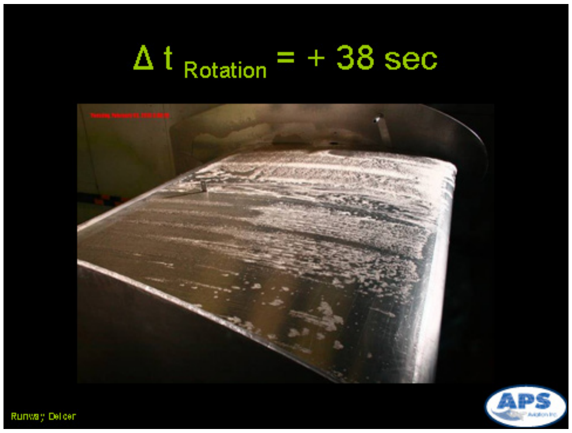
$\Delta t_{\text{Rotation}} = +34$ sec

Runway Deicer



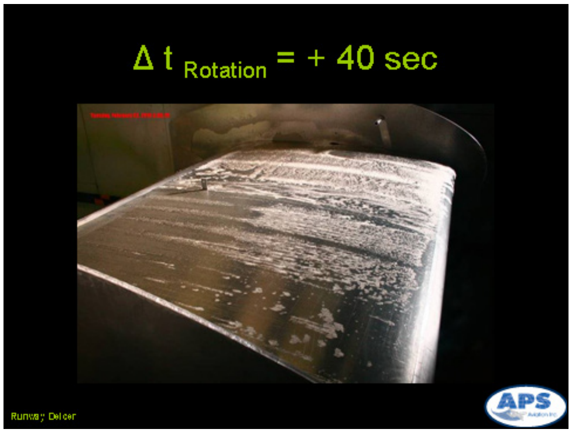
$\Delta t_{Rotation}$ = + 36 sec

Runway Deicer



$\Delta t_{Rotation}$ = + 38 sec

Runway Deicer



$\Delta t_{Rotation}$ = + 40 sec

Runway Deicer

$\Delta t_{Rotation}$ = + 42 sec

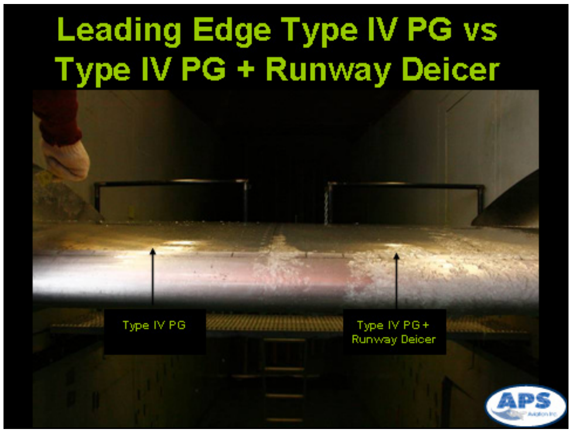
End of Test

Runway Deicer

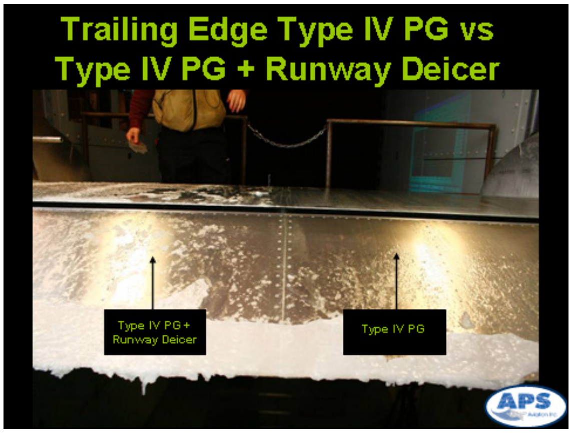
After High Speed Test Run

(still-shots)

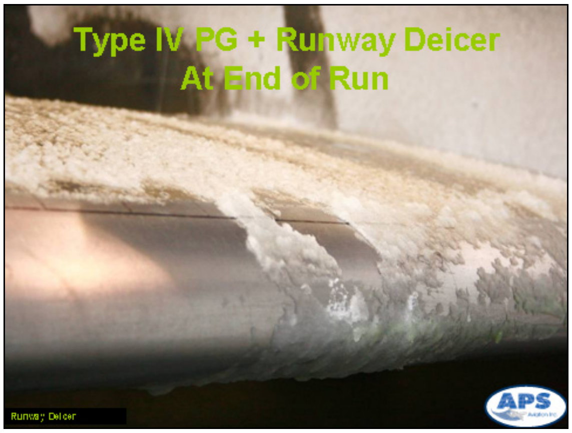
Runway Deicer



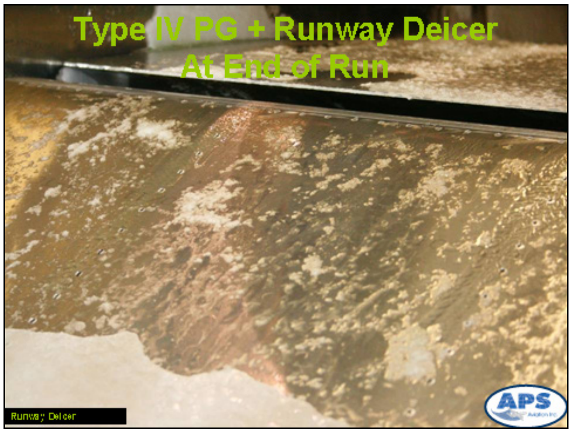
Leading Edge Type IV PG vs Type IV PG + Runway Deicer



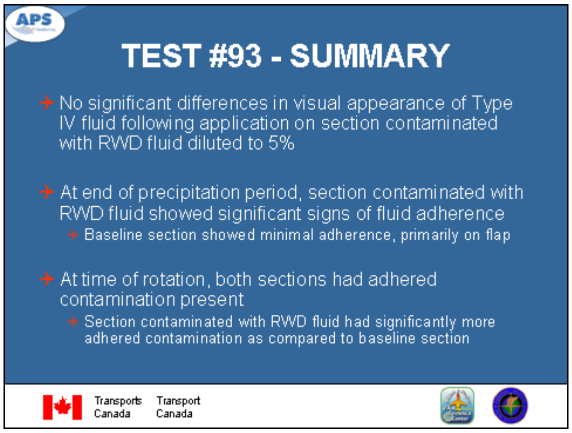
Trailing Edge Type IV PG vs Type IV PG + Runway Deicer



Type IV PG + Runway Deicer At End of Run



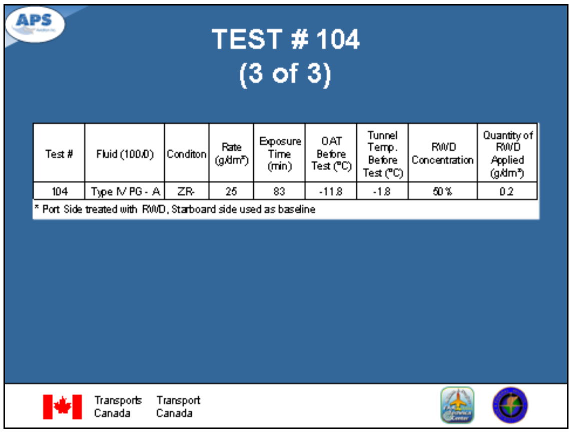
Type IV PG + Runway Deicer At End of Run



TEST #93 - SUMMARY

- No significant differences in visual appearance of Type IV fluid following application on section contaminated with RWD fluid diluted to 5%
- At end of precipitation period, section contaminated with RWD fluid showed significant signs of fluid adherence
  - Baseline section showed minimal adherence, primarily on flap
- At time of rotation, both sections had adhered contamination present
  - Section contaminated with RWD fluid had significantly more adhered contamination as compared to baseline section

Transports Canada Transport Canada

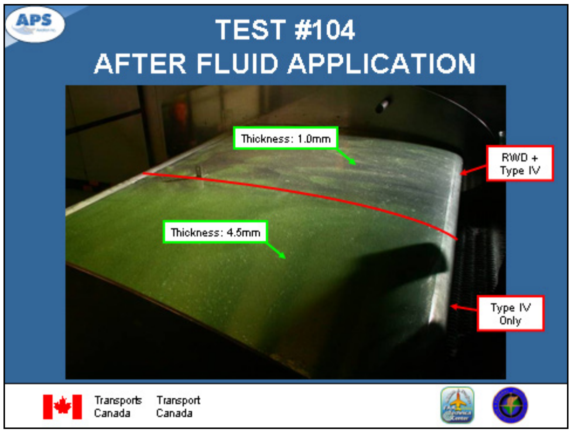


TEST # 104
(3 of 3)

Test #	Fluid (100/0)	Conditon	Rate (g/dm²)	Exposure Time (min)	OAT Before Test (°C)	Tunnel Temp. Before Test (°C)	RWD Concentration	Quantity of RWD Applied (g/dm²)
104	Type IV PG - A	ZR-	25	83	-11.8	-1.8	50 %	0.2

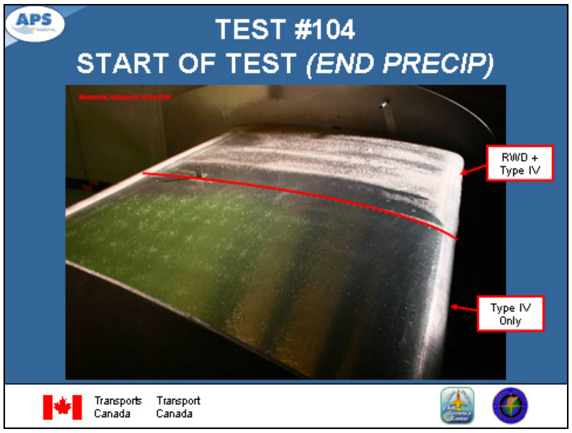
* Port Side treated with RWD, Starboard side used as baseline

Transports Canada Transport Canada



TEST #104
AFTER FLUID APPLICATION

Transports Canada Transport Canada



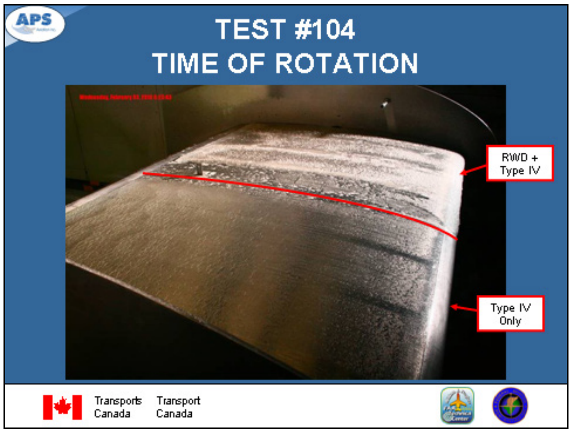
APS

TEST #104
START OF TEST *(END PRECIP)*

RWD +
Type IV

Type IV
Only

Transports Canada Transport Canada



APS

TEST #104
TIME OF ROTATION

RWD +
Type IV

Type IV
Only

Transports Canada Transport Canada

APS

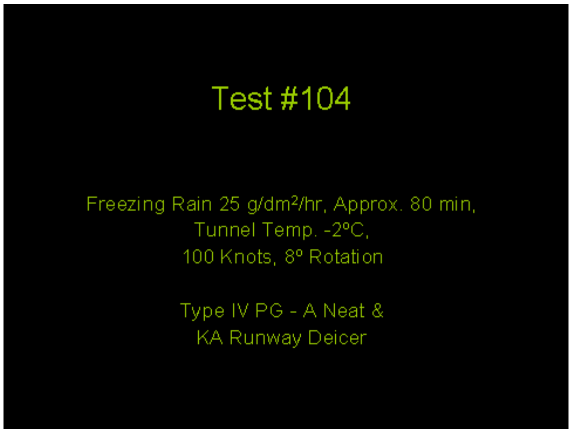
RUN #104

Transports Canada Transport Canada

DEGRADED ANTI-ICING FLUID PERFORMANCE
FOLLOWING CONTAMINATION WITH
RUNWAY DEICING FLUID

APS Aviation Inc.

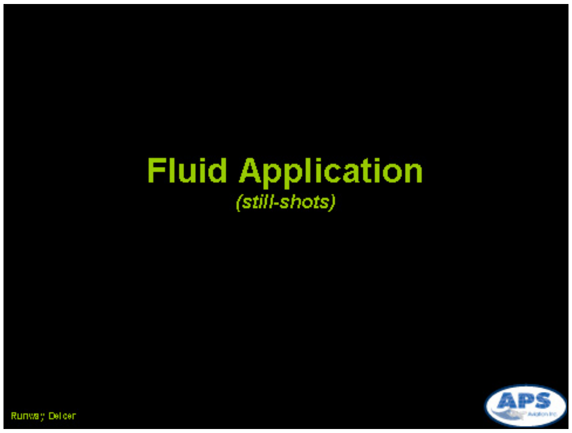
Prepared for
Transportation Development Centre
Transport Canada
and the
Federal Aviation Administration



Test #104

Freezing Rain 25 g/dm²/hr, Approx. 80 min,
Tunnel Temp. -2°C,
100 Knots, 8° Rotation

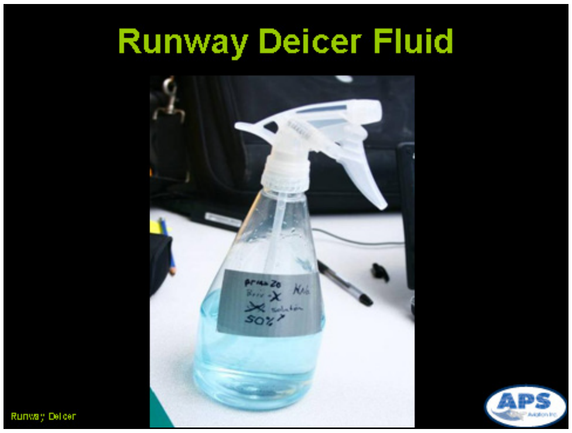
Type IV PG - A Neat &
KA Runway Deicer



Fluid Application
(still-shots)

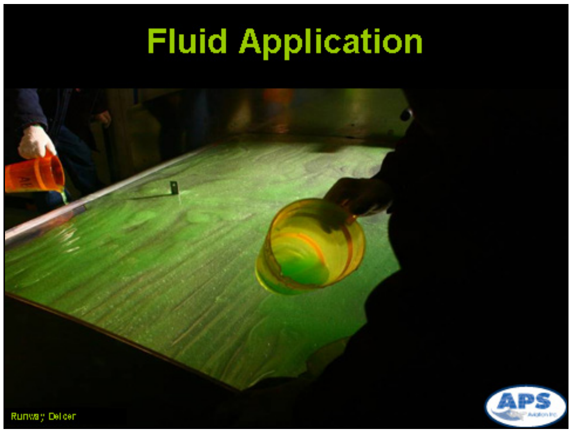
Runway Deicer

APS



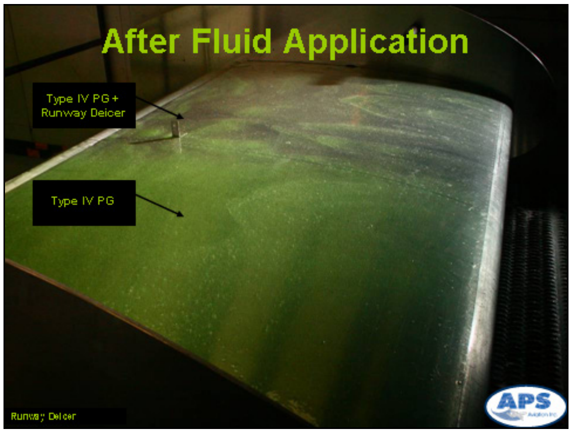
Runway Deicer Fluid

Runway Deicer



Fluid Application

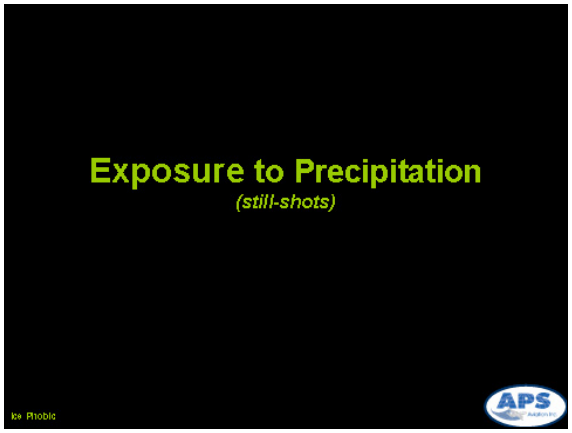
Runway Deicer



After Fluid Application

Type IV PG +
Runway Deicer
Type IV PG

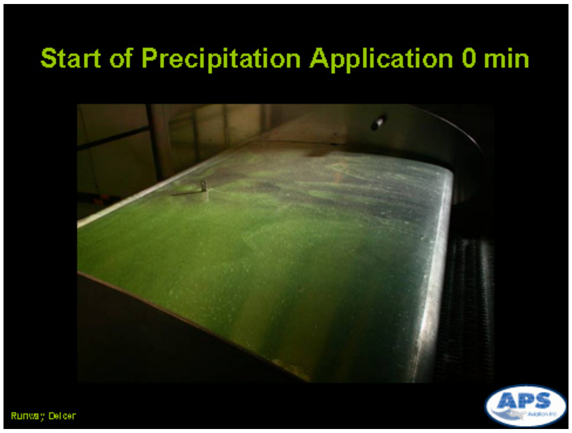
Runway Deicer



Exposure to Precipitation

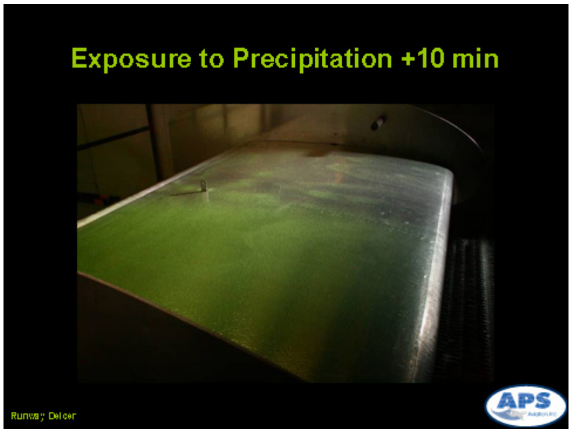
(still-shots)

Ice Phobic



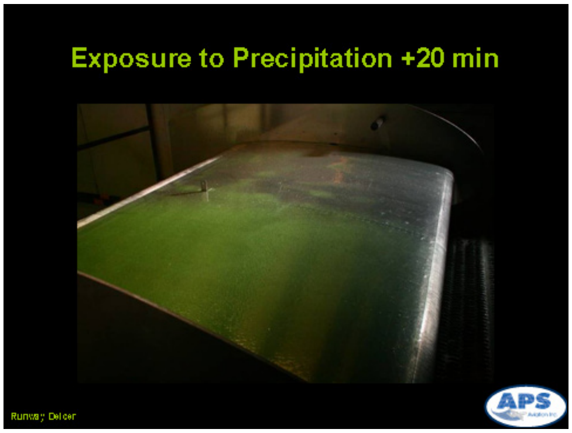
Start of Precipitation Application 0 min

Runway Deicer



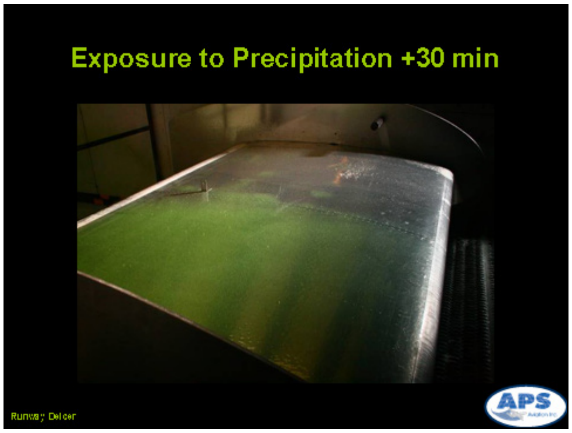
Exposure to Precipitation +10 min

Runway Deicer



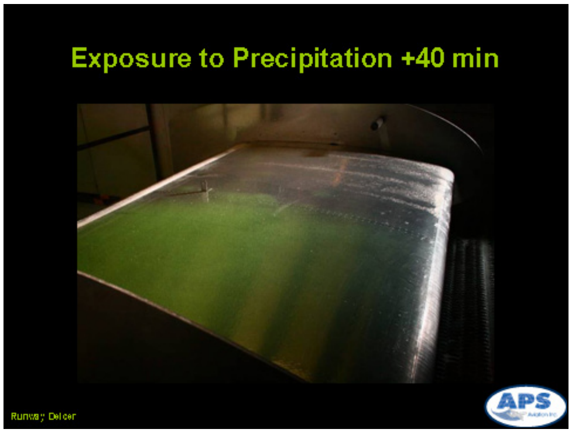
Exposure to Precipitation +20 min

Runway Deicer



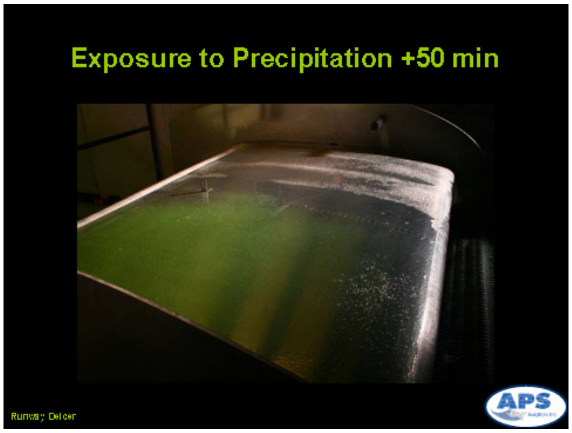
Exposure to Precipitation +30 min

Runway Deicer



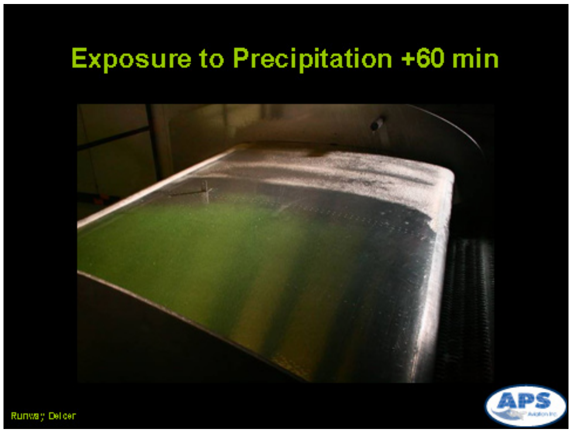
Exposure to Precipitation +40 min

Runway Deicer



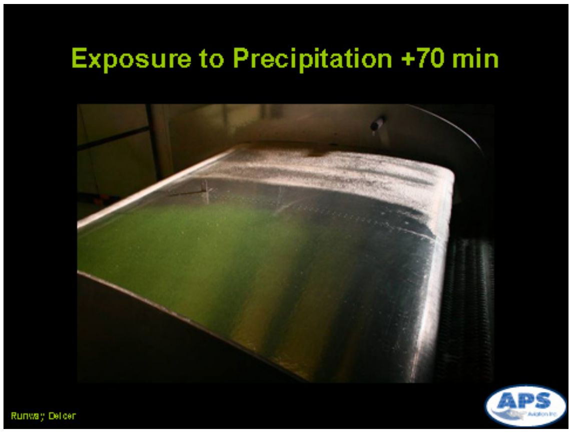
Exposure to Precipitation +50 min

Runway Deicer



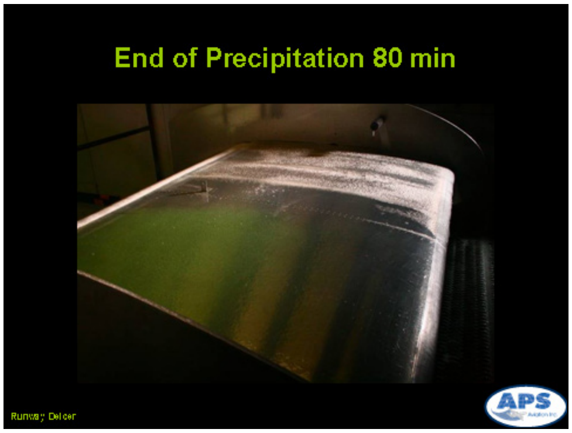
Exposure to Precipitation +60 min

Runway Deicer



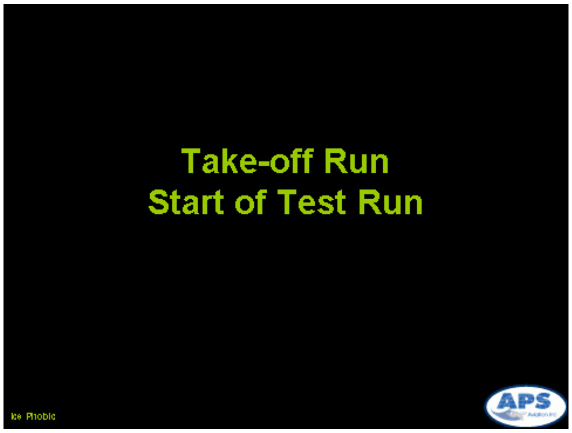
Exposure to Precipitation +70 min

Runway Deicer



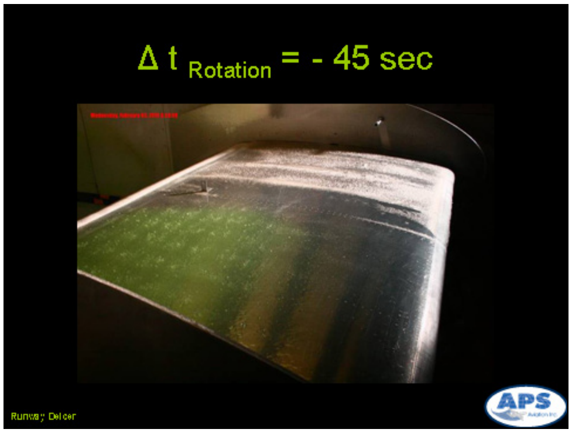
End of Precipitation 80 min

Runway Deicer



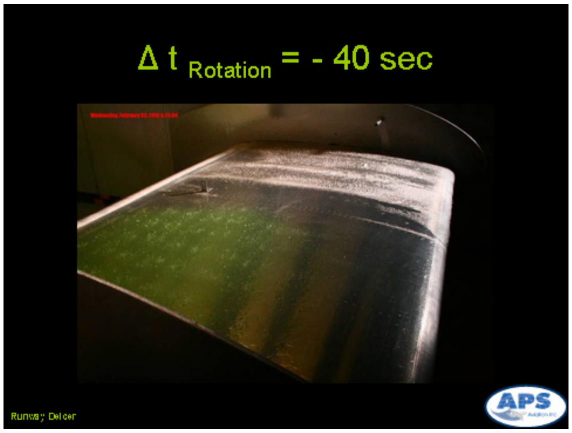
Take-off Run
Start of Test Run

Ice Phobic



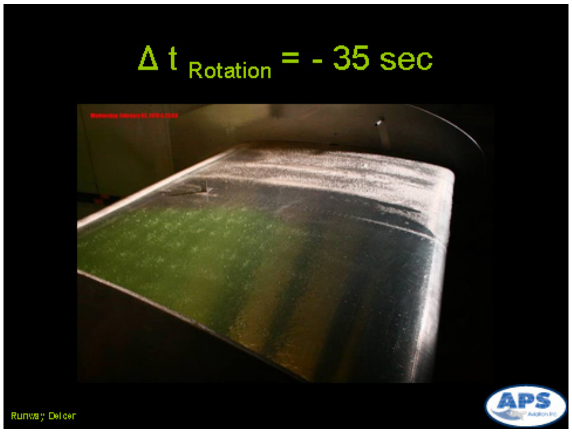
$\Delta t_{\text{Rotation}} = - 45$ sec

Runway Deicer



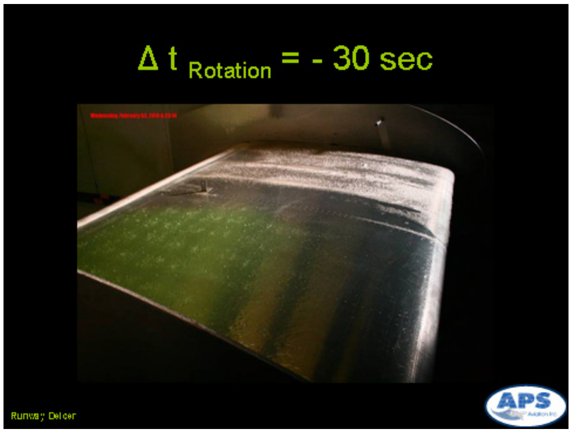
$\Delta t_{\text{Rotation}} = - 40$ sec

Runway Deicer



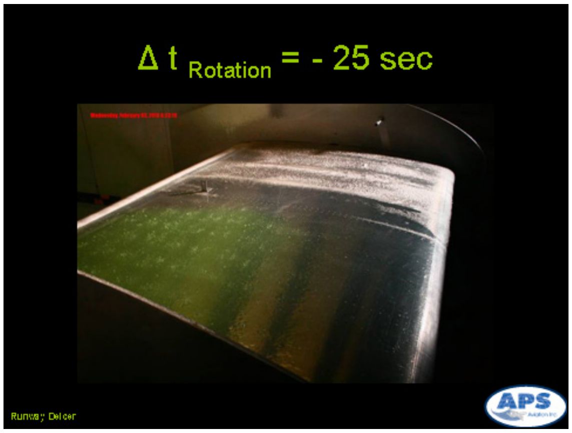
$\Delta t_{\text{Rotation}} = - 35$ sec

Runway Deicer



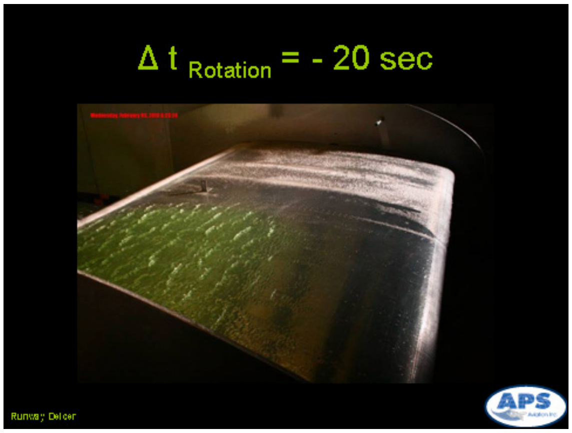
$\Delta t_{\text{Rotation}} = - 30$ sec

Runway Deicer



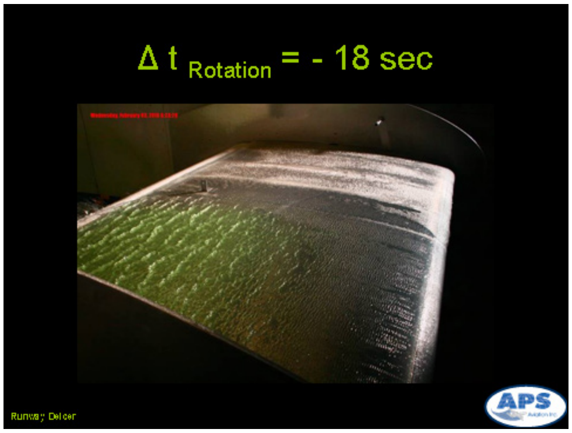
$\Delta t_{\text{Rotation}} = -25$ sec

Runway Deicer



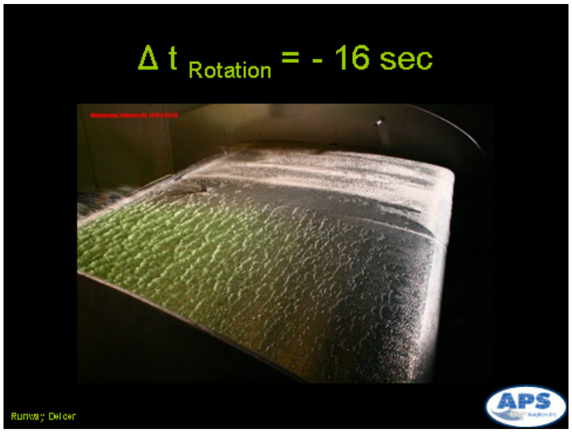
$\Delta t_{\text{Rotation}} = -20$ sec

Runway Deicer



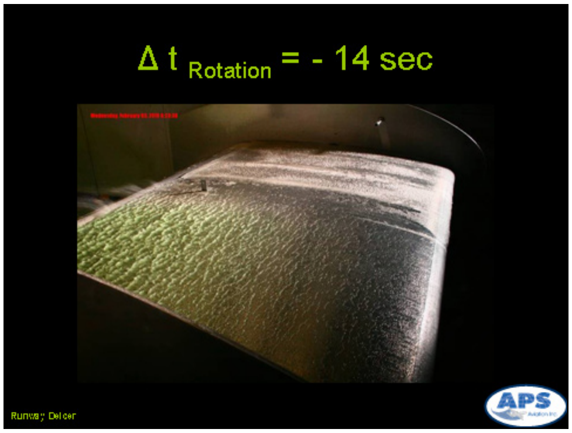
$\Delta t_{\text{Rotation}} = -18$ sec

Runway Deicer



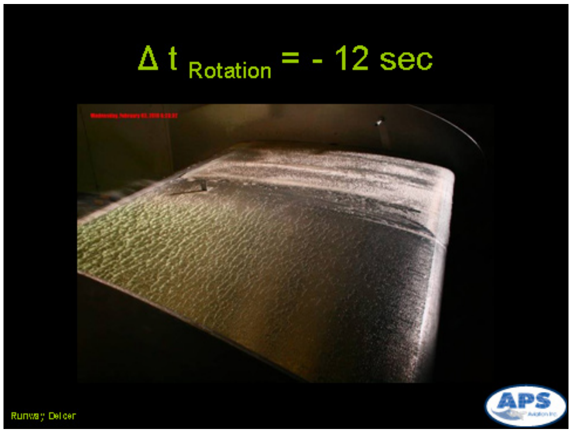
$\Delta t_{\text{Rotation}} = -16$ sec

Runway Deicer



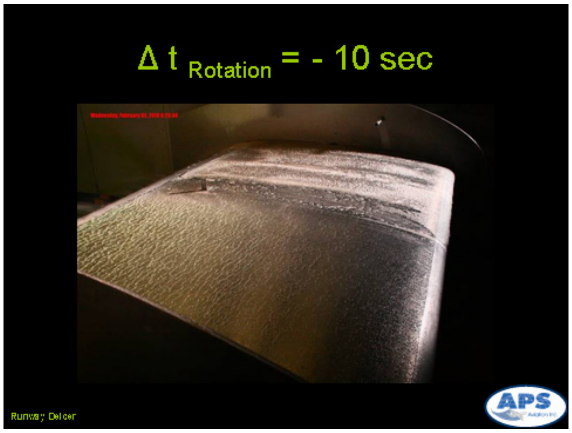
$\Delta t_{\text{Rotation}} = -14$ sec

Runway Deicer



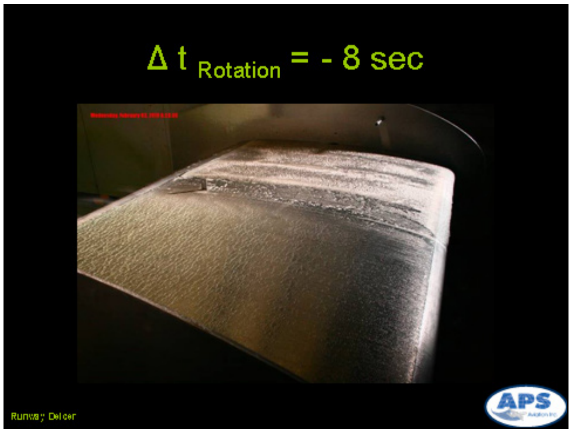
$\Delta t_{\text{Rotation}} = -12$ sec

Runway Deicer



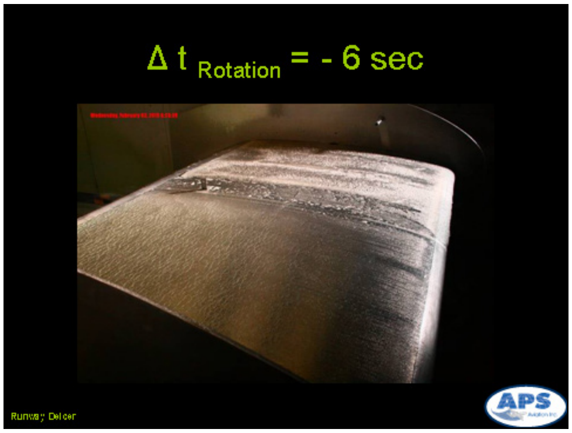
$\Delta t_{\text{Rotation}} = -10$ sec

Runway Deicer



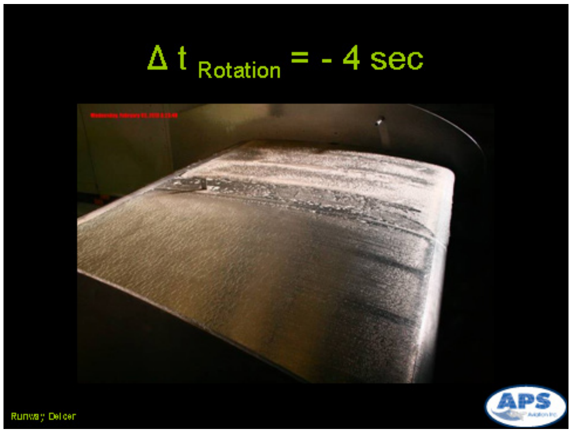
$\Delta t_{\text{Rotation}} = -8$ sec

Runway Deicer



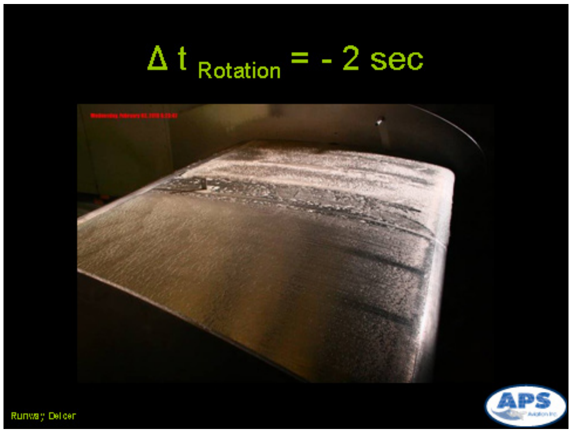
$\Delta t_{\text{Rotation}} = -6$ sec

Runway Deicer



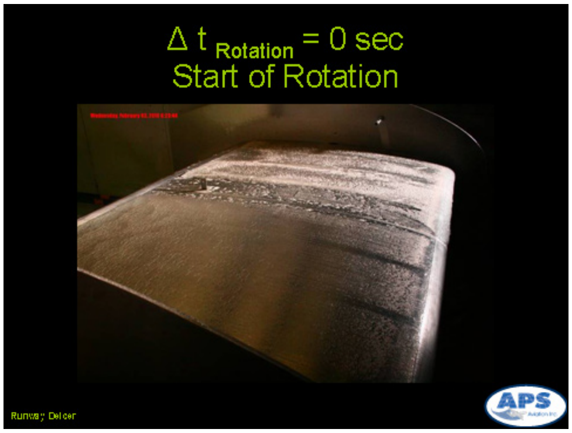
$\Delta t_{\text{Rotation}} = -4$ sec

Runway Deicer



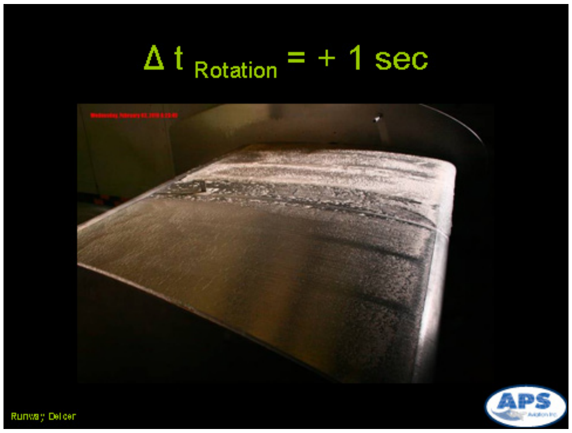
$\Delta t_{\text{Rotation}} = -2$ sec

Runway Deicer



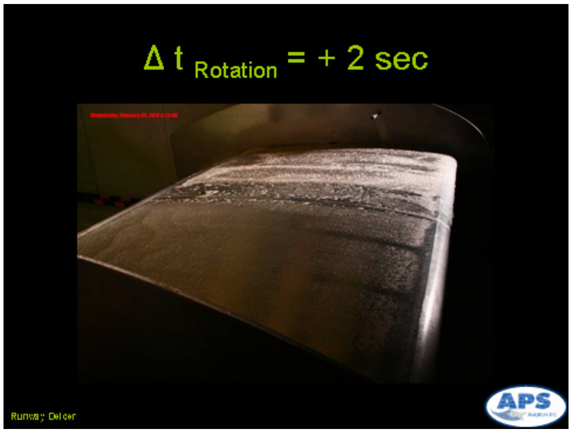
$\Delta t_{\text{Rotation}} = 0$ sec
Start of Rotation

Runway Deicer



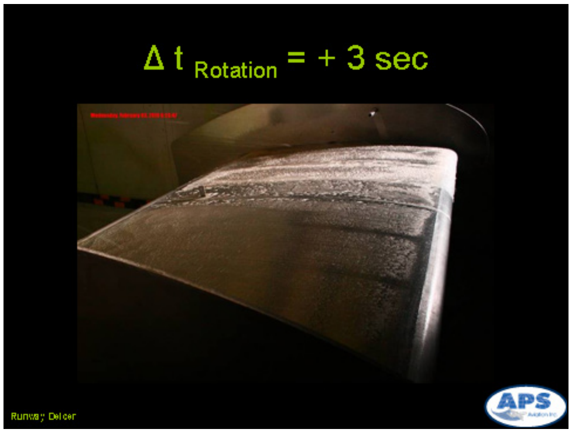
$\Delta t_{\text{Rotation}} = +1$ sec

Runway Deicer



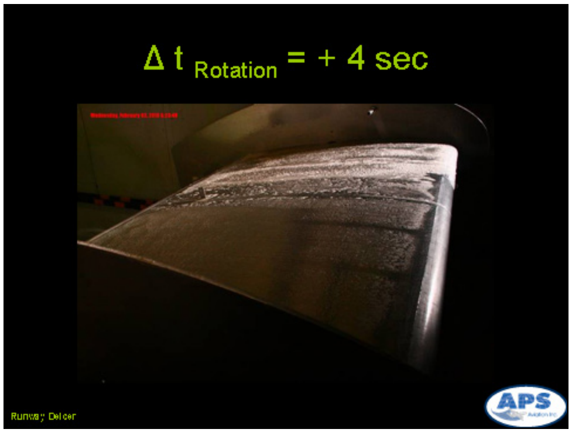
$\Delta t_{\text{Rotation}} = +2$ sec

Runway Deicer



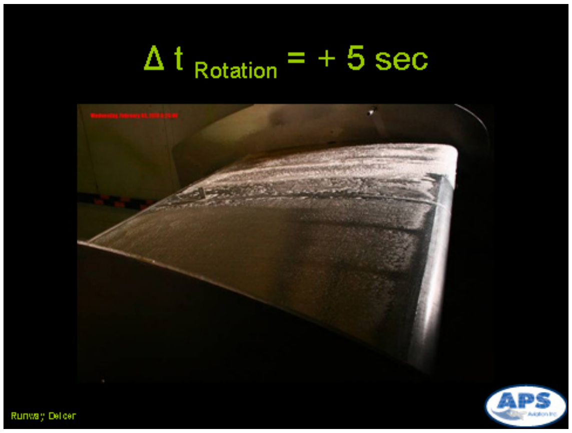
$\Delta t_{\text{Rotation}} = +3$ sec

Runway Deicer



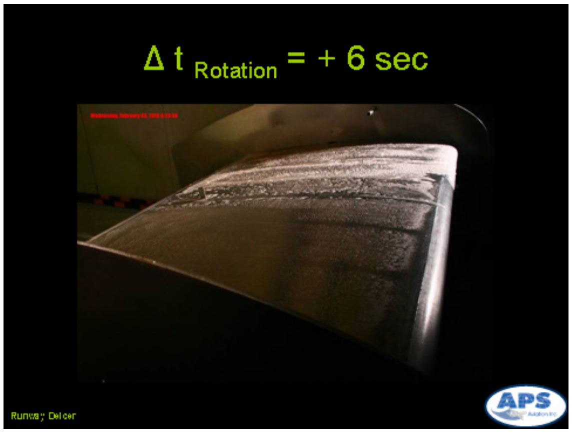
$\Delta t_{\text{Rotation}} = +4$ sec

Runway Deicer



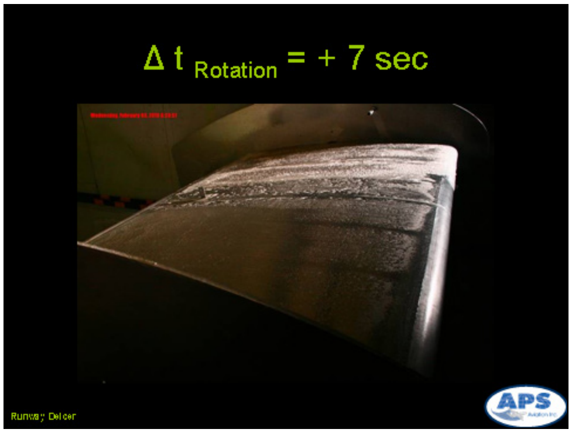
$\Delta t_{\text{Rotation}} = +5$ sec

Runway Deicer



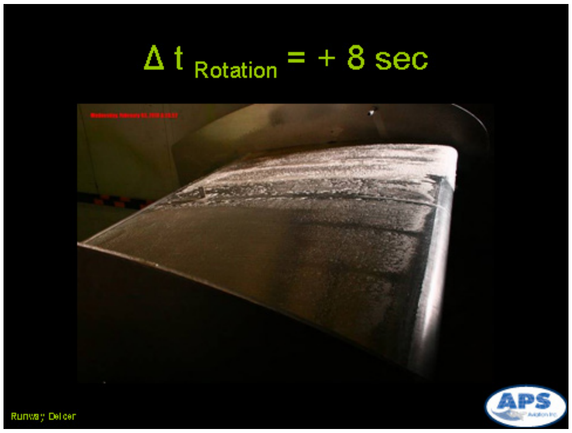
$\Delta t_{\text{Rotation}} = +6$ sec

Runway Deicer



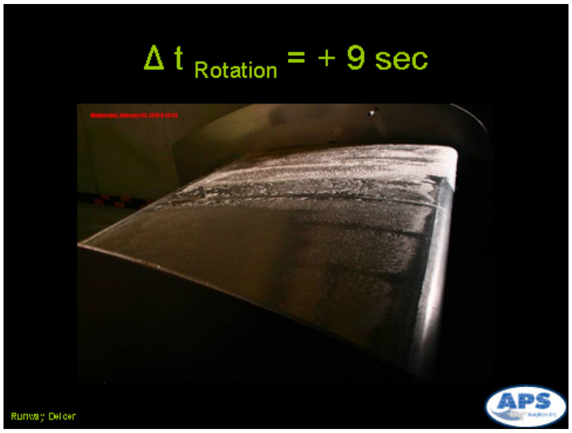
$\Delta t_{\text{Rotation}}$ = + 7 sec

Runway Deicer



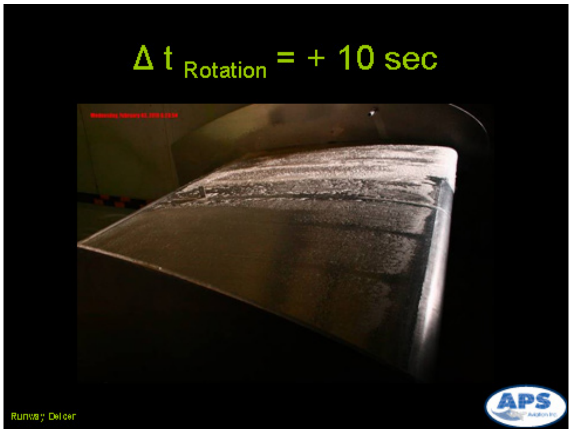
$\Delta t_{\text{Rotation}}$ = + 8 sec

Runway Deicer



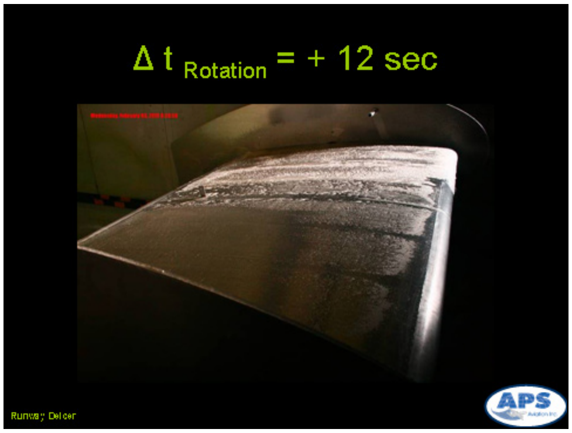
$\Delta t_{\text{Rotation}}$ = + 9 sec

Runway Deicer



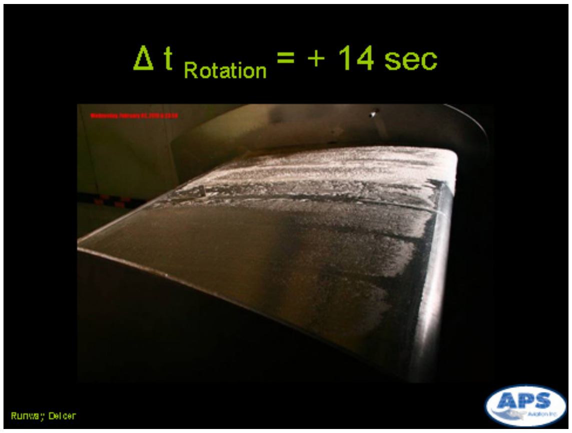
$\Delta t_{\text{Rotation}}$ = + 10 sec

Runway Deicer



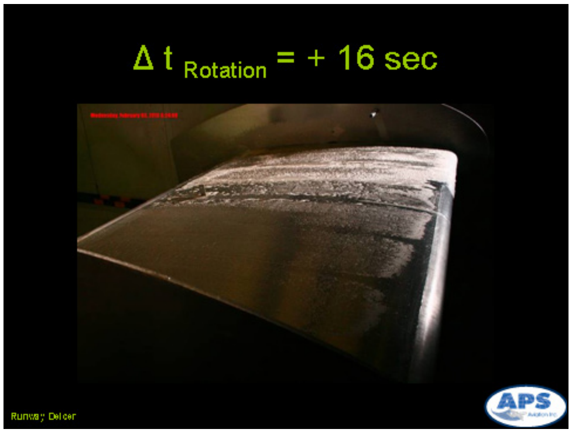
$\Delta t_{\text{Rotation}}$ = + 12 sec

Runway Deicer



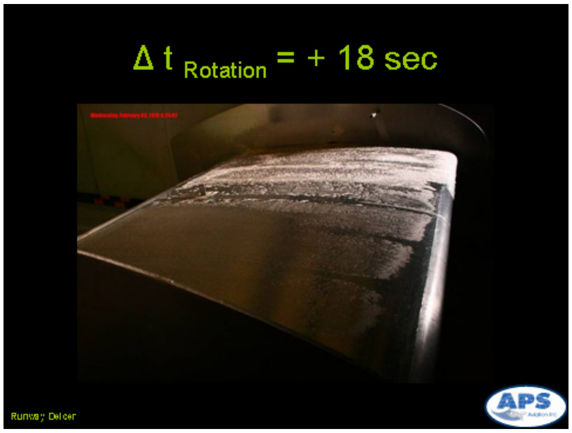
$\Delta t_{\text{Rotation}}$ = + 14 sec

Runway Deicer



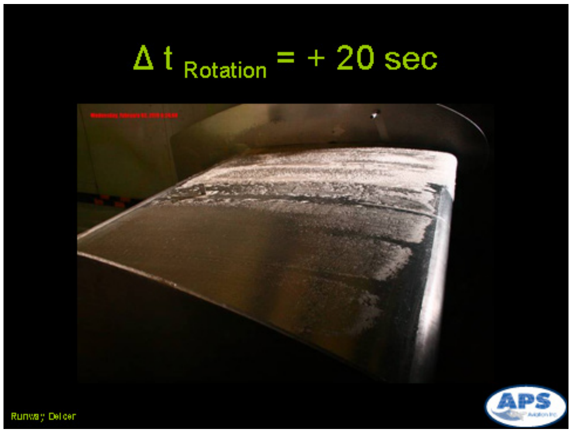
$\Delta t_{Rotation} = +16$ sec

Runway Deicer



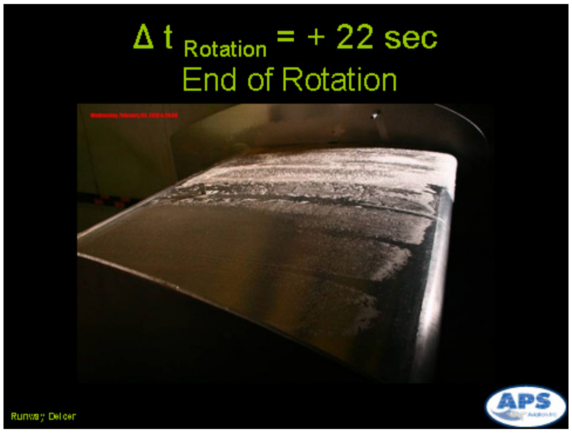
$\Delta t_{Rotation} = +18$ sec

Runway Deicer



$\Delta t_{Rotation} = +20$ sec

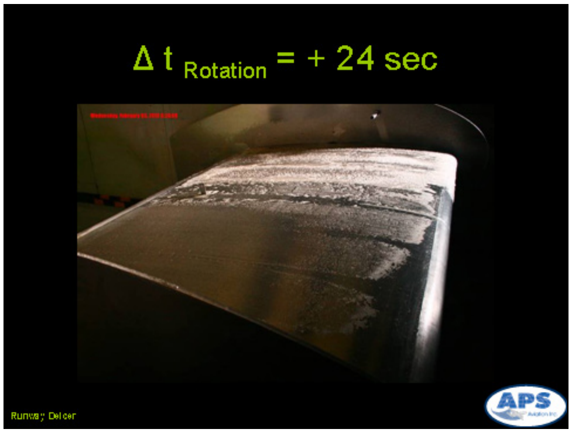
Runway Deicer



$\Delta t_{Rotation} = +22$ sec

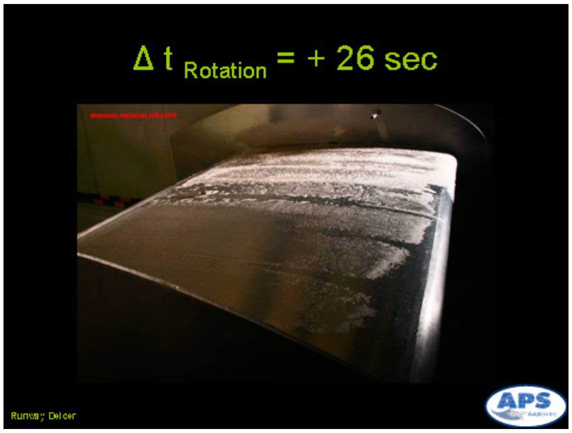
End of Rotation

Runway Deicer



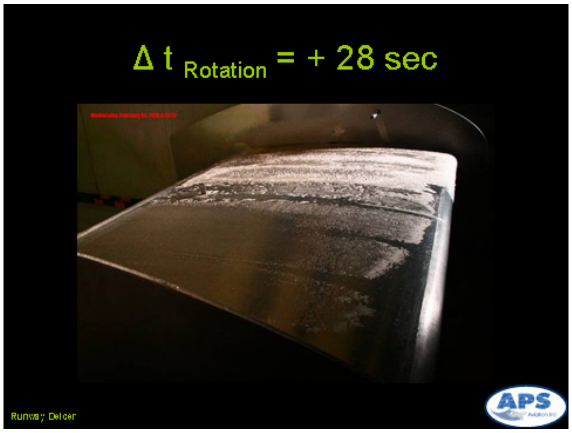
$\Delta t_{Rotation} = +24$ sec

Runway Deicer



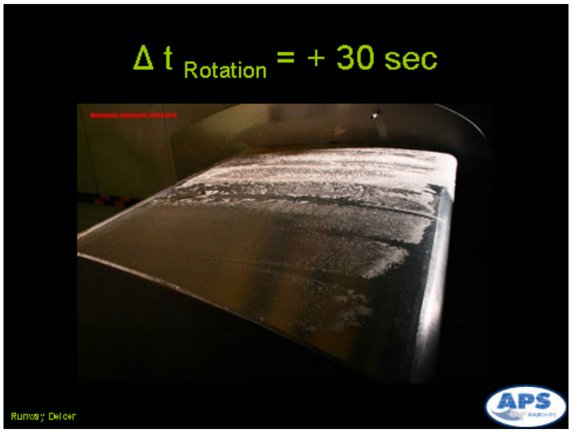
$\Delta t_{Rotation} = +26$ sec

Runway Deicer



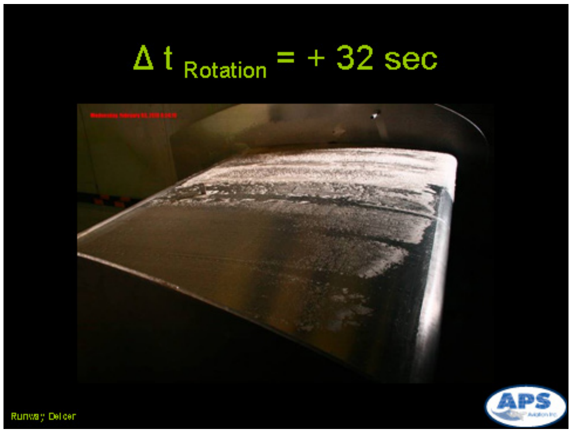
$\Delta t_{\text{Rotation}} = + 28$ sec

Runway Deicer



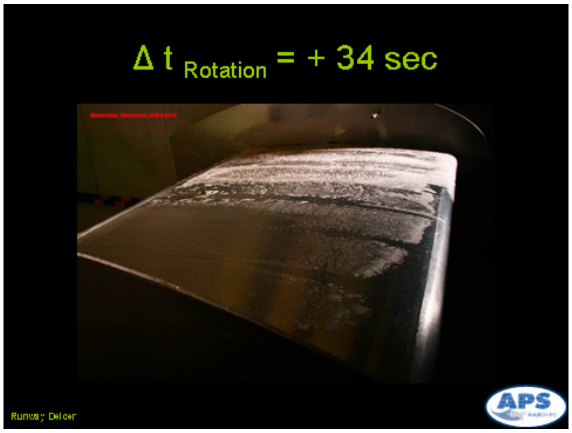
$\Delta t_{\text{Rotation}} = + 30$ sec

Runway Deicer



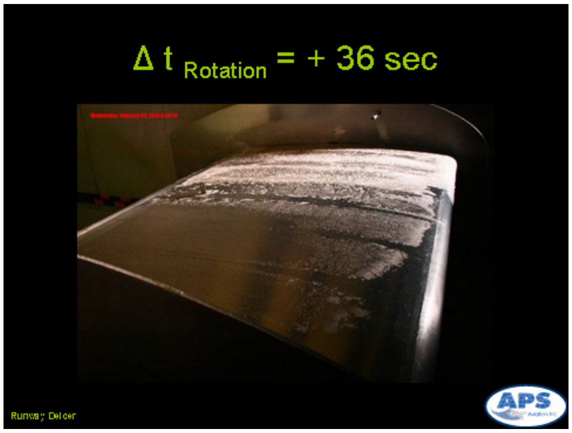
$\Delta t_{\text{Rotation}} = + 32$ sec

Runway Deicer



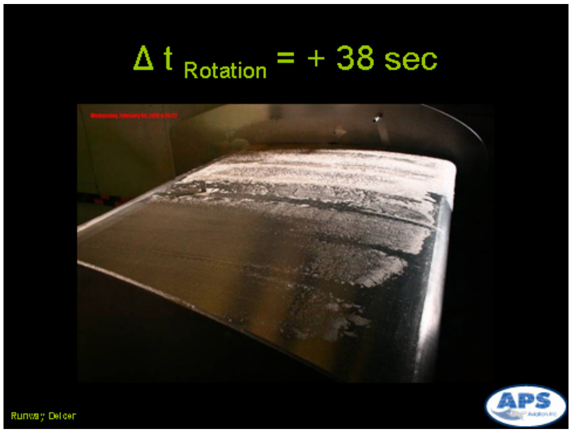
$\Delta t_{\text{Rotation}} = + 34$ sec

Runway Deicer



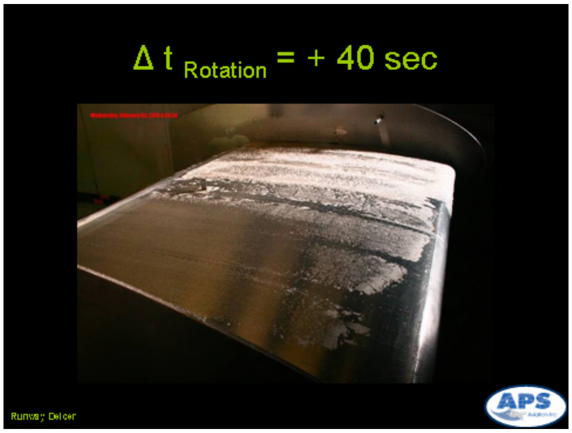
$\Delta t_{\text{Rotation}} = + 36$ sec

Runway Deicer



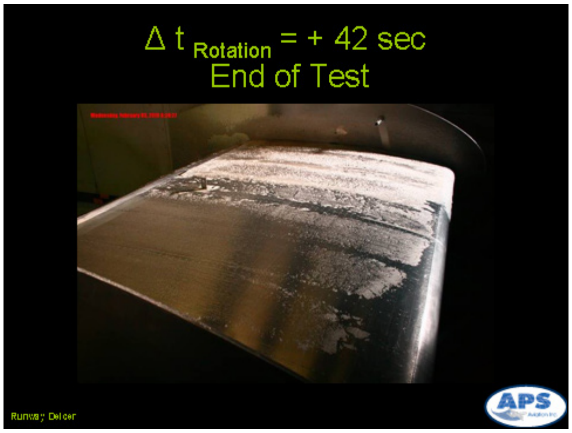
$\Delta t_{\text{Rotation}} = + 38$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = + 40$ sec

Runway Deicer



$\Delta t_{\text{Rotation}} = + 42$ sec

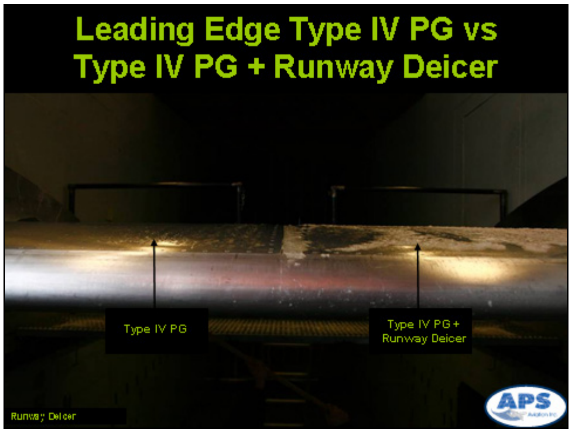
End of Test

Runway Deicer

After High Speed Test Run

(still-shots)

Runway Deicer

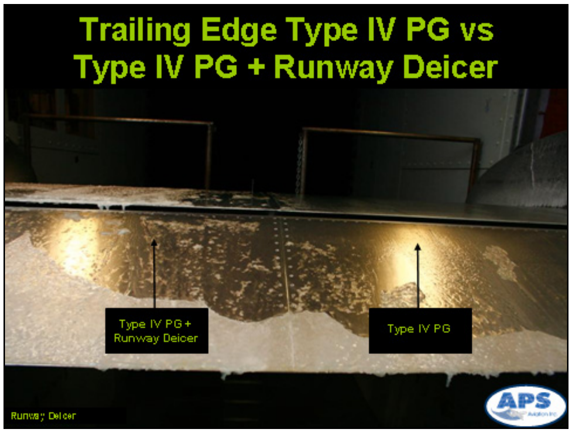


Leading Edge Type IV PG vs Type IV PG + Runway Deicer

Type IV PG
Type IV PG + Runway Deicer

Runway Deicer

APS

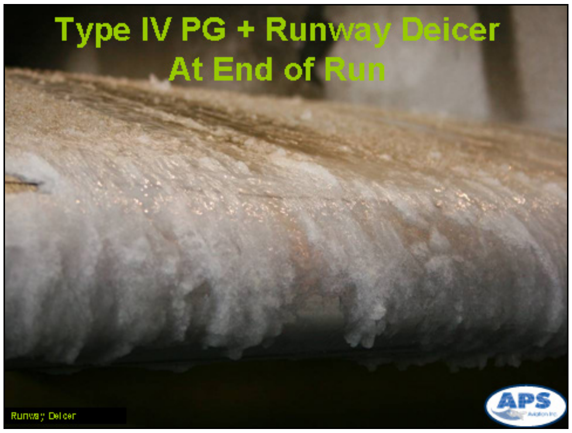


Trailing Edge Type IV PG vs Type IV PG + Runway Deicer

Type IV PG + Runway Deicer
Type IV PG

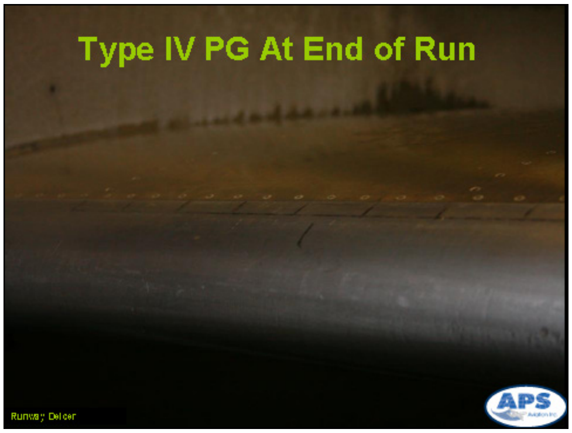
Runway Deicer

APS



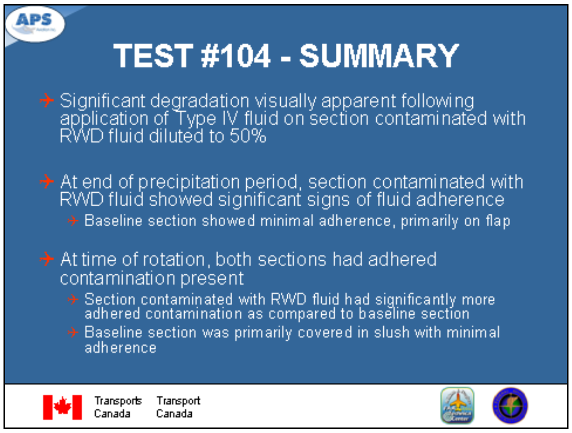
Type IV PG + Runway Deicer At End of Run

Runway Deicer



Type IV PG At End of Run

Runway Deicer



TEST #104 - SUMMARY

- Significant degradation visually apparent following application of Type IV fluid on section contaminated with RWD fluid diluted to 50%
- At end of precipitation period, section contaminated with RWD fluid showed significant signs of fluid adherence
  - Baseline section showed minimal adherence, primarily on flap
- At time of rotation, both sections had adhered contamination present
  - Section contaminated with RWD fluid had significantly more adhered contamination as compared to baseline section
  - Baseline section was primarily covered in slush with minimal adherence

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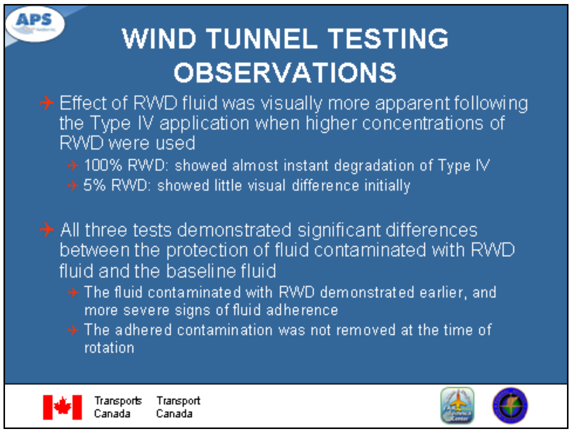

WIND TUNNEL TESTING OBSERVATIONS

- Effect of RWD fluid was visually more apparent following the Type IV application when higher concentrations of RWD were used
  - 100% RWD: showed almost instant degradation of Type IV
  - 5% RWD: showed little visual difference initially
- All three tests demonstrated significant differences between the protection of fluid contaminated with RWD fluid and the baseline fluid
  - The fluid contaminated with RWD demonstrated earlier, and more severe signs of fluid adherence
  - The adhered contamination was not removed at the time of rotation

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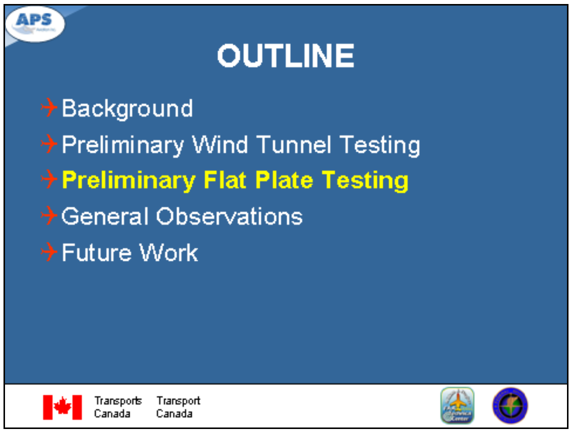

OUTLINE

- Background
- Preliminary Wind Tunnel Testing
- **Preliminary Flat Plate Testing**
- General Observations
- Future Work

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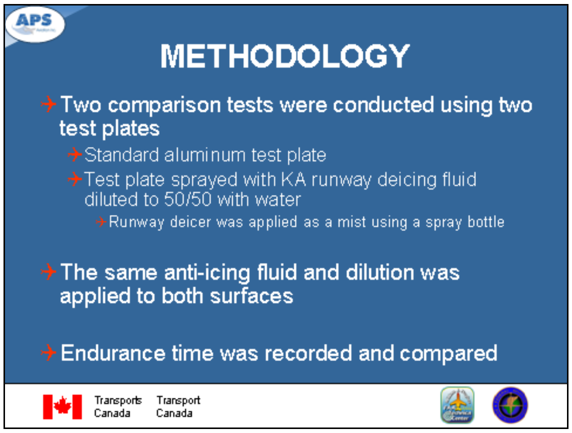

METHODOLOGY

- Two comparison tests were conducted using two test plates
  - Standard aluminum test plate
  - Test plate sprayed with KA runway deicing fluid diluted to 50/50 with water
    - Runway deicer was applied as a mist using a spray bottle
- The same anti-icing fluid and dilution was applied to both surfaces
- Endurance time was recorded and compared

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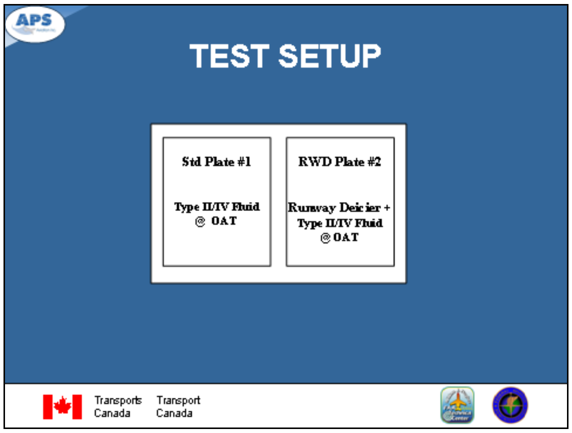

TEST SETUP

Std Plate #1	RWD Plate #2
Type II/IV Fluid @ OAT	Runway Deicer + Type II/IV Fluid @ OAT

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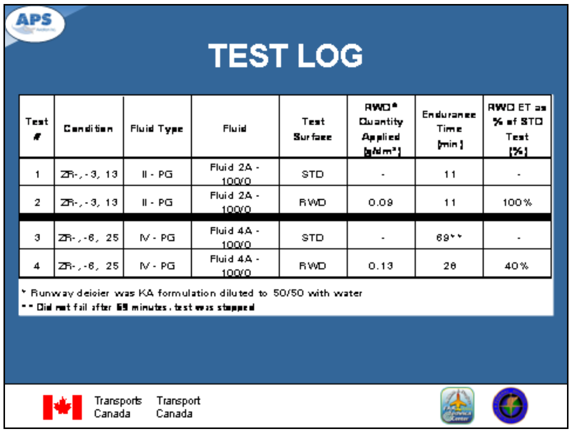

TEST LOG

Test #	Condition	Fluid Type	Fluid	Test Surface	RWD* Quantity Applied (g/dm²)	Endurance Time (min)	RWD ET as % of STD Test (%)
1	ZR-, -3, 13	II - PG	Fluid 2A - 100/0	STD	-	11	-
2	ZR-, -3, 13	II - PG	Fluid 2A - 100/0	RWD	0.09	11	100%
3	ZR-, -6, 25	IV - PG	Fluid 4A - 100/0	STD	-	69**	-
4	ZR-, -6, 25	IV - PG	Fluid 4A - 100/0	RWD	0.13	26	40%

* Runway deicier was KA formulation diluted to 50/50 with water
** Did not fail after 69 minutes, test was stopped

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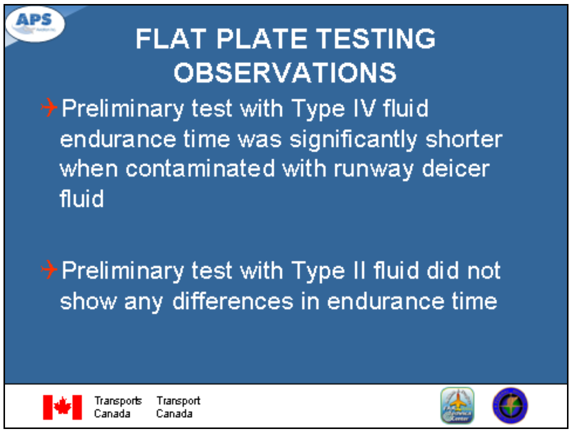

FLAT PLATE TESTING OBSERVATIONS

- Preliminary test with Type IV fluid endurance time was significantly shorter when contaminated with runway deicer fluid
- Preliminary test with Type II fluid did not show any differences in endurance time

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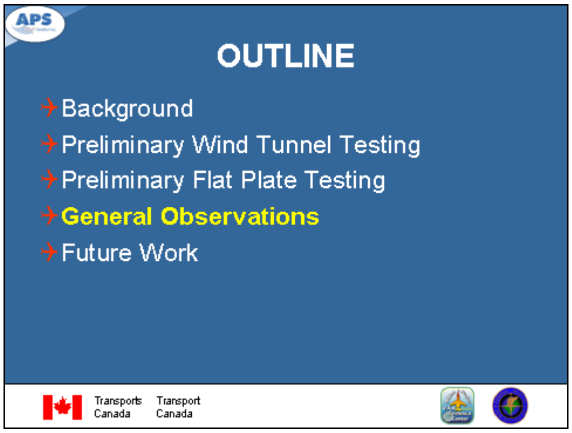

OUTLINE

- Background
- Preliminary Wind Tunnel Testing
- Preliminary Flat Plate Testing
- **General Observations**
- Future Work

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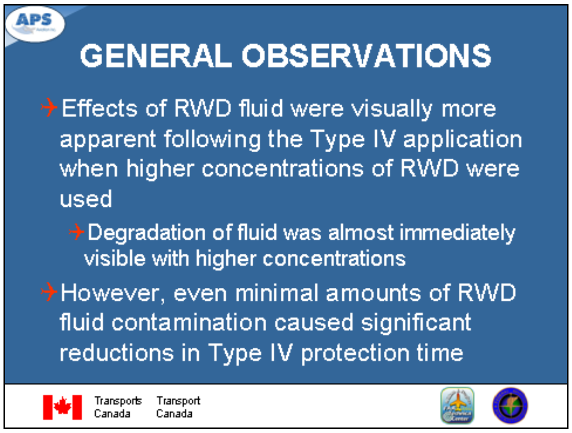

GENERAL OBSERVATIONS

- Effects of RWD fluid were visually more apparent following the Type IV application when higher concentrations of RWD were used
  - Degradation of fluid was almost immediately visible with higher concentrations
- However, even minimal amounts of RWD fluid contamination caused significant reductions in Type IV protection time

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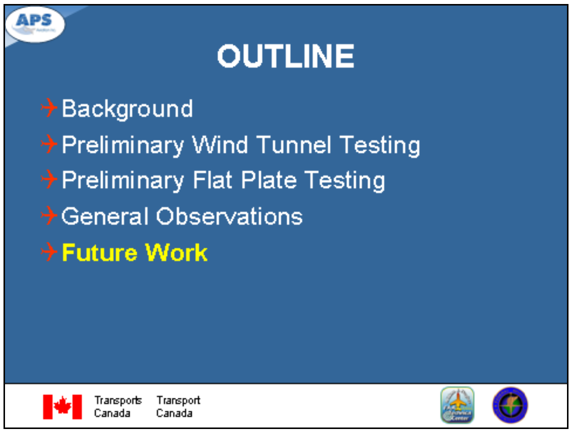
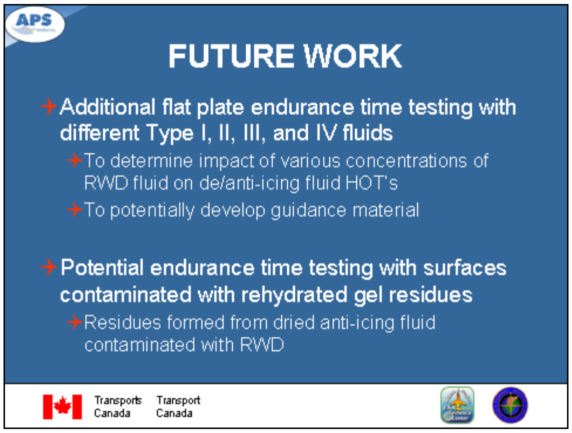


OUTLINE

- Background
- Preliminary Wind Tunnel Testing
- Preliminary Flat Plate Testing
- General Observations
- **Future Work**

Transports Canada Transport Canada



FUTURE WORK

- Additional flat plate endurance time testing with different Type I, II, III, and IV fluids
  - To determine impact of various concentrations of RWD fluid on de/anti-icing fluid HOT's
  - To potentially develop guidance material
- Potential endurance time testing with surfaces contaminated with rehydrated gel residues
  - Residues formed from dried anti-icing fluid contaminated with RWD

Transports Canada Transport Canada

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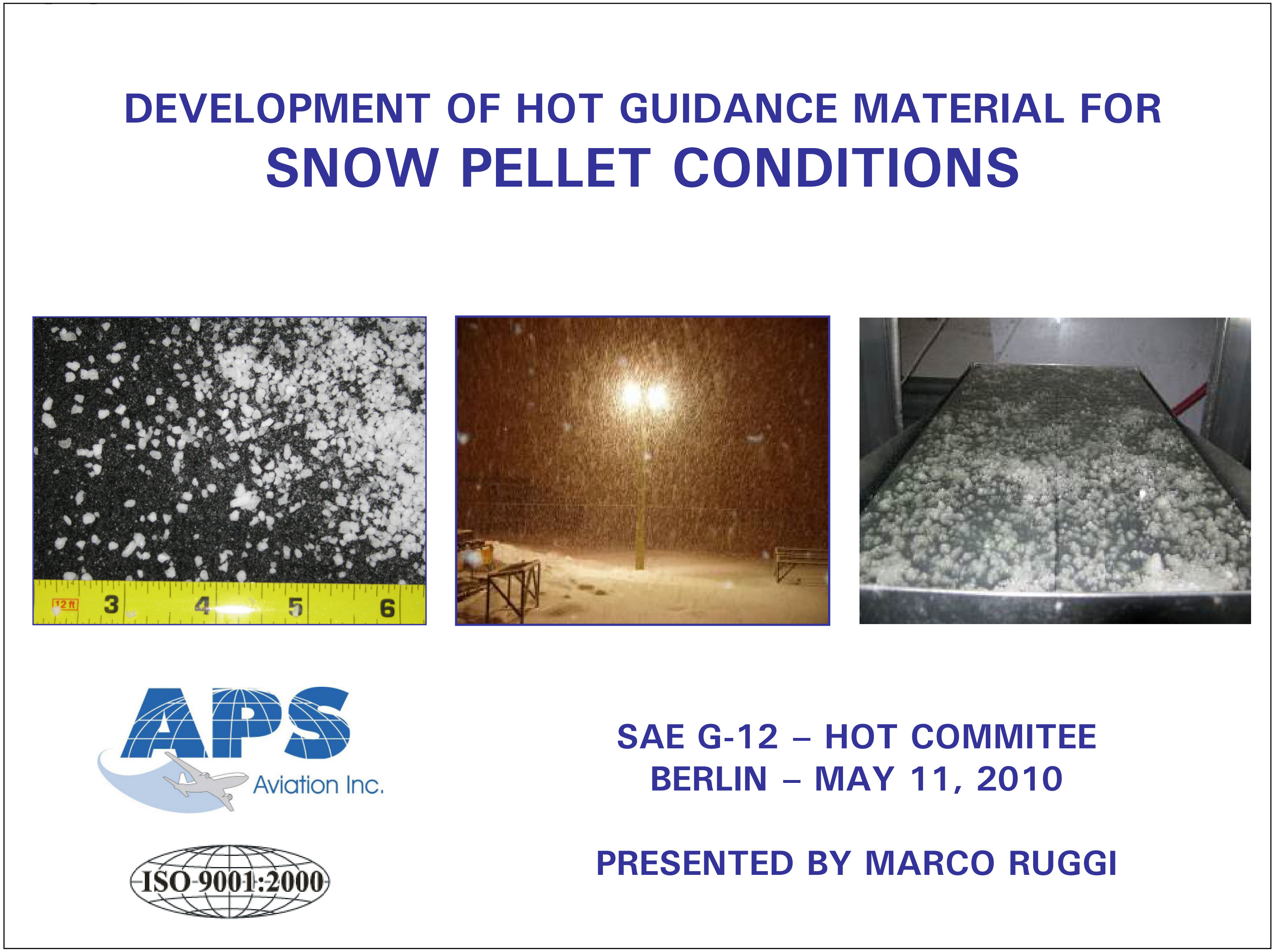


DEVELOPMENT OF HOT GUIDANCE MATERIAL FOR
SNOW PELLET CONDITIONS

APS Aviation Inc.

ISO 9001:2000

SAE G-12 – HOT COMMITEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI

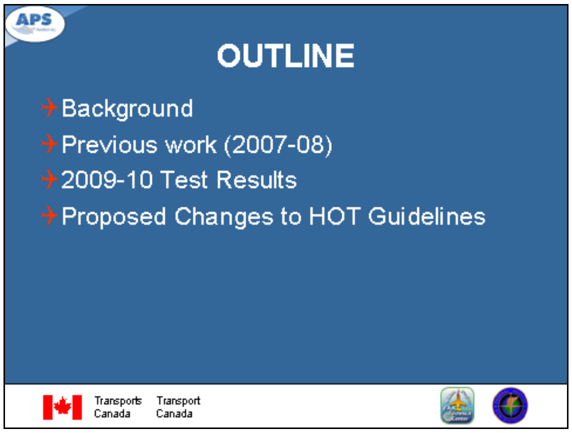
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

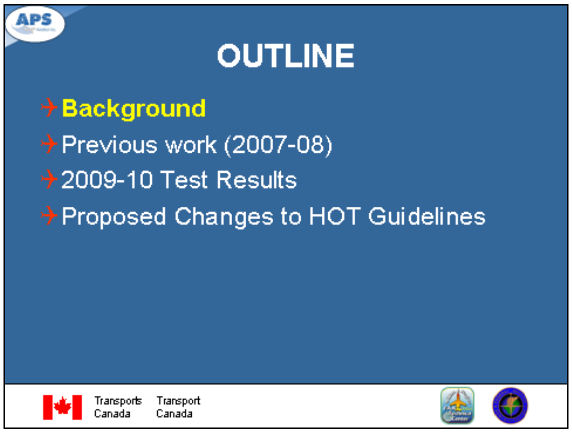
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Previous work (2007-08)
- 2009-10 Test Results
- Proposed Changes to HOT Guidelines

Transports Canada Transport Canada



OUTLINE

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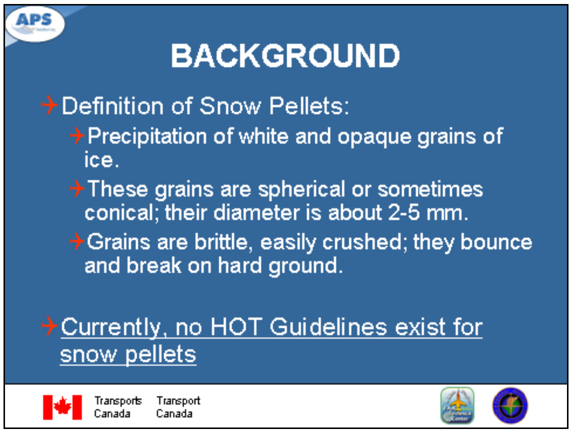
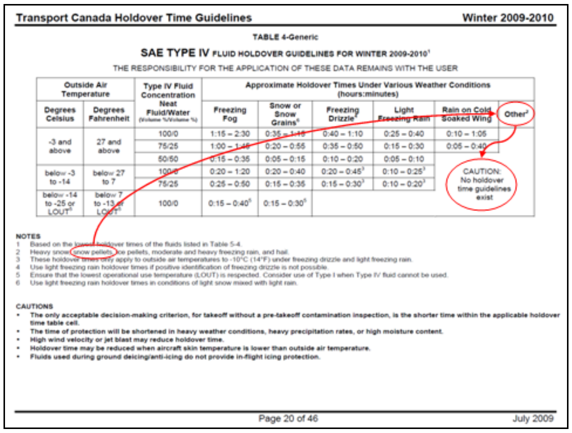
Transports Canada Transport Canada



BACKGROUND

- Definition of Snow Pellets:
  - 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

Transports Canada Transport Canada



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010^{1}

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains^{6}	Freezing Drizzle^{4}	Light Freezing Rain	Rain on Cold Soaked Wing	Other^{2}
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45^{3}	0:10 – 0:25^{3}		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30^{3}	0:10 – 0:20^{3}		
below -14 to -25 or LOUT^{5}	below 7 to -13 or LOUT^{5}	100/0	0:15 – 0:40^{5}	0:15 – 0:30^{5}				

CAUTION:
No holdover time guidelines exist

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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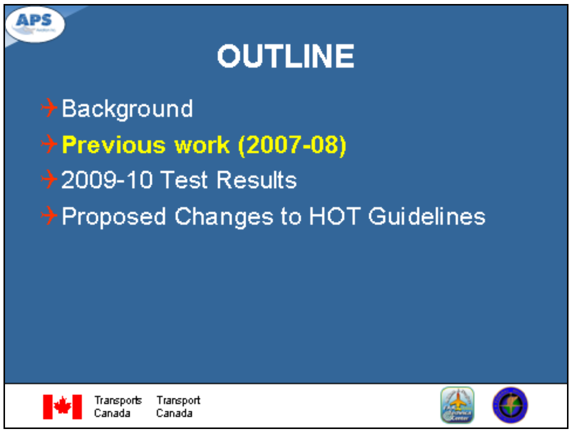
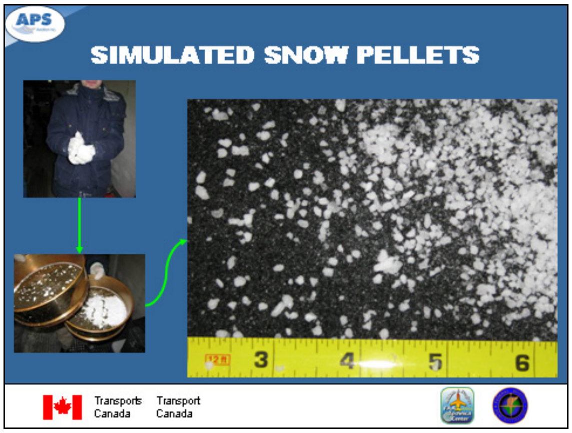


OUTLINE

- Background
- **Previous work (2007-08)**
- 2009-10 Test Results
- Proposed Changes to HOT Guidelines

Transports Canada Transport Canada



SIMULATED SNOW PELLETS

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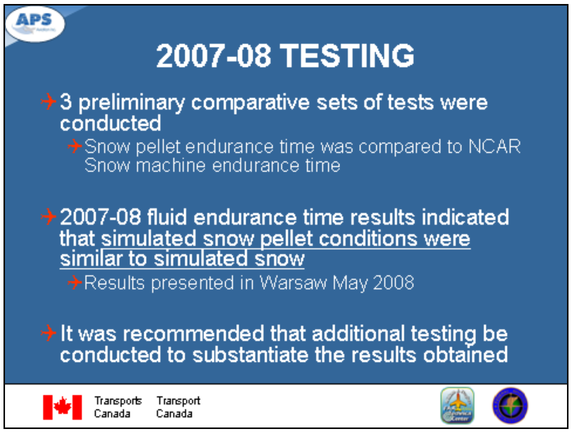

2007-08 TESTING

- 3 preliminary comparative sets of tests were conducted
  - Snow pellet endurance time was compared to NCAR Snow machine endurance time
- 2007-08 fluid endurance time results indicated that simulated snow pellet conditions were similar to simulated snow
  - Results presented in Warsaw May 2008
- It was recommended that additional testing be conducted to substantiate the results obtained

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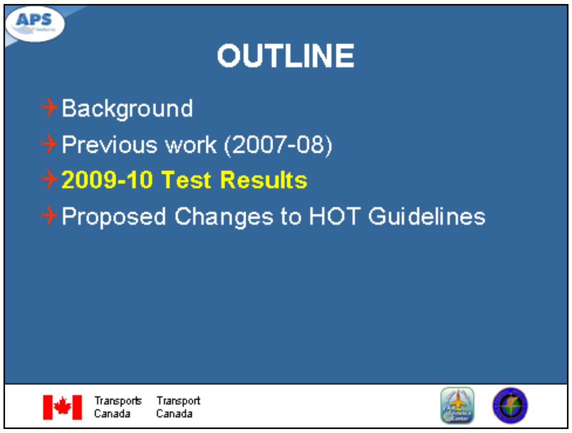

OUTLINE

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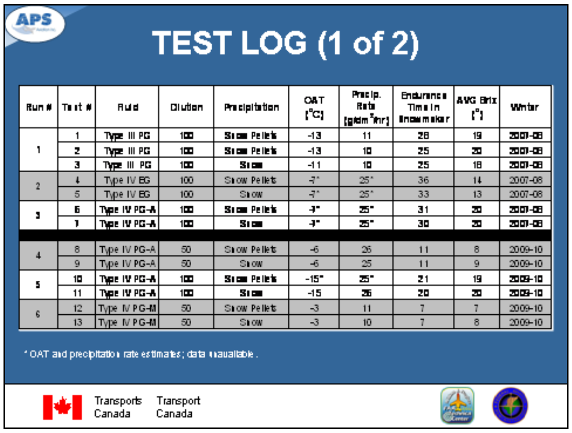
Transports Canada Transport Canada



TEST LOG (1 of 2)

Run #	Test #	Fluid	Dilution	Precipitation	OAT (°C)	Precip. Rate $(g/dm^2/hr)$	Endurance Time in Snowmaker	AVG Brix (°)	Winter
1	1	Type III PG	100	Snow Pellets	-13	11	28	19	2007-08
	2	Type III PG	100	Snow Pellets	-13	10	25	20	2007-08
	3	Type III PG	100	Snow	-11	10	25	18	2007-08
2	4	Type IV EG	100	Snow Pellets	-7*	25*	36	14	2007-08
	5	Type IV EG	100	Snow	-7*	25*	33	13	2007-08
3	6	Type IV PG-A	100	Snow Pellets	-7*	25*	31	20	2007-08
	7	Type IV PG-A	100	Snow	-7*	25*	30	20	2007-08
4	8	Type IV PG-A	50	Snow Pellets	-6	26	11	8	2009-10
	9	Type IV PG-A	50	Snow	-6	25	11	9	2009-10
5	10	Type IV PG-A	100	Snow Pellets	-15*	25*	21	19	2009-10
	11	Type IV PG-A	100	Snow	-15	26	20	20	2009-10
6	12	Type IV PG-M	50	Snow Pellets	-3	11	7	7	2009-10
	13	Type IV PG-M	50	Snow	-3	10	7	8	2009-10

* OAT and precipitation rate estimates; data unavailable.

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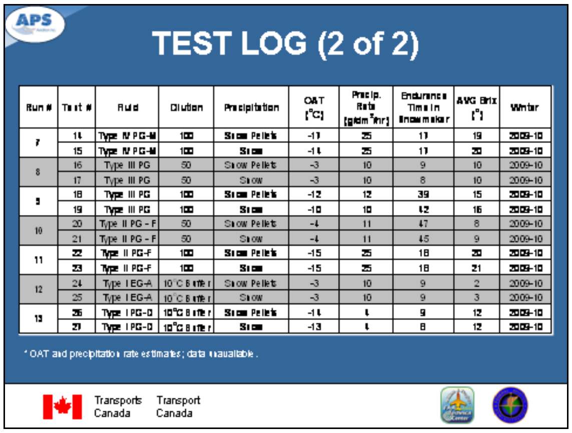

TEST LOG (2 of 2)

Run #	Test #	Fluid	Dilution	Precipitation	OAT (°C)	Precip. Rate $(g/dm^2/hr)$	Endurance Time in Snowmaker	AVG Brix (°)	Winter
7	14	Type IV PG-M	100	Snow Pellets	-17	25	17	19	2009-10
	15	Type IV PG-M	100	Snow	-14	25	17	20	2009-10
8	16	Type III PG	50	Snow Pellets	-3	10	9	10	2009-10
	17	Type III PG	50	Snow	-3	10	8	10	2009-10
9	18	Type III PG	100	Snow Pellets	-12	12	39	15	2009-10
	19	Type III PG	100	Snow	-10	10	42	16	2009-10
10	20	Type II PG - F	50	Snow Pellets	-4	11	47	8	2009-10
	21	Type II PG - F	50	Snow	-4	11	45	9	2009-10
11	22	Type II PG-F	100	Snow Pellets	-15	25	18	20	2009-10
	23	Type II PG-F	100	Snow	-15	25	18	21	2009-10
12	24	Type I EG-A	10°C Buffer	Snow Pellets	-3	10	9	2	2009-10
	25	Type I EG-A	10°C Buffer	Snow	-3	10	9	3	2009-10
13	26	Type I PG-D	10°C Buffer	Snow Pellets	-14	4	9	12	2009-10
	27	Type I PG-D	10°C Buffer	Snow	-13	4	8	12	2009-10

* OAT and precipitation rate estimates; data unavailable.

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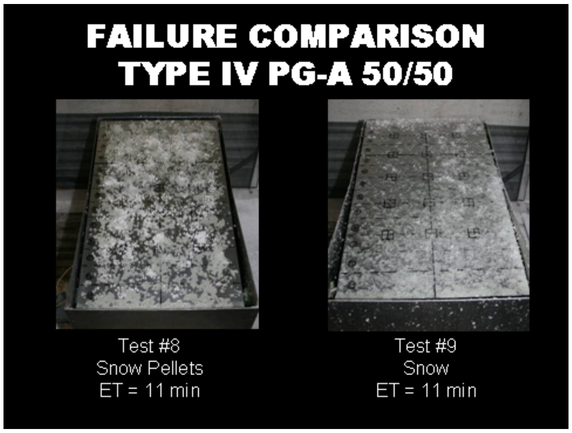
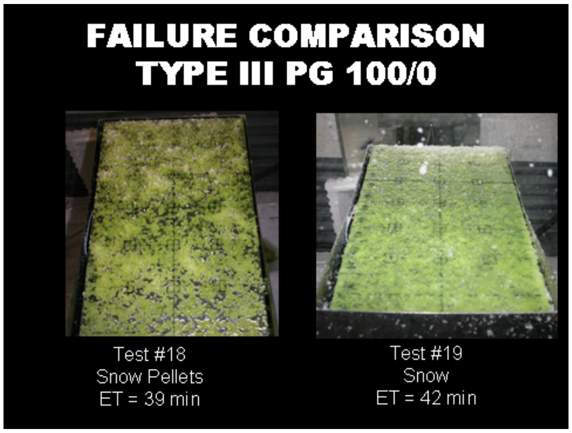


FAILURE COMPARISON TYPE IV PG-A 50/50

Test #8
Snow Pellets
ET = 11 min

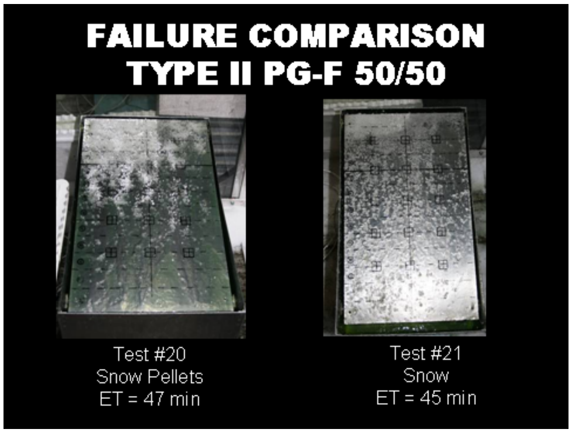
Test #9
Snow
ET = 11 min



FAILURE COMPARISON TYPE III PG 100/0

Test #18
Snow Pellets
ET = 39 min

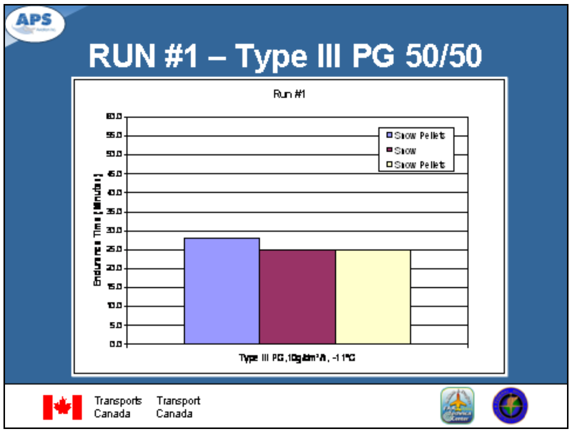
Test #19
Snow
ET = 42 min



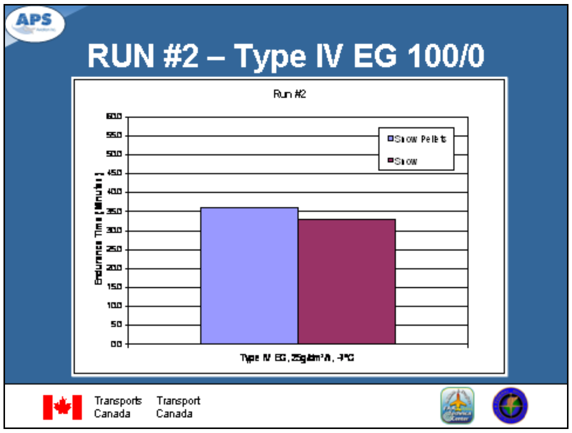
FAILURE COMPARISON TYPE II PG-F 50/50

Test #20
Snow Pellets
ET = 47 min

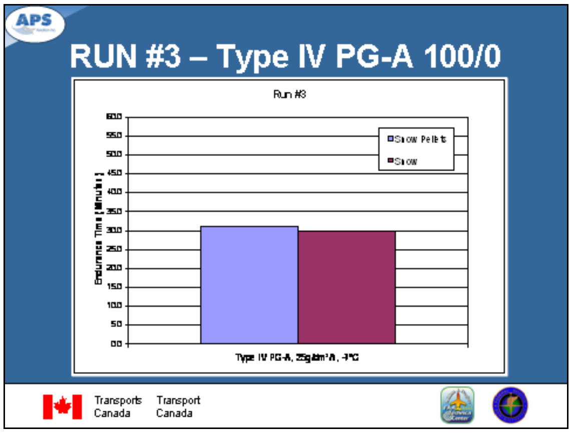
Test #21
Snow
ET = 45 min



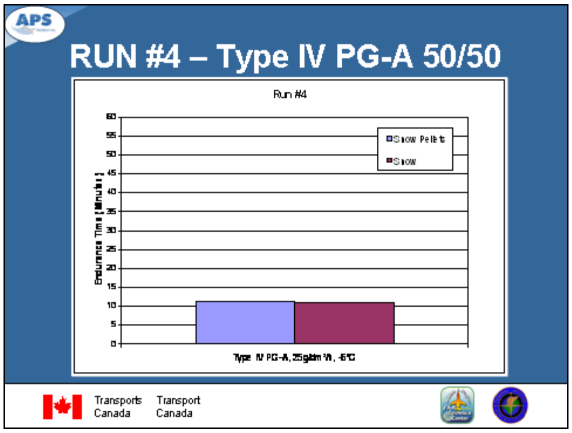
RUN #1 – Type III PG 50/50



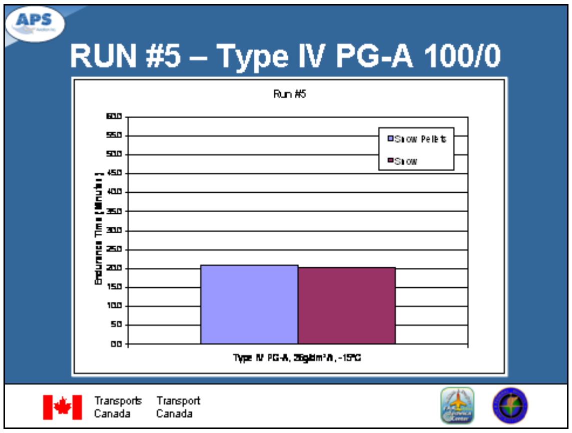
RUN #2 – Type IV EG 100/0



RUN #3 – Type IV PG-A 100/0



RUN #4 – Type IV PG-A 50/50



RUN #5 – Type IV PG-A 100/0

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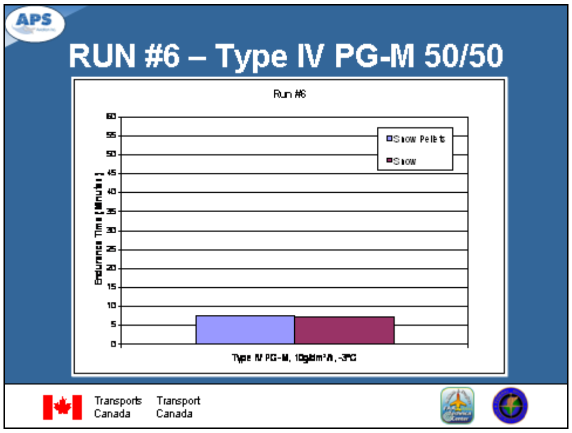
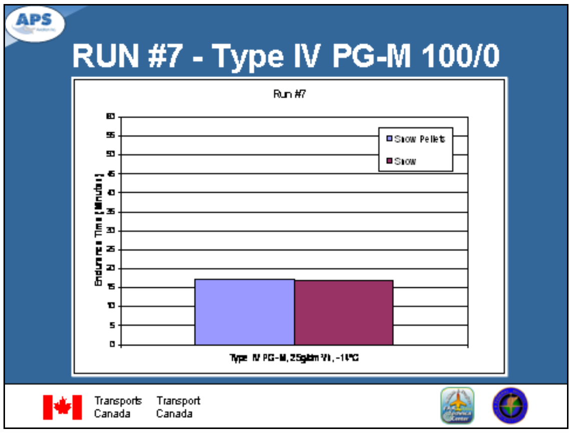


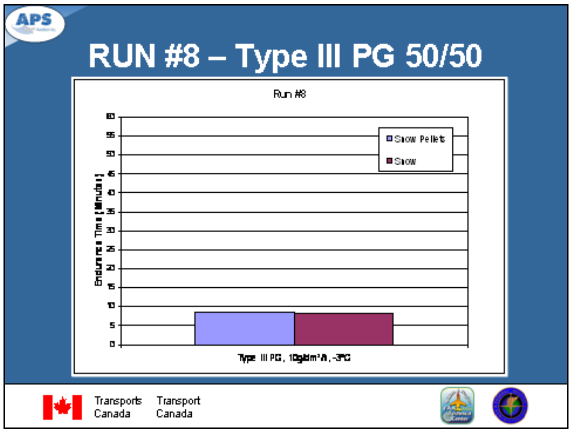
RUN #6 – Type IV PG-M 50/50

Transports Canada Transport Canada



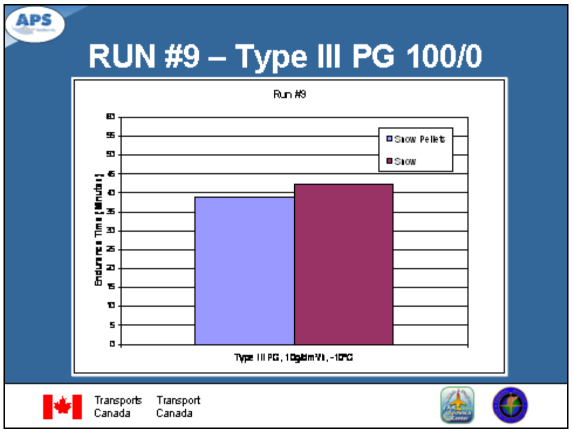
RUN #7 - Type IV PG-M 100/0

Transports Canada Transport Canada



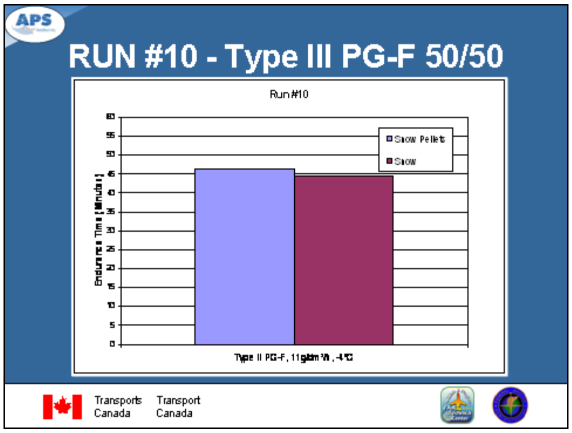
RUN #8 – Type III PG 50/50

Transports Canada Transport Canada



RUN #9 – Type III PG 100/0

Transports Canada Transport Canada



RUN #10 - Type III PG-F 50/50

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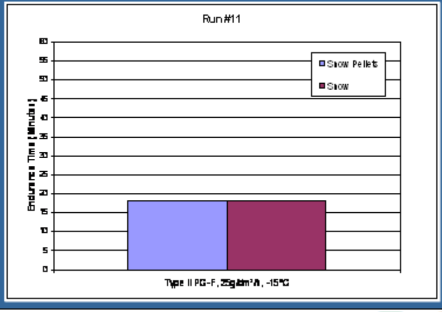
RUN #11 - Type III PG-F 100/0



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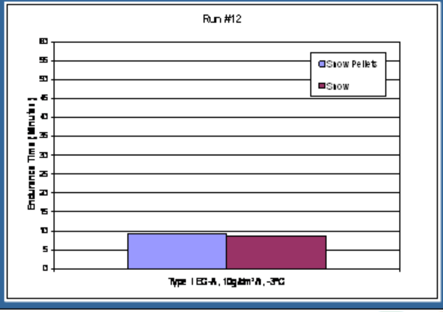
RUN #12 – TYPE I EG-A 10° BUFFER



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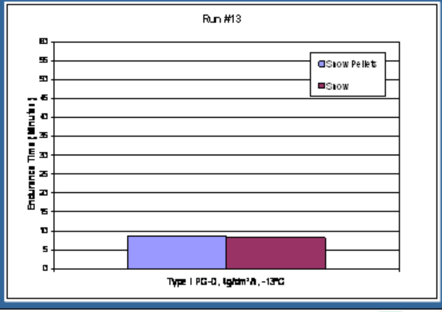
RUN #13 – TYPE I PG-D 10° BUFFER



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SUMMARY OF TEST RESULTS

- 10 comparative tests were conducted during the winter of 2009-10
  - 3 tests had been previously conducted in 2007-08
- Results from 2009-10 were inline with the 2007-08 test results
- Overall, fluid endurance times in simulated snow pellet conditions were generally similar or slightly longer than simulated snow
  - Results were typically 3% longer ±3.7%

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ADDITIONAL INFORMATION

- Data used to generate snow holdover times may already include snow pellets
  - Snow pellet events are usually brief
  - Endurance time testing conducted during snow pellets would not have been discarded unless the condition was severe
- Snow pellets will generally occur during snow conditions, not during freezing rain or freezing drizzle conditions, therefore low risk of adherence

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OUTLINE

- Background
- Previous work (2007-08)
- 2009-10 Test Results
- **Proposed Changes to HOT Guidelines**

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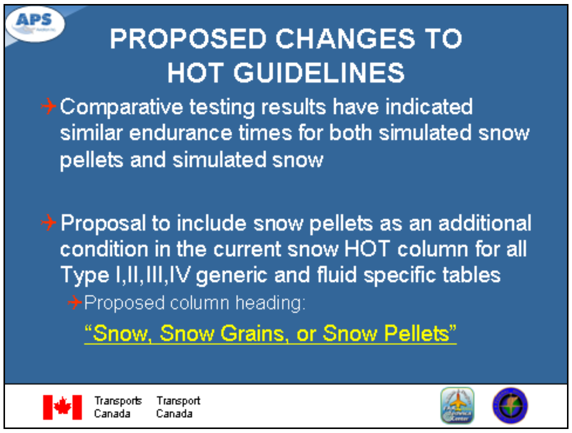

PROPOSED CHANGES TO HOT GUIDELINES

- Comparative testing results have indicated similar endurance times for both simulated snow pellets and simulated snow
- Proposal to include snow pellets as an additional condition in the current snow HOT column for all Type I,II,III,IV generic and fluid specific tables
  - Proposed column heading:

    "Snow, Snow Grains, or Snow Pellets"

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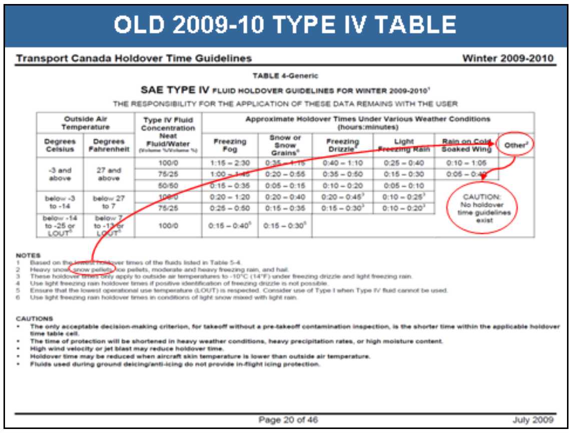

OLD 2009-10 TYPE IV TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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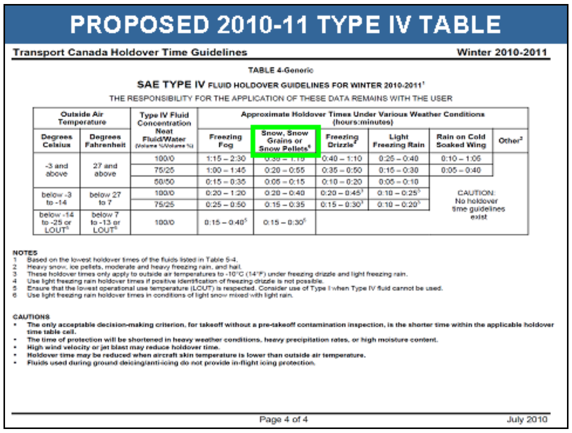

PROPOSED 2010-11 TYPE IV TABLE

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
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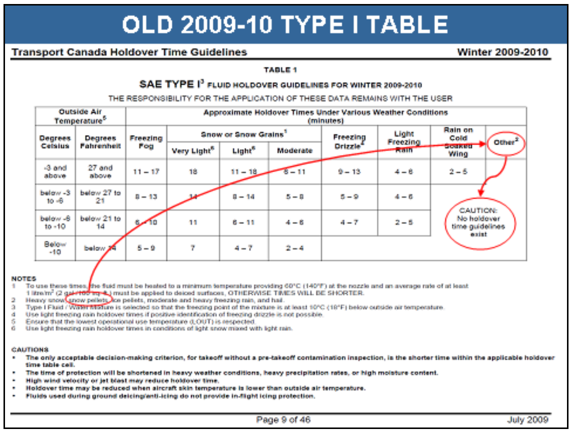

OLD 2009-10 TYPE I TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
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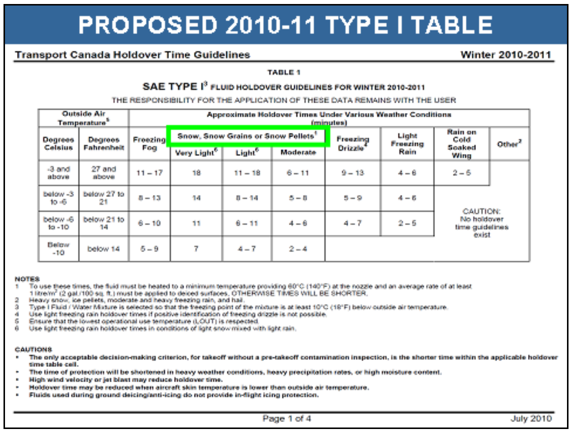

PROPOSED 2010-11 TYPE I TABLE

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow, Snow Grains or Snow Pellets[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, 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.
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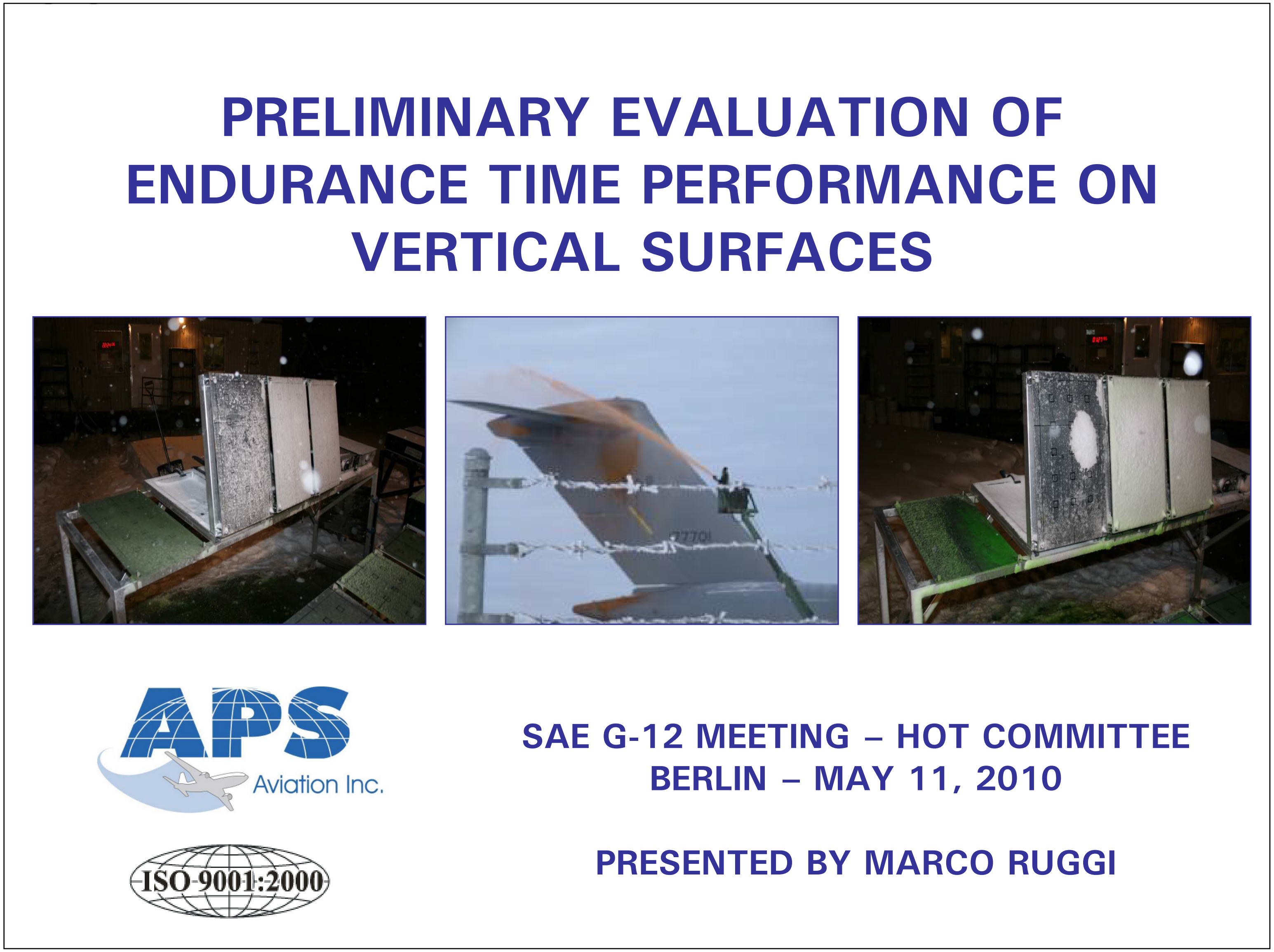


PRELIMINARY EVALUATION OF ENDURANCE TIME PERFORMANCE ON VERTICAL SURFACES

APS Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING – HOT COMMITTEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI

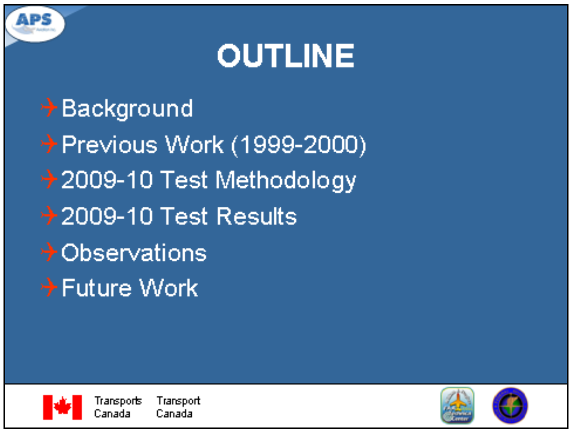
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Previous Work (1999-2000)
- 2009-10 Test Methodology
- 2009-10 Test Results
- Observations
- Future Work

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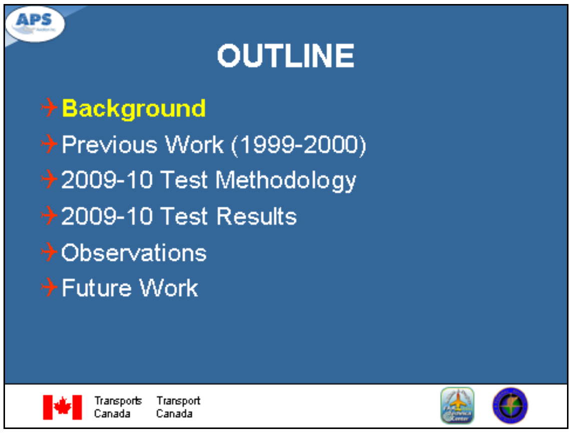

OUTLINE

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- Previous Work (1999-2000)
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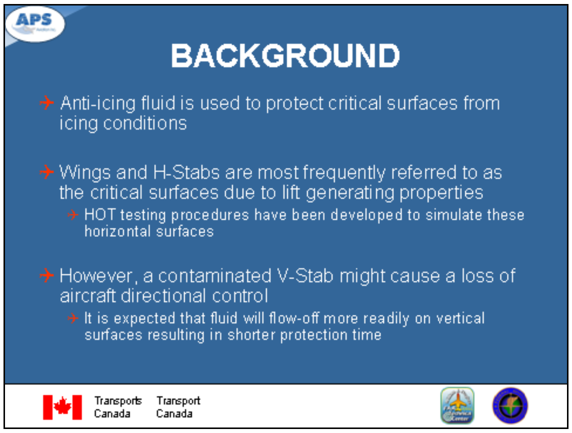

BACKGROUND

- Anti-icing fluid is used to protect critical surfaces from icing conditions
- Wings and H-Stabs are most frequently referred to as the critical surfaces due to lift generating properties
  - HOT testing procedures have been developed to simulate these horizontal surfaces
- However, a contaminated V-Stab might cause a loss of aircraft directional control
  - It is expected that fluid will flow-off more readily on vertical surfaces resulting in shorter protection time

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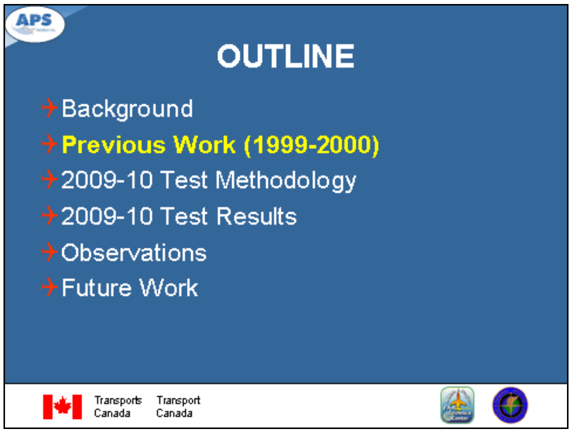
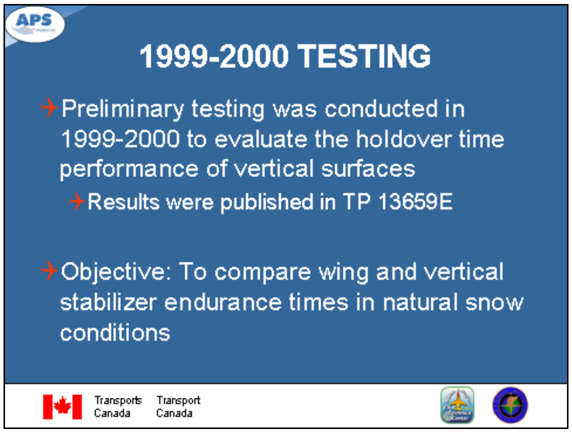


OUTLINE

- Background
- **Previous Work (1999-2000)**
- 2009-10 Test Methodology
- 2009-10 Test Results
- Observations
- Future Work

Transports Canada Transport Canada



1999-2000 TESTING

- Preliminary testing was conducted in 1999-2000 to evaluate the holdover time performance of vertical surfaces
  - Results were published in TP 13659E
- Objective: To compare wing and vertical stabilizer endurance times in natural snow conditions

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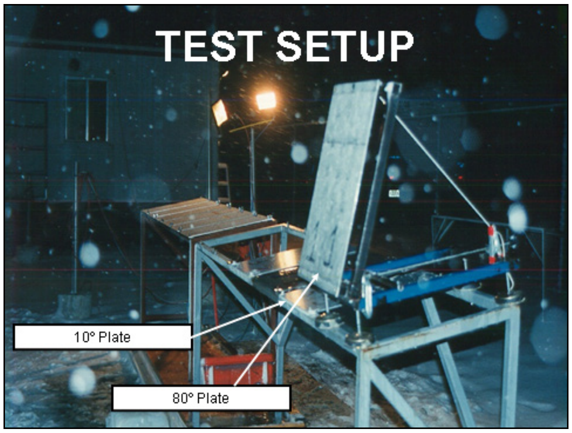
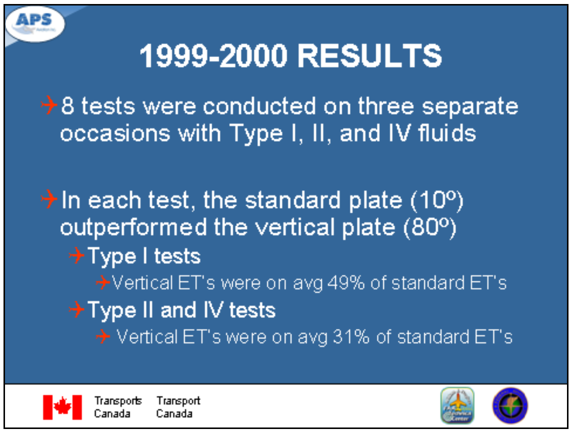


TEST SETUP



1999-2000 RESULTS

- 8 tests were conducted on three separate occasions with Type I, II, and IV fluids
- In each test, the standard plate (10º) outperformed the vertical plate (80º)
  - Type I tests
    - Vertical ET's were on avg 49% of standard ET's
  - Type II and IV tests
    - Vertical ET's were on avg 31% of standard ET's

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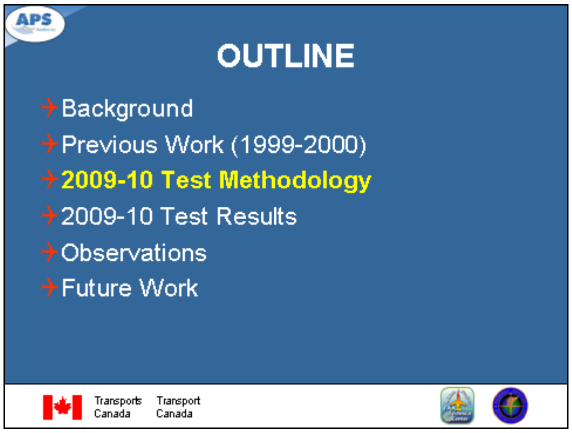
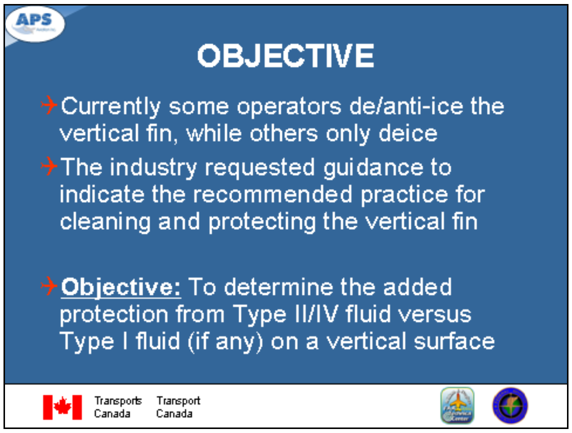


OUTLINE

- Background
- Previous Work (1999-2000)
- **2009-10 Test Methodology**
- 2009-10 Test Results
- Observations
- Future Work

Transports Canada Transport Canada



OBJECTIVE

- Currently some operators de/anti-ice the vertical fin, while others only deice
- The industry requested guidance to indicate the recommended practice for cleaning and protecting the vertical fin
- **Objective:** To determine the added protection from Type II/IV fluid versus Type I fluid (if any) on a vertical surface

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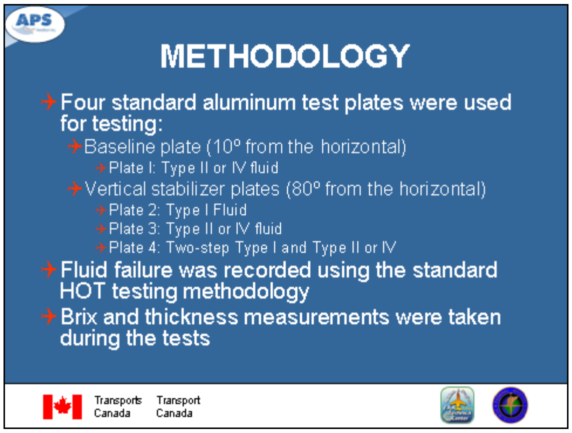

METHODOLOGY

- Four standard aluminum test plates were used for testing:
  - Baseline plate (10º from the horizontal)
    - Plate I: Type II or IV fluid
  - Vertical stabilizer plates (80º from the horizontal)
    - Plate 2: Type I Fluid
    - Plate 3: Type II or IV fluid
    - Plate 4: Two-step Type I and Type II or IV
- Fluid failure was recorded using the standard HOT testing methodology
- Brix and thickness measurements were taken during the tests

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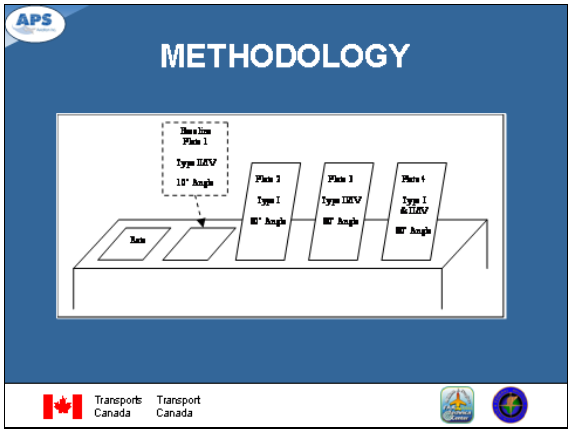

METHODOLOGY

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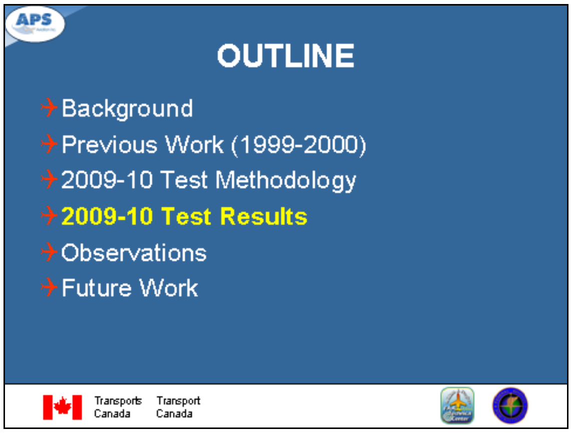

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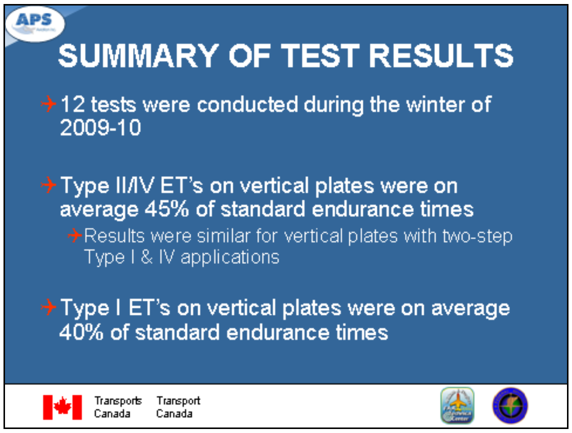

SUMMARY OF TEST RESULTS

- 12 tests were conducted during the winter of 2009-10
- Type II/IV ET's on vertical plates were on average 45% of standard endurance times
  - Results were similar for vertical plates with two-step Type I & IV applications
- Type I ET's on vertical plates were on average 40% of standard endurance times

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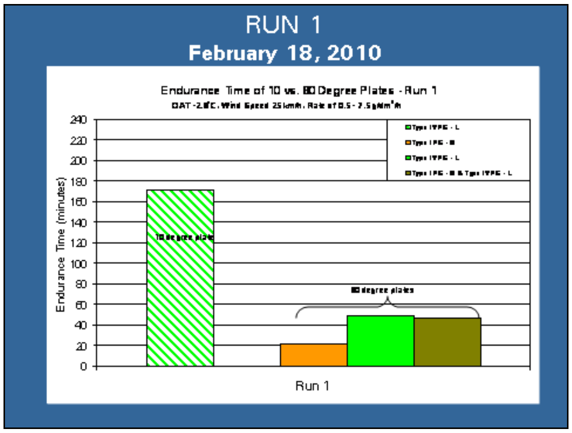
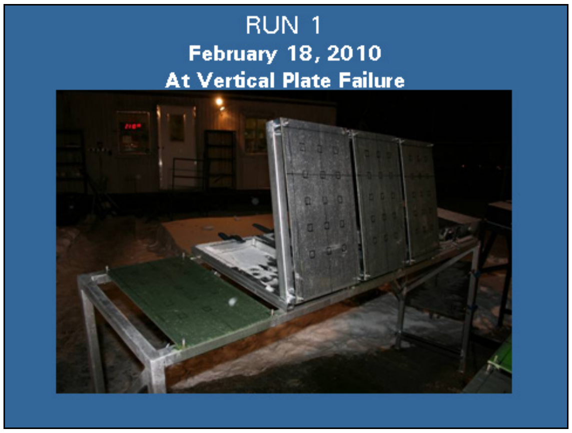
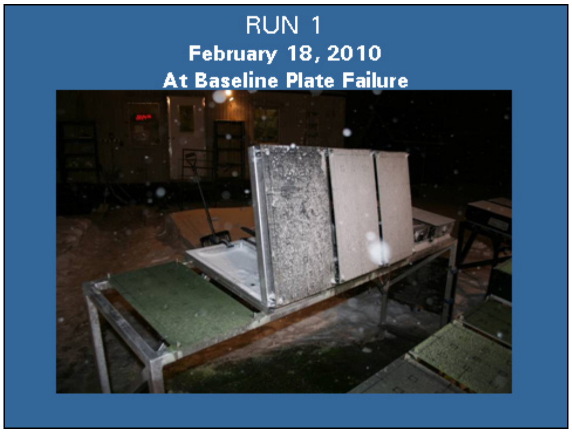
Photo Examples



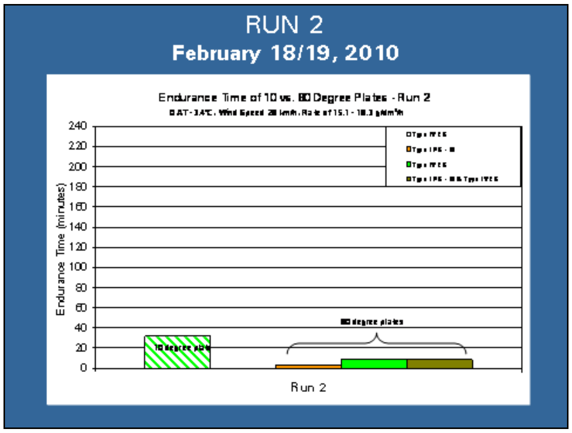
RUN 1
February 18, 2010



RUN 1
February 18, 2010
At Vertical Plate Failure

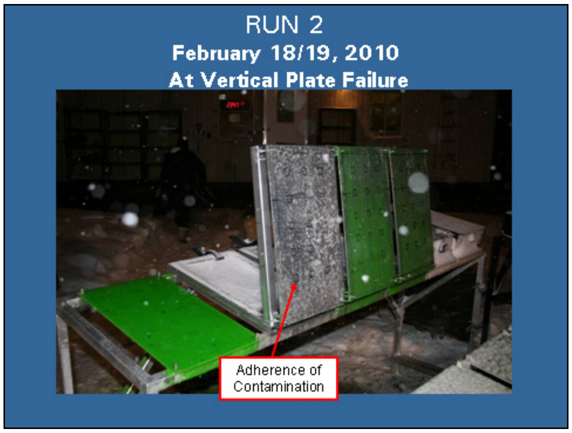


RUN 1
February 18, 2010
At Baseline Plate Failure



RUN 2

February 18/19, 2010

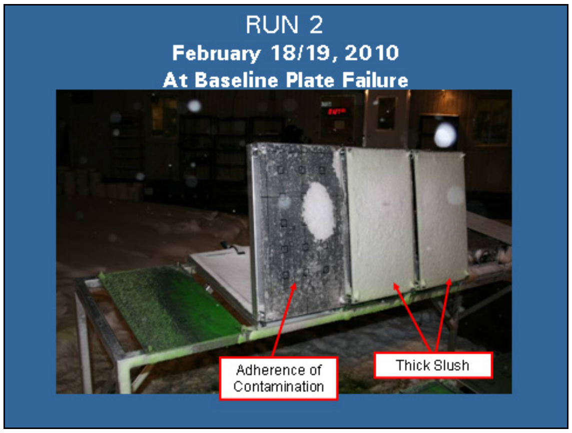


RUN 2

February 18/19, 2010

At Vertical Plate Failure

Adherence of Contamination



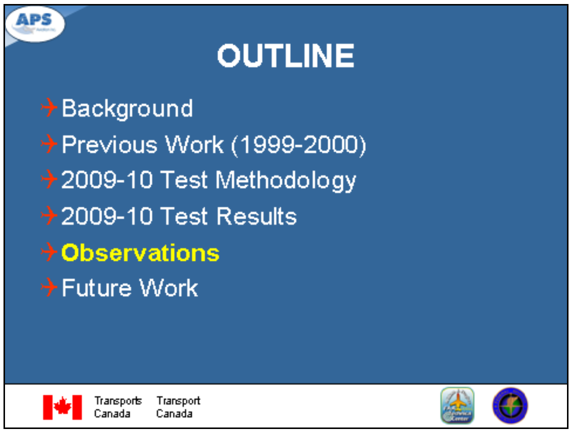
RUN 2

February 18/19, 2010

At Baseline Plate Failure

Adherence of Contamination

Thick Slush



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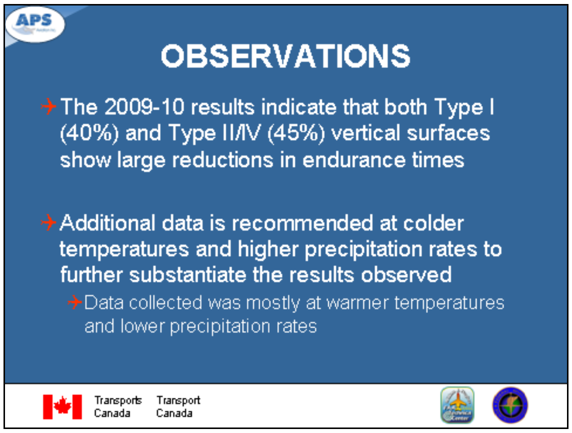

OBSERVATIONS

- The 2009-10 results indicate that both Type I (40%) and Type II/IV (45%) vertical surfaces show large reductions in endurance times
- Additional data is recommended at colder temperatures and higher precipitation rates to further substantiate the results observed
  - Data collected was mostly at warmer temperatures and lower precipitation rates

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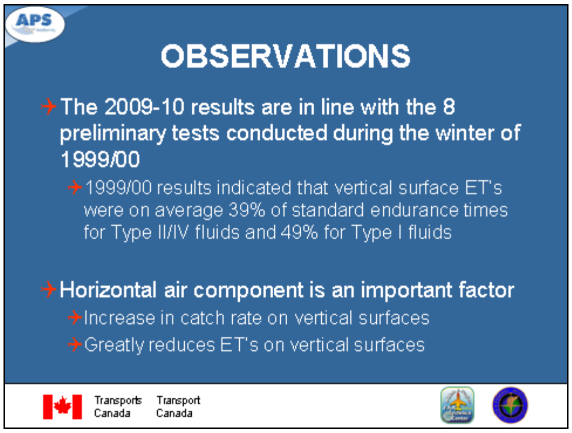

OBSERVATIONS

- The 2009-10 results are in line with the 8 preliminary tests conducted during the winter of 1999/00
  - 1999/00 results indicated that vertical surface ET's were on average 39% of standard endurance times for Type II/IV fluids and 49% for Type I fluids
- Horizontal air component is an important factor
  - Increase in catch rate on vertical surfaces
  - Greatly reduces ET's on vertical surfaces

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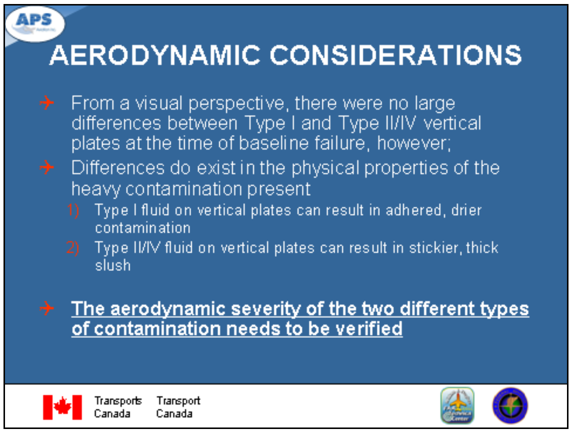

AERODYNAMIC CONSIDERATIONS

- From a visual perspective, there were no large differences between Type I and Type II/IV vertical plates at the time of baseline failure, however;
- Differences do exist in the physical properties of the heavy contamination present
  1) Type I fluid on vertical plates can result in adhered, drier contamination
  2) Type II/IV fluid on vertical plates can result in stickier, thick slush
- **The aerodynamic severity of the two different types of contamination needs to be verified**

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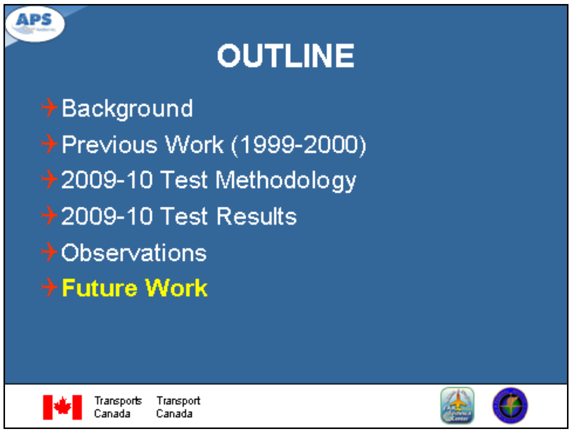

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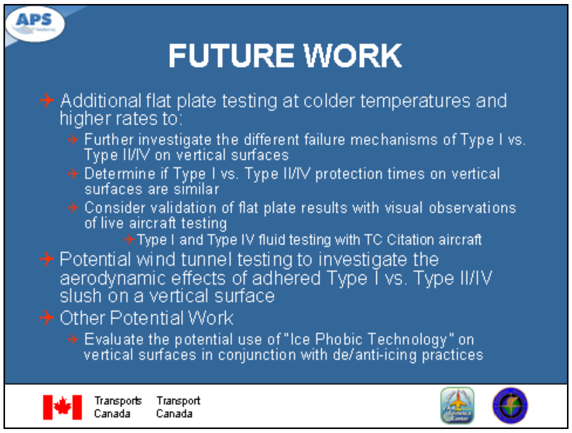

FUTURE WORK

- Additional flat plate testing at colder temperatures and higher rates to:
  - Further investigate the different failure mechanisms of Type I vs. Type II/IV on vertical surfaces
  - Determine if Type I vs. Type II/IV protection times on vertical surfaces are similar
  - Consider validation of flat plate results with visual observations of live aircraft testing
    - Type I and Type IV fluid testing with TC Citation aircraft
- Potential wind tunnel testing to investigate the aerodynamic effects of adhered Type I vs. Type II/IV slush on a vertical surface
- Other Potential Work
  - Evaluate the potential use of "Ice Phobic Technology" on vertical surfaces in conjunction with de/anti-icing practices

APS
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APS
Aviation Inc.

Marco Ruggi
mruggi@adga.ca

UPDATE:

WIND TUNNEL RESEARCH

TO SUPPORT THE DEVELOPMENT OF

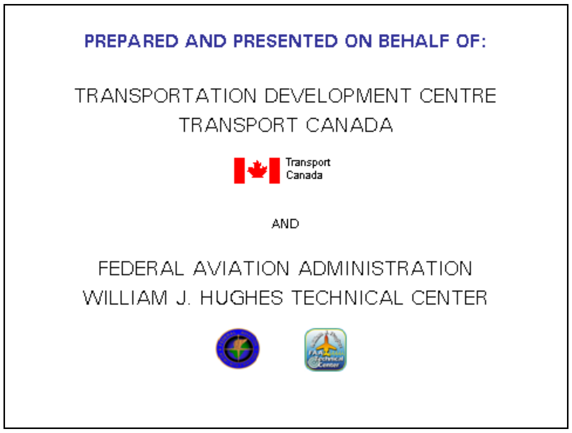
ICE PELLET ALLOWANCE TIME TABLES

APS Aviation Inc.

ISO 9001:2000

SAE G-12 – HOT COMMITEE
BERLIN, MAY 11, 2010

PRESENTED BY MARCO RUGGI



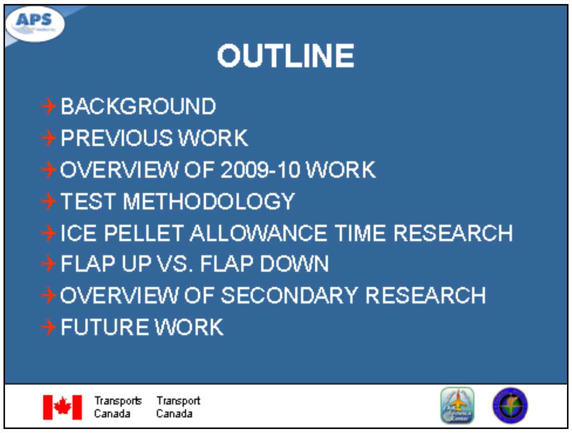
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



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- OVERVIEW OF 2009-10 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
- FLAP UP VS. FLAP DOWN
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

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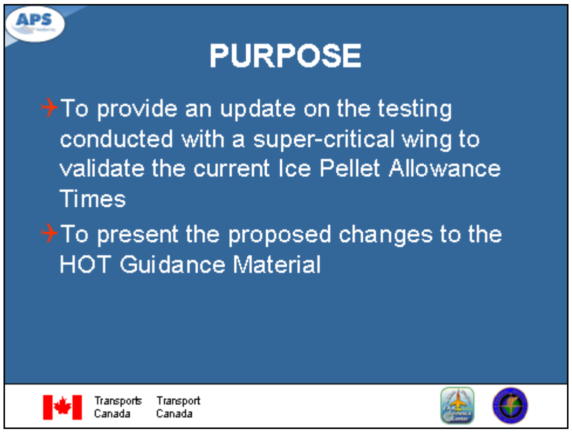

PURPOSE

- To provide an update on the testing conducted with a super-critical wing to validate the current Ice Pellet Allowance Times
- To present the proposed changes to the HOT Guidance Material

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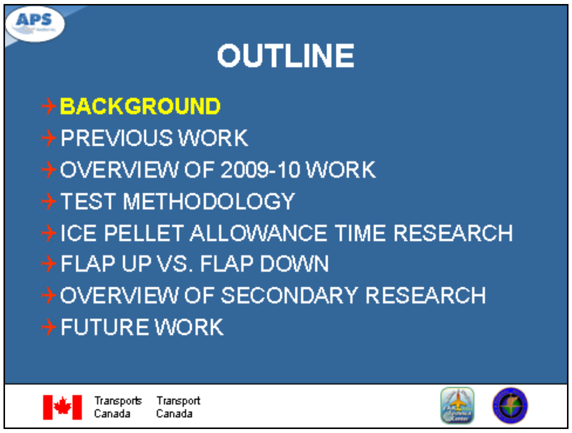

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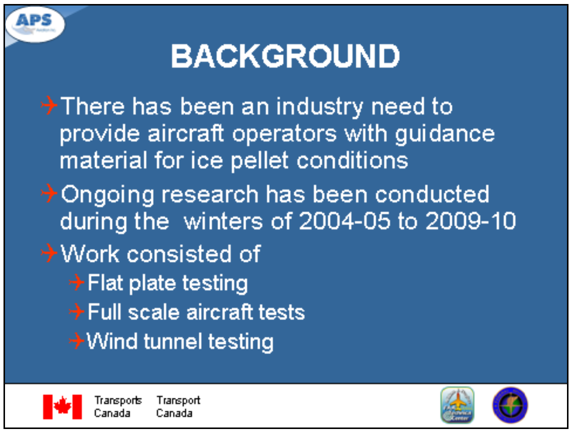

BACKGROUND

- There has been an industry need to provide aircraft operators with guidance material for ice pellet conditions
- Ongoing research has been conducted during the winters of 2004-05 to 2009-10
- Work consisted of
  - Flat plate testing
  - Full scale aircraft tests
  - Wind tunnel testing

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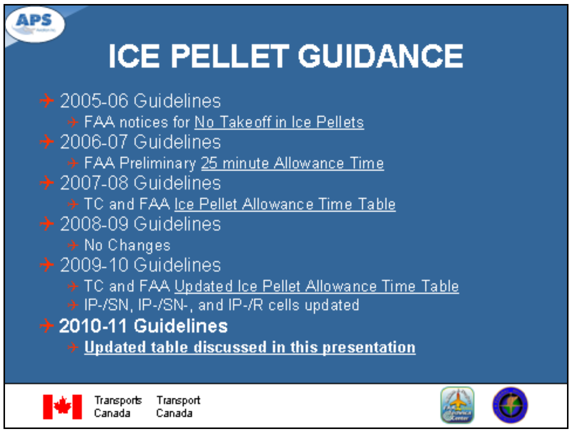

ICE PELLET GUIDANCE

- 2005-06 Guidelines
  - FAA notices for No Takeoff in Ice Pellets
- 2006-07 Guidelines
  - FAA Preliminary 25 minute Allowance Time
- 2007-08 Guidelines
  - TC and FAA Ice Pellet Allowance Time Table
- 2008-09 Guidelines
  - No Changes
- 2009-10 Guidelines
  - TC and FAA Updated Ice Pellet Allowance Time Table
  - IP-/SN, IP-/SN-, and IP-/R cells updated
- **2010-11 Guidelines**
  - **Updated table discussed in this presentation**

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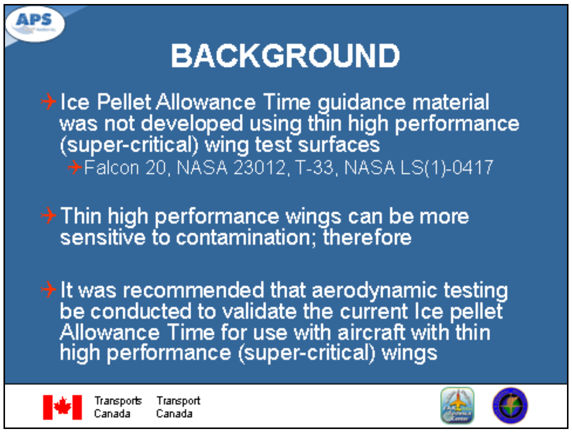

BACKGROUND

- Ice Pellet Allowance Time guidance material was not developed using thin high performance (super-critical) wing test surfaces
  - Falcon 20, NASA 23012, T-33, NASA LS(1)-0417
- Thin high performance wings can be more sensitive to contamination; therefore
- It was recommended that aerodynamic testing be conducted to validate the current Ice pellet Allowance Time for use with aircraft with thin high performance (super-critical) wings

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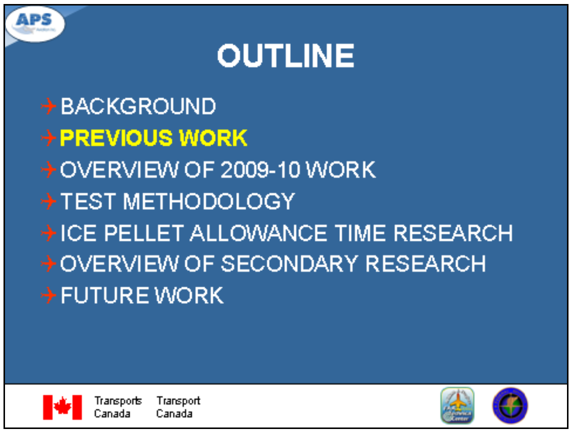

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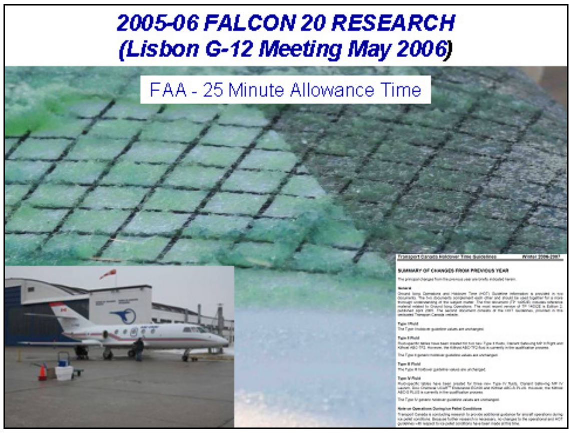
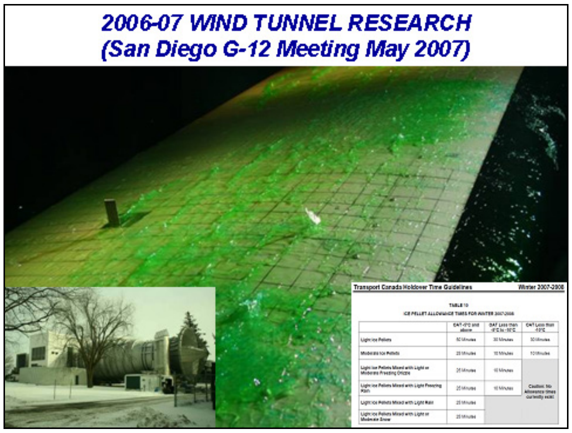
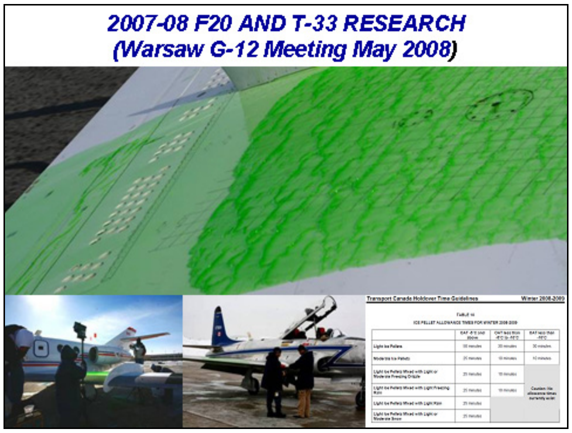


2005-06 FALCON 20 RESEARCH (Lisbon G-12 Meeting May 2006)

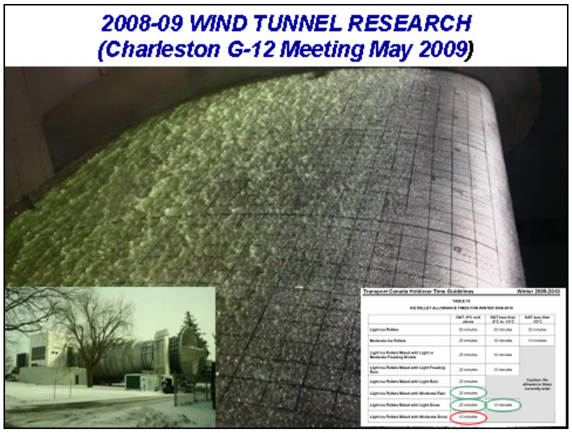
FAA - 25 Minute Allowance Time



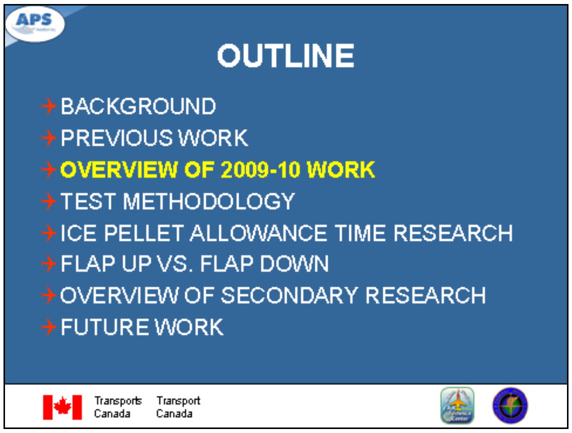
2006-07 WIND TUNNEL RESEARCH (San Diego G-12 Meeting May 2007)



2007-08 F20 AND T-33 RESEARCH (Warsaw G-12 Meeting May 2008)



2008-09 WIND TUNNEL RESEARCH (Charleston G-12 Meeting May 2009)



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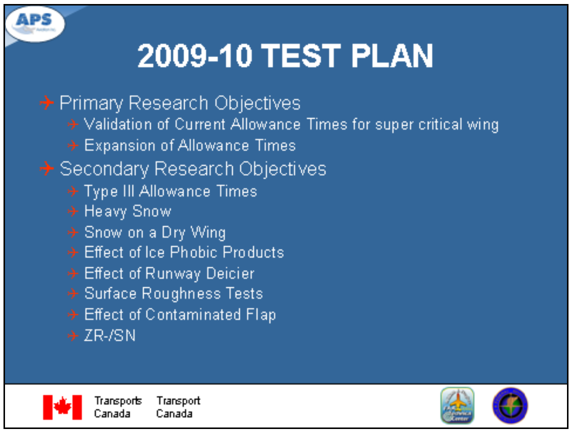

2009-10 TEST PLAN

- Primary Research Objectives
  - Validation of Current Allowance Times for super critical wing
  - Expansion of Allowance Times
- Secondary Research Objectives
  - Type III Allowance Times
  - Heavy Snow
  - Snow on a Dry Wing
  - Effect of Ice Phobic Products
  - Effect of Runway Deicier
  - Surface Roughness Tests
  - Effect of Contaminated Flap
  - ZR-/SN

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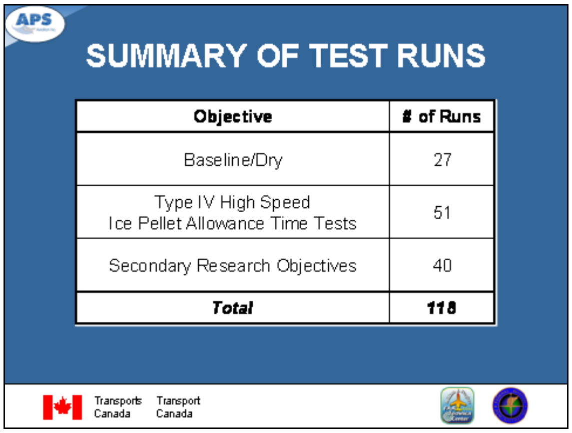

SUMMARY OF TEST RUNS

Objective	# of Runs
Baseline/Dry	27
Type IV High Speed Ice Pellet Allowance Time Tests	51
Secondary Research Objectives	40
Total	***118***

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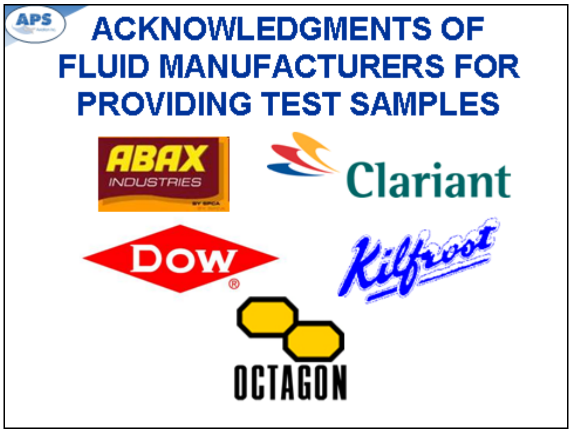
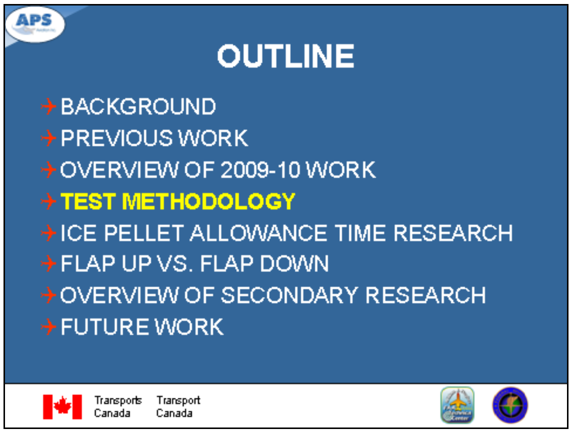


ACKNOWLEDGMENTS OF FLUID MANUFACTURERS FOR PROVIDING TEST SAMPLES

2009-10 RESEARCH TEAM



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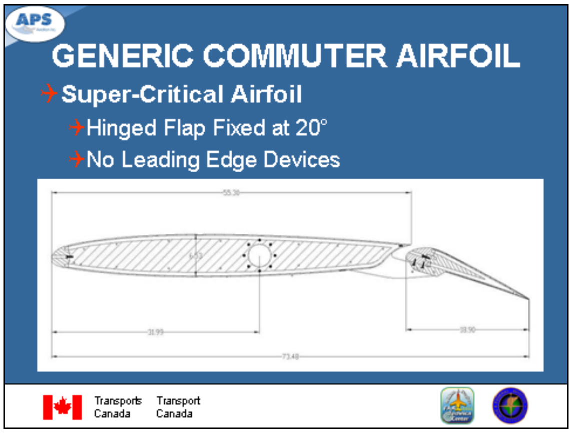
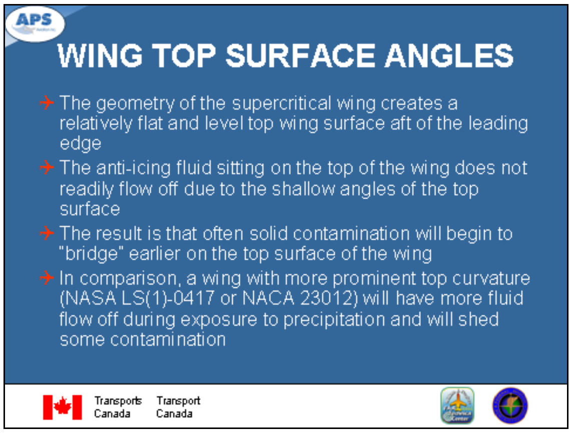


GENERIC COMMUTER AIRFOIL

- Super-Critical Airfoil
  - Hinged Flap Fixed at 20°
  - No Leading Edge Devices

55.30
31.99
18.90
73.48

Transports Canada Transport Canada



WING TOP SURFACE ANGLES

- The geometry of the supercritical wing creates a relatively flat and level top wing surface aft of the leading edge
- The anti-icing fluid sitting on the top of the wing does not readily flow off due to the shallow angles of the top surface
- The result is that often solid contamination will begin to "bridge" earlier on the top surface of the wing
- In comparison, a wing with more prominent top curvature (NASA LS(1)-0417 or NACA 23012) will have more fluid flow off during exposure to precipitation and will shed some contamination

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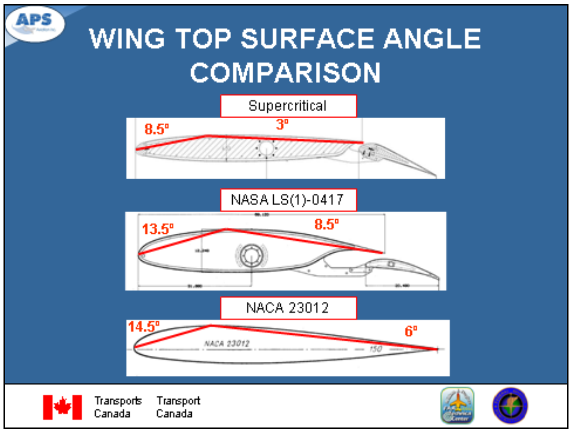

WING TOP SURFACE ANGLE COMPARISON

Supercritical

8.5°
3°

NASA LS(1)-0417

13.5°
8.5°

NACA 23012

14.5°
6°
NACA 23012

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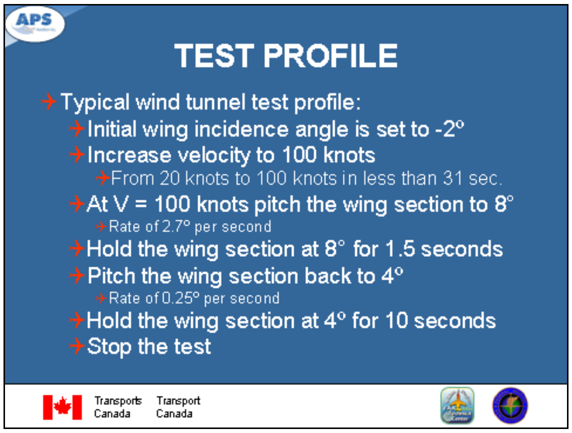

TEST PROFILE

- Typical wind tunnel test profile:
  - Initial wing incidence angle is set to -2°
  - Increase velocity to 100 knots
    - From 20 knots to 100 knots in less than 31 sec.
  - At V = 100 knots pitch the wing section to 8°
    - Rate of 2.7° per second
  - Hold the wing section at 8° for 1.5 seconds
  - Pitch the wing section back to 4°
    - Rate of 0.25° per second
  - Hold the wing section at 4° for 10 seconds
  - Stop the test

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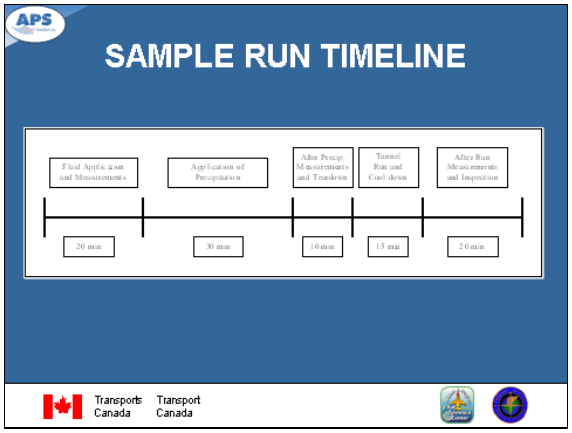

SAMPLE RUN TIMELINE

Fluid Application and Measurements
20 min
Application of Precipitation
30 min
After Precip. Measurements and Teardown
10 min
Tunnel Run and Cool down
15 min
After Run Measurements and Inspection
20 min

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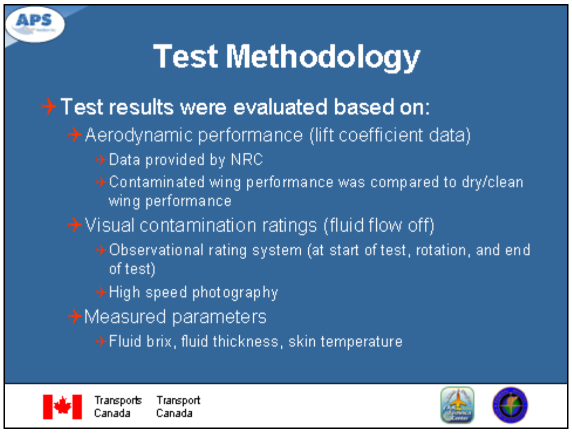

Test Methodology

- Test results were evaluated based on:
  - Aerodynamic performance (lift coefficient data)
    - Data provided by NRC
    - Contaminated wing performance was compared to dry/clean wing performance
  - Visual contamination ratings (fluid flow off)
    - Observational rating system (at start of test, rotation, and end of test)
    - High speed photography
  - Measured parameters
    - Fluid brix, fluid thickness, skin temperature

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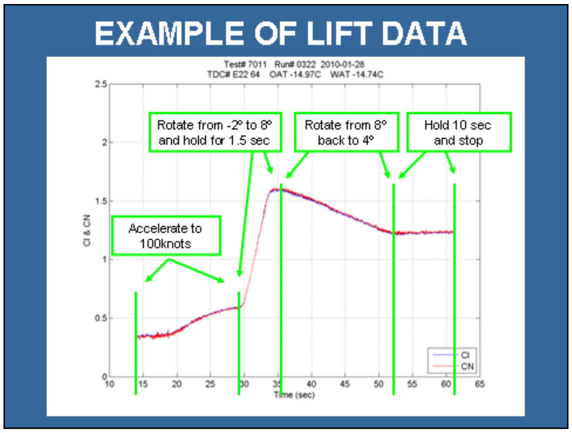


EXAMPLE OF LIFT DATA

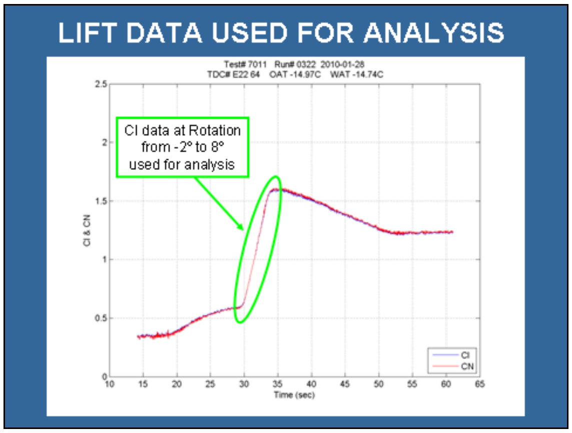
Test# 7011 Run# 0322 2010-01-28
TDC# E22 64 OAT -14.97C WAT -14.74C

Rotate from -2° to 8° and hold for 1.5 sec

Rotate from 8° back to 4°

Hold 10 sec and stop

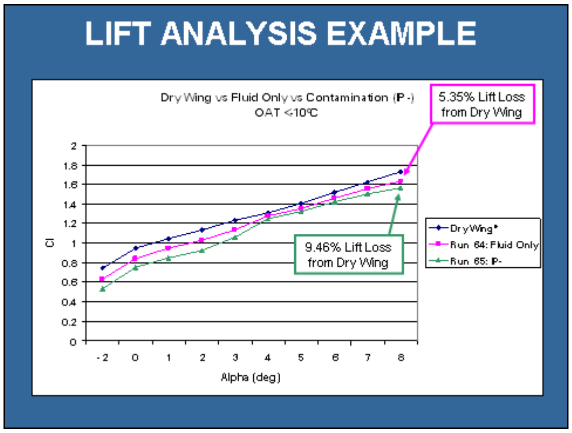
Accelerate to 100knots



LIFT DATA USED FOR ANALYSIS

Test# 7011 Run# 0322 2010-01-28
TDC# E22 64 OAT -14.97C WAT -14.74C

Cl data at Rotation from -2° to 8° used for analysis

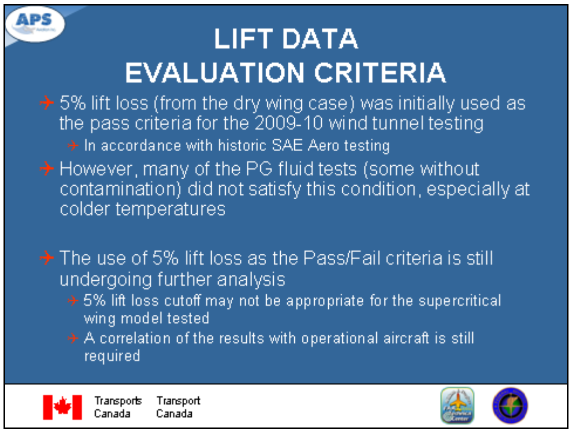


LIFT ANALYSIS EXAMPLE

Dry Wing vs Fluid Only vs Contamination (P-)
OAT <10°C

5.35% Lift Loss from Dry Wing

9.46% Lift Loss from Dry Wing



LIFT DATA EVALUATION CRITERIA

- 5% lift loss (from the dry wing case) was initially used as the pass criteria for the 2009-10 wind tunnel testing
  - In accordance with historic SAE Aero testing
- However, many of the PG fluid tests (some without contamination) did not satisfy this condition, especially at colder temperatures
- The use of 5% lift loss as the Pass/Fail criteria is still undergoing further analysis
  - 5% lift loss cutoff may not be appropriate for the supercritical wing model tested
  - A correlation of the results with operational aircraft is still required

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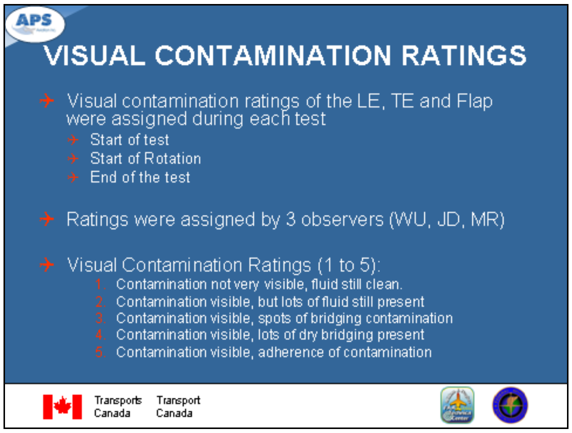

VISUAL CONTAMINATION RATINGS

- Visual contamination ratings of the LE, TE and Flap were assigned during each test
  - Start of test
  - Start of Rotation
  - End of the test
- Ratings were assigned by 3 observers (WU, JD, MR)
- Visual Contamination Ratings (1 to 5):
  1. Contamination not very visible, fluid still clean.
  2. Contamination visible, but lots of fluid still present
  3. Contamination visible, spots of bridging contamination
  4. Contamination visible, lots of dry bridging present
  5. Contamination visible, adherence of contamination

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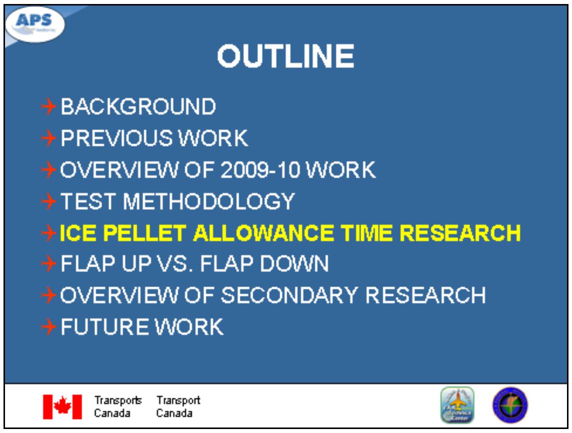

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2009-10 WORK
- TEST METHODOLOGY
- **ICE PELLET ALLOWANCE TIME RESEARCH**
- FLAP UP VS. FLAP DOWN
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

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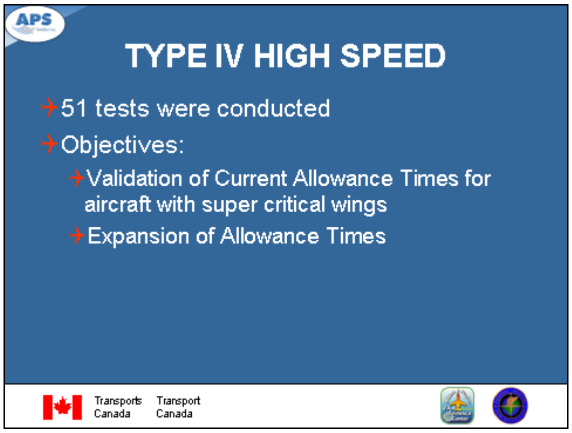

TYPE IV HIGH SPEED

- 51 tests were conducted
- Objectives:
  - Validation of Current Allowance Times for aircraft with super critical wings
  - Expansion of Allowance Times

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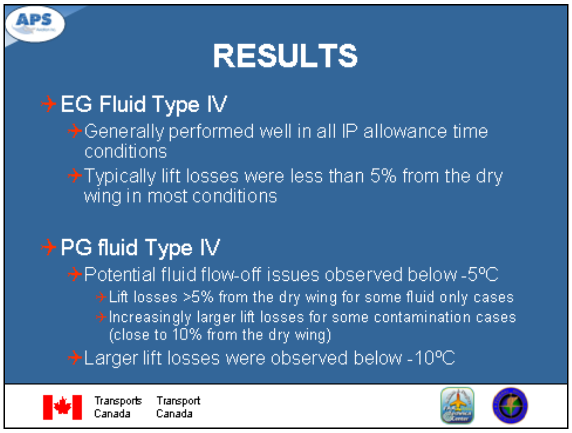

RESULTS

- EG Fluid Type IV
  - Generally performed well in all IP allowance time conditions
  - Typically lift losses were less than 5% from the dry wing in most conditions
- PG fluid Type IV
  - Potential fluid flow-off issues observed below -5ºC
    - Lift losses >5% from the dry wing for some fluid only cases
    - Increasingly larger lift losses for some contamination cases (close to 10% from the dry wing)
  - Larger lift losses were observed below -10ºC

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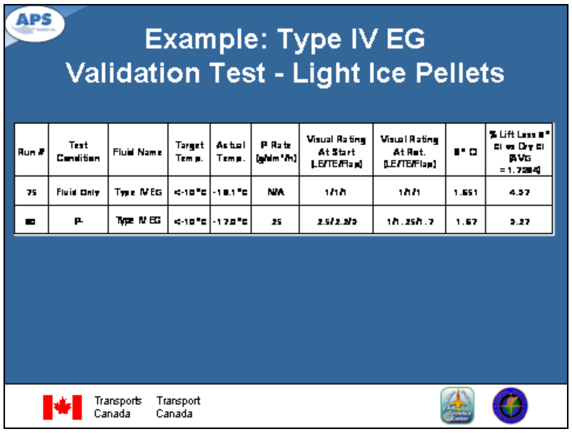

Example: Type IV EG Validation Test - Light Ice Pellets

Run #	Test Condition	Fluid Name	Target Temp.	Actual Temp.	IP Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7284)
75	Fluid Only	Type IV EG	<-10°C	-18.1°C	N/A	1/1/1	1/1/1	1.651	4.37
80	IP-	Type IV EG	<-10°C	-17.0°C	25	2.5/2.3/3	1/1.25/1.7	1.67	3.27

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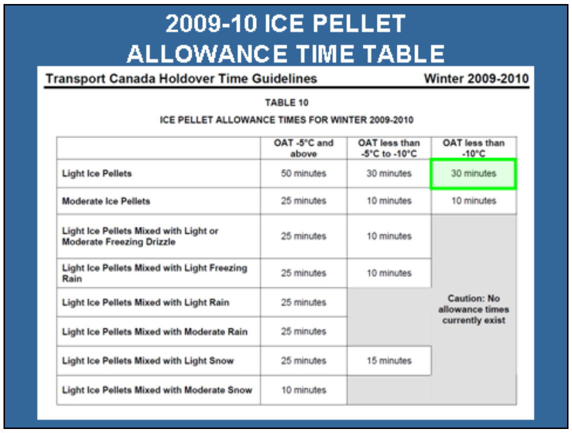


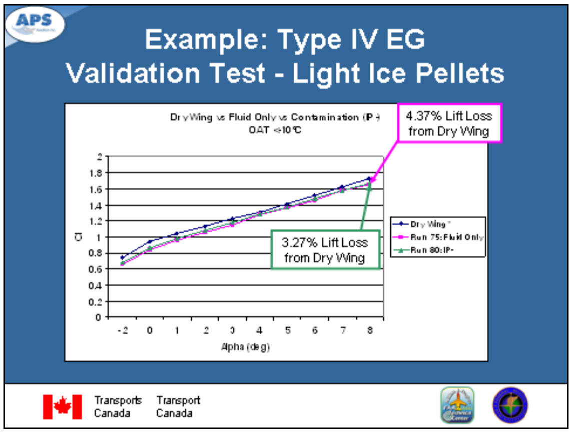
2009-10 ICE PELLET ALLOWANCE TIME TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		



Example: Type IV EG Validation Test - Light Ice Pellets

4.37% Lift Loss from Dry Wing

3.27% Lift Loss from Dry Wing

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RUN #80

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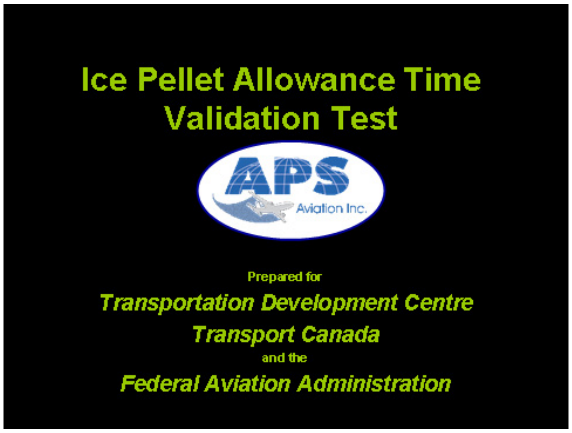


Ice Pellet Allowance Time Validation Test

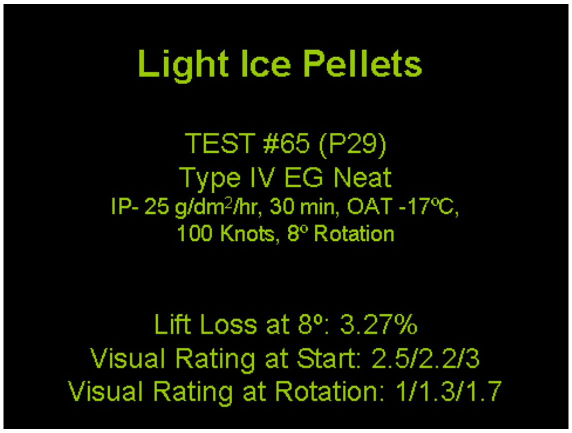
Prepared for

Transportation Development Centre

Transport Canada

and the

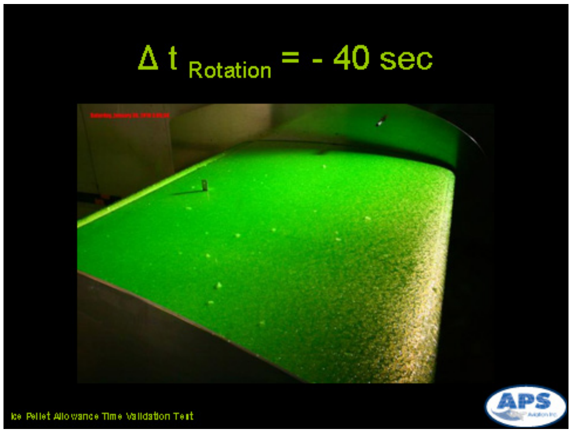
Federal Aviation Administration



Light Ice Pellets

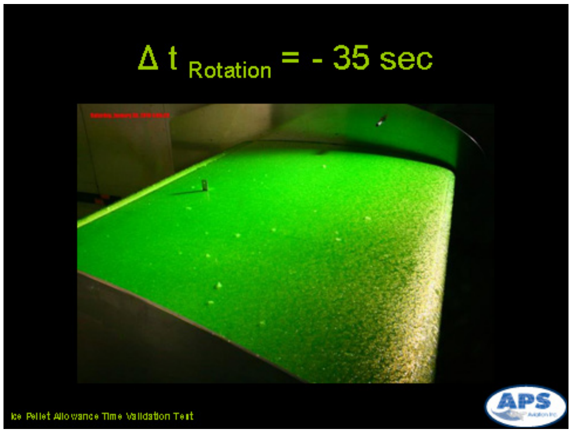
TEST #65 (P29)
Type IV EG Neat
IP- 25 $g/dm^2/hr$, 30 min, OAT -17ºC,
100 Knots, 8º Rotation

Lift Loss at 8º: 3.27%
Visual Rating at Start: 2.5/2.2/3
Visual Rating at Rotation: 1/1.3/1.7



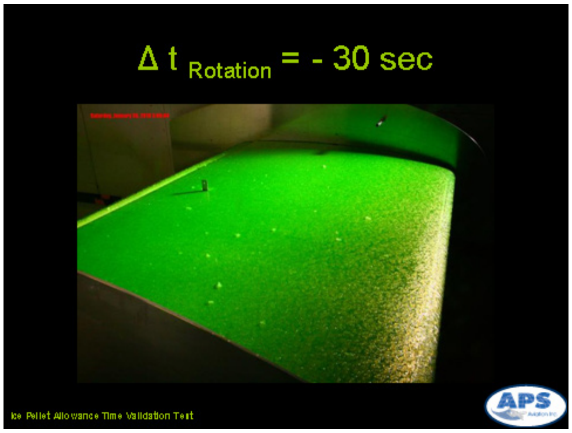
$\Delta t_{\text{Rotation}} = -40$ sec

Ice Pellet Allowance Time Validation Test



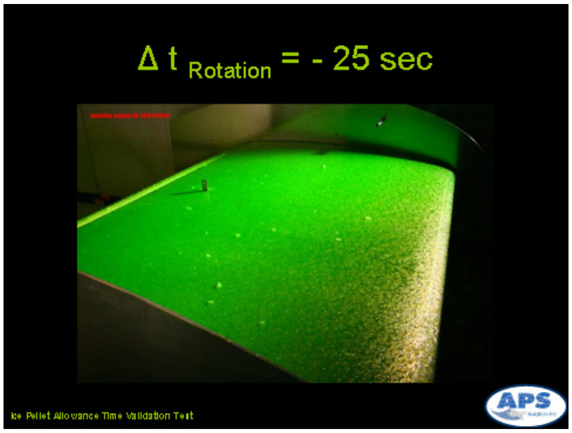
$\Delta t_{\text{Rotation}} = -35$ sec

Ice Pellet Allowance Time Validation Test



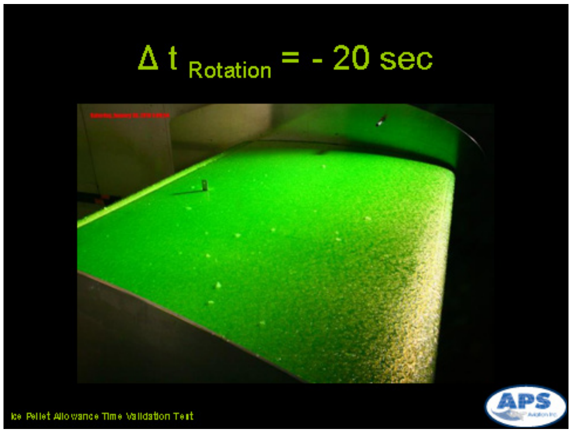
$\Delta t_{\text{Rotation}} = -30$ sec

Ice Pellet Allowance Time Validation Test



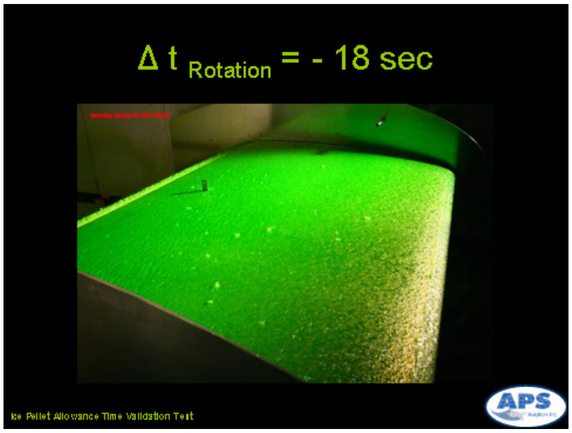
$\Delta t_{\text{Rotation}} = -25$ sec

Ice Pellet Allowance Time Validation Test



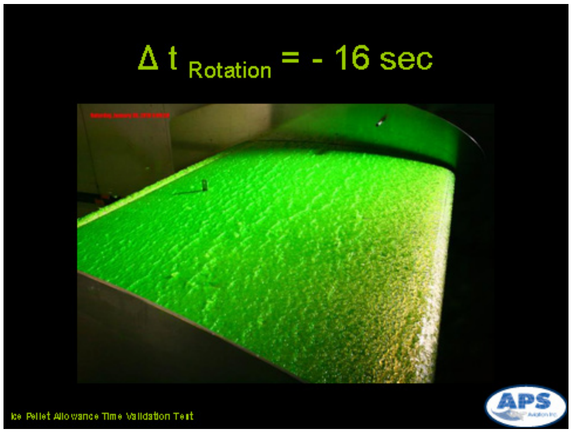
$\Delta t_{Rotation}$ = - 20 sec

Ice Pellet Allowance Time Validation Test



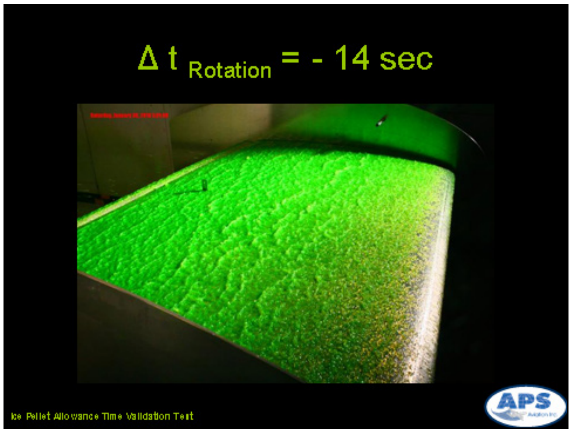
$\Delta t_{Rotation}$ = - 18 sec

Ice Pellet Allowance Time Validation Test



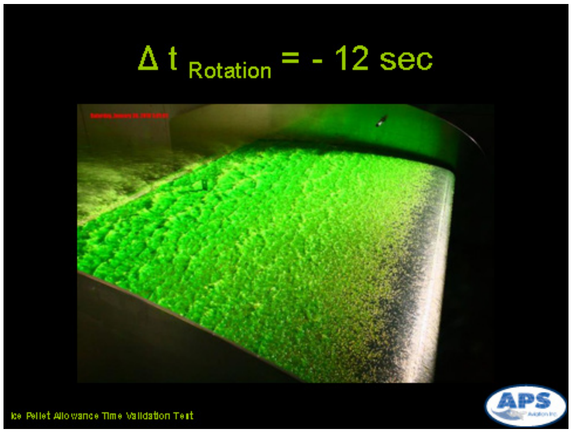
$\Delta t_{Rotation}$ = - 16 sec

Ice Pellet Allowance Time Validation Test



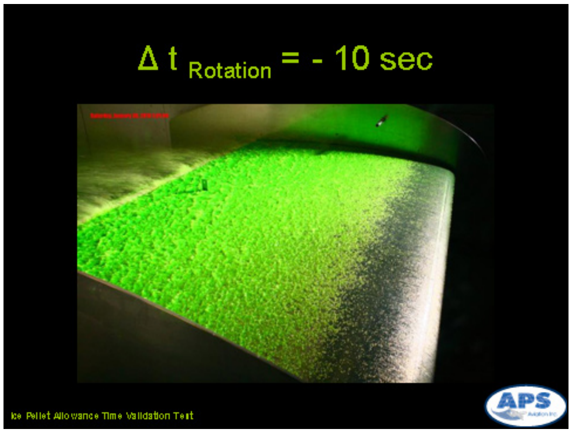
$\Delta t_{Rotation}$ = - 14 sec

Ice Pellet Allowance Time Validation Test



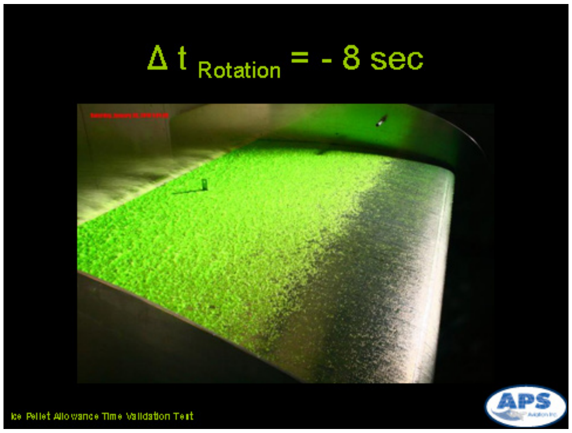
$\Delta t_{Rotation}$ = - 12 sec

Ice Pellet Allowance Time Validation Test



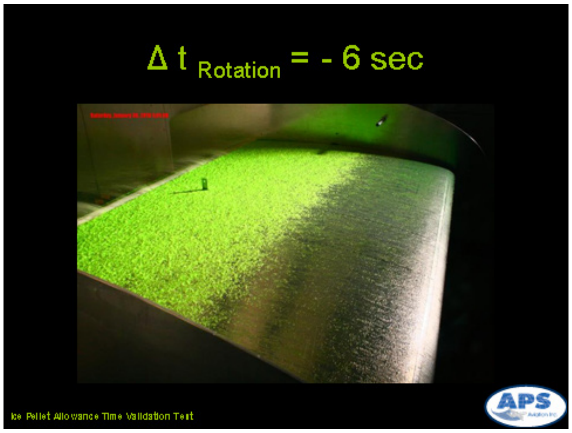
$\Delta t_{Rotation}$ = - 10 sec

Ice Pellet Allowance Time Validation Test



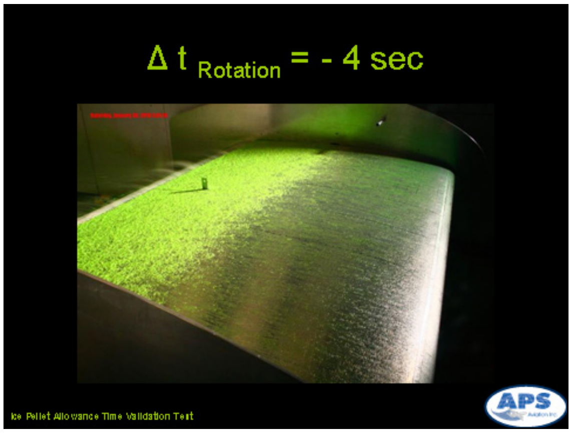
$\Delta t_{\text{Rotation}} = -8$ sec

Ice Pellet Allowance Time Validation Test



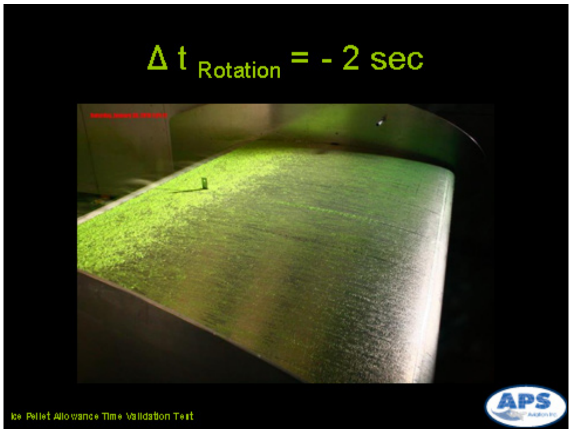
$\Delta t_{\text{Rotation}} = -6$ sec

Ice Pellet Allowance Time Validation Test



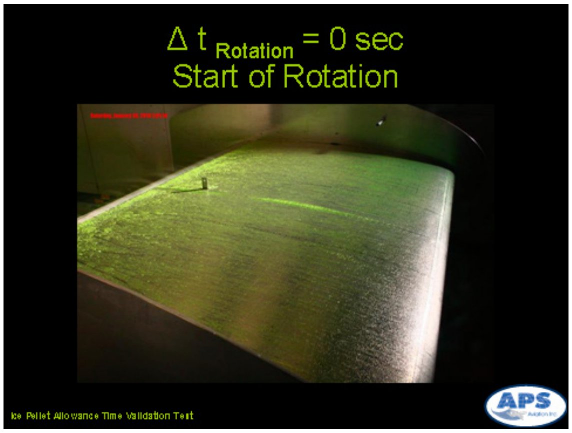
$\Delta t_{\text{Rotation}} = -4$ sec

Ice Pellet Allowance Time Validation Test



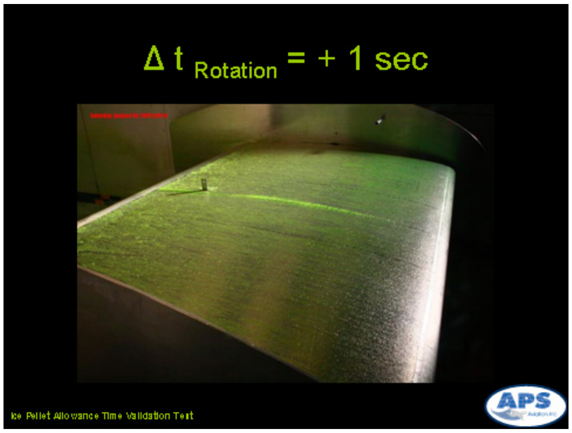
$\Delta t_{\text{Rotation}} = -2$ sec

Ice Pellet Allowance Time Validation Test



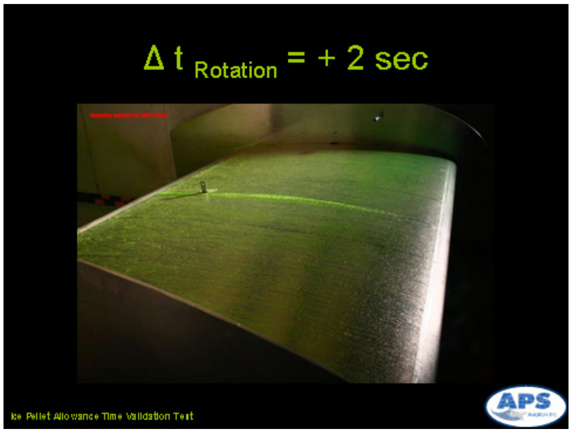
$\Delta t_{\text{Rotation}} = 0$ sec
Start of Rotation

Ice Pellet Allowance Time Validation Test

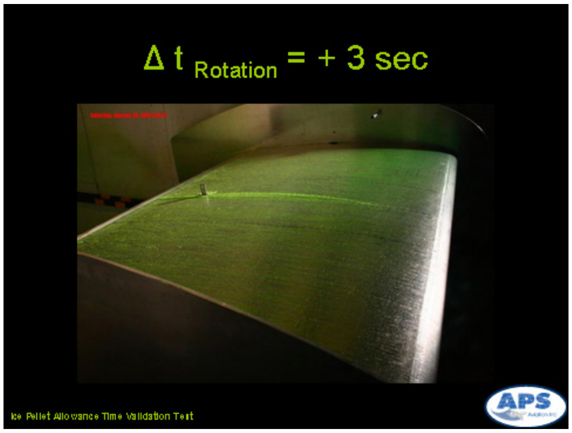


$\Delta t_{\text{Rotation}} = +1$ sec

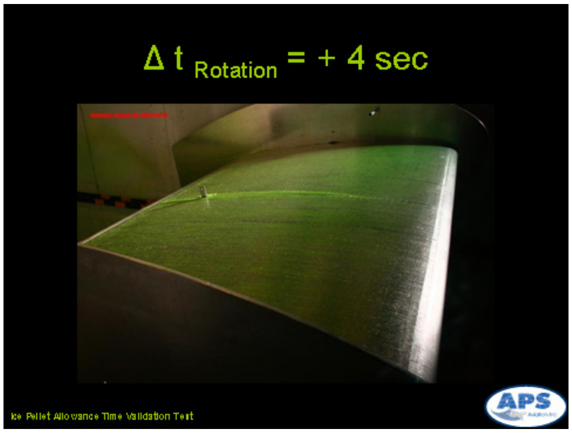
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = +2$ sec

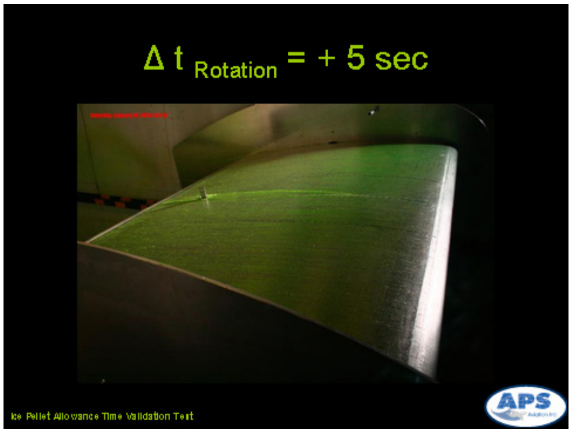
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = +3$ sec

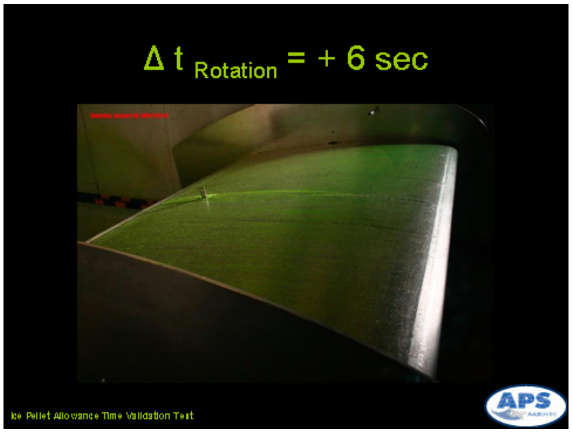
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = +4$ sec

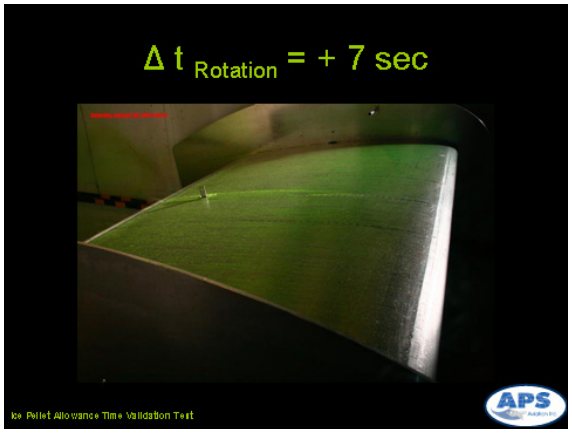
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = +5$ sec

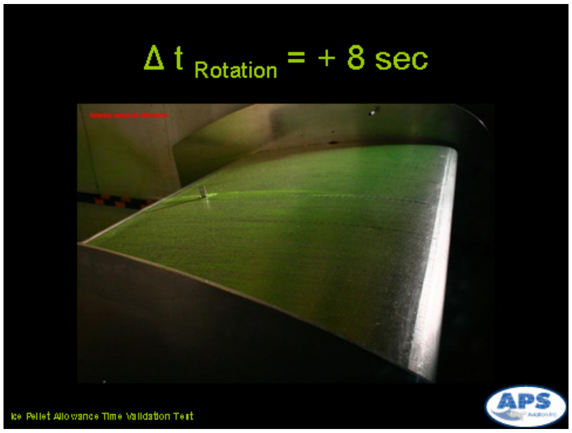
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = +6$ sec

Ice Pellet Allowance Time Validation Test

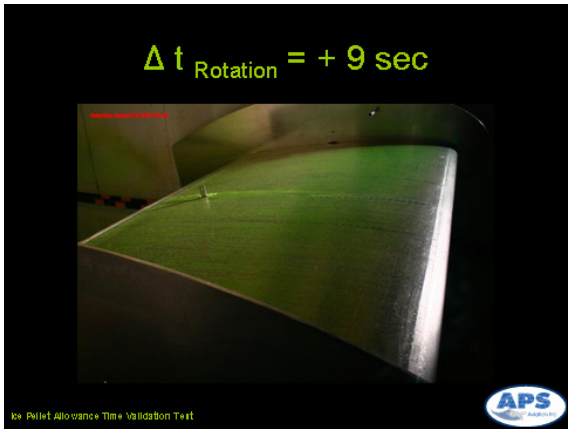

$\Delta t_{\text{Rotation}} = +7$ sec

Ice Pellet Allowance Time Validation Test



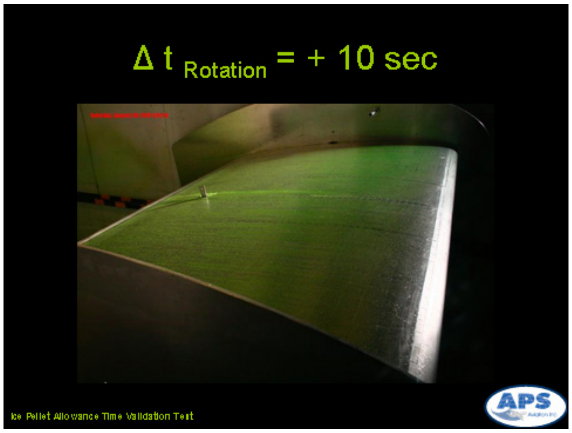
$\Delta t_{\text{Rotation}} = +8$ sec

Ice Pellet Allowance Time Validation Test



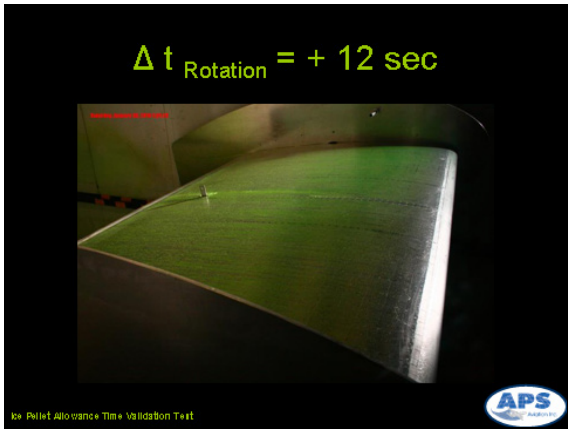
$\Delta t_{\text{Rotation}} = +9$ sec

Ice Pellet Allowance Time Validation Test



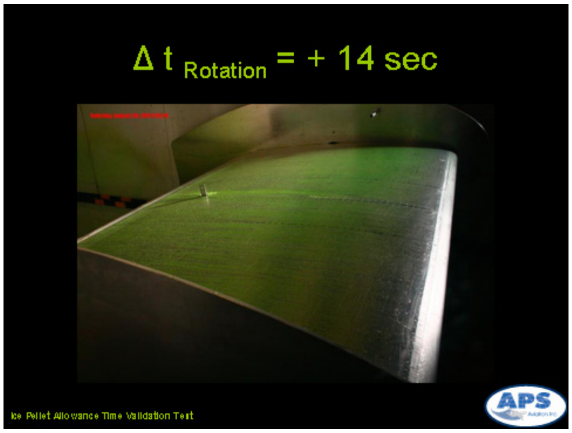
$\Delta t_{\text{Rotation}} = +10$ sec

Ice Pellet Allowance Time Validation Test



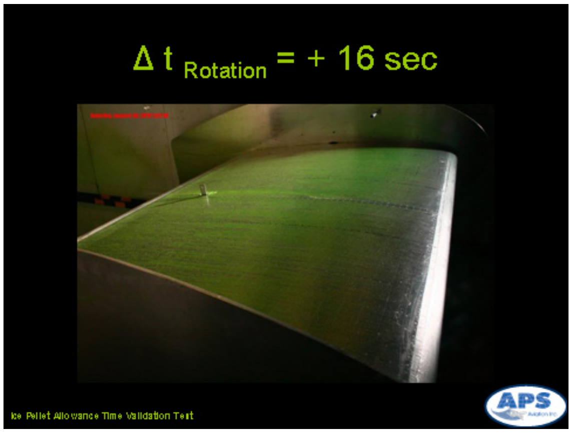
$\Delta t_{\text{Rotation}} = +12$ sec

Ice Pellet Allowance Time Validation Test



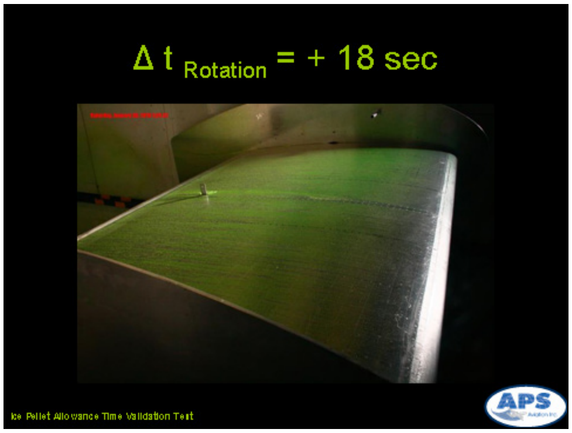
$\Delta t_{\text{Rotation}} = +14$ sec

Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = +16$ sec

Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = + 18$ sec

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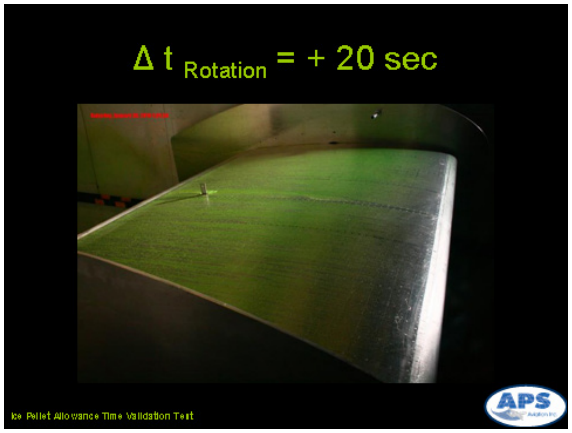
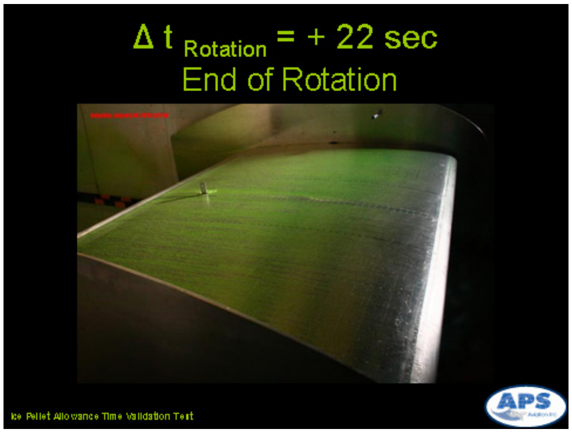


$\Delta t_{\text{Rotation}} = + 20$ sec

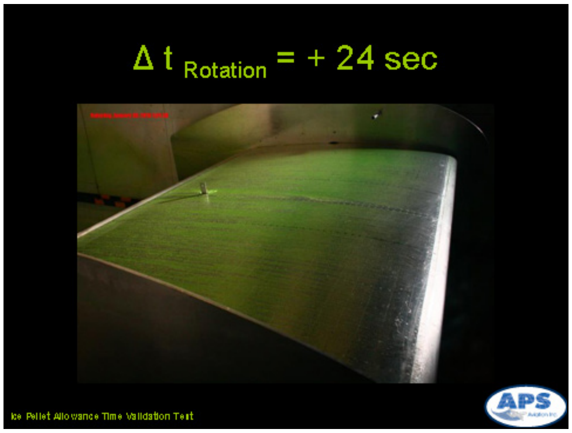
Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = + 22$ sec

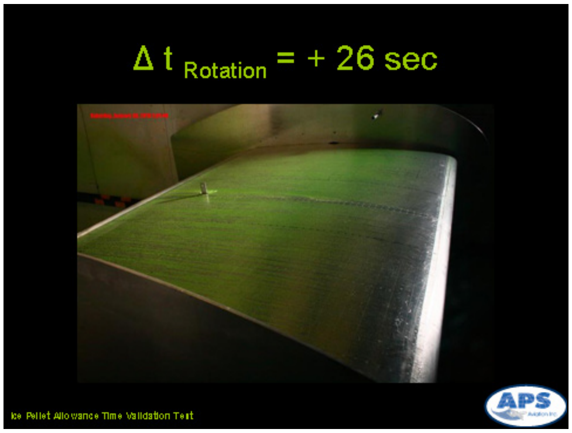
End of Rotation

Ice Pellet Allowance Time Validation Test



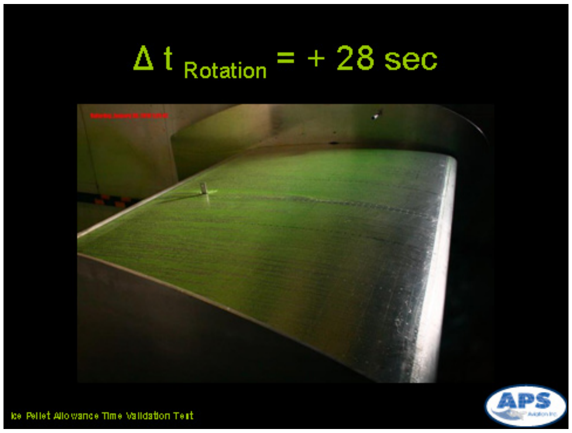
$\Delta t_{\text{Rotation}} = + 24$ sec

Ice Pellet Allowance Time Validation Test



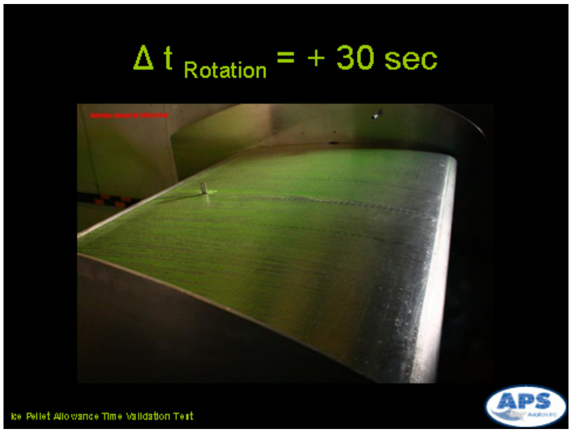
$\Delta t_{\text{Rotation}} = + 26$ sec

Ice Pellet Allowance Time Validation Test



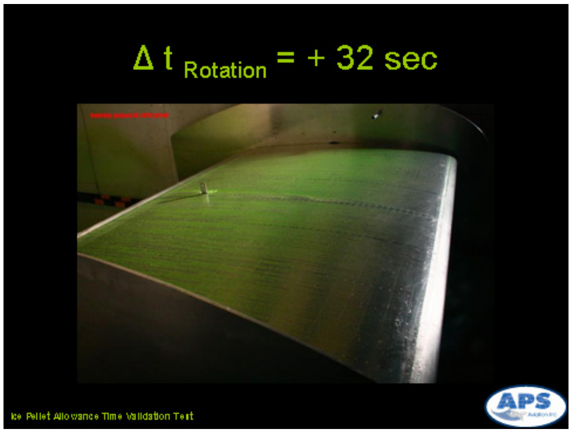
$\Delta t_{\text{Rotation}} = + 28$ sec

Ice Pellet Allowance Time Validation Test



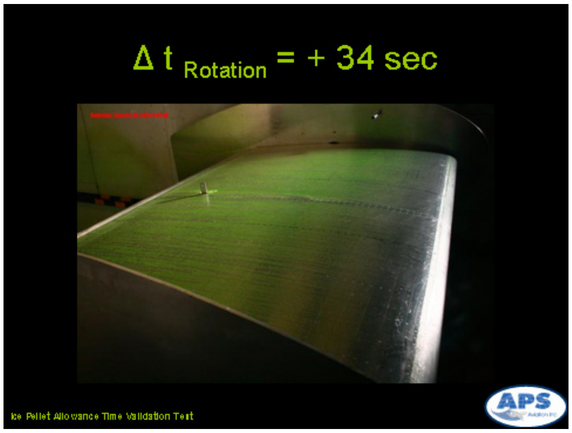
$\Delta t_{\text{Rotation}} = +\ 30$ sec

Ice Pellet Allowance Time Validation Test



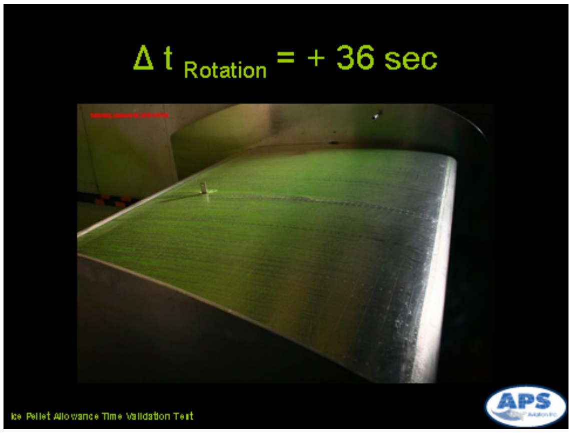
$\Delta t_{\text{Rotation}} = +\ 32$ sec

Ice Pellet Allowance Time Validation Test



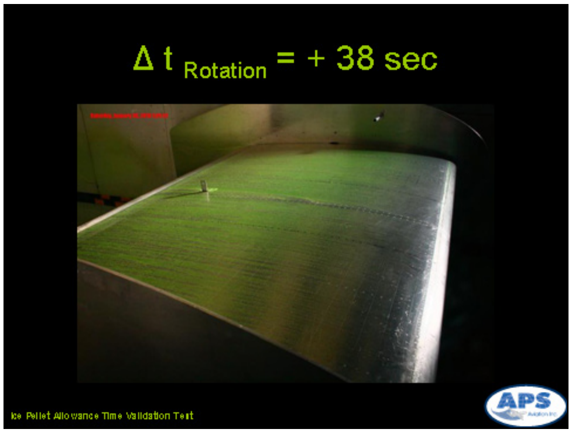
$\Delta t_{\text{Rotation}} = +\ 34$ sec

Ice Pellet Allowance Time Validation Test



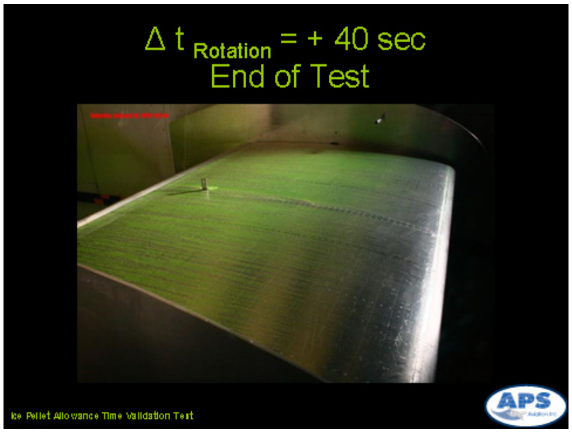
$\Delta t_{\text{Rotation}} = +\ 36$ sec

Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = +\ 38$ sec

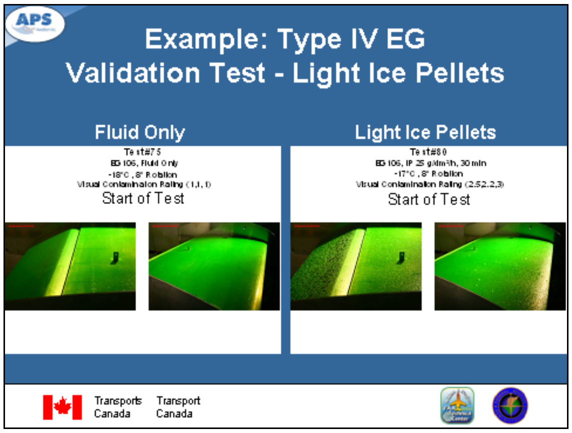
Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = +\ 40$ sec

End of Test

Ice Pellet Allowance Time Validation Test



Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test#75
EG 106, Fluid Only
-18°C , 8° Rotation
Visual Contamination Rating (1,1,1)
Start of Test

Light Ice Pellets

Test#80
EG 106, IP 25 g/dm²/h, 30 min
-17°C , 8° Rotation
Visual Contamination Rating (2.5,2.2,3)
Start of Test

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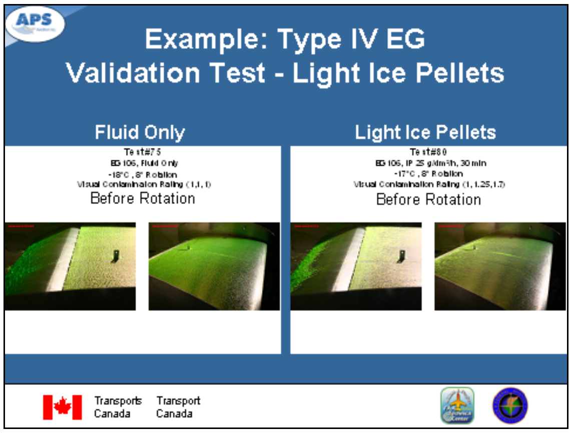


Example: Type IV EG Validation Test - Light Ice Pellets

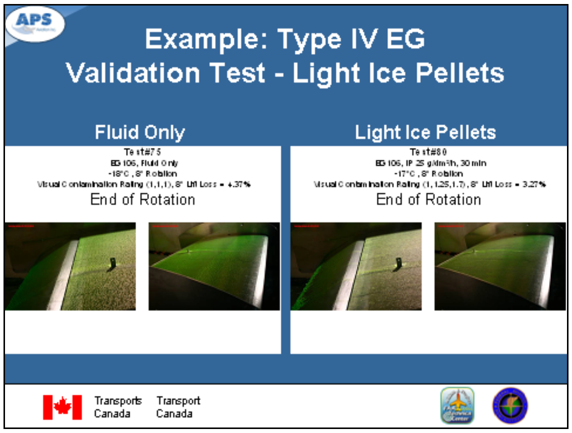
Fluid Only

Test#75
EG 106, Fluid Only
-18°C , 8° Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

Light Ice Pellets

Test#80
EG 106, IP 25 g/dm²/h, 30 min
-17°C , 8° Rotation
Visual Contamination Rating (1, 1.25,1.7)
Before Rotation

Transports Canada Transport Canada



Example: Type IV EG Validation Test - Light Ice Pellets

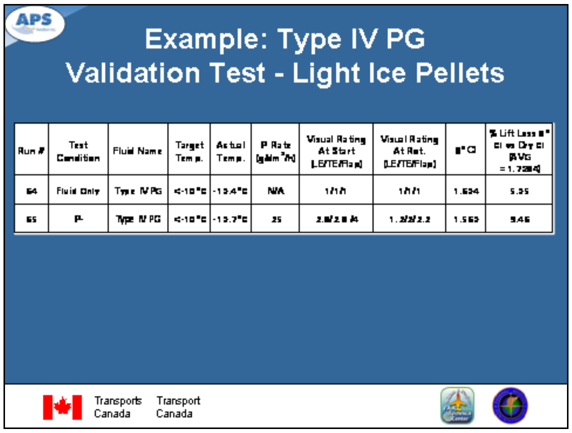
Fluid Only

Test#75
EG 106, Fluid Only
-18°C , 8° Rotation
Visual Contamination Rating (1,1,1), 8° Lift Loss = 4.37%
End of Rotation

Light Ice Pellets

Test#80
EG 106, IP 25 g/dm²/h, 30 min
-17°C , 8° Rotation
Visual Contamination Rating (1, 1.25,1.7) , 8° Lift Loss = 3.27%
End of Rotation

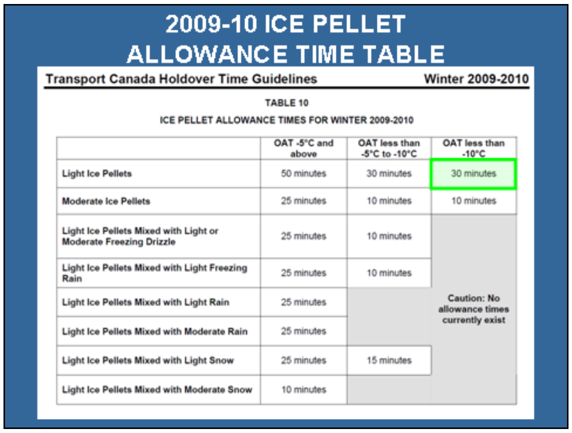
Transports Canada Transport Canada



Example: Type IV PG Validation Test - Light Ice Pellets

Run #	Test Condition	Fluid Name	Target Temp.	Actual Temp.	IP Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7284)
64	Fluid Only	Type IV PG	<-10°C	-13.4°C	N/A	1/1/1	1/1/1	1.634	5.35
65	IP-	Type IV PG	<-10°C	-13.7°C	25	2.8/2.8/4	1.3/2/2.2	1.563	9.46

Transports Canada Transport Canada



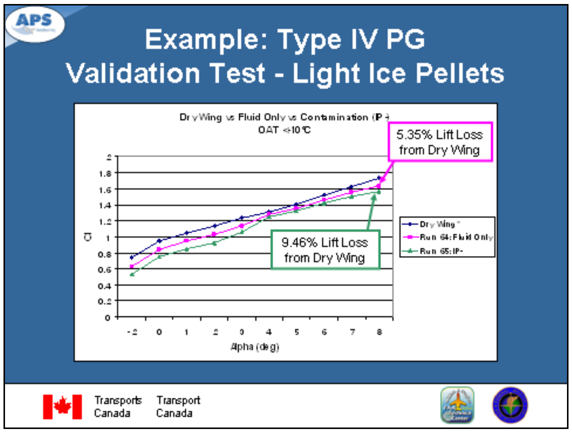
2009-10 ICE PELLET ALLOWANCE TIME TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		



Example: Type IV PG Validation Test - Light Ice Pellets

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RUN #65

Transports Canada Transport Canada

Ice Pellet Allowance Time Validation Test

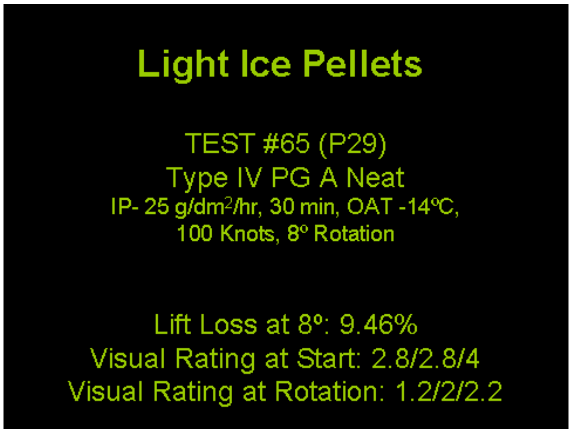
Prepared for

Transportation Development Centre

Transport Canada

and the

Federal Aviation Administration



Light Ice Pellets

TEST #65 (P29)

Type IV PG A Neat

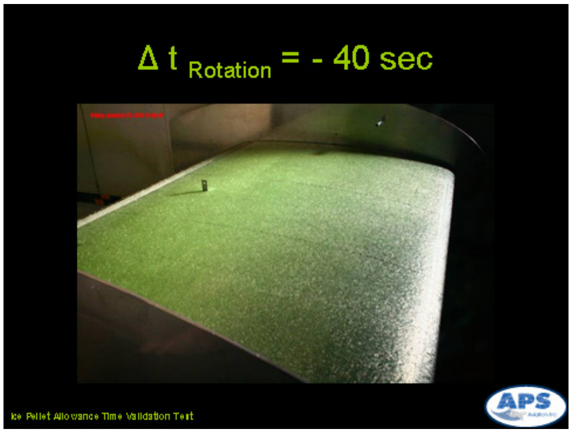
IP- 25 g/dm^2/hr, 30 min, OAT -14ºC,

100 Knots, 8º Rotation

Lift Loss at 8º: 9.46%

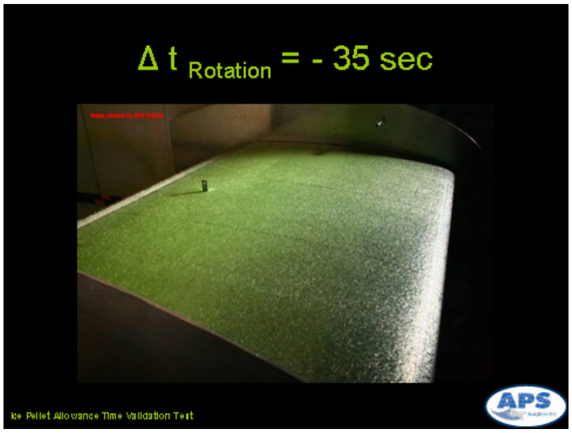
Visual Rating at Start: 2.8/2.8/4

Visual Rating at Rotation: 1.2/2/2.2



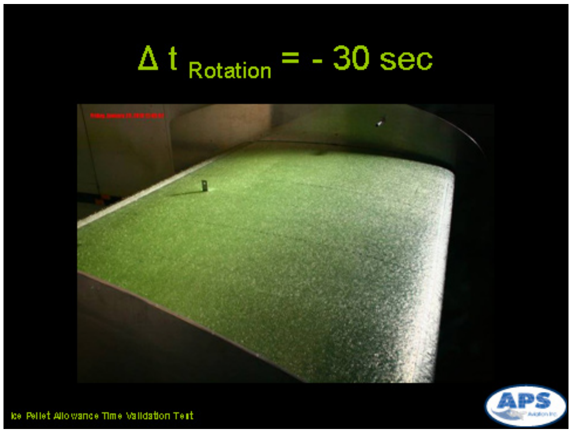
Δ t $_{\text{Rotation}}$ = - 40 sec

Ice Pellet Allowance Time Validation Test



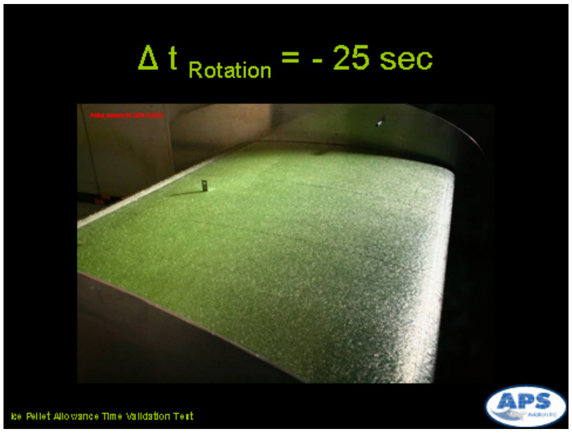
Δ t $_{\text{Rotation}}$ = - 35 sec

Ice Pellet Allowance Time Validation Test

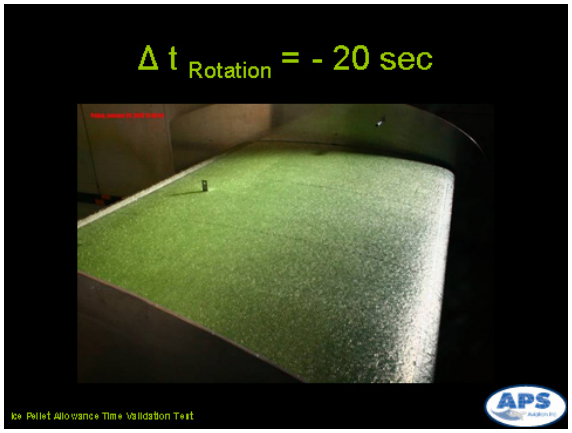


Δ t $_{\text{Rotation}}$ = - 30 sec

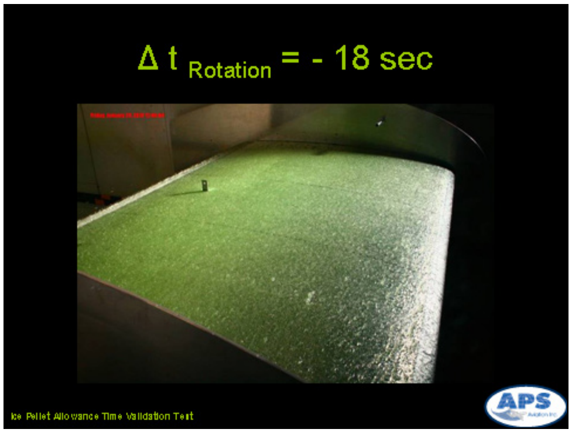
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -25$ sec

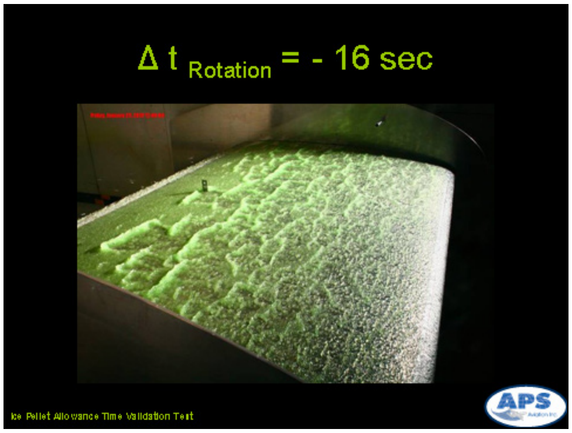
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -20$ sec

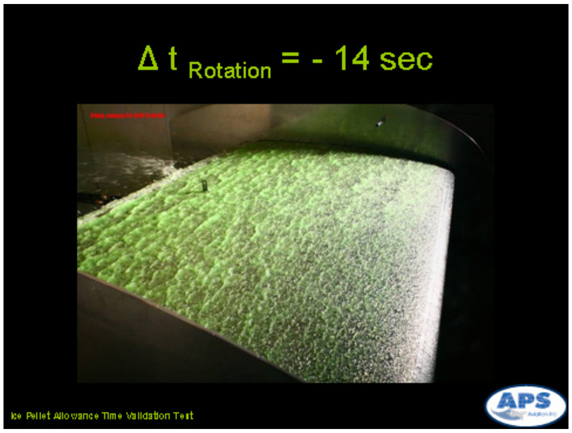
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -18$ sec

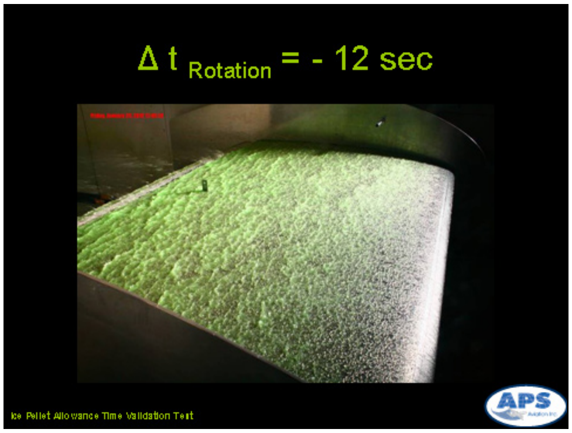
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -16$ sec

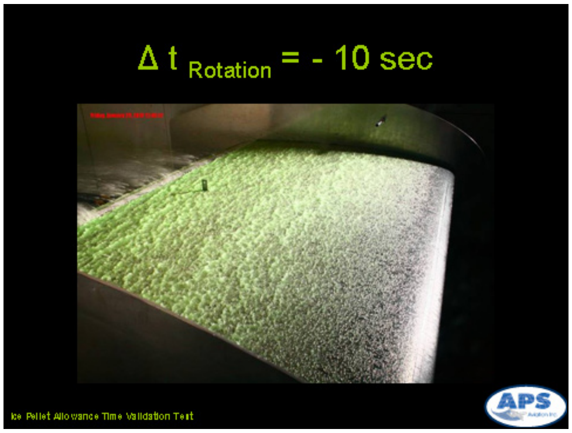
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -14$ sec

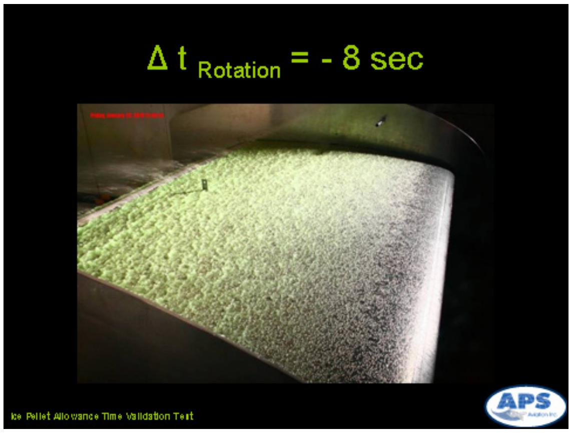
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -12$ sec

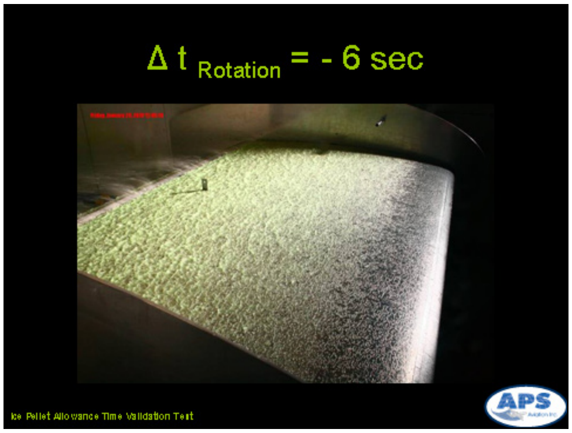
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -10$ sec

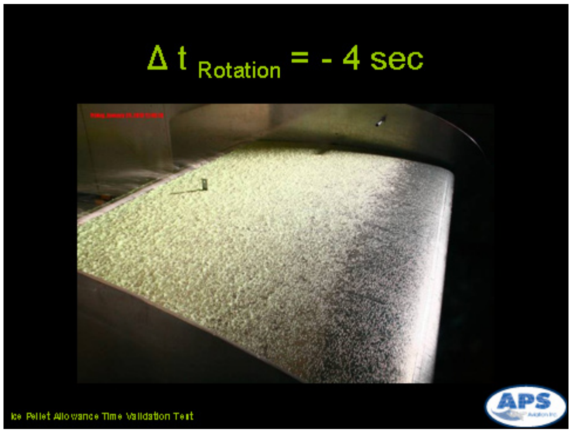
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -8$ sec

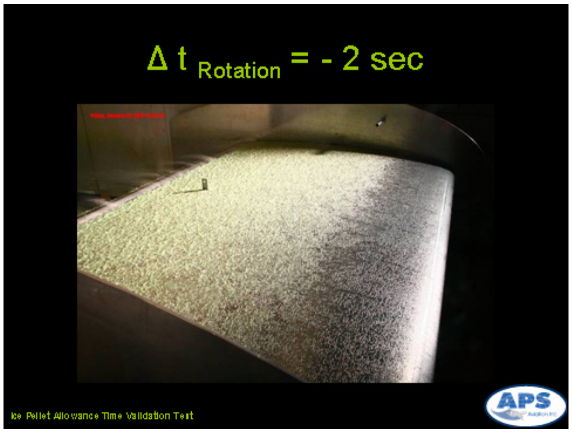
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -6$ sec

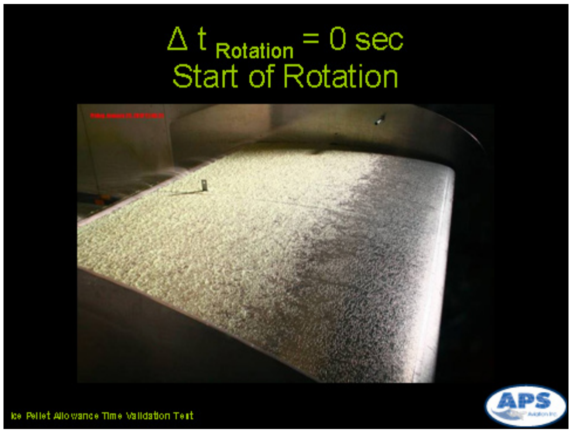
Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = -4$ sec

Ice Pellet Allowance Time Validation Test

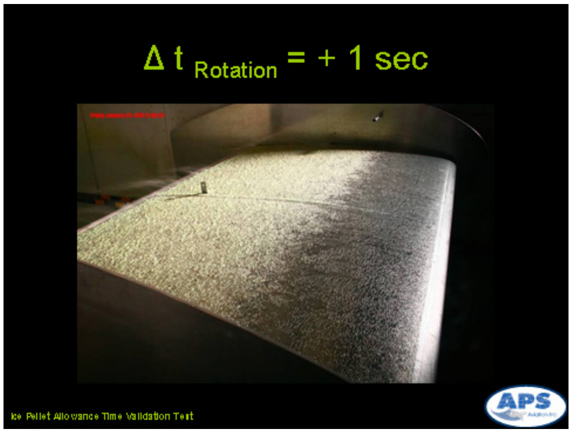

$\Delta t_{\text{Rotation}} = -2$ sec

Ice Pellet Allowance Time Validation Test


$\Delta t_{\text{Rotation}} = 0$ sec

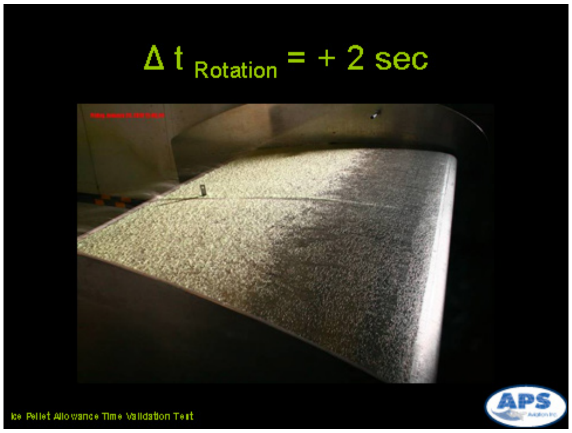
Start of Rotation

Ice Pellet Allowance Time Validation Test



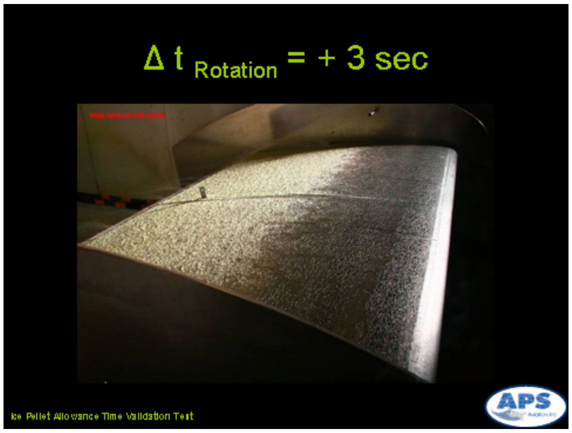
$\Delta t_{Rotation} = +1$ sec

Ice Pellet Allowance Time Validation Test



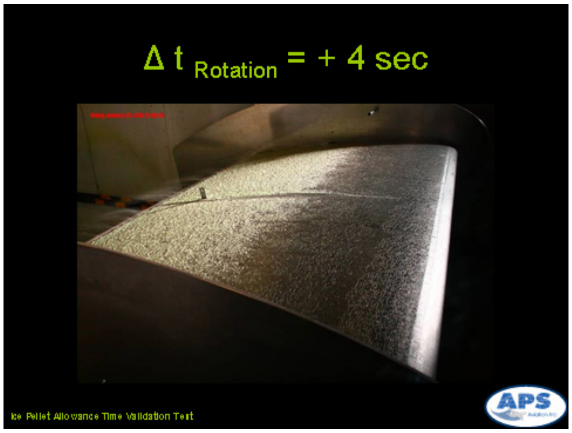
$\Delta t_{Rotation} = +2$ sec

Ice Pellet Allowance Time Validation Test



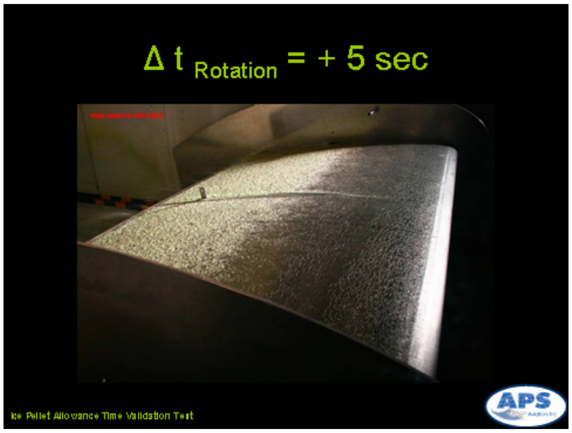
$\Delta t_{Rotation} = +3$ sec

Ice Pellet Allowance Time Validation Test



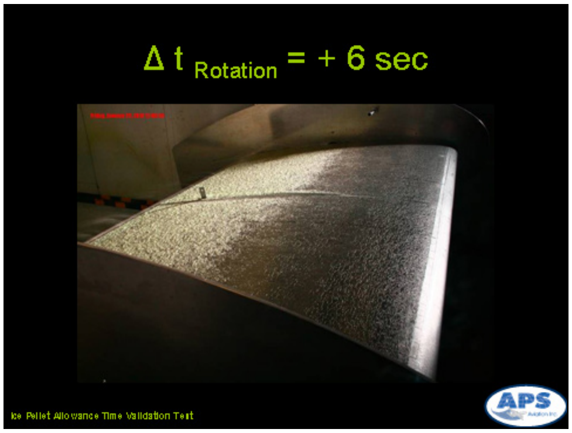
$\Delta t_{Rotation} = +4$ sec

Ice Pellet Allowance Time Validation Test



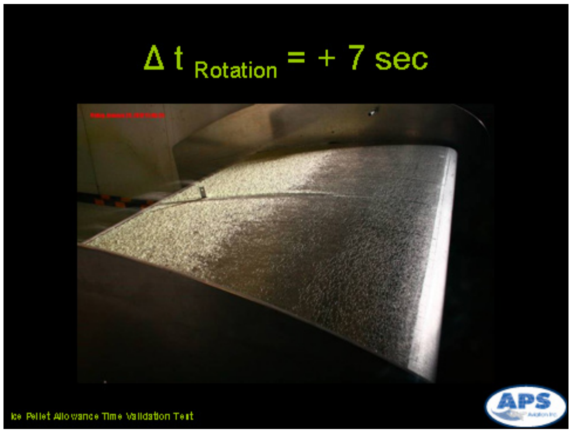
$\Delta t_{Rotation} = +5$ sec

Ice Pellet Allowance Time Validation Test



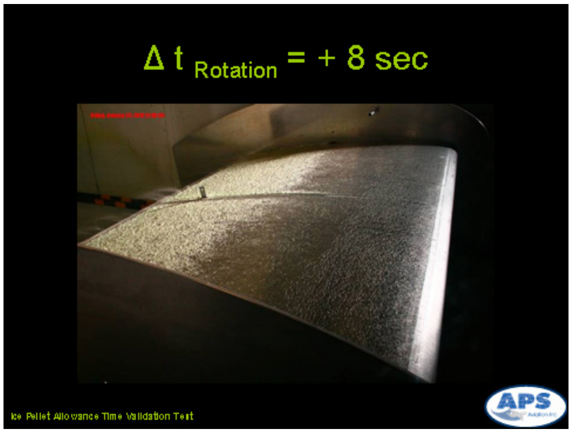
$\Delta t_{Rotation} = +6$ sec

Ice Pellet Allowance Time Validation Test



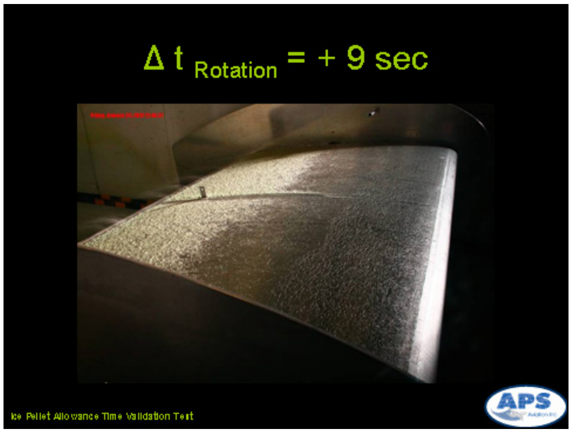
$\Delta t_{\text{Rotation}} = + 7$ sec

Ice Pellet Allowance Time Validation Test



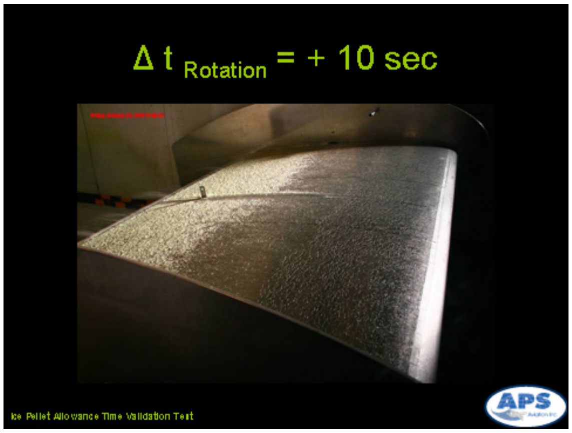
$\Delta t_{\text{Rotation}} = + 8$ sec

Ice Pellet Allowance Time Validation Test



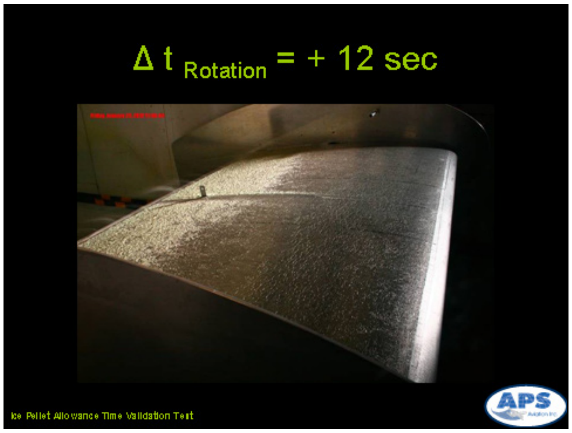
$\Delta t_{\text{Rotation}} = + 9$ sec

Ice Pellet Allowance Time Validation Test



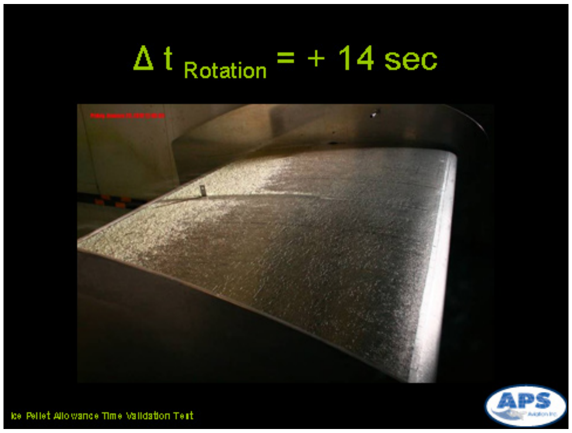
$\Delta t_{\text{Rotation}} = + 10$ sec

Ice Pellet Allowance Time Validation Test



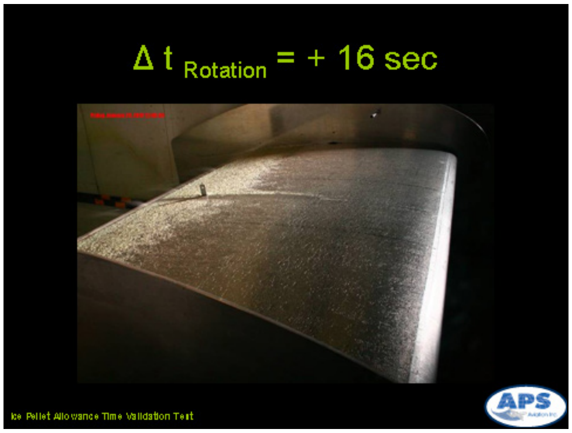
$\Delta t_{\text{Rotation}} = + 12$ sec

Ice Pellet Allowance Time Validation Test



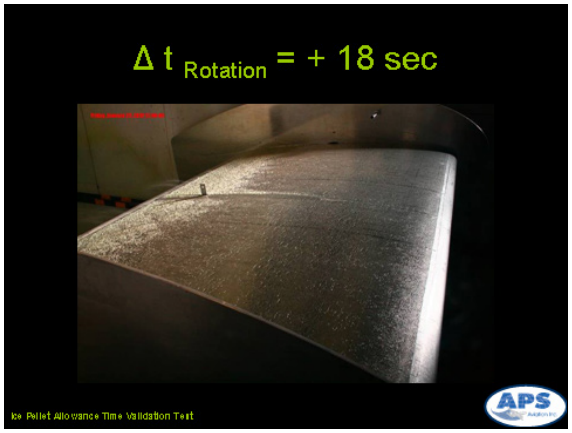
$\Delta t_{\text{Rotation}} = + 14$ sec

Ice Pellet Allowance Time Validation Test



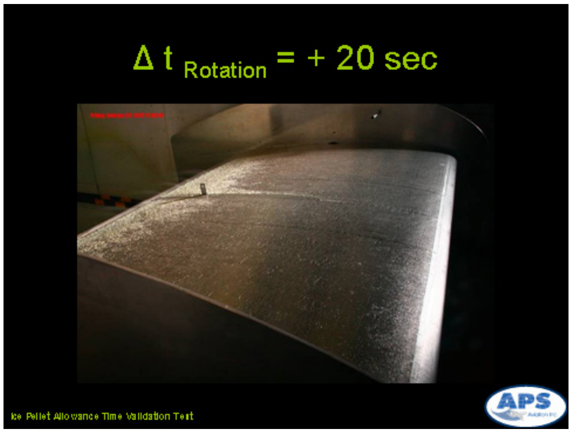
$\Delta t_{\text{Rotation}} = + 16$ sec

Ice Pellet Allowance Time Validation Test



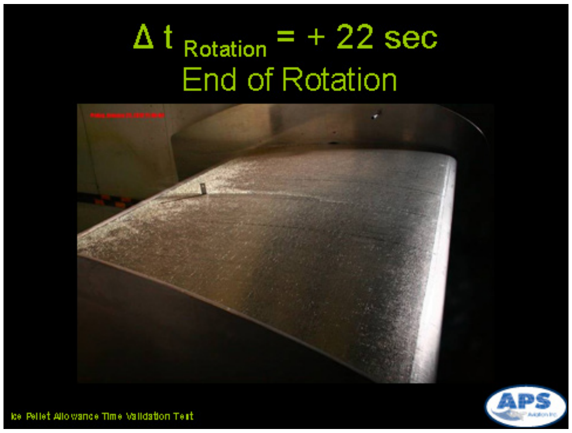
$\Delta t_{\text{Rotation}} = + 18$ sec

Ice Pellet Allowance Time Validation Test



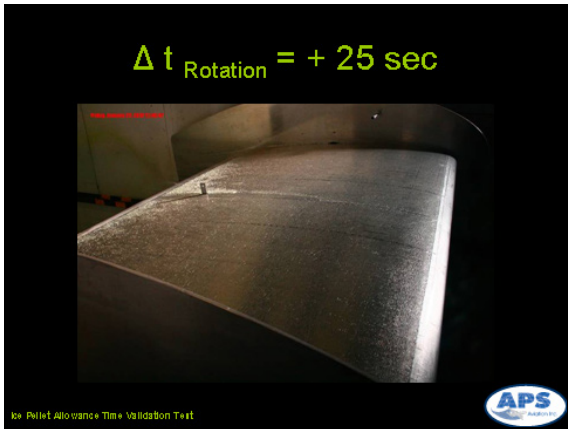
$\Delta t_{\text{Rotation}} = + 20$ sec

Ice Pellet Allowance Time Validation Test



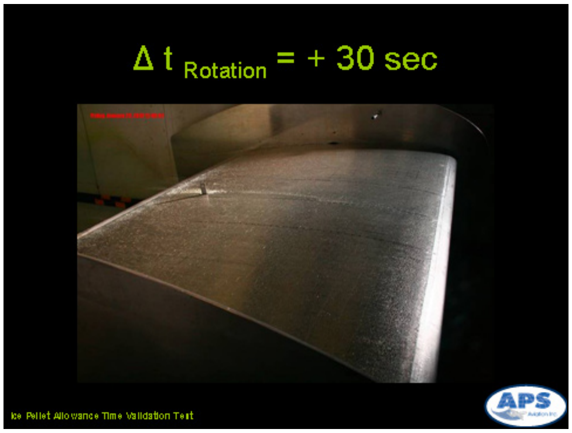
$\Delta t_{\text{Rotation}} = + 22$ sec
End of Rotation

Ice Pellet Allowance Time Validation Test



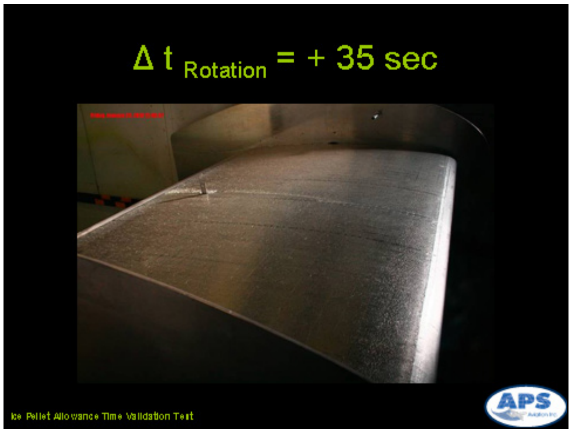
$\Delta t_{\text{Rotation}} = + 25$ sec

Ice Pellet Allowance Time Validation Test



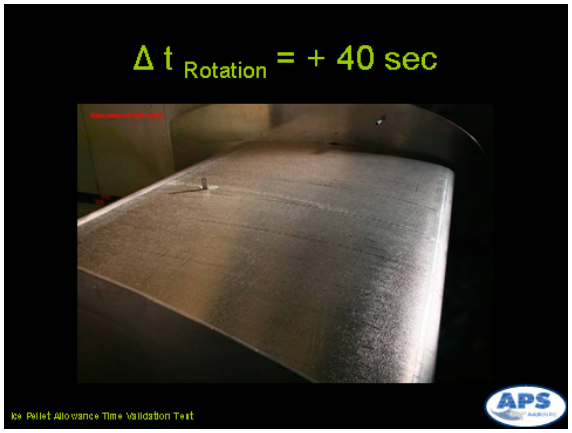
$\Delta t_{\text{Rotation}} = + 30$ sec

Ice Pellet Allowance Time Validation Test



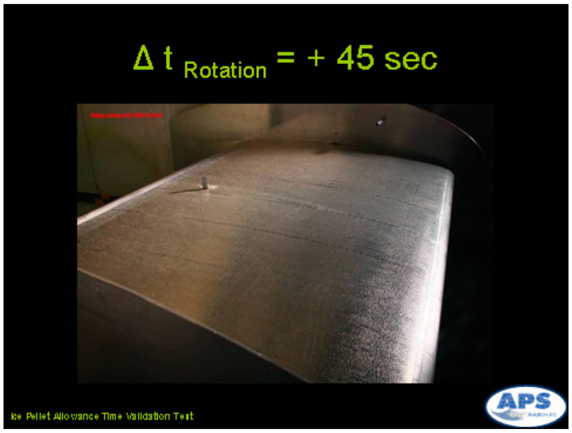
$\Delta t_{\text{Rotation}} = +\ 35$ sec

Ice Pellet Allowance Time Validation Test



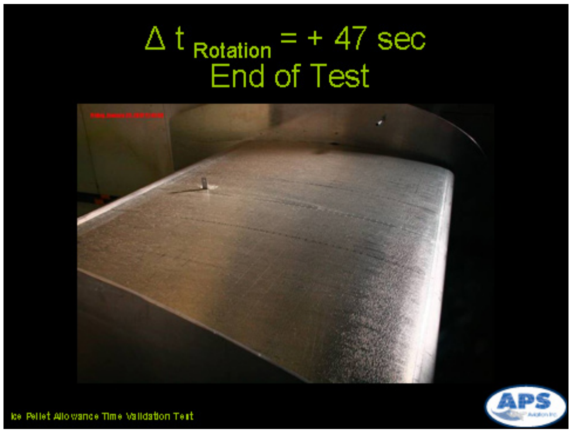
$\Delta t_{\text{Rotation}} = +\ 40$ sec

Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = +\ 45$ sec

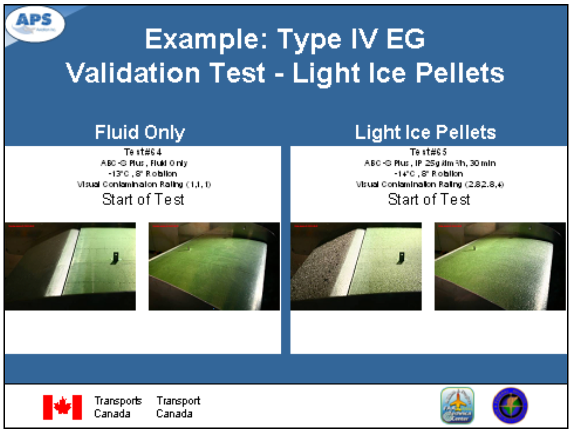
Ice Pellet Allowance Time Validation Test



$\Delta t_{\text{Rotation}} = +\ 47$ sec

End of Test

Ice Pellet Allowance Time Validation Test



Example: Type IV EG Validation Test - Light Ice Pellets

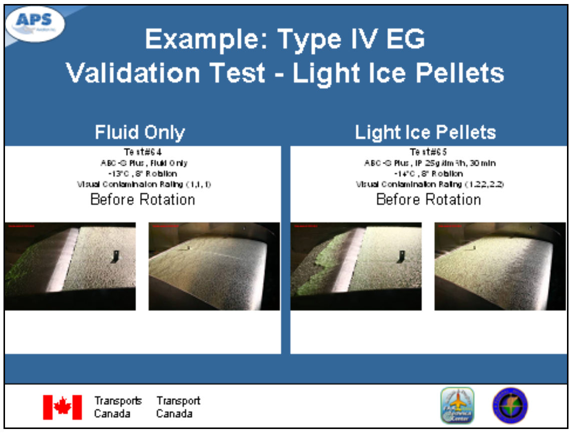
Fluid Only

Test#64
ABC-S Plus, Fluid Only
-13°C, 8" Rotation
Visual Contamination Rating (1,1,1)
Start of Test

Light Ice Pellets

Test#65
ABC-S Plus, IP 25g/dm^2/h, 30 min
-14°C, 8" Rotation
Visual Contamination Rating (2.8,2.8,4)
Start of Test

Transports Canada Transport Canada



Example: Type IV EG Validation Test - Light Ice Pellets

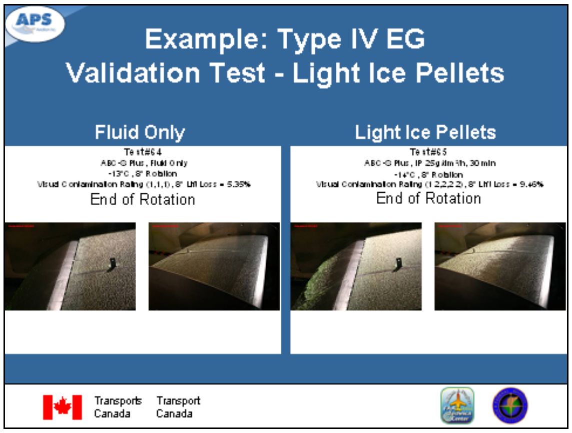
Fluid Only

Test#64
ABC-S Plus, Fluid Only
-13°C, 8" Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

Light Ice Pellets

Test#65
ABC-S Plus, IP 25g/dm^2/h, 30 min
-14°C, 8" Rotation
Visual Contamination Rating (1.2,2,2.2)
Before Rotation

Transports Canada Transport Canada



Example: Type IV EG Validation Test - Light Ice Pellets

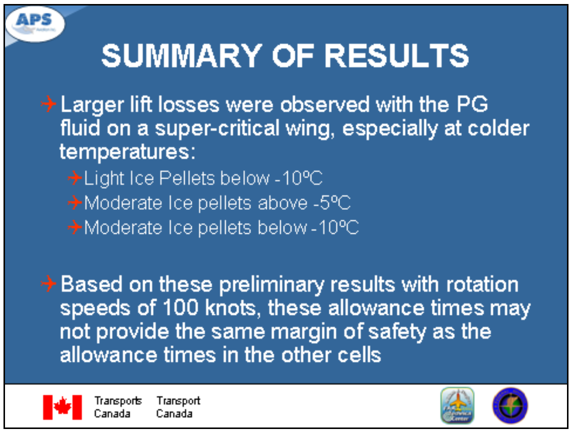
Fluid Only

Test#64
ABC-S Plus, Fluid Only
-13°C, 8" Rotation
Visual Contamination Rating (1,1,1), 8" Lift Loss = 5.35%
End of Rotation

Light Ice Pellets

Test#65
ABC-S Plus, IP 25g/dm^2/h, 30 min
-14°C, 8" Rotation
Visual Contamination Rating (1.2,2,2.2), 8" Lift Loss = 9.46%
End of Rotation

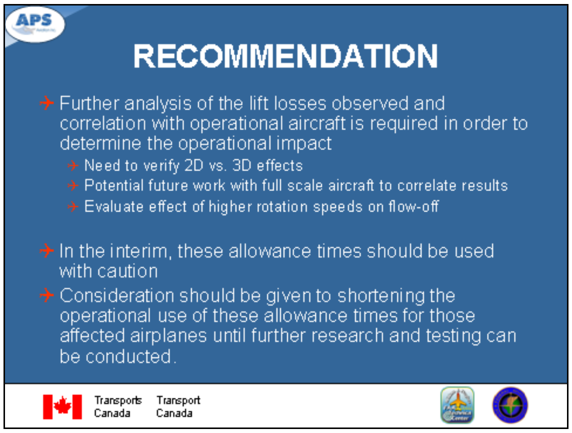
Transports Canada Transport Canada



SUMMARY OF RESULTS

- Larger lift losses were observed with the PG fluid on a super-critical wing, especially at colder temperatures:
  - Light Ice Pellets below -10°C
  - Moderate Ice pellets above -5°C
  - Moderate Ice pellets below -10°C
- Based on these preliminary results with rotation speeds of 100 knots, these allowance times may not provide the same margin of safety as the allowance times in the other cells

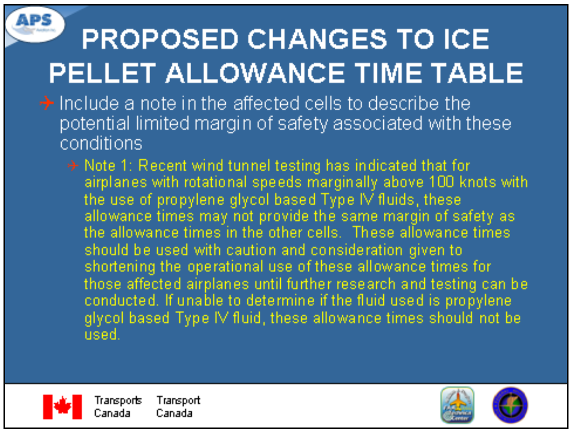
Transports Canada Transport Canada



RECOMMENDATION

- Further analysis of the lift losses observed and correlation with operational aircraft is required in order to determine the operational impact
  - Need to verify 2D vs. 3D effects
  - Potential future work with full scale aircraft to correlate results
  - Evaluate effect of higher rotation speeds on flow-off
- In the interim, these allowance times should be used with caution
- Consideration should be given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted.

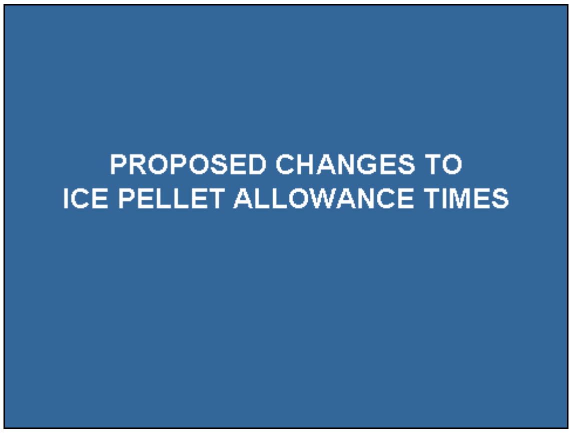
Transports Canada Transport Canada



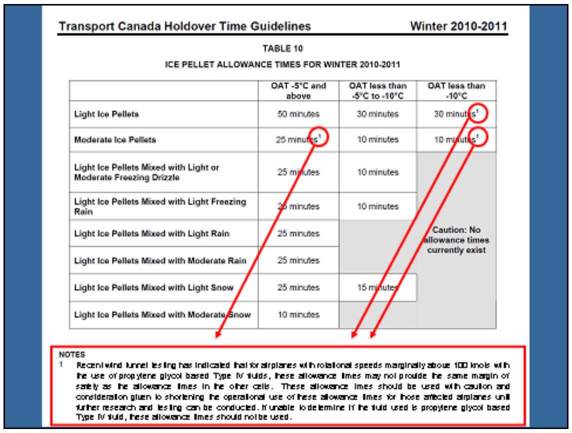
PROPOSED CHANGES TO ICE PELLET ALLOWANCE TIME TABLE

- Include a note in the affected cells to describe the potential limited margin of safety associated with these conditions
  - Note 1: Recent wind tunnel testing has indicated that for airplanes with rotational speeds marginally above 100 knots with the use of propylene glycol based Type IV fluids, these allowance times may not provide the same margin of safety as the allowance times in the other cells. These allowance times should be used with caution and consideration given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted. If unable to determine if the fluid used is propylene glycol based Type IV fluid, these allowance times should not be used.

Transports Canada Transport Canada



PROPOSED CHANGES TO ICE PELLET ALLOWANCE TIMES



Transport Canada Holdover Time Guidelines Winter 2010-2011

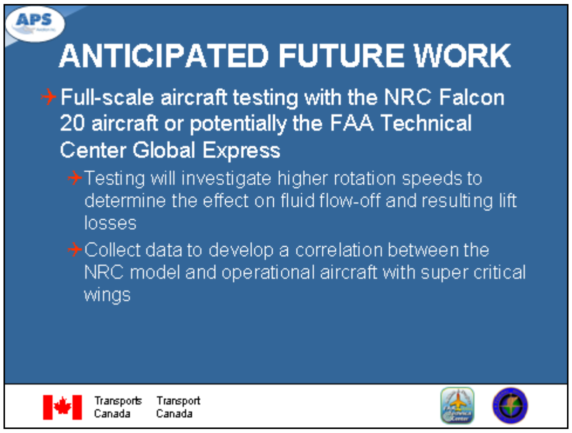
TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[1]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

[1] Recent wind tunnel testing has indicated that for airplanes with rotational speeds marginally above 100 knots with the use of propylene glycol based Type IV fluids, these allowance times may not provide the same margin of safety as the allowance times in the other cells. These allowance times should be used with caution and consideration given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted. If unable to determine if the fluid used is propylene glycol based Type IV fluid, these allowance times should not be used.



ANTICIPATED FUTURE WORK

- Full-scale aircraft testing with the NRC Falcon 20 aircraft or potentially the FAA Technical Center Global Express
  - Testing will investigate higher rotation speeds to determine the effect on fluid flow-off and resulting lift losses
  - Collect data to develop a correlation between the NRC model and operational aircraft with super critical wings

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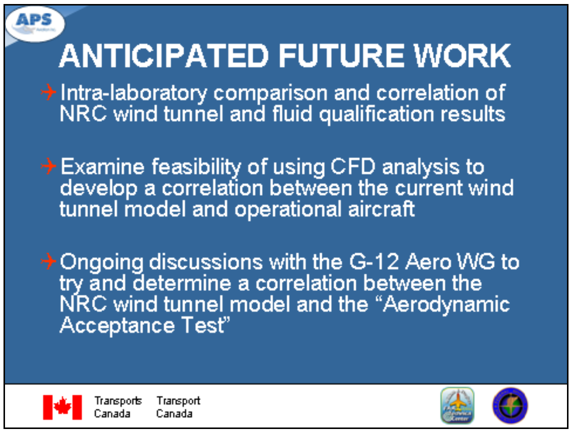

ANTICIPATED FUTURE WORK

- Intra-laboratory comparison and correlation of NRC wind tunnel and fluid qualification results
- Examine feasibility of using CFD analysis to develop a correlation between the current wind tunnel model and operational aircraft
- Ongoing discussions with the G-12 Aero WG to try and determine a correlation between the NRC wind tunnel model and the “Aerodynamic Acceptance Test”

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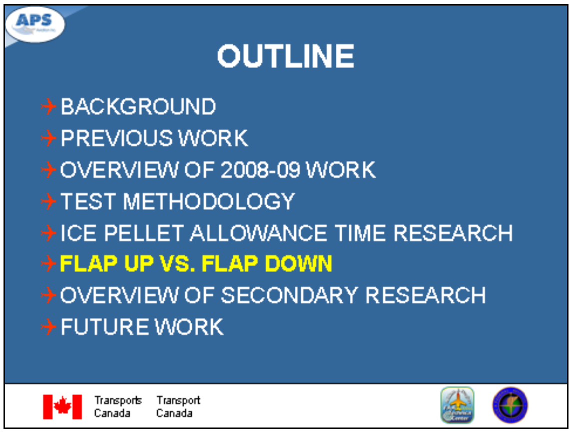

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- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
- **FLAP UP VS. FLAP DOWN**
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

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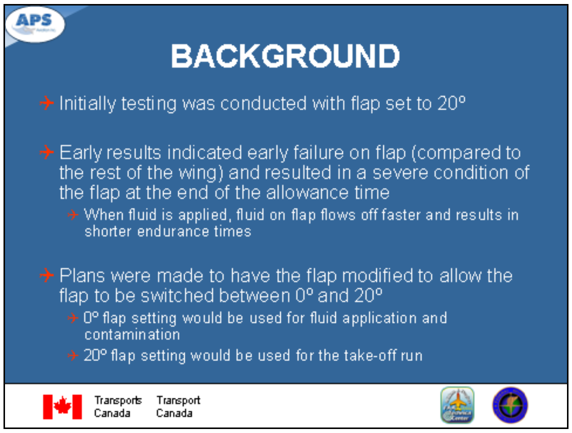

BACKGROUND

- Initially testing was conducted with flap set to 20°
- Early results indicated early failure on flap (compared to the rest of the wing) and resulted in a severe condition of the flap at the end of the allowance time
  - When fluid is applied, fluid on flap flows off faster and results in shorter endurance times
- Plans were made to have the flap modified to allow the flap to be switched between 0° and 20°
  - 0° flap setting would be used for fluid application and contamination
  - 20° flap setting would be used for the take-off run

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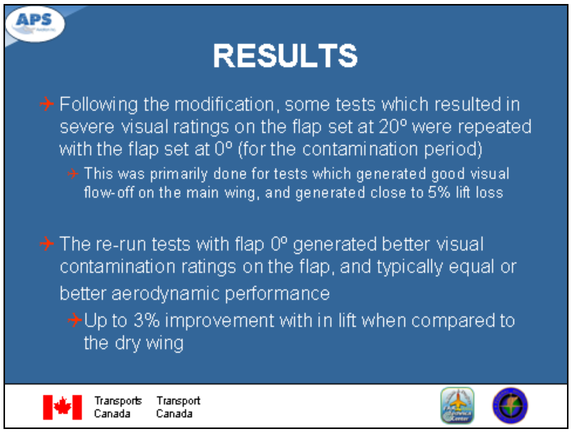

RESULTS

- Following the modification, some tests which resulted in severe visual ratings on the flap set at 20° were repeated with the flap set at 0° (for the contamination period)
  - This was primarily done for tests which generated good visual flow-off on the main wing, and generated close to 5% lift loss
- The re-run tests with flap 0° generated better visual contamination ratings on the flap, and typically equal or better aerodynamic performance
  - Up to 3% improvement with in lift when compared to the dry wing

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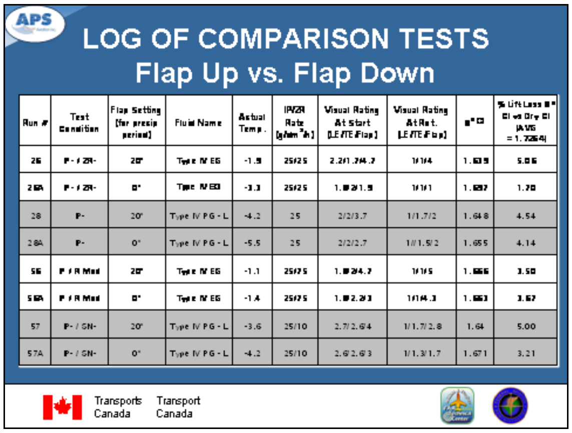

LOG OF COMPARISON TESTS Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	IP/ZR Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
26	P-/ZR-	20°	Type IV EG	-1.9	25/25	2.2/1.7/4.7	1/1/4	1.639	5.06
26A	P-/ZR-	0°	Type IV EG	-3.3	25/25	1.8/2/1.9	1/1/1	1.697	1.70
28	P-	20°	Type IV PG - L	-4.2	25	2/2/3.7	1/1.7/2	1.648	4.54
28A	P-	0°	Type IV PG - L	-5.5	25	2/2/2.7	1/1.5/2	1.655	4.14
56	P/R Mod	20°	Type IV EG	-1.1	25/75	1.8/2/4.7	1/1/5	1.666	3.50
56A	P/R Mod	0°	Type IV EG	-1.4	25/75	1.8/2.2/3	1/1/4.3	1.663	3.67
57	P- / SN-	20°	Type IV PG - L	-3.6	25/10	2.7/2.6/4	1/1.7/2.8	1.64	5.00
57A	P- / SN-	0°	Type IV PG - L	-4.2	25/10	2.6/2.6/3	1/1.3/1.7	1.671	3.21

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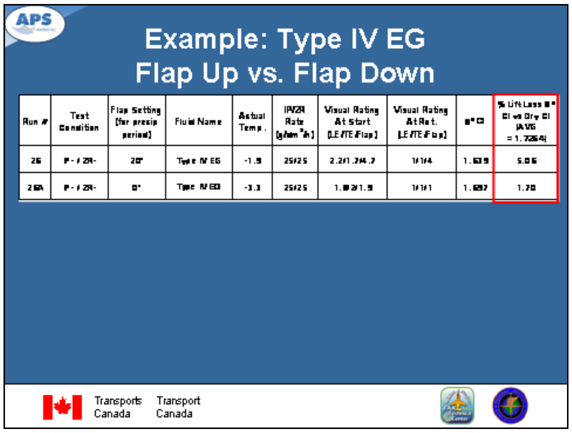

Example: Type IV EG Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	IP/ZR Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
26	P-/ZR-	20°	Type IV EG	-1.9	25/25	2.2/1.7/4.7	1/1/4	1.639	5.06
26A	P-/ZR-	0°	Type IV EG	-3.3	25/25	1.8/2/1.9	1/1/1	1.697	1.70

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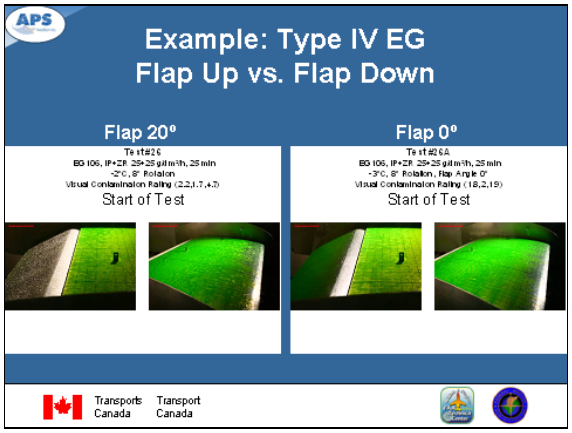

Example: Type IV EG Flap Up vs. Flap Down

Flap 20°

Test#26
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (2.2,1.7,4.7)
Start of Test

Flap 0°

Test#26A
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1.8,2,1.9)
Start of Test

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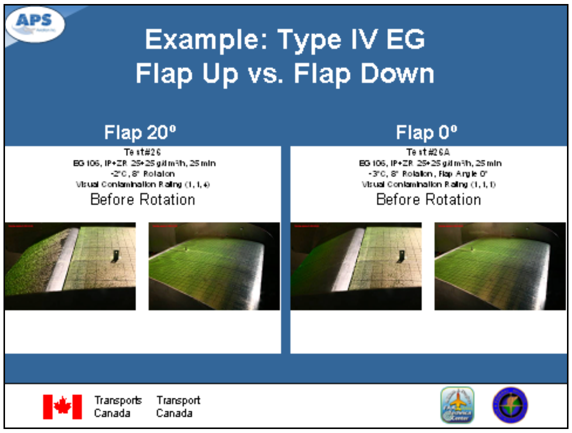

Example: Type IV EG Flap Up vs. Flap Down

Flap 20°

Test#26
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (1,1,4)
Before Rotation

Flap 0°

Test#26A
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1,1,1)
Before Rotation

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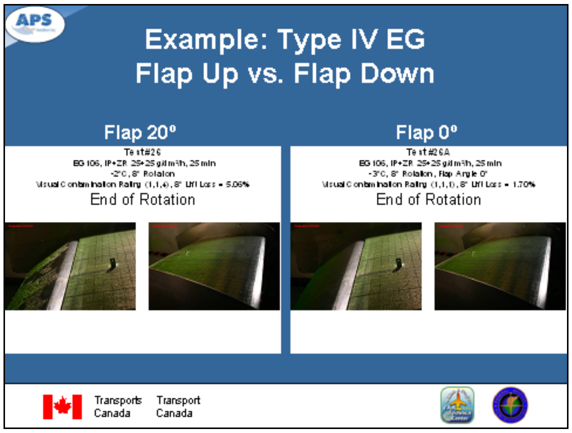

Example: Type IV EG Flap Up vs. Flap Down

Flap 20°

Test#26
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (1,1,4), 8° Lift Loss = 5.06%
End of Rotation

Flap 0°

Test#26A
EG 106, IP+ZR 25+25 g/dm²/h, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1,1,1), 8° Lift Loss = 1.70%
End of Rotation

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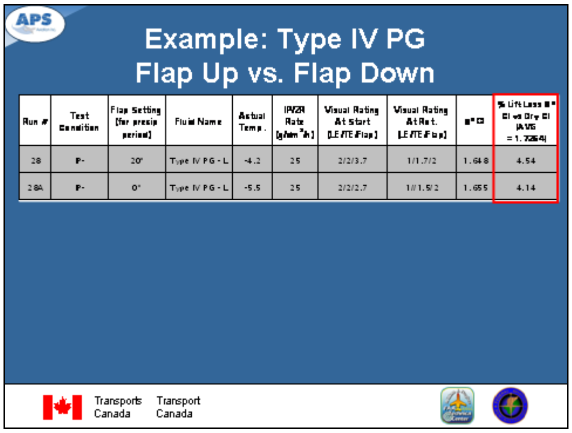

Example: Type IV PG Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	IP/ZR Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
28	P-	20°	Type IV PG - L	-4.2	25	2/2/3.7	1/1.7/2	1.648	4.54
28A	P-	0°	Type IV PG - L	-5.5	25	2/2/2.7	1//1.5/2	1.655	4.14

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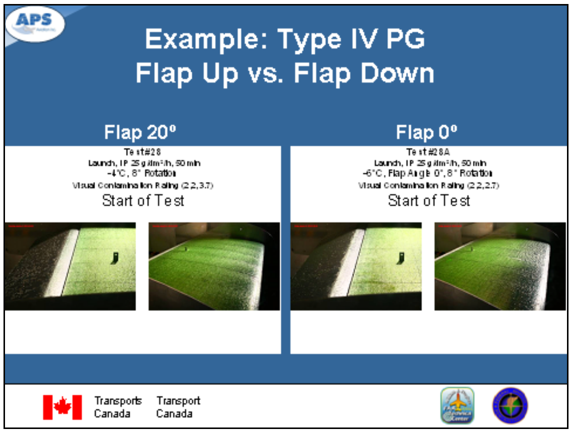

Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (2,2,3.7)
Start of Test

Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (2,2,2.7)
Start of Test

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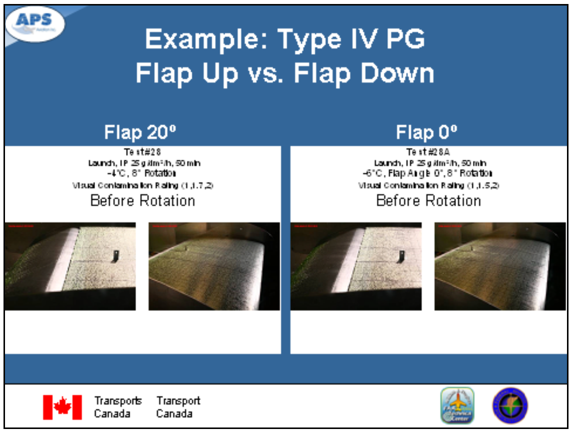

Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.7,2)
Before Rotation

Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (1,1.5,2)
Before Rotation

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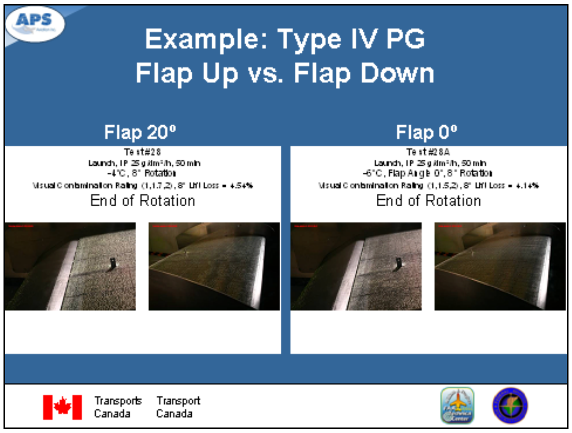

Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.7,2), 8° Lift Loss = 4.54%
End of Rotation

Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (1,1.5,2), 8° Lift Loss = 4.14%
End of Rotation

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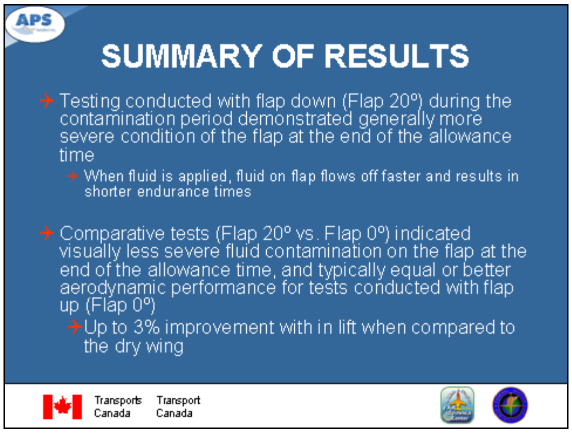

SUMMARY OF RESULTS

- Testing conducted with flap down (Flap 20°) during the contamination period demonstrated generally more severe condition of the flap at the end of the allowance time
  - When fluid is applied, fluid on flap flows off faster and results in shorter endurance times
- Comparative tests (Flap 20° vs. Flap 0°) indicated visually less severe fluid contamination on the flap at the end of the allowance time, and typically equal or better aerodynamic performance for tests conducted with flap up (Flap 0°)
  - Up to 3% improvement with in lift when compared to the dry wing

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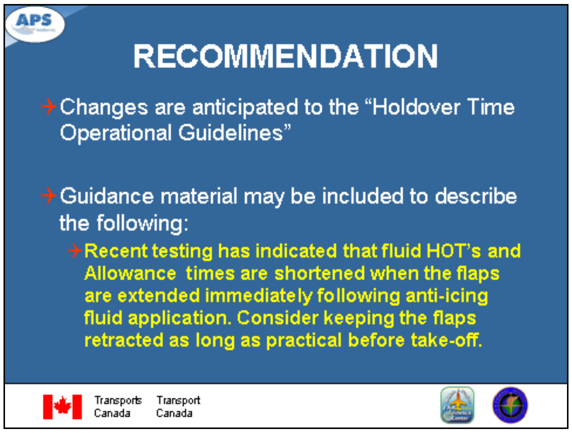

RECOMMENDATION

- Changes are anticipated to the “Holdover Time Operational Guidelines”
- Guidance material may be included to describe the following:
  - **Recent testing has indicated that fluid HOT’s and Allowance times are shortened when the flaps are extended immediately following anti-icing fluid application. Consider keeping the flaps retracted as long as practical before take-off.**

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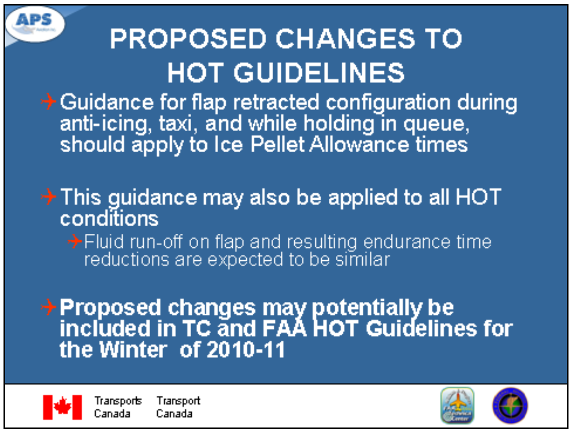

PROPOSED CHANGES TO HOT GUIDELINES

- Guidance for flap retracted configuration during anti-icing, taxi, and while holding in queue, should apply to Ice Pellet Allowance times
- This guidance may also be applied to all HOT conditions
  - Fluid run-off on flap and resulting endurance time reductions are expected to be similar
- **Proposed changes may potentially be included in TC and FAA HOT Guidelines for the Winter of 2010-11**

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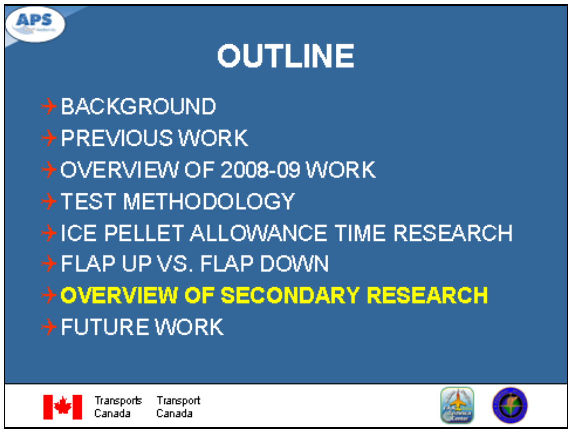

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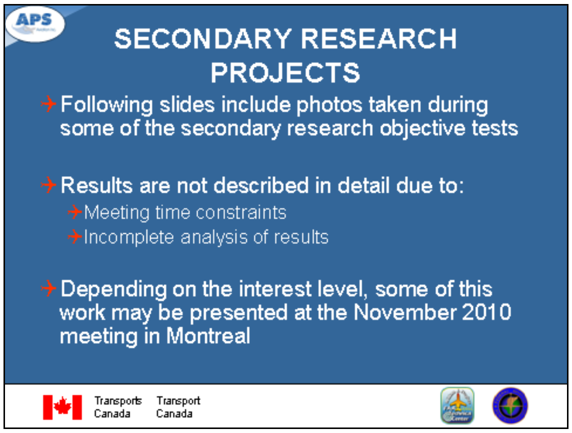

SECONDARY RESEARCH PROJECTS

- Following slides include photos taken during some of the secondary research objective tests
- Results are not described in detail due to:
  - Meeting time constraints
  - Incomplete analysis of results
- Depending on the interest level, some of this work may be presented at the November 2010 meeting in Montreal

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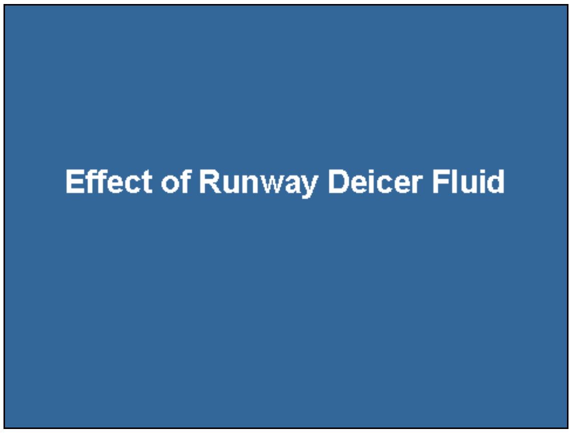
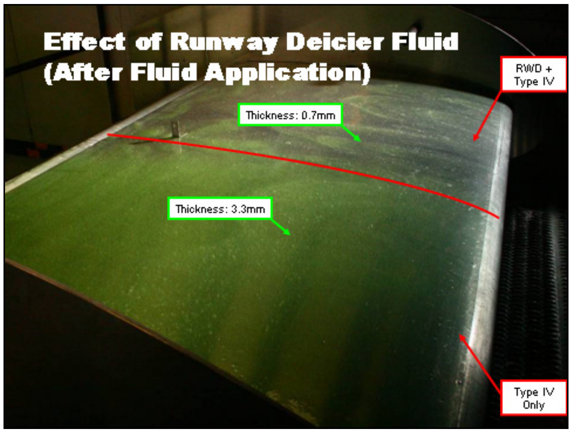
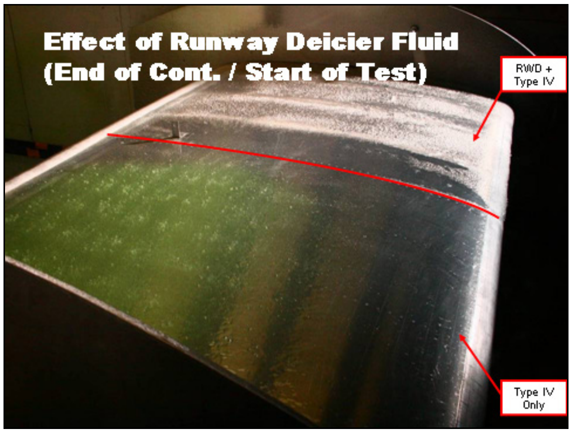


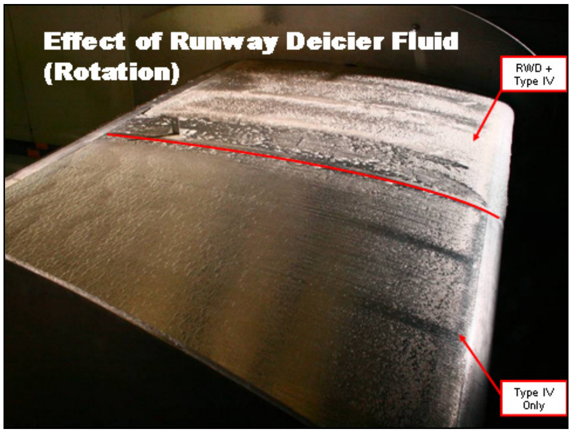
Effect of Runway Deicer Fluid



Effect of Runway Deicer Fluid (After Fluid Application)



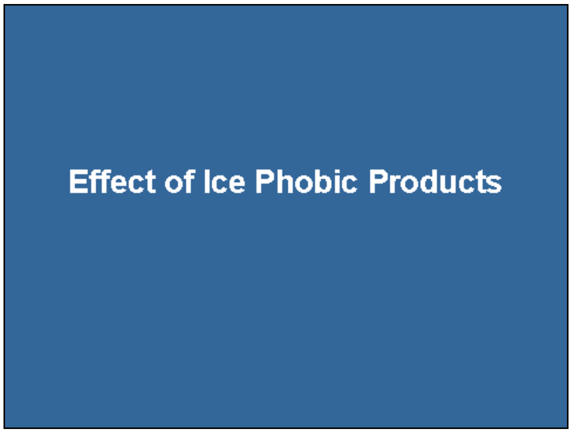
Effect of Runway Deicer Fluid (End of Cont. / Start of Test)



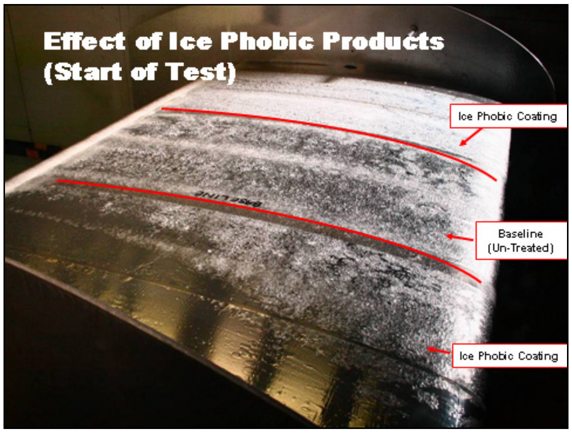
Effect of Runway Deicier Fluid (Rotation)

RWD + Type IV

Type IV Only



Effect of Ice Phobic Products

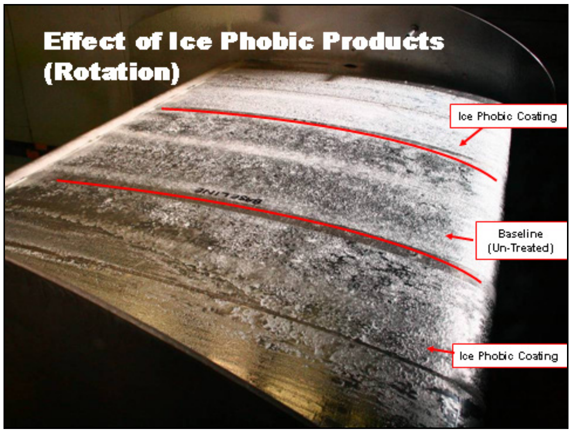


Effect of Ice Phobic Products (Start of Test)

Ice Phobic Coating

Baseline (Un-Treated)

Ice Phobic Coating



Effect of Ice Phobic Products (Rotation)

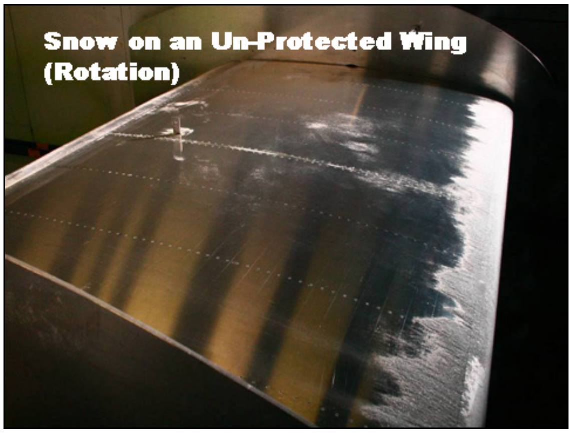
Ice Phobic Coating

Baseline (Un-Treated)

Ice Phobic Coating

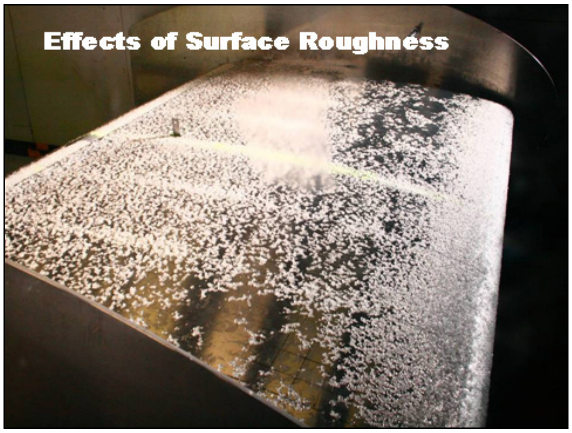
Snow on an Un-Protected Wing

Snow on an Un-Protected Wing (Start of Test)



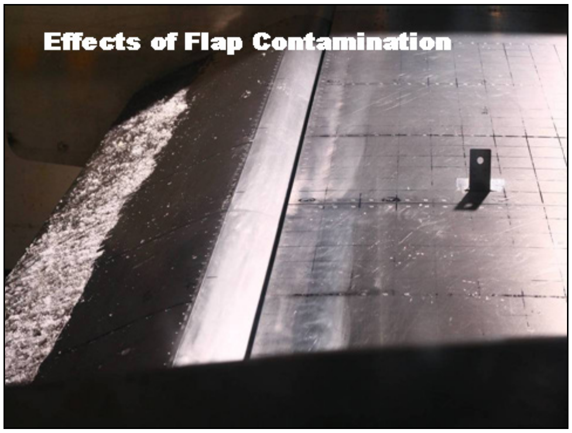
Snow on an Un-Protected Wing (Rotation)

Effects of Surface Roughness



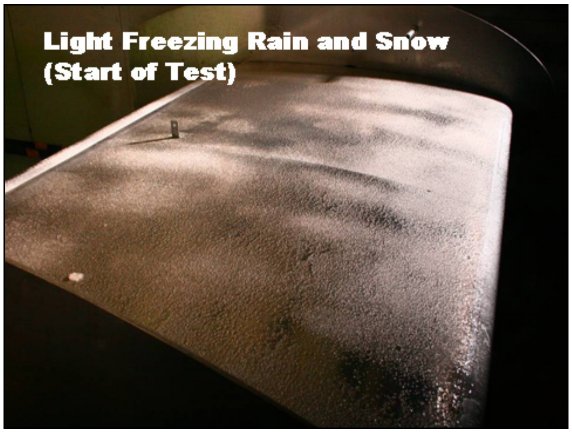
Effects of Surface Roughness

Effects of Flap Contamination

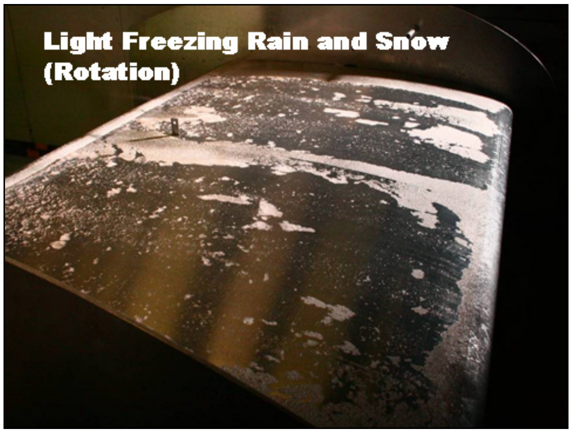


Effects of Flap Contamination

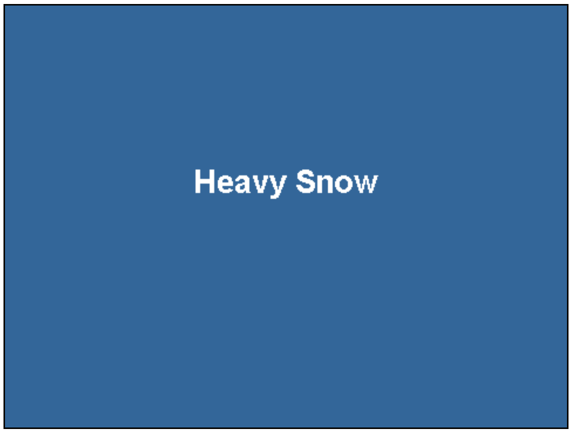
Light Freezing Rain and Snow



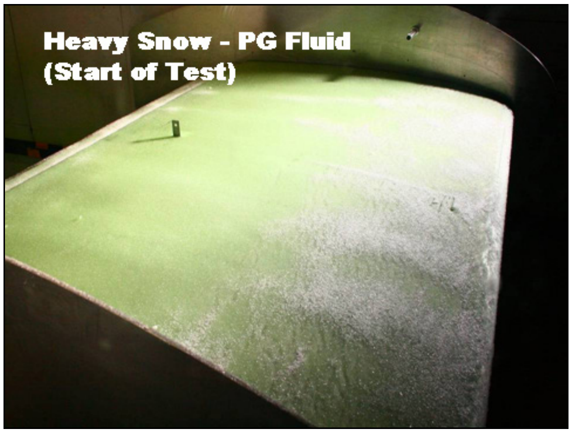
Light Freezing Rain and Snow
(Start of Test)



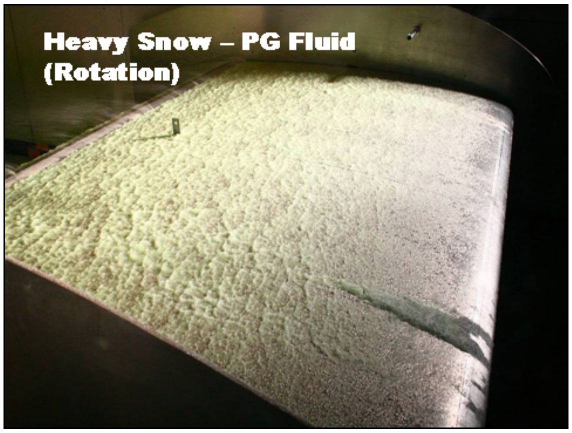
Light Freezing Rain and Snow
(Rotation)



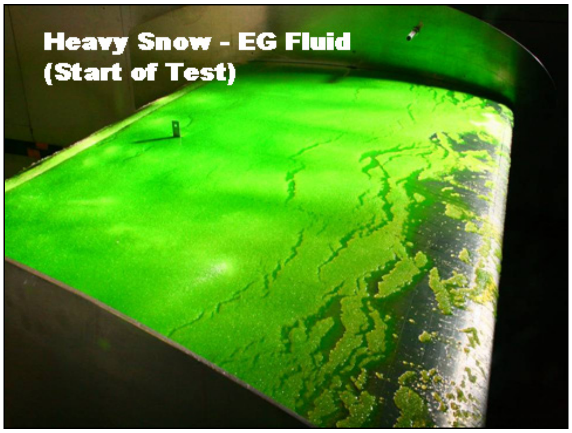
Heavy Snow



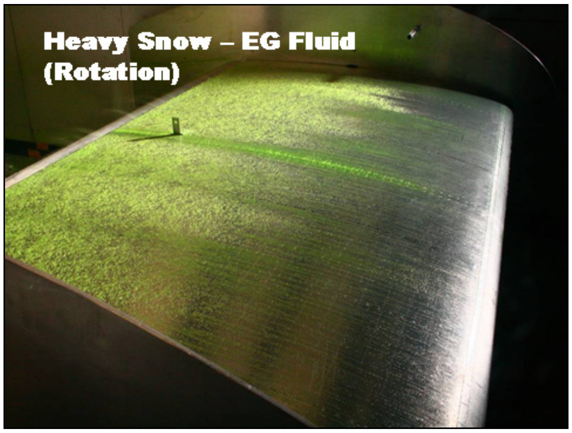
Heavy Snow - PG Fluid
(Start of Test)



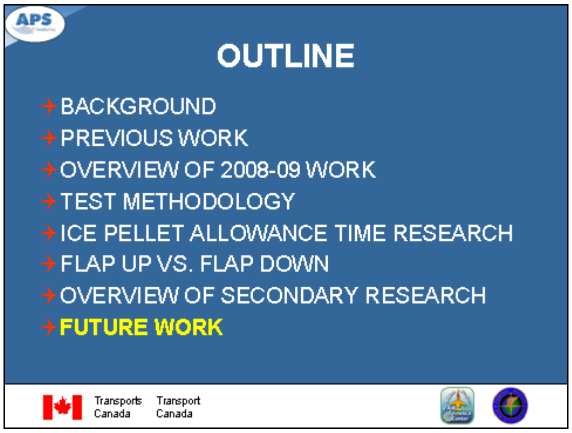
Heavy Snow – PG Fluid
(Rotation)



Heavy Snow - EG Fluid
(Start of Test)



Heavy Snow – EG Fluid (Rotation)



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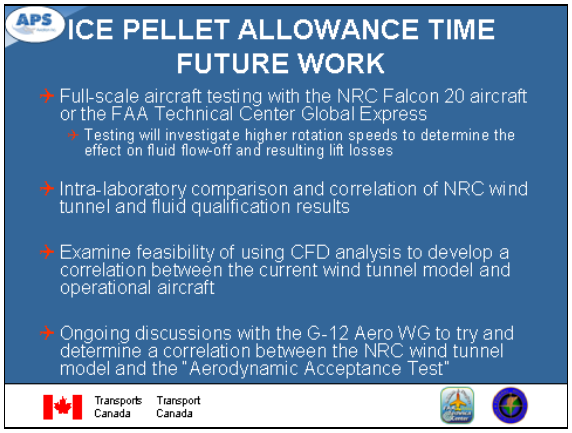

ICE PELLET ALLOWANCE TIME FUTURE WORK

- Full-scale aircraft testing with the NRC Falcon 20 aircraft or the FAA Technical Center Global Express
  - Testing will investigate higher rotation speeds to determine the effect on fluid flow-off and resulting lift losses
- Intra-laboratory comparison and correlation of NRC wind tunnel and fluid qualification results
- Examine feasibility of using CFD analysis to develop a correlation between the current wind tunnel model and operational aircraft
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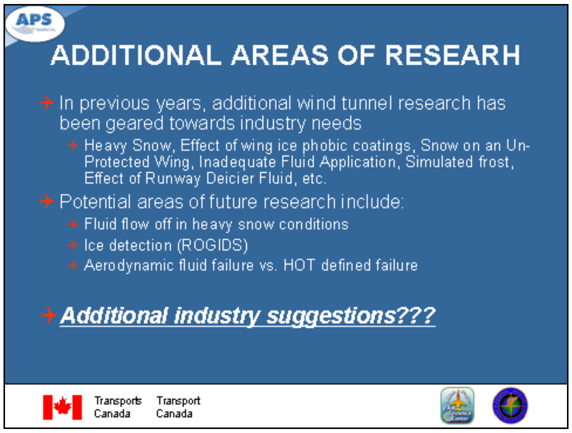

ADDITIONAL AREAS OF RESEARH

- In previous years, additional wind tunnel research has been geared towards industry needs
  - Heavy Snow, Effect of wing ice phobic coatings, Snow on an Un-Protected Wing, Inadequate Fluid Application, Simulated frost, Effect of Runway Deicier Fluid, etc.
- Potential areas of future research include:
  - Fluid flow off in heavy snow conditions
  - Ice detection (ROGIDS)
  - Aerodynamic fluid failure vs. HOT defined failure
- ***Additional industry suggestions???***

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C-FIGD
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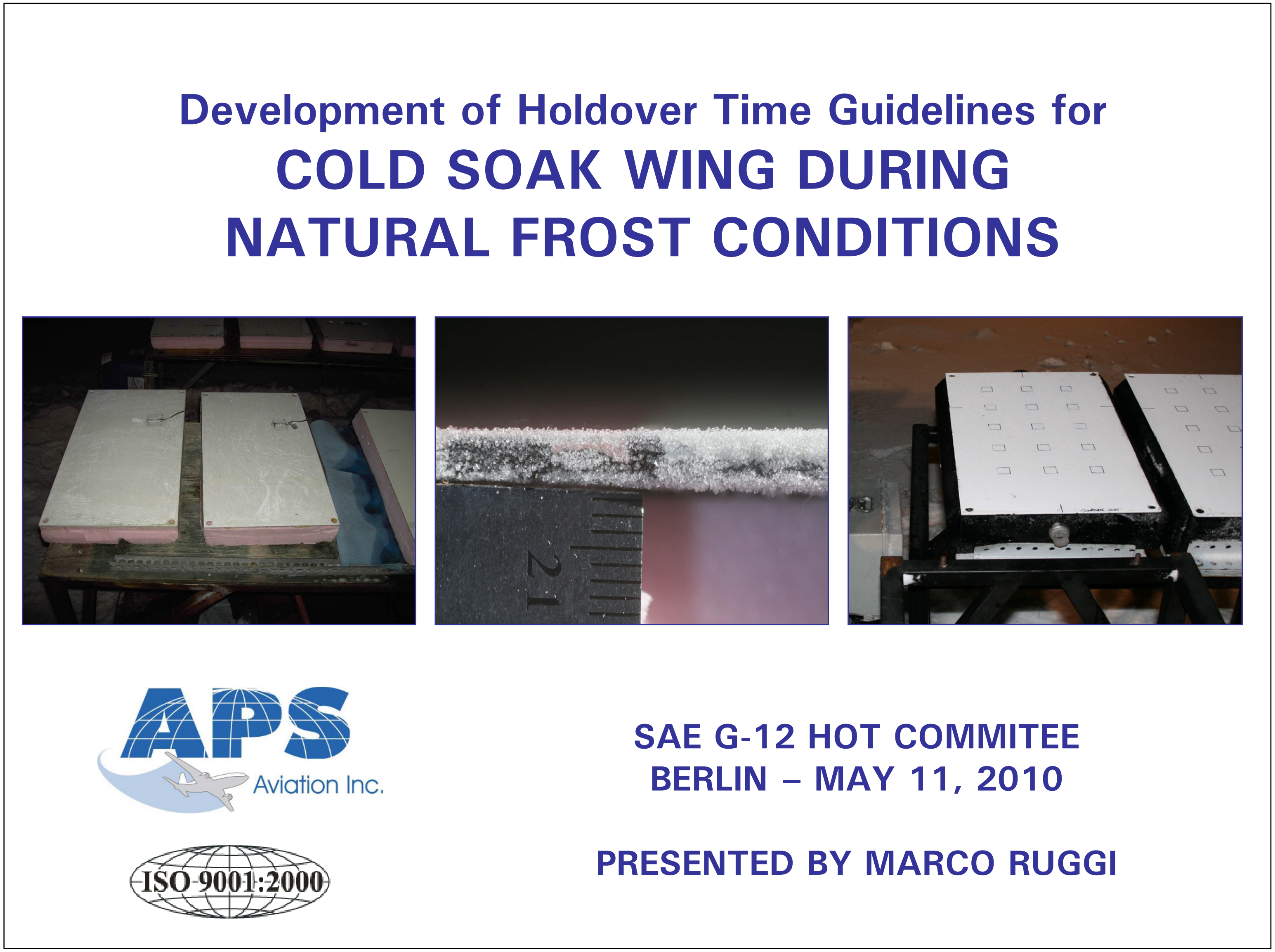


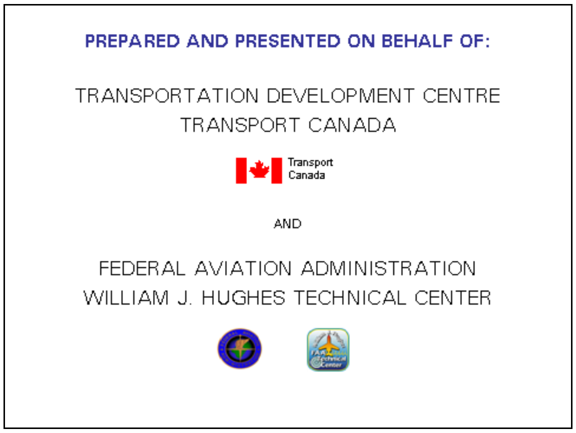
Development of Holdover Time Guidelines for
COLD SOAK WING DURING NATURAL FROST CONDITIONS

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT COMMITEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI



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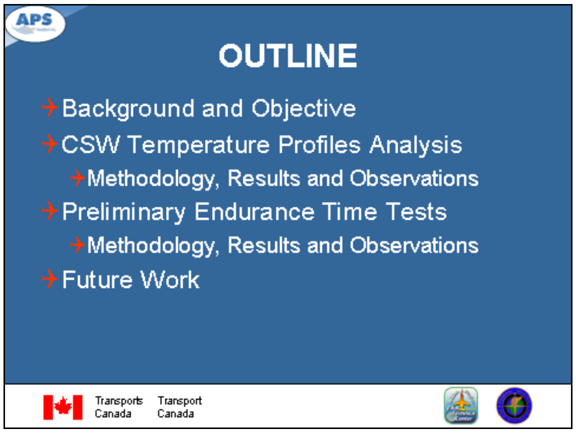
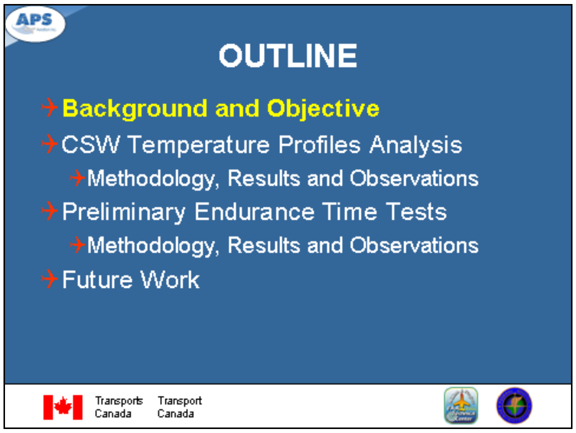
FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background and Objective
- CSW Temperature Profiles Analysis
  - Methodology, Results and Observations
- Preliminary Endurance Time Tests
  - Methodology, Results and Observations
- Future Work



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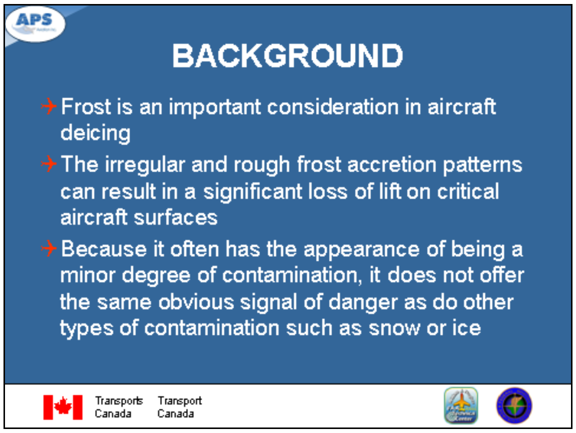
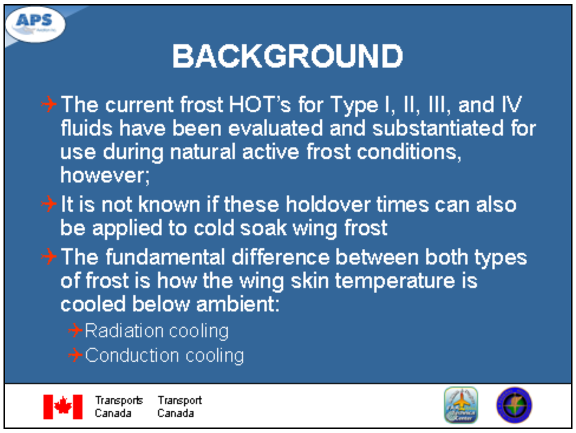


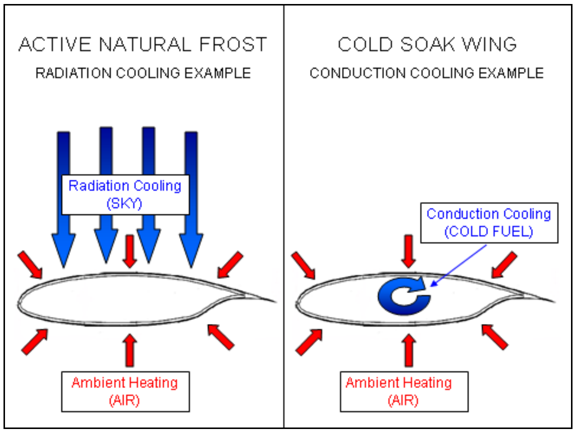
BACKGROUND

- Frost is an important consideration in aircraft deicing
- The irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces
- Because it often has the appearance of being a minor degree of contamination, it does not offer the same obvious signal of danger as do other types of contamination such as snow or ice



BACKGROUND

- The current frost HOT's for Type I, II, III, and IV fluids have been evaluated and substantiated for use during natural active frost conditions, however;
- It is not known if these holdover times can also be applied to cold soak wing frost
- The fundamental difference between both types of frost is how the wing skin temperature is cooled below ambient:
  - Radiation cooling
  - Conduction cooling



ACTIVE NATURAL FROST
RADIATION COOLING EXAMPLE

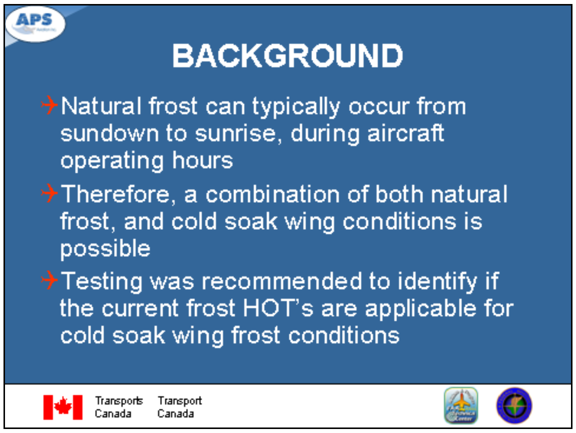
Radiation Cooling
(SKY)

Ambient Heating
(AIR)

COLD SOAK WING
CONDUCTION COOLING EXAMPLE

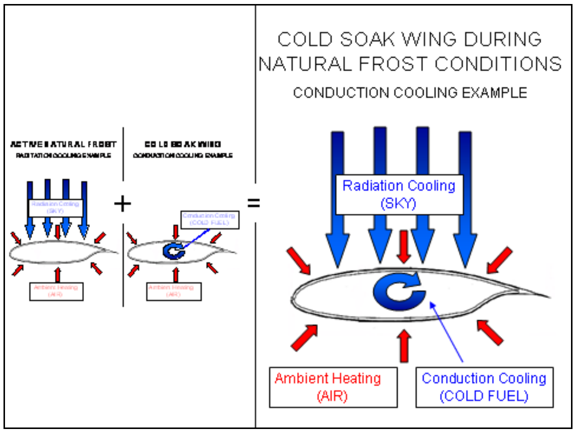
Conduction Cooling
(COLD FUEL)

Ambient Heating
(AIR)



BACKGROUND

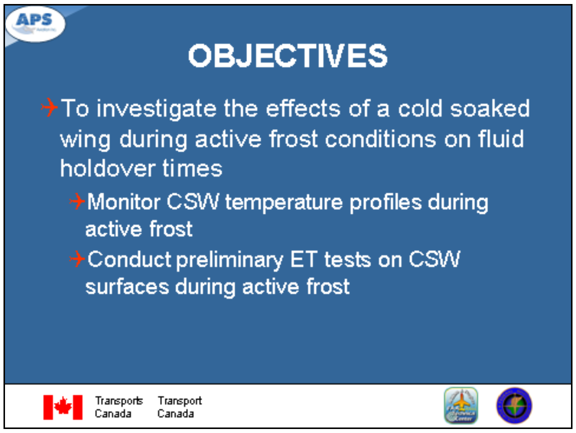
- Natural frost can typically occur from sundown to sunrise, during aircraft operating hours
- Therefore, a combination of both natural frost, and cold soak wing conditions is possible
- Testing was recommended to identify if the current frost HOT's are applicable for cold soak wing frost conditions



COLD SOAK WING DURING NATURAL FROST CONDITIONS

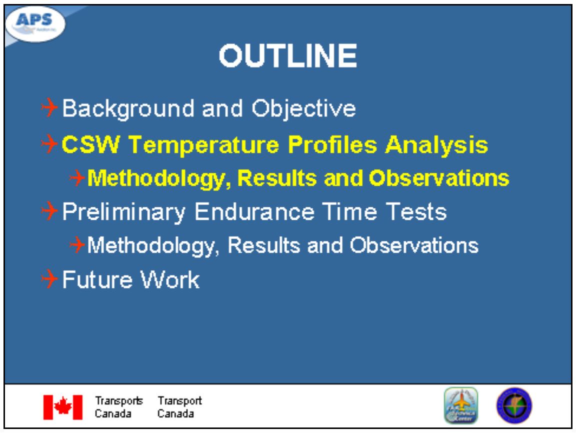
CONDUCTION COOLING EXAMPLE

ACTIVE NATURAL FROST
RADIATION COOLING EXAMPLE
COLD SOAK WING
CONDUCTION COOLING EXAMPLE
+
=
Radiation Cooling (SKY)
Conduction Cooling (COLD FUEL)
Ambient Heating (AIR)
Radiation Cooling (SKY)
Ambient Heating (AIR)
Conduction Cooling (COLD FUEL)



OBJECTIVES

- To investigate the effects of a cold soaked wing during active frost conditions on fluid holdover times
  - Monitor CSW temperature profiles during active frost
  - Conduct preliminary ET tests on CSW surfaces during active frost



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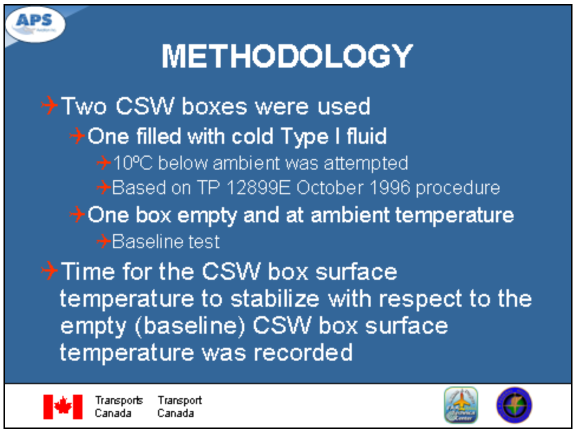
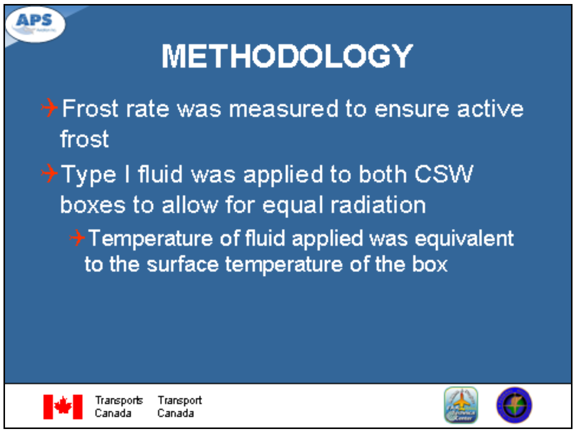


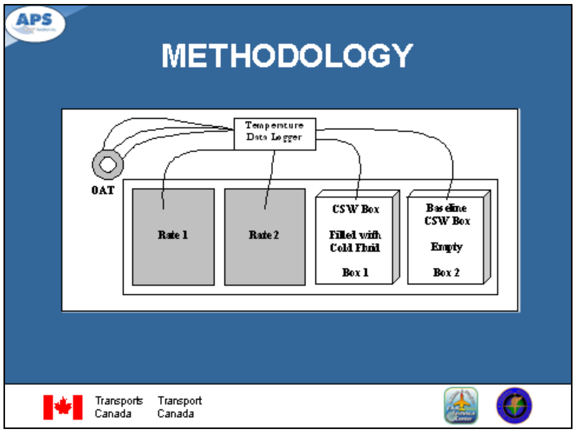
METHODOLOGY

- Two CSW boxes were used
  - One filled with cold Type I fluid
    - 10ºC below ambient was attempted
    - Based on TP 12899E October 1996 procedure
  - One box empty and at ambient temperature
    - Baseline test
- Time for the CSW box surface temperature to stabilize with respect to the empty (baseline) CSW box surface temperature was recorded



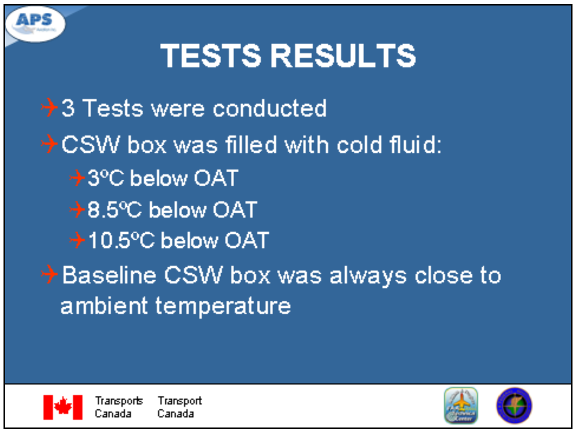
METHODOLOGY

- Frost rate was measured to ensure active frost
- Type I fluid was applied to both CSW boxes to allow for equal radiation
  - Temperature of fluid applied was equivalent to the surface temperature of the box



METHODOLOGY

Temperature Data Logger
OAT
Rate 1
Rate 2
CSW Box
Filled with Cold Fluid
Box 1
Baseline CSW Box
Empty
Box 2
Transports Canada
Transport Canada



TESTS RESULTS

- 3 Tests were conducted
- CSW box was filled with cold fluid:
  - 3°C below OAT
  - 8.5°C below OAT
  - 10.5°C below OAT
- Baseline CSW box was always close to ambient temperature

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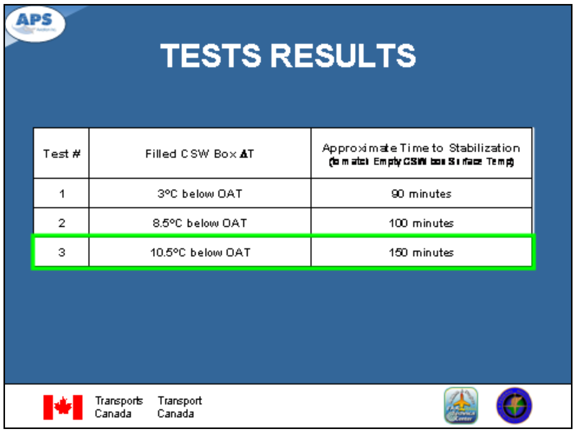

TESTS RESULTS

Test #	Filled CSW Box ΔT	Approximate Time to Stabilization (to match Empty CSW box Surface Temp)
1	3°C below OAT	90 minutes
2	8.5°C below OAT	100 minutes
3	10.5°C below OAT	150 minutes

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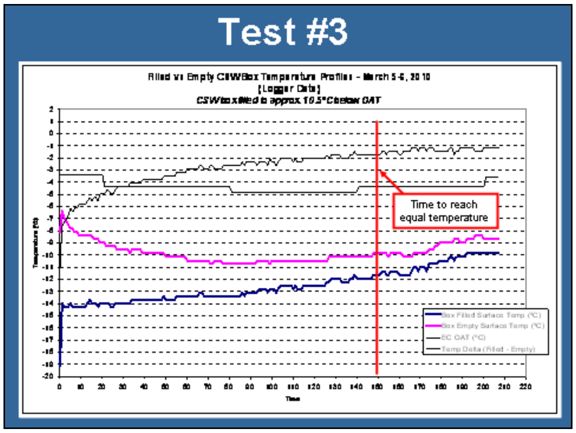
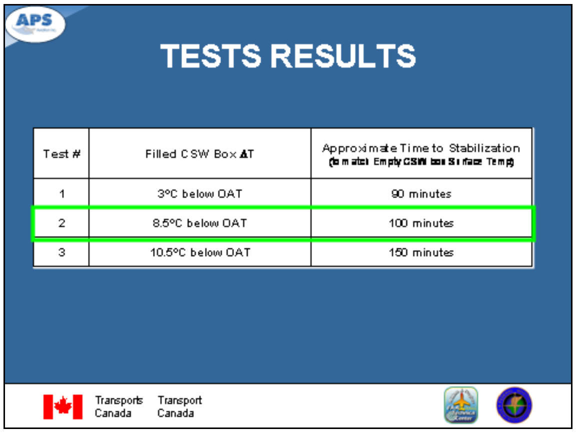


Test #3

Filled vs Empty CSW Box Temperature Profiles – March 5-6, 2010
(Logger Data)
CSW box filled to approx 10.5°C below OAT

Time to reach equal temperature



TESTS RESULTS

Test #	Filled CSW Box ΔT	Approximate Time to Stabilization (to match Empty CSW box Surface Temp)
1	3°C below OAT	90 minutes
2	8.5°C below OAT	100 minutes
3	10.5°C below OAT	150 minutes

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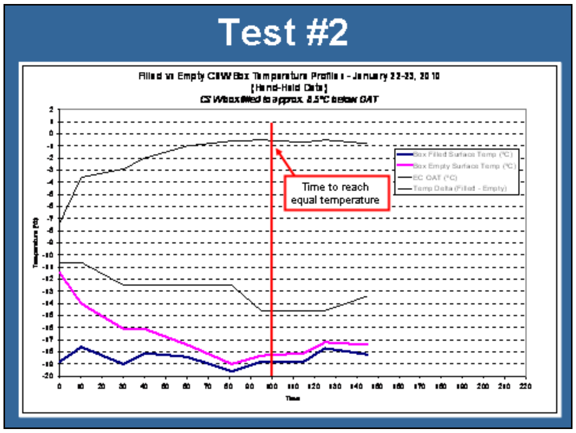
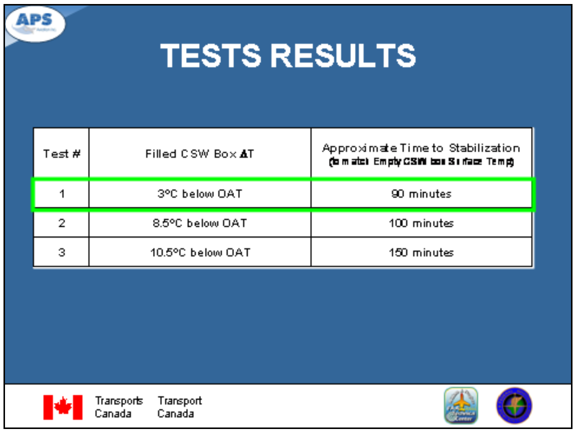
Transport Canada



Test #2

Filled vs Empty CSW Box Temperature Profiles – January 22-23, 2010
(Hand-Held Data)
CSW box filled to approx. 8.5°C below OAT

Time to reach equal temperature



TESTS RESULTS

Test #	Filled CSW Box ΔT	Approximate Time to Stabilization (to match Empty CSW box Surface Temp)
1	3°C below OAT	90 minutes
2	8.5°C below OAT	100 minutes
3	10.5°C below OAT	150 minutes

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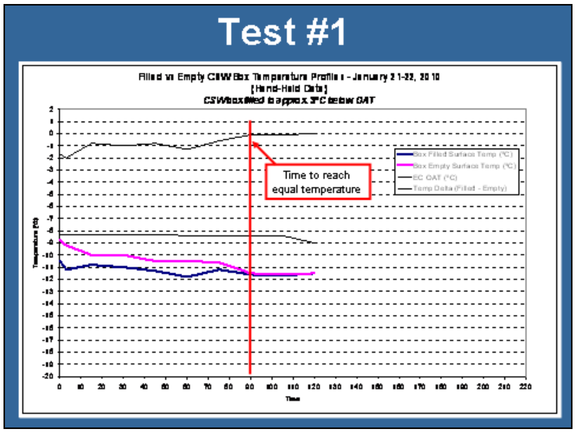
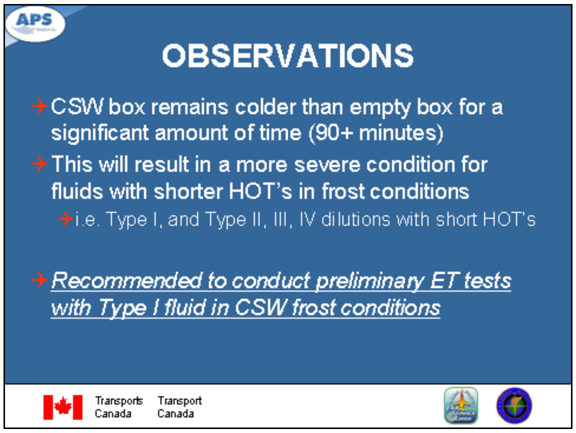


Test #1

Filled vs Empty CSW Box Temperature Profiles - January 21-22, 2010
(Hand-Held Data)
CSW box filled to approx 3°C below OAT

Time to reach equal temperature



OBSERVATIONS

- CSW box remains colder than empty box for a significant amount of time (90+ minutes)
- This will result in a more severe condition for fluids with shorter HOT's in frost conditions
  - i.e. Type I, and Type II, III, IV dilutions with short HOT's
- *Recommended to conduct preliminary ET tests with Type I fluid in CSW frost conditions*

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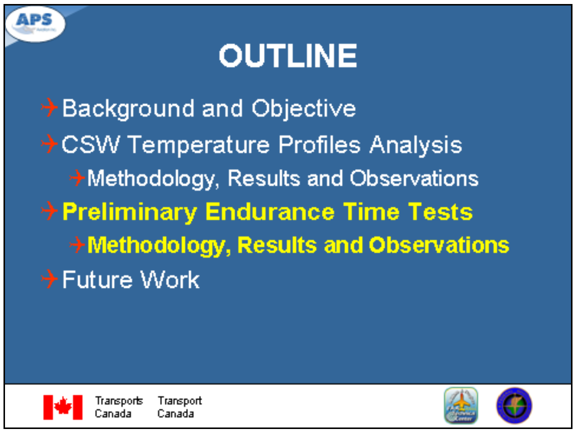

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  - **Methodology, Results and Observations**
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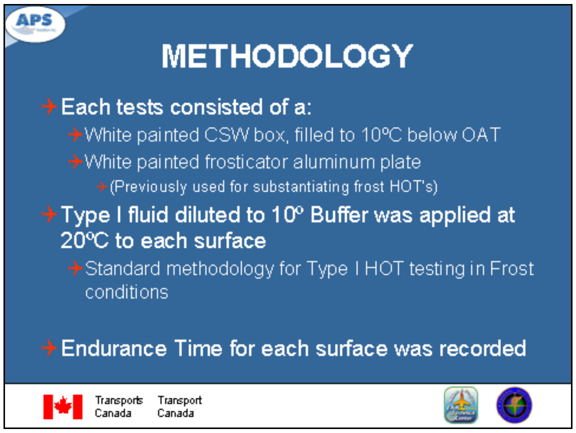

METHODOLOGY

- Each tests consisted of a:
  - White painted CSW box, filled to 10°C below OAT
  - White painted frosticator aluminum plate
    - (Previously used for substantiating frost HOT's)
- Type I fluid diluted to 10° Buffer was applied at 20°C to each surface
  - Standard methodology for Type I HOT testing in Frost conditions
- Endurance Time for each surface was recorded

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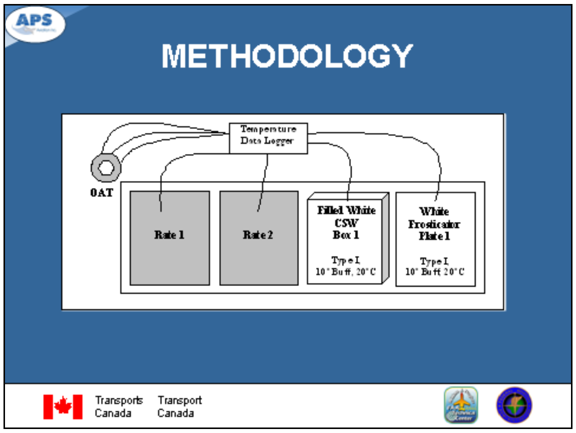

METHODOLOGY

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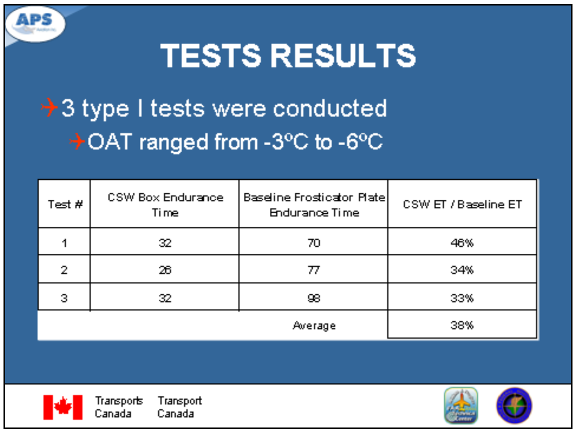

TESTS RESULTS

- 3 type I tests were conducted
  - OAT ranged from -3°C to -6°C

Test #	CSW Box Endurance Time	Baseline Frosticator Plate Endurance Time	CSW ET / Baseline ET
1	32	70	46%
2	26	77	34%
3	32	98	33%
		Average	38%

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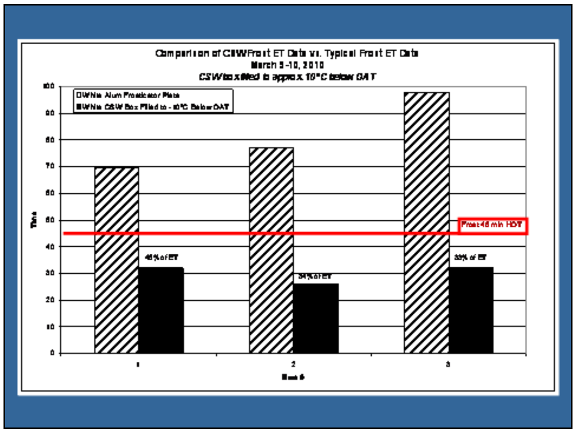

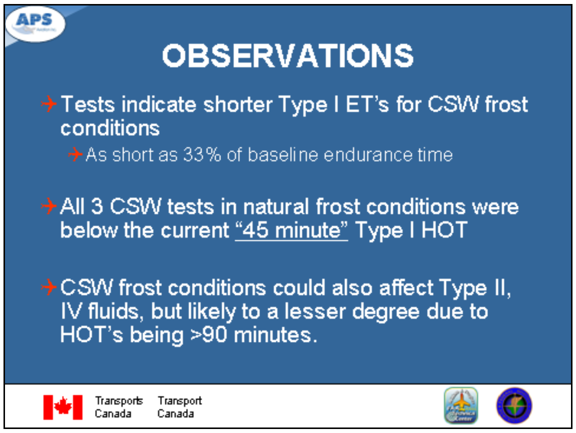

OBSERVATIONS

- Tests indicate shorter Type I ET's for CSW frost conditions
  - As short as 33% of baseline endurance time
- All 3 CSW tests in natural frost conditions were below the current "45 minute" Type I HOT
- CSW frost conditions could also affect Type II, IV fluids, but likely to a lesser degree due to HOT's being >90 minutes.

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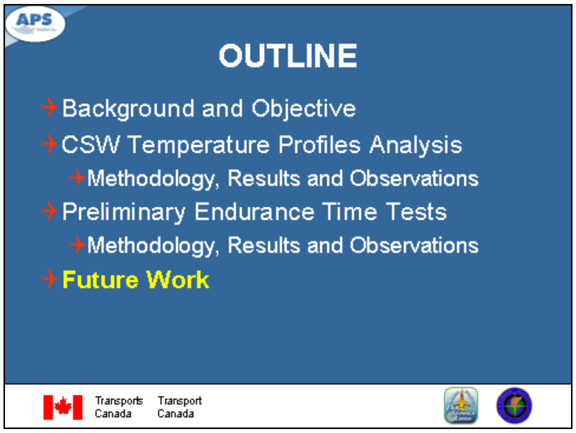

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- **Future Work**

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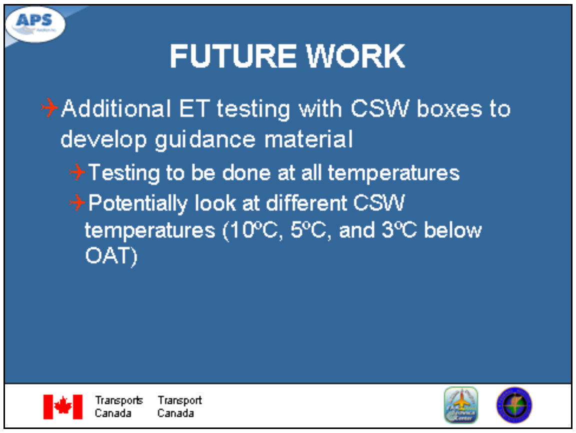

FUTURE WORK

- Additional ET testing with CSW boxes to develop guidance material
  - Testing to be done at all temperatures
  - Potentially look at different CSW temperatures (10°C, 5°C, and 3°C below OAT)

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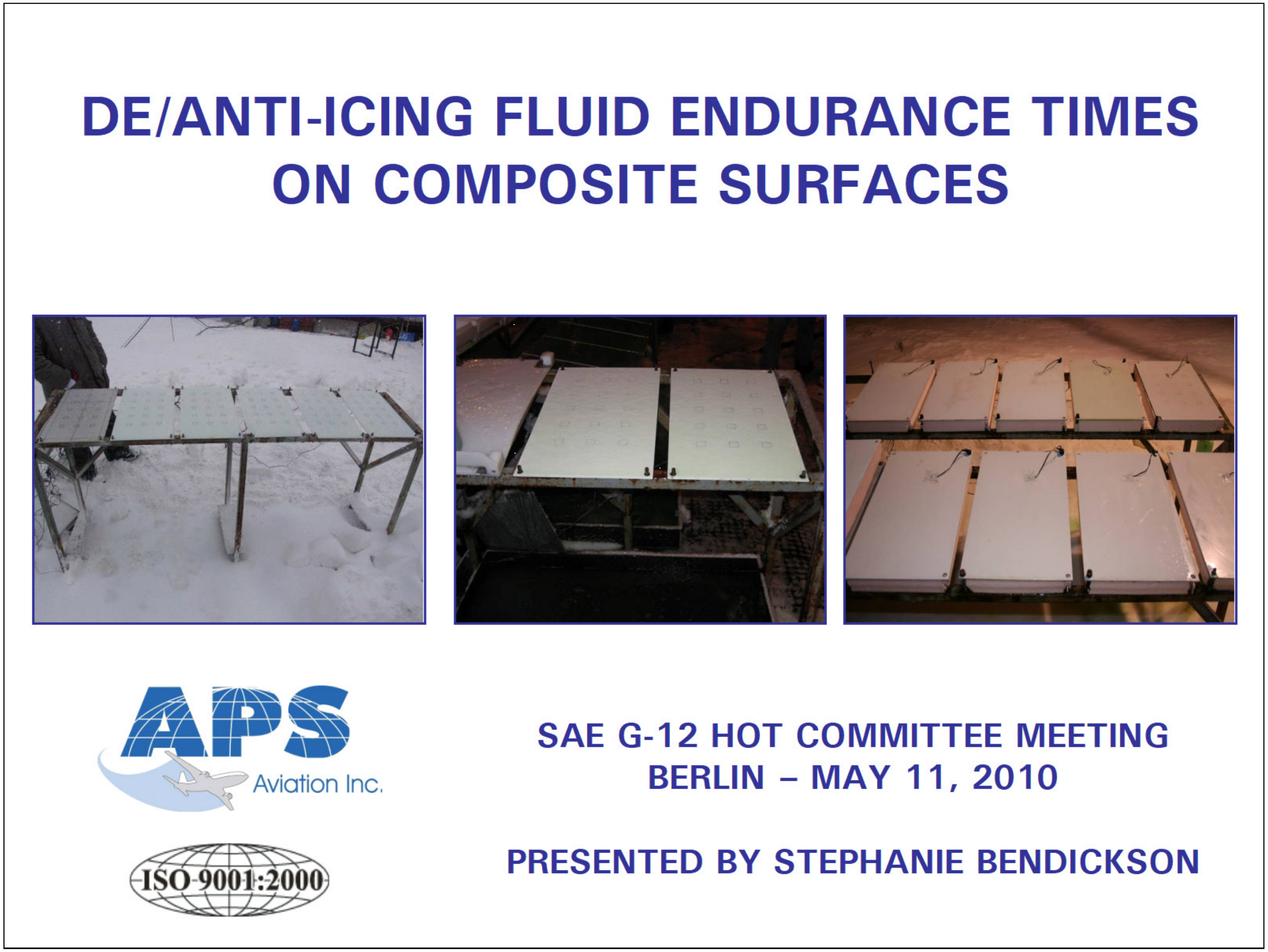
Marco Ruggi
mruggi@adga.ca



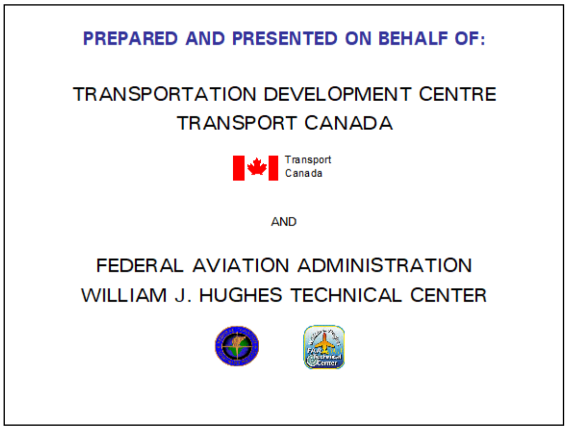
DE/ANTI-ICING FLUID ENDURANCE TIMES ON COMPOSITE SURFACES

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT COMMITTEE MEETING
BERLIN – MAY 11, 2010

PRESENTED BY STEPHANIE BENDICKSON



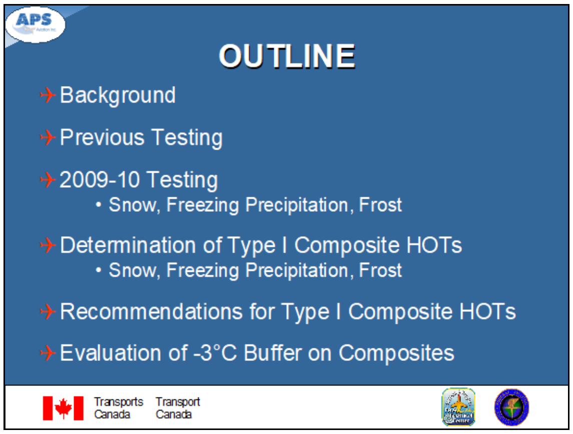
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Previous Testing
- 2009-10 Testing
  - Snow, Freezing Precipitation, Frost
- Determination of Type I Composite HOTs
  - Snow, Freezing Precipitation, Frost
- Recommendations for Type I Composite HOTs
- Evaluation of -3°C Buffer on Composites

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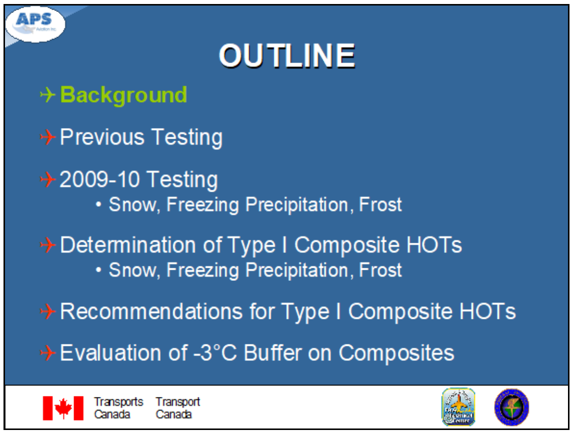

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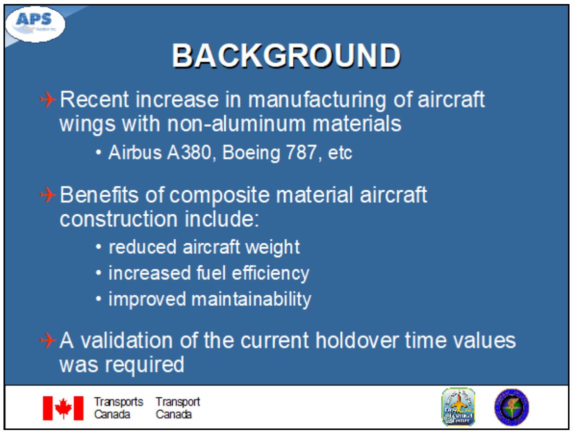

BACKGROUND

- Recent increase in manufacturing of aircraft wings with non-aluminum materials
  - Airbus A380, Boeing 787, etc
- Benefits of composite material aircraft construction include:
  - reduced aircraft weight
  - increased fuel efficiency
  - improved maintainability
- A validation of the current holdover time values was required

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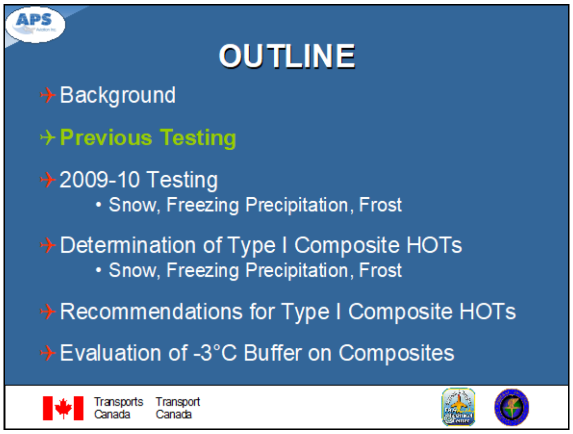

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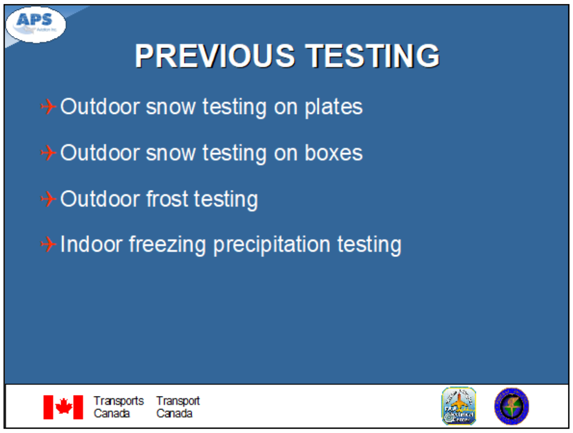

PREVIOUS TESTING

- Outdoor snow testing on plates
- Outdoor snow testing on boxes
- Outdoor frost testing
- Indoor freezing precipitation testing

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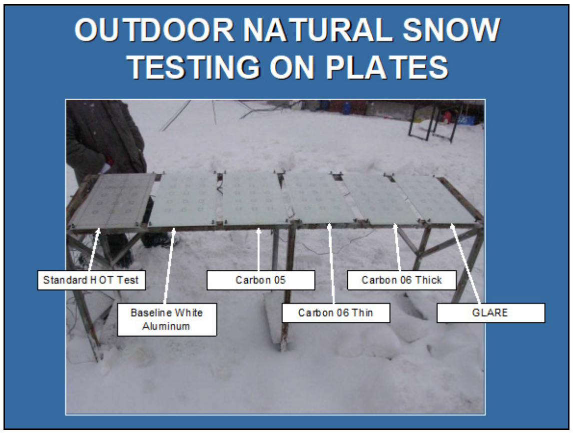
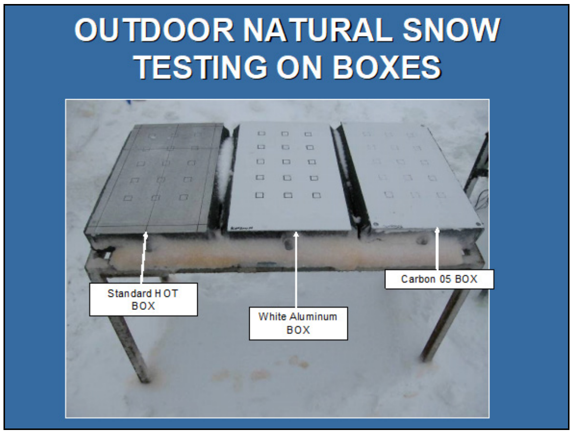


OUTDOOR NATURAL SNOW TESTING ON PLATES

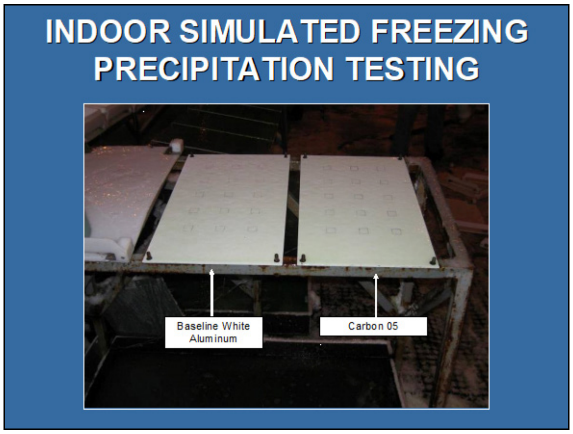
Standard HOT Test
Baseline White Aluminum
Carbon 05
Carbon 06 Thin
Carbon 06 Thick
GLARE



OUTDOOR NATURAL SNOW TESTING ON BOXES

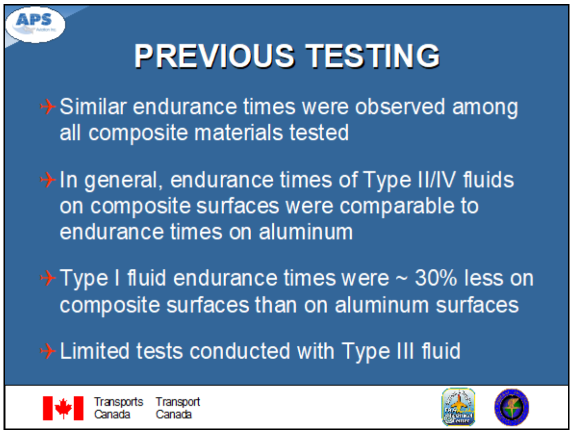
Standard HOT BOX
White Aluminum BOX
Carbon 05 BOX

OUTDOOR NATURAL FROST TESTING



INDOOR SIMULATED FREEZING PRECIPITATION TESTING

Baseline White Aluminum
Carbon 05



PREVIOUS TESTING

- Similar endurance times were observed among all composite materials tested
- In general, endurance times of Type II/IV fluids on composite surfaces were comparable to endurance times on aluminum
- Type I fluid endurance times were ~ 30% less on composite surfaces than on aluminum surfaces
- Limited tests conducted with Type III fluid

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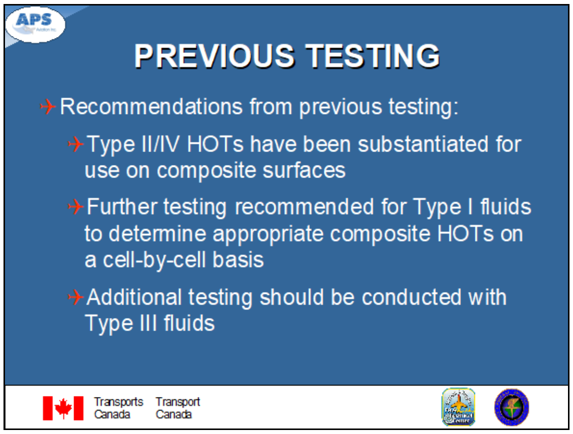

PREVIOUS TESTING

- Recommendations from previous testing:
  - Type II/IV HOTs have been substantiated for use on composite surfaces
  - Further testing recommended for Type I fluids to determine appropriate composite HOTs on a cell-by-cell basis
  - Additional testing should be conducted with Type III fluids

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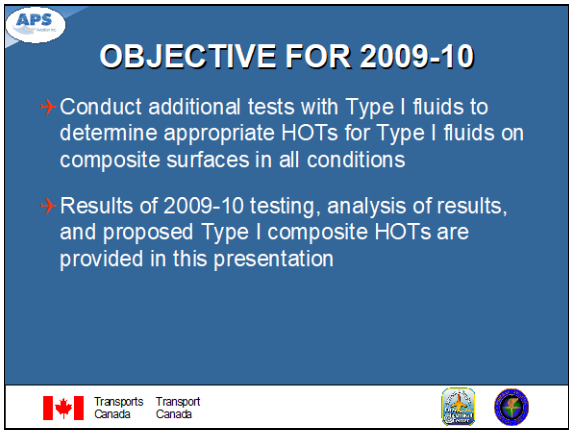

OBJECTIVE FOR 2009-10

- Conduct additional tests with Type I fluids to determine appropriate HOTs for Type I fluids on composite surfaces in all conditions
- Results of 2009-10 testing, analysis of results, and proposed Type I composite HOTs are provided in this presentation

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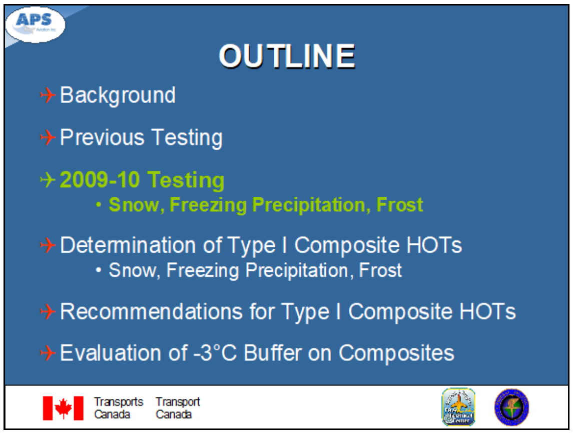

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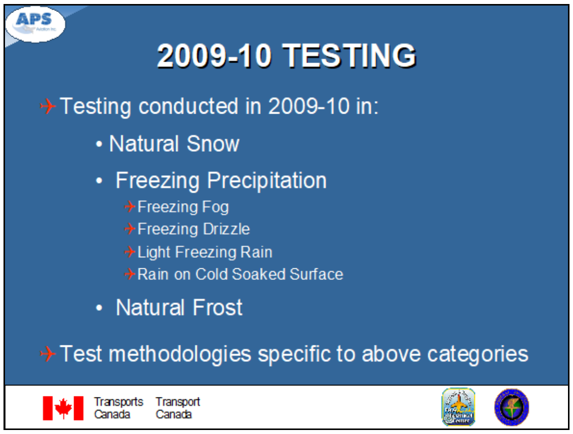

2009-10 TESTING

- Testing conducted in 2009-10 in:
  - Natural Snow
  - Freezing Precipitation
    - Freezing Fog
    - Freezing Drizzle
    - Light Freezing Rain
    - Rain on Cold Soaked Surface
  - Natural Frost
- Test methodologies specific to above categories

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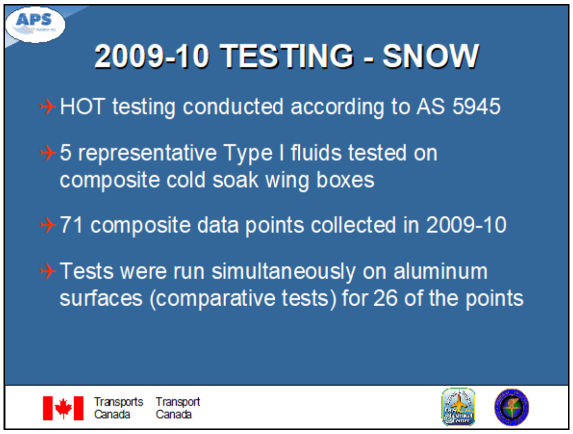
SNOW



2009-10 TESTING - SNOW

- HOT testing conducted according to AS 5945
- 5 representative Type I fluids tested on composite cold soak wing boxes
- 71 composite data points collected in 2009-10
- Tests were run simultaneously on aluminum surfaces (comparative tests) for 26 of the points

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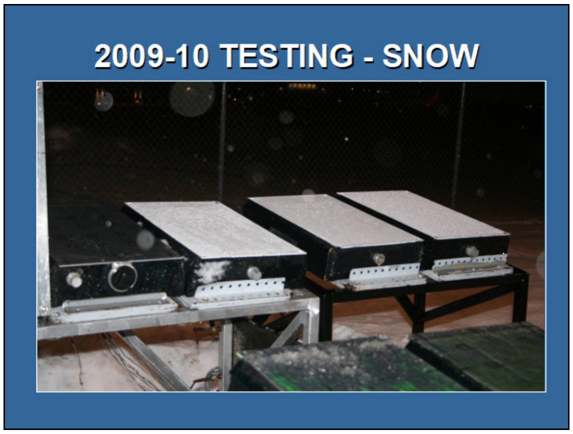

2009-10 TESTING - SNOW

2009-10 TESTING - SNOW

- Precipitation Rates: 0.8 g/dm²/h to 22 g/dm²/h
  - Very Light Snow (0 to 4 g/dm²/h): 13 points
  - Light Snow (4 to 10 g/dm²/h): 38 points
  - Moderate Snow (10 to 25 g/dm²/h): 20 points
  - Heavy Snow (> 25 g/dm²/h): 0 points
- Air temperatures: -12°C to +1°C
  - Above -3°C: 54 points
  - -3 to -6°C: 11 points
  - -6 to -10°C: 0 points
  - Below -10°C: 6 points

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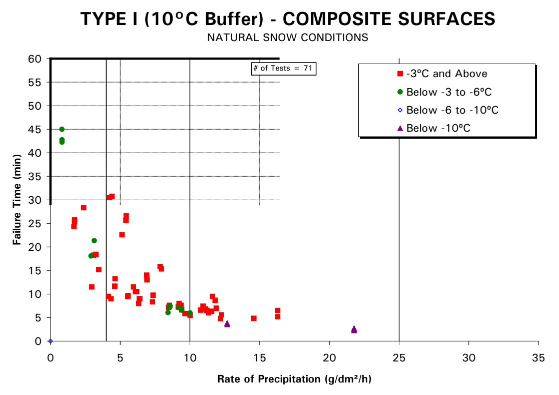
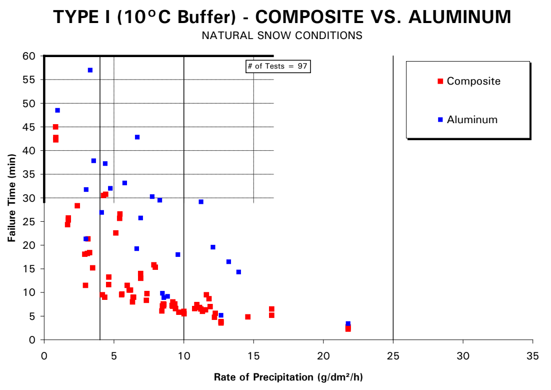


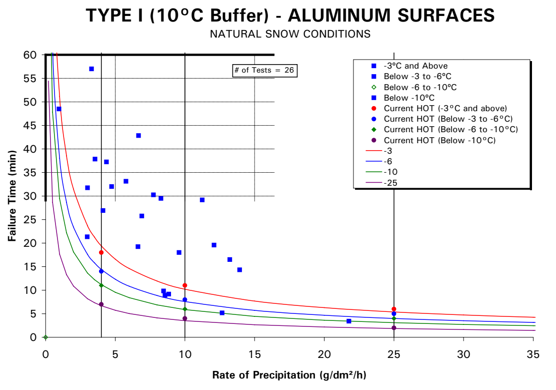
TYPE I (10°C Buffer) - COMPOSITE SURFACES

NATURAL SNOW CONDITIONS



TYPE I (10°C Buffer) - COMPOSITE VS. ALUMINUM

NATURAL SNOW CONDITIONS



TYPE I (10°C Buffer) - ALUMINUM SURFACES

NATURAL SNOW CONDITIONS

FREEZING PRECIPITATION

2009-10 TESTING – FREEZING PRECIP

- HOT testing conducted according to AS 5945
- 5 representative Type I fluids tested on composite surfaces
- 1 representative fluid also tested simultaneously on aluminum plates (for comparison)
- Data collected in each Type I HOT table condition
  - Temperatures: +1, -3, -6, -10, -25°C
  - Precip Types: ZF, ZD, ZR, CSW
  - Precip Rates: 2, 5, 13, 25, 75 g/dm²/h

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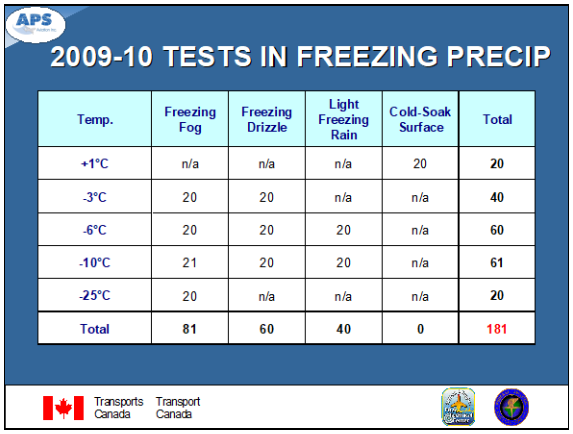
2009-10 TESTING – FREEZING PRECIP



2009-10 TESTS IN FREEZING PRECIP

Temp.	Freezing Fog	Freezing Drizzle	Light Freezing Rain	Cold-Soak Surface	Total
+1°C	n/a	n/a	n/a	20	**20**
-3°C	20	20	n/a	n/a	**40**
-6°C	20	20	20	n/a	**60**
-10°C	21	20	20	n/a	**61**
-25°C	20	n/a	n/a	n/a	**20**
Total	**81**	**60**	**40**	**0**	**181**

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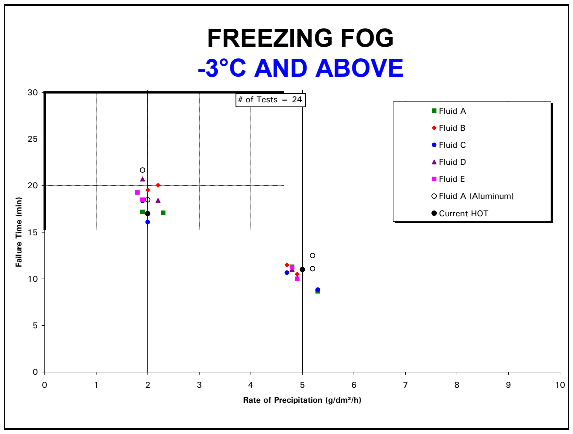
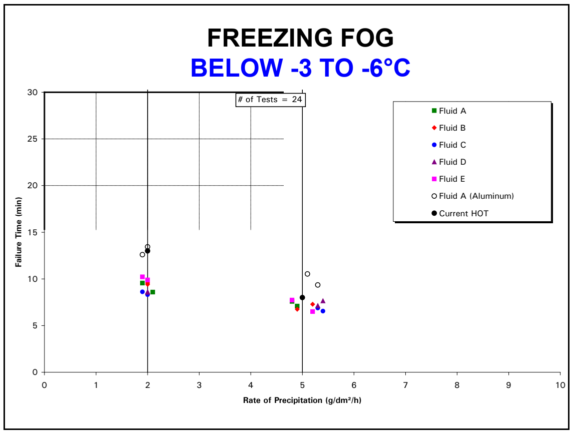
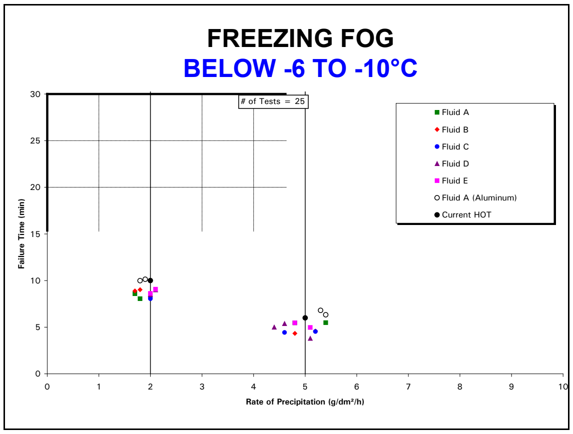


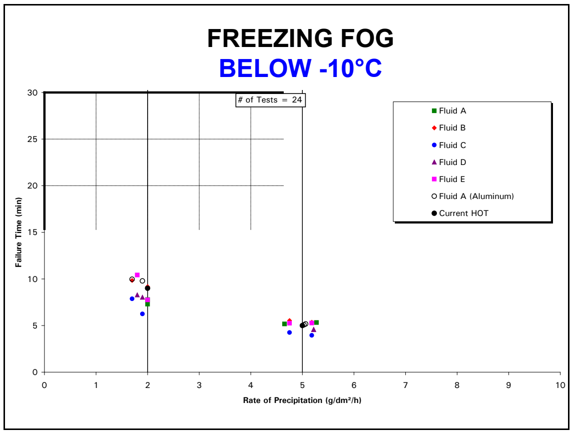
FREEZING FOG
-3°C AND ABOVE



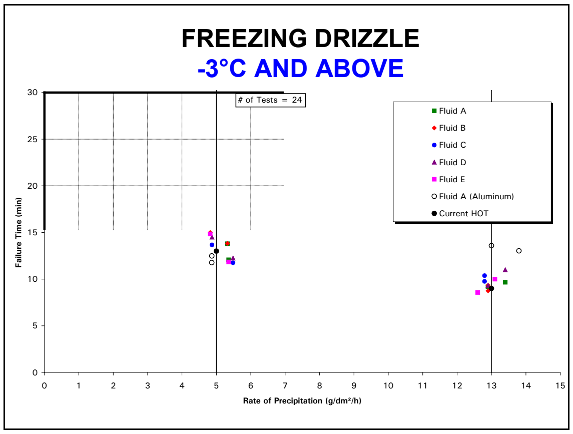
FREEZING FOG
BELOW -3 TO -6°C

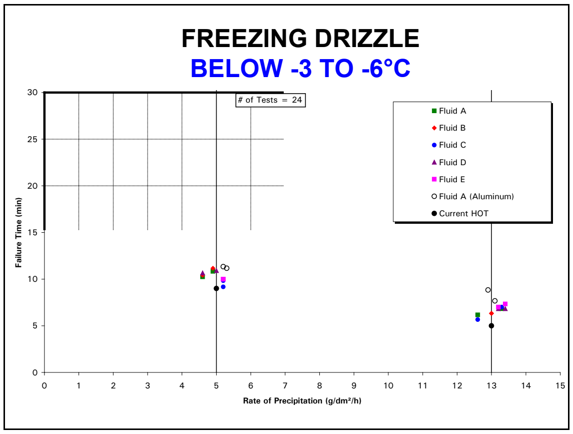


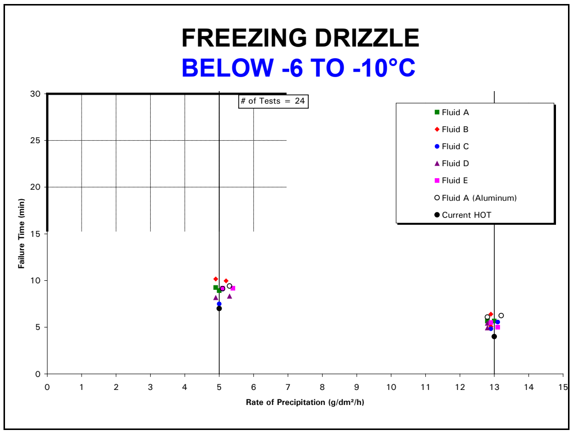
FREEZING FOG
BELOW -6 TO -10°C

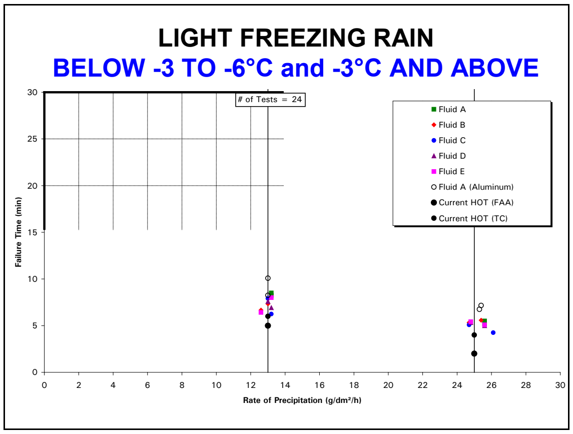


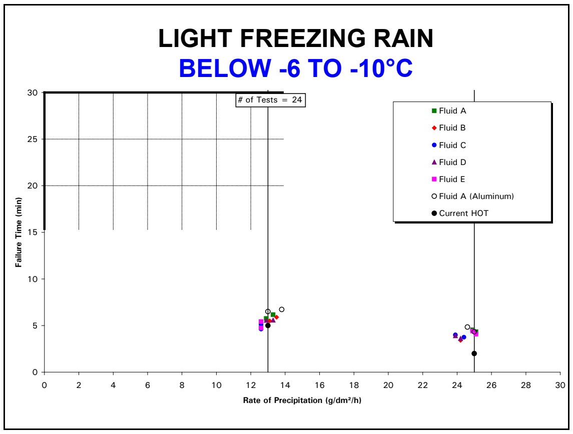
FREEZING FOG
BELOW -10°C

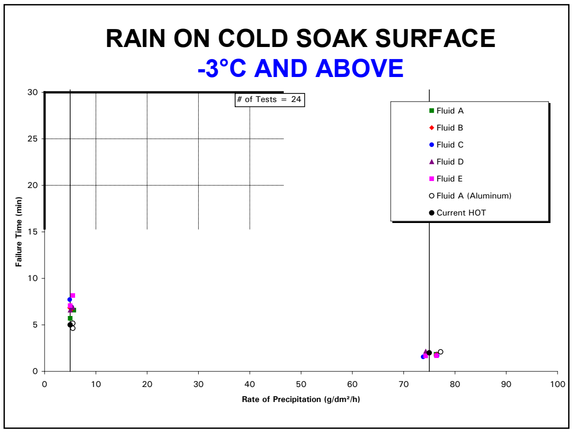

FREEZING DRIZZLE
-3°C AND ABOVE
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


FREEZING DRIZZLE
BELOW -3 TO -6°C
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

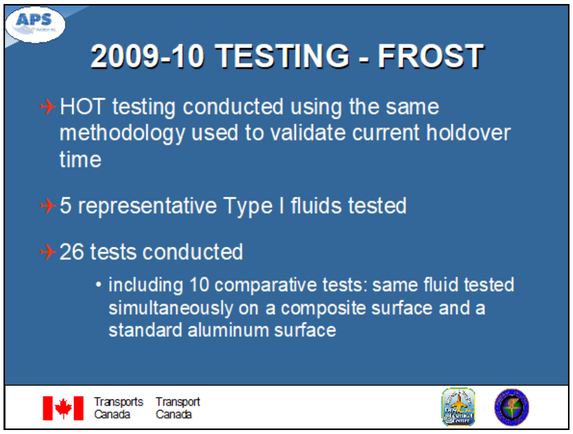

FREEZING DRIZZLE
BELOW -6 TO -10°C
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


LIGHT FREEZING RAIN
BELOW -3 TO -6°C and -3°C AND ABOVE
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT (FAA)
Current HOT (TC)
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30


LIGHT FREEZING RAIN
BELOW -6 TO -10°C
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30


RAIN ON COLD SOAK SURFACE
-3°C AND ABOVE
# of Tests = 24
Fluid A
Fluid B
Fluid C
Fluid D
Fluid E
Fluid A (Aluminum)
Current HOT
Failure Time (min)
0
5
10
15
20
25
30
Rate of Precipitation (g/dm²/h)
0
10
20
30
40
50
60
70
80
90
100

FROST



2009-10 TESTING - FROST

- HOT testing conducted using the same methodology used to validate current holdover time
- 5 representative Type I fluids tested
- 26 tests conducted
  - including 10 comparative tests: same fluid tested simultaneously on a composite surface and a standard aluminum surface

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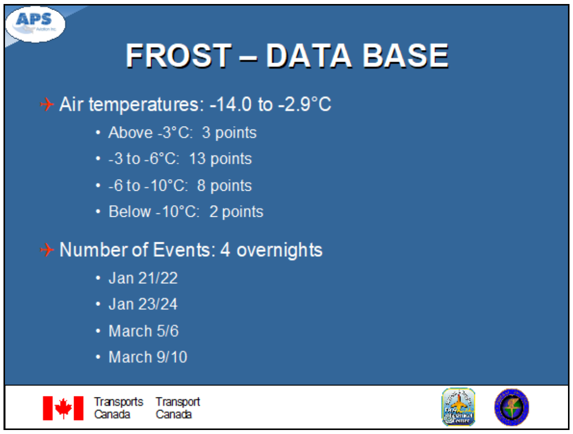
2009-10 TESTING - FROST



FROST – DATA BASE

- Air temperatures: -14.0 to -2.9°C
  - Above -3°C: 3 points
  - -3 to -6°C: 13 points
  - -6 to -10°C: 8 points
  - Below -10°C: 2 points
- Number of Events: 4 overnights
  - Jan 21/22
  - Jan 23/24
  - March 5/6
  - March 9/10

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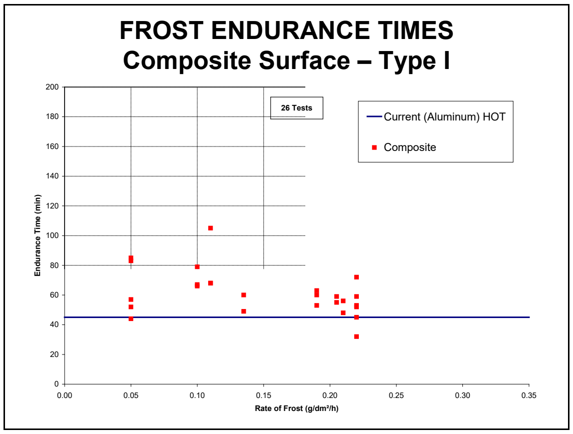
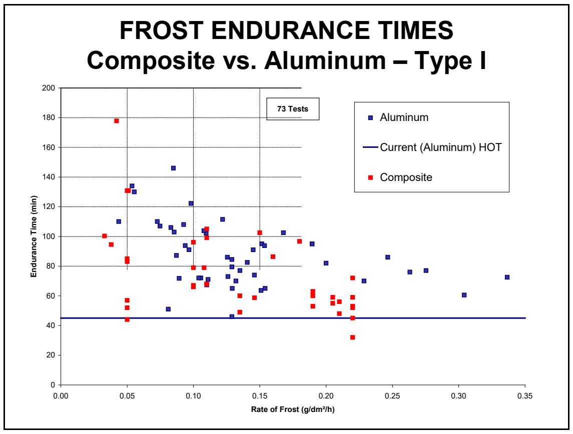
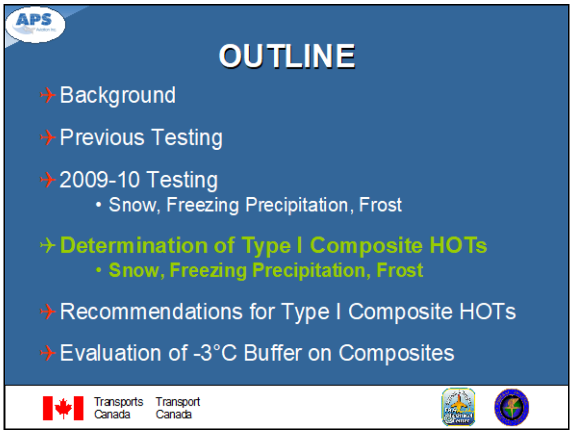


FROST ENDURANCE TIMES
Composite Surface – Type I



FROST ENDURANCE TIMES
Composite vs. Aluminum – Type I



OUTLINE

- Background
- Previous Testing
- 2009-10 Testing
  - Snow, Freezing Precipitation, Frost
- **Determination of Type I Composite HOTs**
  - **Snow, Freezing Precipitation, Frost**
- Recommendations for Type I Composite HOTs
- Evaluation of -3°C Buffer on Composites

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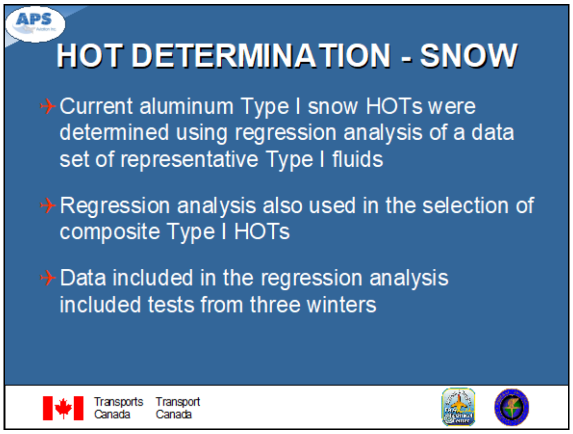
SNOW



HOT DETERMINATION - SNOW

- Current aluminum Type I snow HOTs were determined using regression analysis of a data set of representative Type I fluids
- Regression analysis also used in the selection of composite Type I HOTs
- Data included in the regression analysis included tests from three winters

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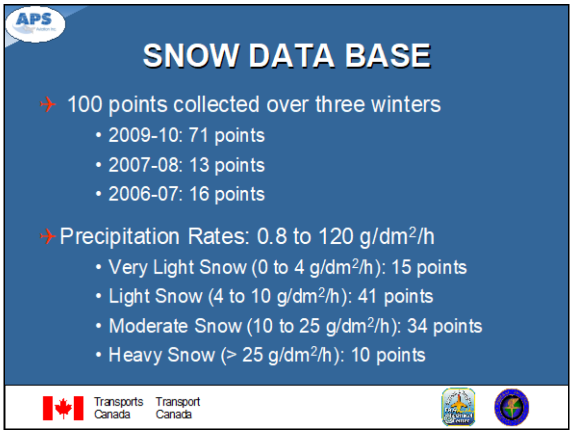

SNOW DATA BASE

- 100 points collected over three winters
  - 2009-10: 71 points
  - 2007-08: 13 points
  - 2006-07: 16 points
- Precipitation Rates: 0.8 to 120 g/dm^2/h
  - Very Light Snow (0 to 4 g/dm^2/h): 15 points
  - Light Snow (4 to 10 g/dm^2/h): 41 points
  - Moderate Snow (10 to 25 g/dm^2/h): 34 points
  - Heavy Snow (> 25 g/dm^2/h): 10 points

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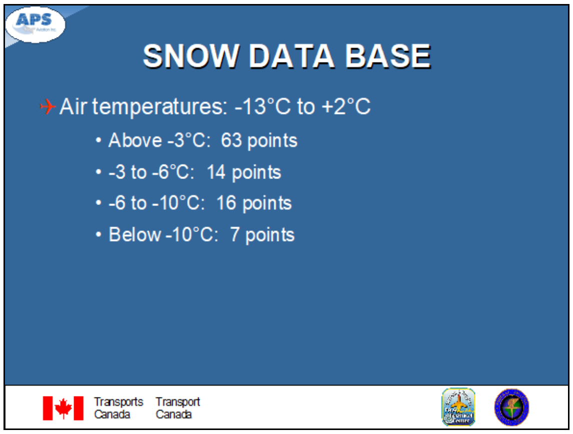

SNOW DATA BASE

- Air temperatures: -13°C to +2°C
  - Above -3°C: 63 points
  - -3 to -6°C: 14 points
  - -6 to -10°C: 16 points
  - Below -10°C: 7 points

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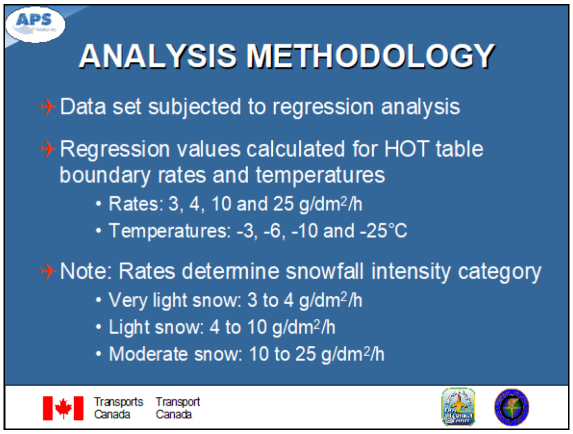

ANALYSIS METHODOLOGY

- Data set subjected to regression analysis
- Regression values calculated for HOT table boundary rates and temperatures
  - Rates: 3, 4, 10 and 25 g/dm^2/h
  - Temperatures: -3, -6, -10 and -25°C
- Note: Rates determine snowfall intensity category
  - Very light snow: 3 to 4 g/dm^2/h
  - Light snow: 4 to 10 g/dm^2/h
  - Moderate snow: 10 to 25 g/dm^2/h

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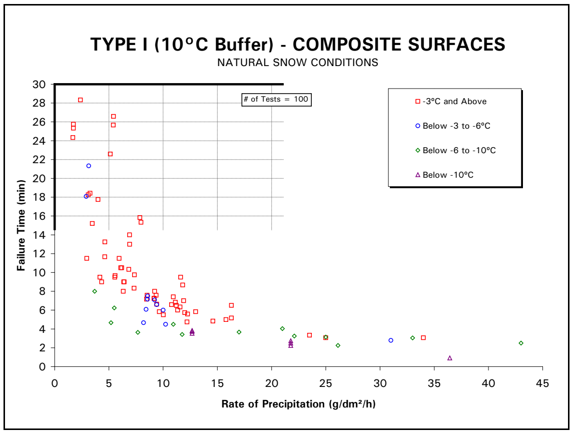
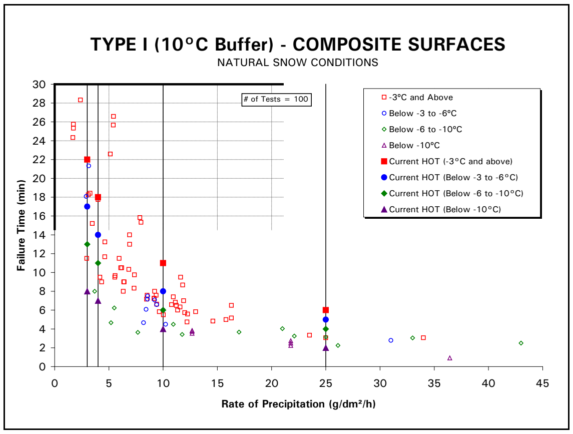


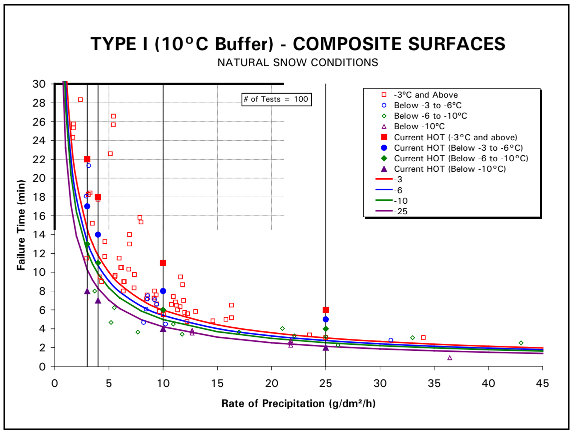
TYPE I (10°C Buffer) - COMPOSITE SURFACES

NATURAL SNOW CONDITIONS



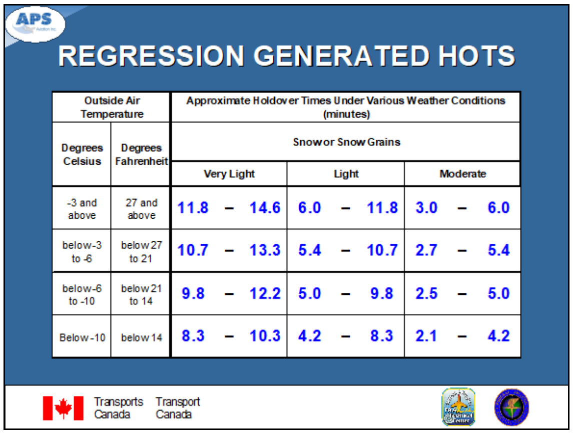
TYPE I (10°C Buffer) - COMPOSITE SURFACES

NATURAL SNOW CONDITIONS



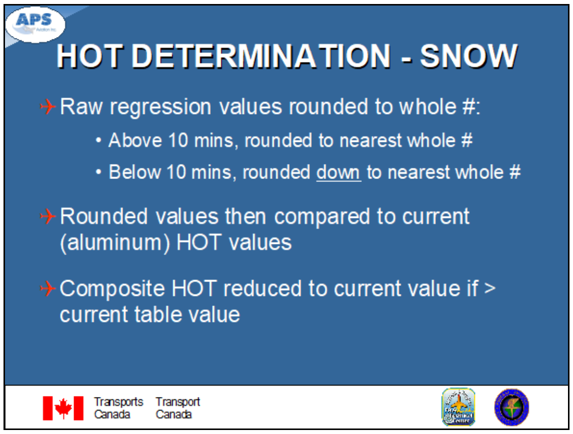
TYPE I (10°C Buffer) - COMPOSITE SURFACES

NATURAL SNOW CONDITIONS



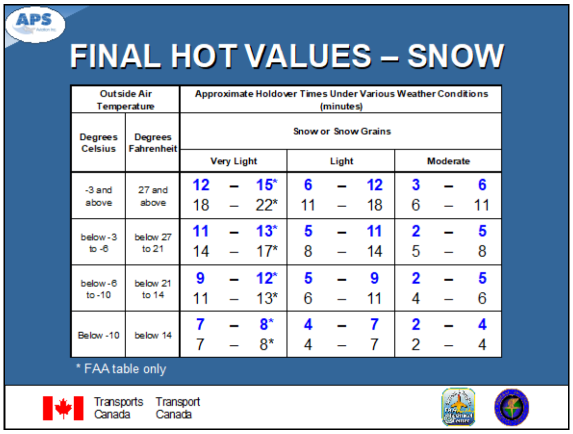
REGRESSION GENERATED HOTS

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)		
		Snow or Snow Grains		
Degrees Celsius	Degrees Fahrenheit	Very Light	Light	Moderate
-3 and above	27 and above	11.8 – 14.6	6.0 – 11.8	3.0 – 6.0
below -3 to -6	below 27 to 21	10.7 – 13.3	5.4 – 10.7	2.7 – 5.4
below -6 to -10	below 21 to 14	9.8 – 12.2	5.0 – 9.8	2.5 – 5.0
Below -10	below 14	8.3 – 10.3	4.2 – 8.3	2.1 – 4.2



HOT DETERMINATION - SNOW

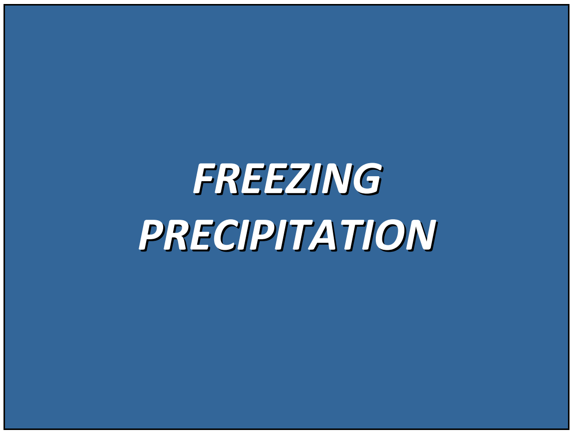
- Raw regression values rounded to whole #:
  - Above 10 mins, rounded to nearest whole #
  - Below 10 mins, rounded down to nearest whole #
- Rounded values then compared to current (aluminum) HOT values
- Composite HOT reduced to current value if > current table value



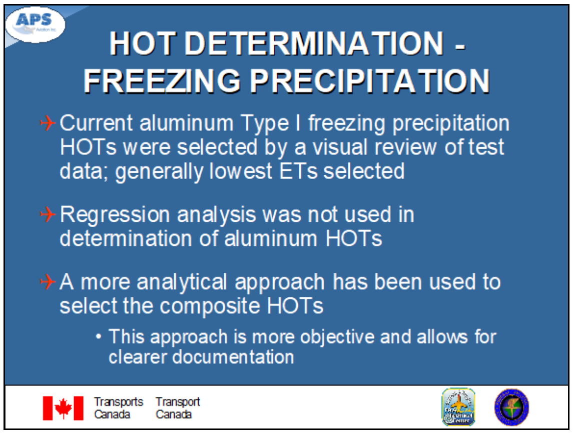
FINAL HOT VALUES – SNOW

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)		
		Snow or Snow Grains		
Degrees Celsius	Degrees Fahrenheit	Very Light	Light	Moderate
-3 and above	27 and above	**12 – 15*** 18 – 22*	**6 – 12** 11 – 18	**3 – 6** 6 – 11
below -3 to -6	below 27 to 21	**11 – 13*** 14 – 17*	**5 – 11** 8 – 14	**2 – 5** 5 – 8
below -6 to -10	below 21 to 14	**9 – 12*** 11 – 13*	**5 – 9** 6 – 11	**2 – 5** 4 – 6
Below -10	below 14	**7 – 8*** 7 – 8*	**4 – 7** 4 – 7	**2 – 4** 2 – 4

* FAA table only



FREEZING PRECIPITATION



HOT DETERMINATION - FREEZING PRECIPITATION

- Current aluminum Type I freezing precipitation HOTs were selected by a visual review of test data; generally lowest ETs selected
- Regression analysis was not used in determination of aluminum HOTs
- A more analytical approach has been used to select the composite HOTs
  - This approach is more objective and allows for clearer documentation

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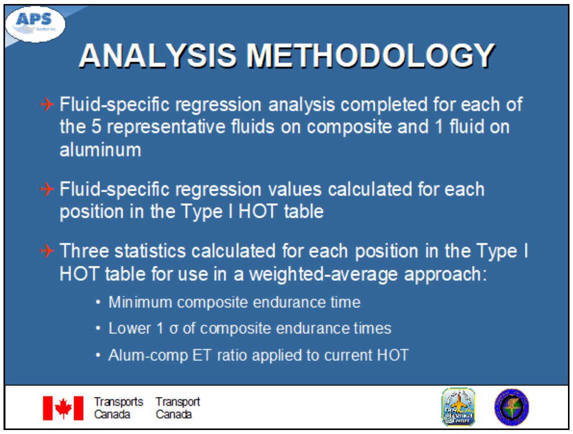

ANALYSIS METHODOLOGY

- Fluid-specific regression analysis completed for each of the 5 representative fluids on composite and 1 fluid on aluminum
- Fluid-specific regression values calculated for each position in the Type I HOT table
- Three statistics calculated for each position in the Type I HOT table for use in a weighted-average approach:
  - Minimum composite endurance time
  - Lower 1 σ of composite endurance times
  - Alum-comp ET ratio applied to current HOT

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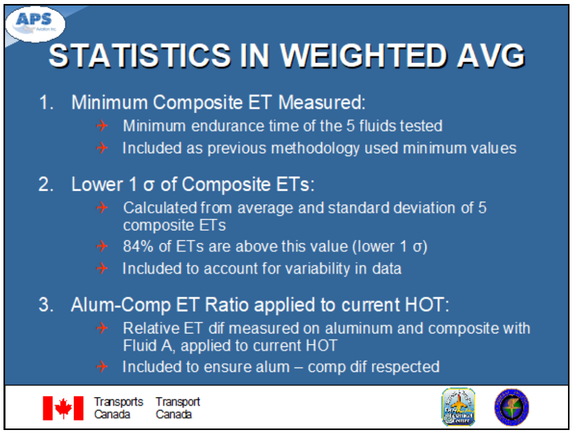

STATISTICS IN WEIGHTED AVG

1. Minimum Composite ET Measured:
   - Minimum endurance time of the 5 fluids tested
   - Included as previous methodology used minimum values
2. Lower 1 σ of Composite ETs:
   - Calculated from average and standard deviation of 5 composite ETs
   - 84% of ETs are above this value (lower 1 σ)
   - Included to account for variability in data
3. Alum-Comp ET Ratio applied to current HOT:
   - Relative ET dif measured on aluminum and composite with Fluid A, applied to current HOT
   - Included to ensure alum – comp dif respected

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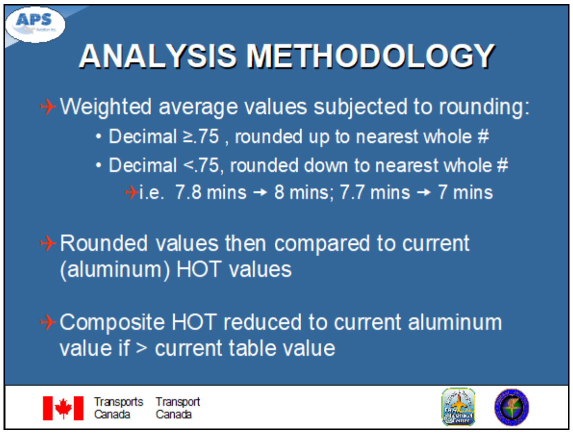

ANALYSIS METHODOLOGY

- Weighted average values subjected to rounding:
  - Decimal ≥.75 , rounded up to nearest whole #
  - Decimal <.75, rounded down to nearest whole #
    - i.e. 7.8 mins → 8 mins; 7.7 mins → 7 mins
- Rounded values then compared to current (aluminum) HOT values
- Composite HOT reduced to current aluminum value if > current table value

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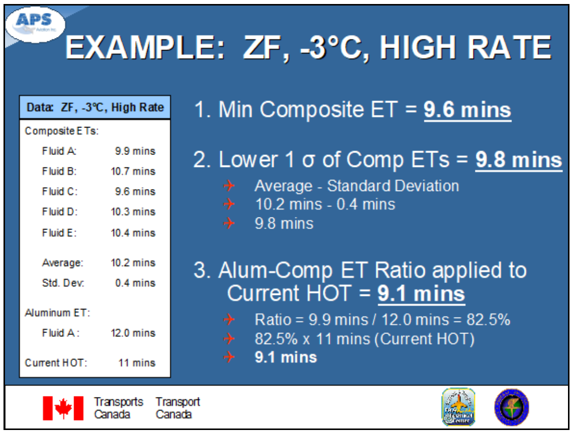

EXAMPLE: ZF, -3°C, HIGH RATE

Data: ZF, -3°C, High Rate	
Composite ETs:	
Fluid A:	9.9 mins
Fluid B:	10.7 mins
Fluid C:	9.6 mins
Fluid D:	10.3 mins
Fluid E:	10.4 mins
Average:	10.2 mins
Std. Dev:	0.4 mins
Aluminum ET:	
Fluid A:	12.0 mins
Current HOT:	11 mins

1. Min Composite ET = **9.6 mins**
2. Lower 1 σ of Comp ETs = **9.8 mins**
   - Average - Standard Deviation
   - 10.2 mins - 0.4 mins
   - 9.8 mins
3. Alum-Comp ET Ratio applied to Current HOT = **9.1 mins**
   - Ratio = 9.9 mins / 12.0 mins = 82.5%
   - 82.5% x 11 mins (Current HOT)
   - **9.1 mins**

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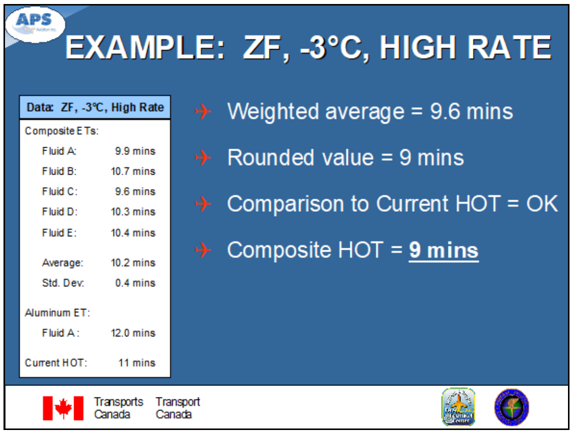

EXAMPLE: ZF, -3°C, HIGH RATE

Data: ZF, -3°C, High Rate	
Composite ETs:	
Fluid A:	9.9 mins
Fluid B:	10.7 mins
Fluid C:	9.6 mins
Fluid D:	10.3 mins
Fluid E:	10.4 mins
Average:	10.2 mins
Std. Dev:	0.4 mins
Aluminum ET:	
Fluid A:	12.0 mins
Current HOT:	11 mins

- Weighted average = 9.6 mins
- Rounded value = 9 mins
- Comparison to Current HOT = OK
- Composite HOT = **9 mins**

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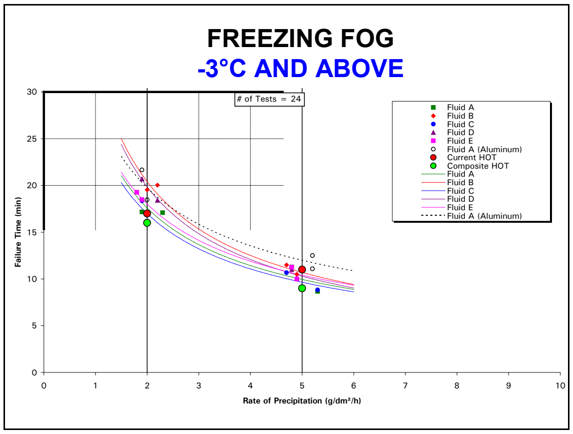
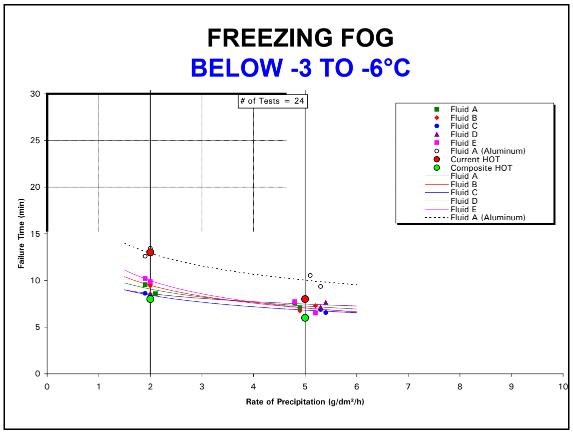
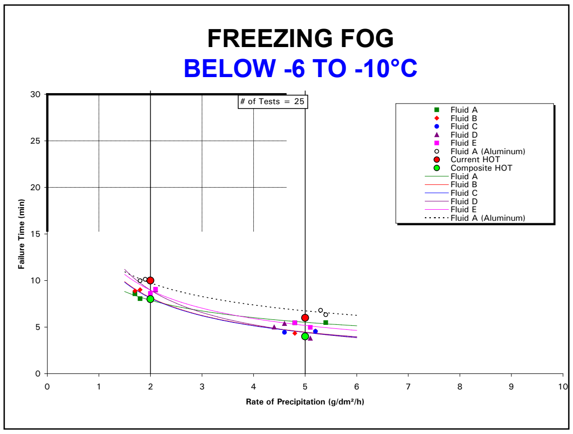


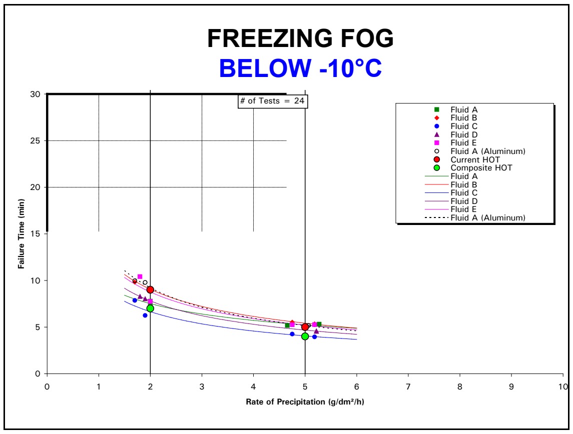
FREEZING FOG
-3°C AND ABOVE



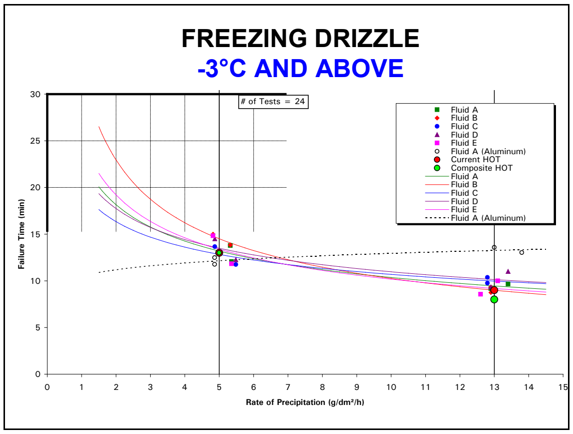
FREEZING FOG
BELOW -3 TO -6°C



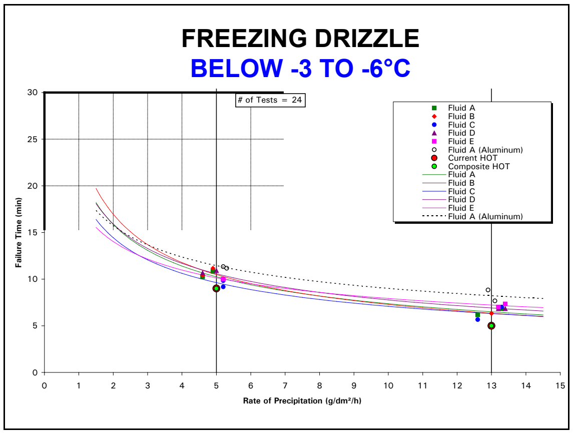
FREEZING FOG
BELOW -6 TO -10°C



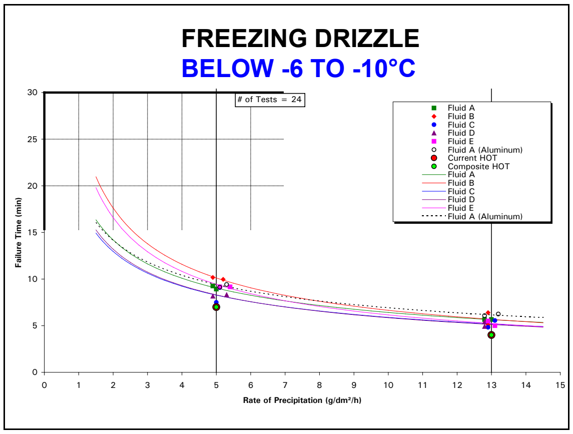
FREEZING FOG
BELOW -10°C



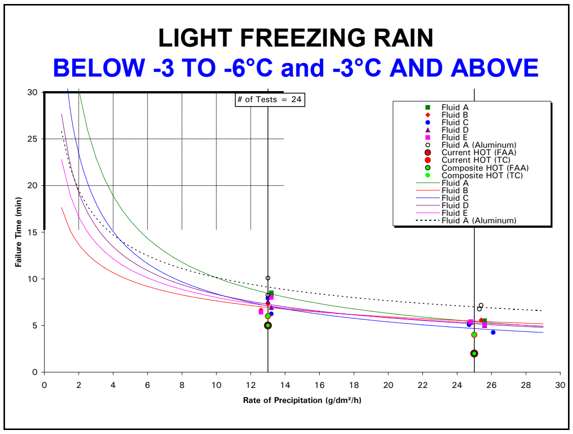
FREEZING DRIZZLE
-3°C AND ABOVE



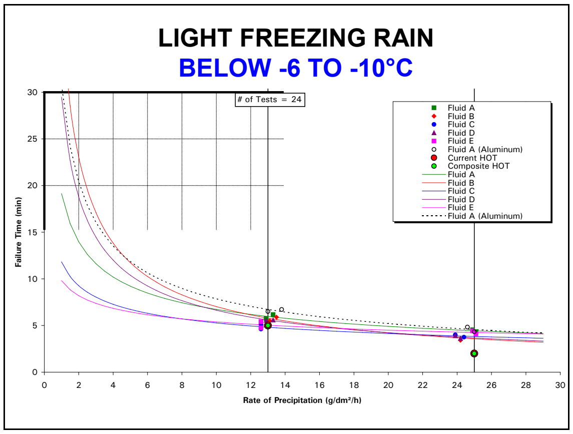
FREEZING DRIZZLE
BELOW -3 TO -6°C



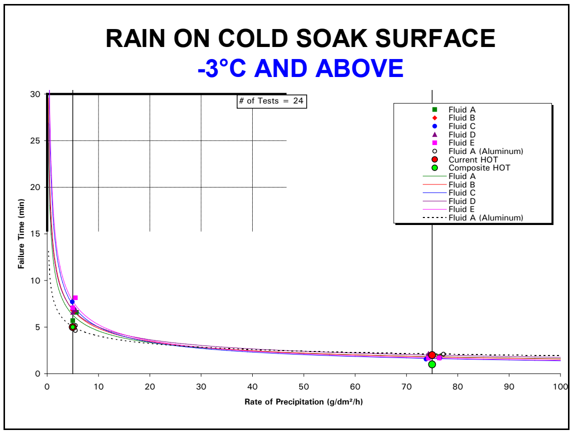
FREEZING DRIZZLE
BELOW -6 TO -10°C



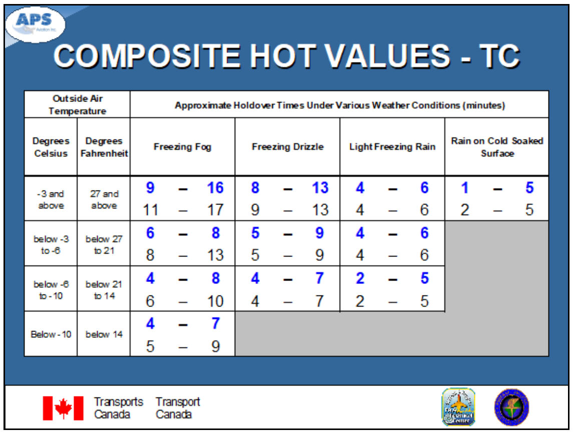
LIGHT FREEZING RAIN
BELOW -3 TO -6°C and -3°C AND ABOVE



LIGHT FREEZING RAIN
BELOW -6 TO -10°C

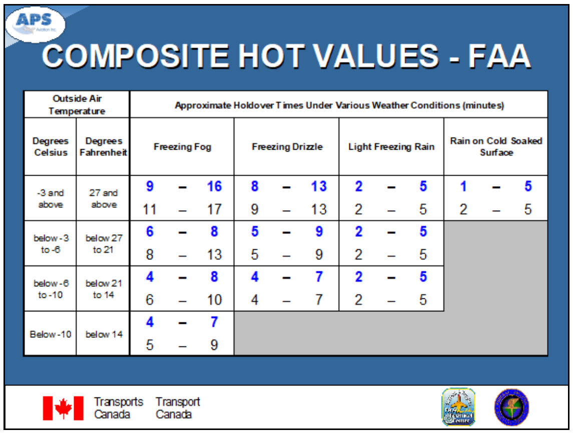


RAIN ON COLD SOAK SURFACE
-3°C AND ABOVE



COMPOSITE HOT VALUES - TC

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)			
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Surface
-3 and above	27 and above	**9 – 16** 11 – 17	**8 – 13** 9 – 13	**4 – 6** 4 – 6	**1 – 5** 2 – 5
below -3 to -6	below 27 to 21	**6 – 8** 8 – 13	**5 – 9** 5 – 9	**4 – 6** 4 – 6	
below -6 to -10	below 21 to 14	**4 – 8** 6 – 10	**4 – 7** 4 – 7	**2 – 5** 2 – 5	
Below -10	below 14	**4 – 7** 5 – 9			



COMPOSITE HOT VALUES - FAA

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (minutes)			
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Surface
-3 and above	27 and above	**9 – 16** 11 – 17	**8 – 13** 9 – 13	**2 – 5** 2 – 5	**1 – 5** 2 – 5
below -3 to -6	below 27 to 21	**6 – 8** 8 – 13	**5 – 9** 5 – 9	**2 – 5** 2 – 5	
below -6 to -10	below 21 to 14	**4 – 8** 6 – 10	**4 – 7** 4 – 7	**2 – 5** 2 – 5	
Below -10	below 14	**4 – 7** 5 – 9			

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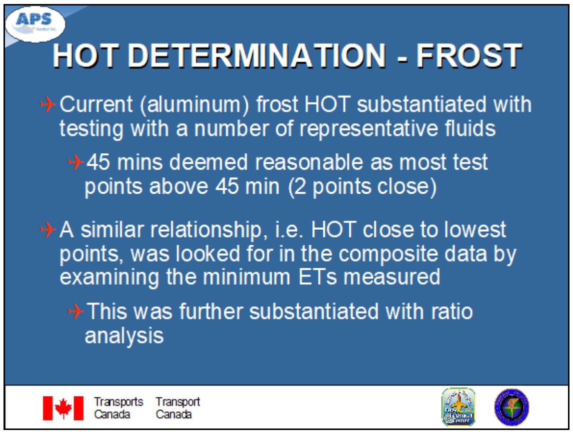
FROST



HOT DETERMINATION - FROST

- Current (aluminum) frost HOT substantiated with testing with a number of representative fluids
  - 45 mins deemed reasonable as most test points above 45 min (2 points close)
- A similar relationship, i.e. HOT close to lowest points, was looked for in the composite data by examining the minimum ETs measured
  - This was further substantiated with ratio analysis

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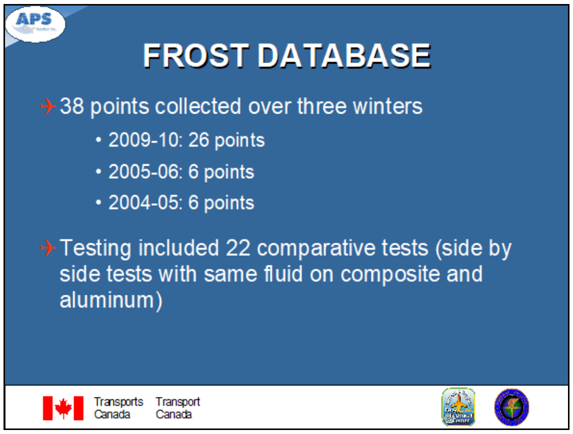

FROST DATABASE

- 38 points collected over three winters
  - 2009-10: 26 points
  - 2005-06: 6 points
  - 2004-05: 6 points
- Testing included 22 comparative tests (side by side tests with same fluid on composite and aluminum)

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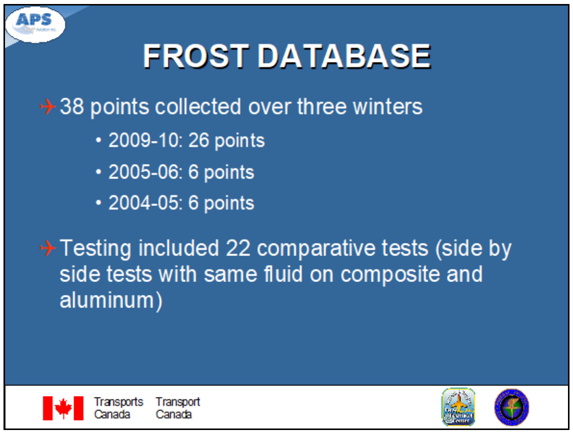

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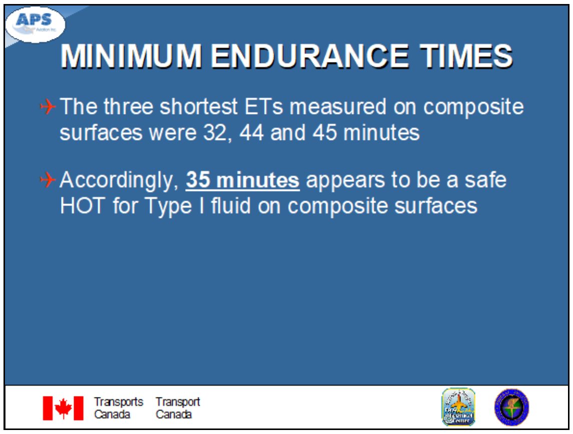

MINIMUM ENDURANCE TIMES

- The three shortest ETs measured on composite surfaces were 32, 44 and 45 minutes
- Accordingly, **35 minutes** appears to be a safe HOT for Type I fluid on composite surfaces

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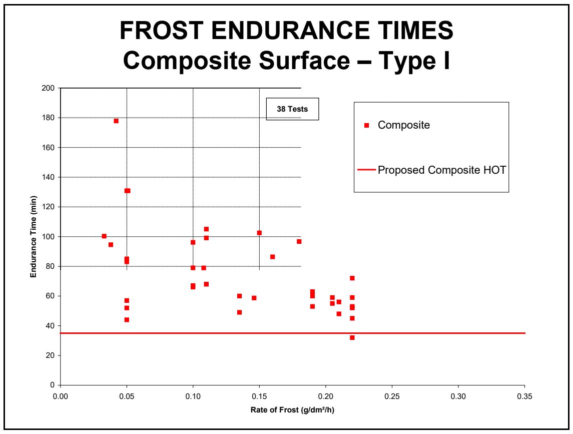
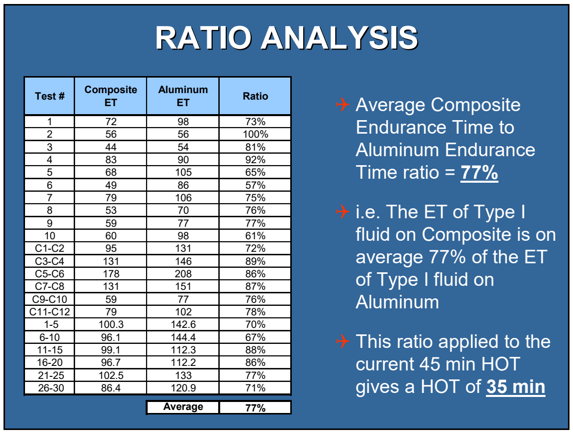


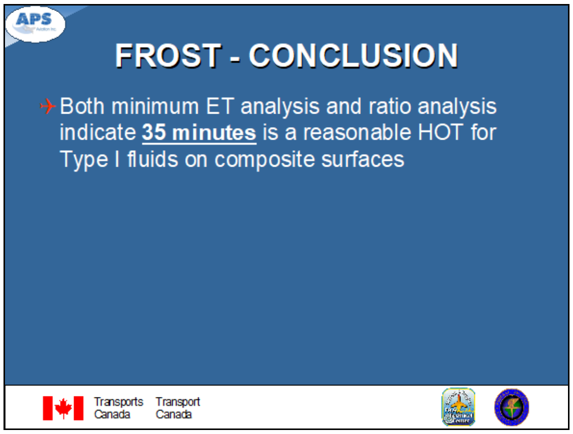
FROST ENDURANCE TIMES
Composite Surface – Type I



RATIO ANALYSIS

Test #	Composite ET	Aluminum ET	Ratio
1	72	98	73%
2	56	56	100%
3	44	54	81%
4	83	90	92%
5	68	105	65%
6	49	86	57%
7	79	106	75%
8	53	70	76%
9	59	77	77%
10	60	98	61%
C1-C2	95	131	72%
C3-C4	131	146	89%
C5-C6	178	208	86%
C7-C8	131	151	87%
C9-C10	59	77	76%
C11-C12	79	102	78%
1-5	100.3	142.6	70%
6-10	96.1	144.4	67%
11-15	99.1	112.3	88%
16-20	96.7	112.2	86%
21-25	102.5	133	77%
26-30	86.4	120.9	71%
		Average	**77%**

- Average Composite Endurance Time to Aluminum Endurance Time ratio = **77%**
- i.e. The ET of Type I fluid on Composite is on average 77% of the ET of Type I fluid on Aluminum
- This ratio applied to the current 45 min HOT gives a HOT of **35 min**



FROST - CONCLUSION

- Both minimum ET analysis and ratio analysis indicate **35 minutes** is a reasonable HOT for Type I fluids on composite surfaces

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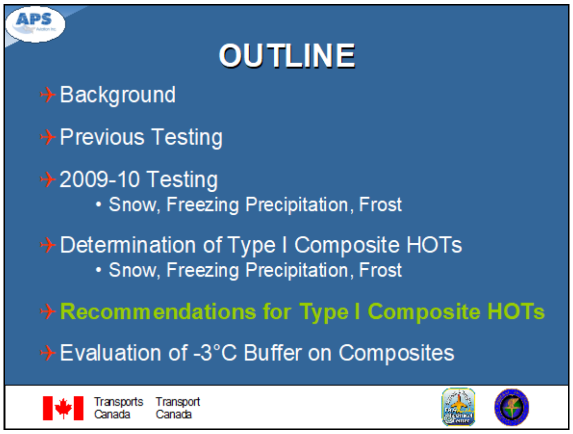

OUTLINE

- Background
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  - Snow, Freezing Precipitation, Frost
- Determination of Type I Composite HOTs
  - Snow, Freezing Precipitation, Frost
- **Recommendations for Type I Composite HOTs**
- Evaluation of -3°C Buffer on Composites

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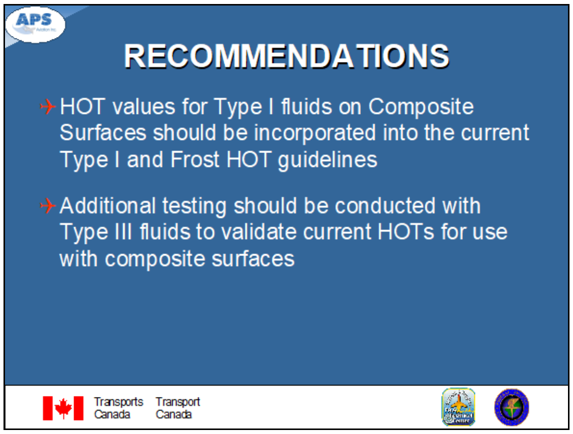

RECOMMENDATIONS

- HOT values for Type I fluids on Composite Surfaces should be incorporated into the current Type I and Frost HOT guidelines
- Additional testing should be conducted with Type III fluids to validate current HOTs for use with composite surfaces

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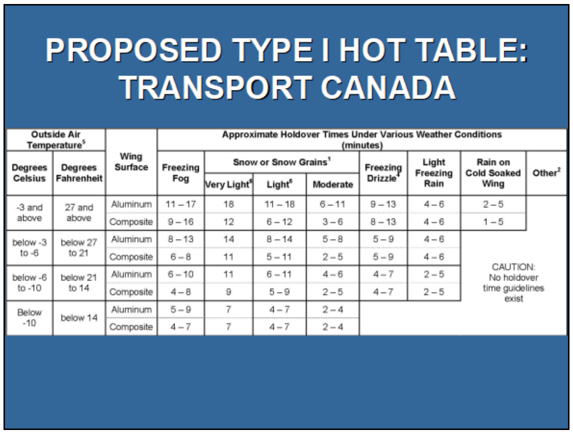
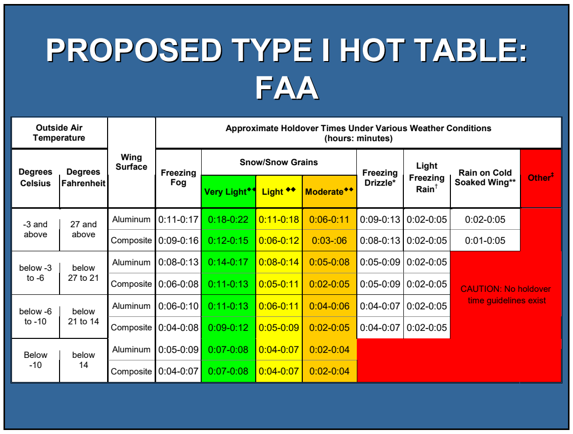


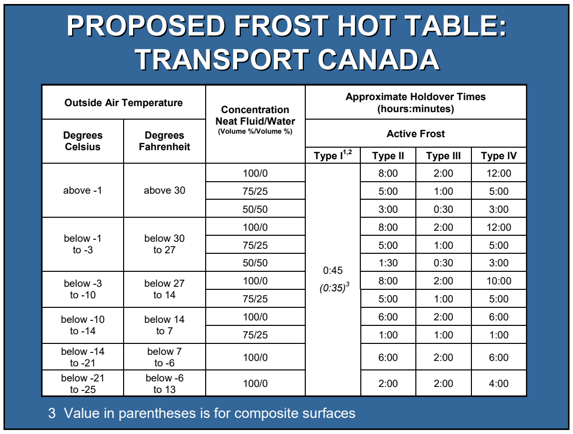
PROPOSED TYPE I HOT TABLE: TRANSPORT CANADA

Outside Air Temperature[5]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
Below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				



PROPOSED TYPE I HOT TABLE: FAA

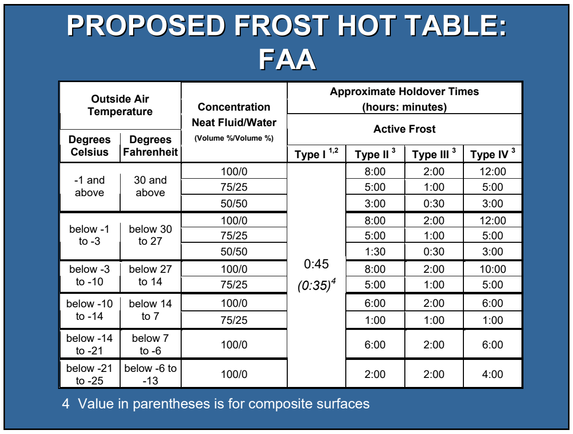
Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/Snow Grains: Very Light◆◆	Snow/Snow Grains: Light ◆◆	Snow/Snow Grains: Moderate◆◆	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-:06	0:08-0:13	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
		Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
		Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				
		Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				



PROPOSED FROST HOT TABLE: TRANSPORT CANADA

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45 (0:35)[3]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to 13	100/0		2:00	2:00	4:00

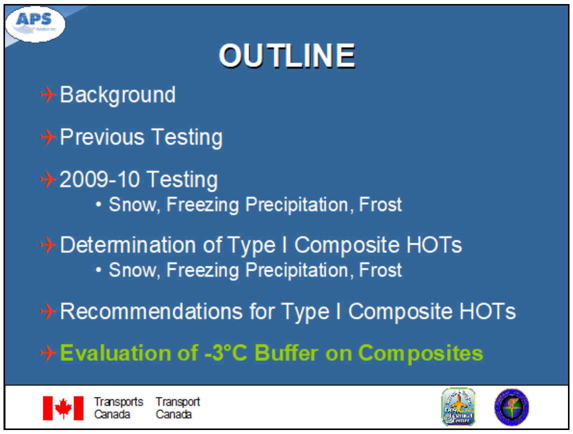
3 Value in parentheses is for composite surfaces



PROPOSED FROST HOT TABLE: FAA

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

4 Value in parentheses is for composite surfaces



OUTLINE

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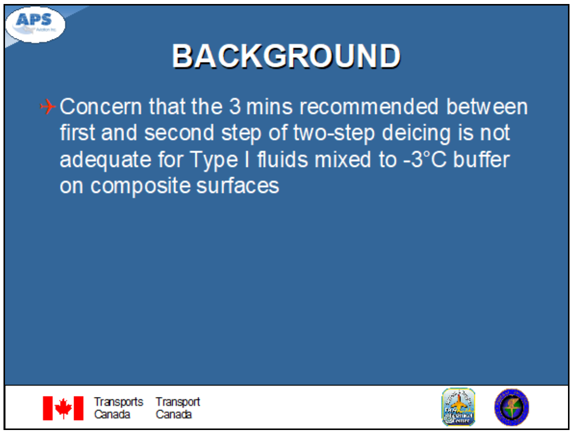

BACKGROUND

- Concern that the 3 mins recommended between first and second step of two-step deicing is not adequate for Type I fluids mixed to -3°C buffer on composite surfaces

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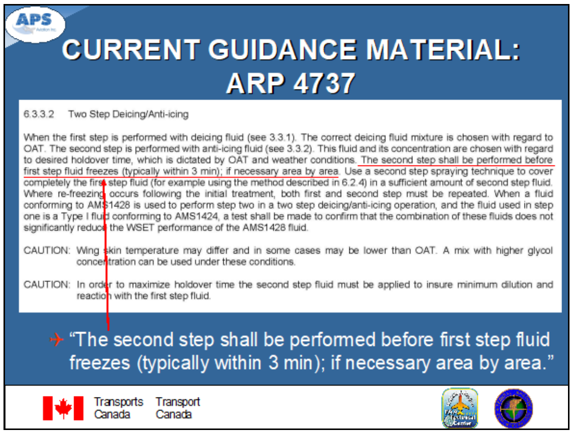

CURRENT GUIDANCE MATERIAL: ARP 4737

6.3.3.2 Two Step Deicing/Anti-icing

When the first step is performed with deicing fluid (see 3.3.1). The correct deicing fluid mixture is chosen with regard to OAT. The second step is performed with anti-icing fluid (see 3.3.2). This fluid and its concentration are chosen with regard to desired holdover time, which is dictated by OAT and weather conditions. The second step shall be performed before first step fluid freezes (typically within 3 min); if necessary area by area. Use a second step spraying technique to cover completely the first step fluid (for example using the method described in 6.2.4) in a sufficient amount of second step fluid. Where re-freezing occurs following the initial treatment, both first and second step must be repeated. When a fluid conforming to AMS1428 is used to perform step two in a two step deicing/anti-icing operation, and the fluid used in step one is a Type I fluid conforming to AMS1424, a test shall be made to confirm that the combination of these fluids does not significantly reduce the WSET performance of the AMS1428 fluid.

CAUTION: Wing skin temperature may differ and in some cases may be lower than OAT. A mix with higher glycol concentration can be used under these conditions.

CAUTION: In order to maximize holdover time the second step fluid must be applied to insure minimum dilution and reaction with the first step fluid.

- "The second step shall be performed before first step fluid freezes (typically within 3 min); if necessary area by area."

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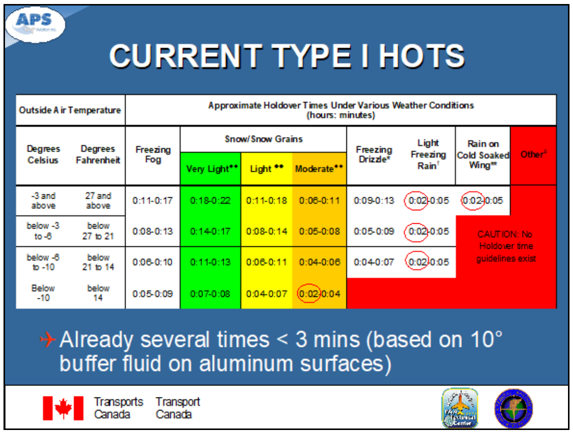

CURRENT TYPE I HOTS

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
			Very Light**	Light **	Moderate**				
-3 and above	27 and above	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No Holdover time guidelines exist	
below -6 to -10	below 21 to 14	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
Below -10	below 14	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

- Already several times < 3 mins (based on 10° buffer fluid on aluminum surfaces)

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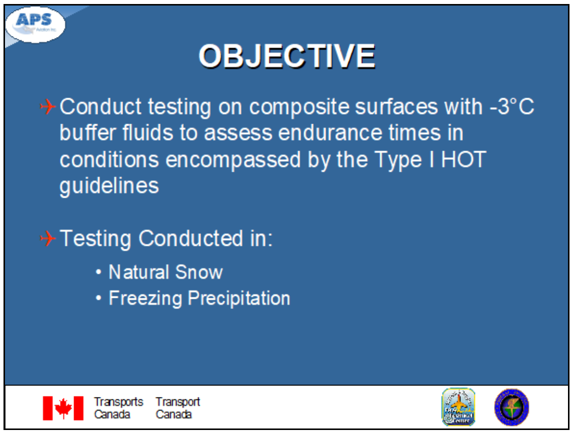

OBJECTIVE

- Conduct testing on composite surfaces with -3°C buffer fluids to assess endurance times in conditions encompassed by the Type I HOT guidelines
- Testing Conducted in:
  - Natural Snow
  - Freezing Precipitation

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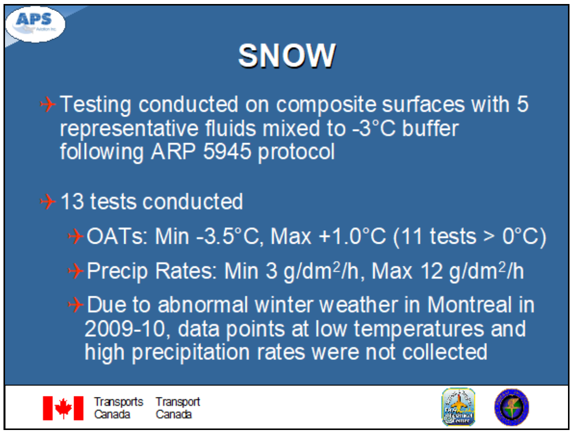

SNOW

- Testing conducted on composite surfaces with 5 representative fluids mixed to -3°C buffer following ARP 5945 protocol
- 13 tests conducted
  - OATs: Min -3.5°C, Max +1.0°C (11 tests > 0°C)
  - Precip Rates: Min 3 g/dm²/h, Max 12 g/dm²/h
  - Due to abnormal winter weather in Montreal in 2009-10, data points at low temperatures and high precipitation rates were not collected

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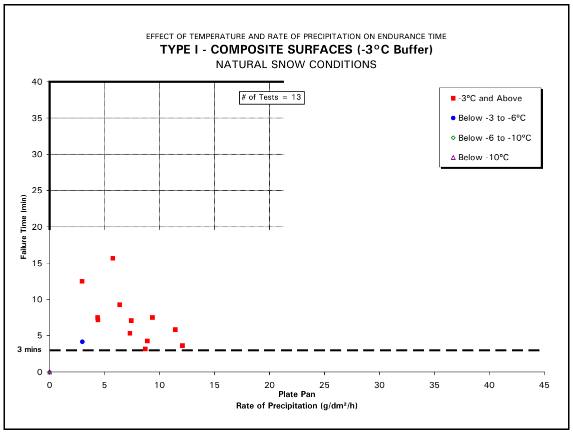
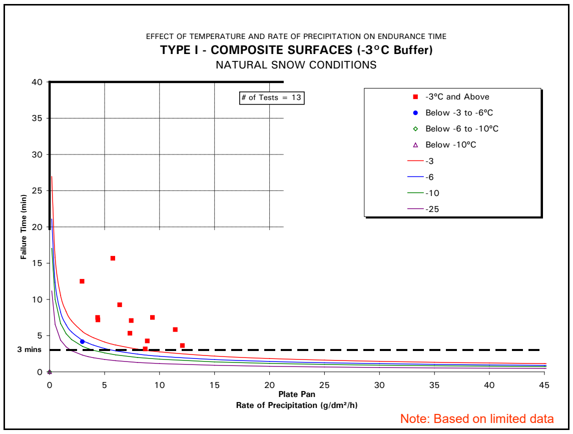


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I - COMPOSITE SURFACES (-3°C Buffer)

NATURAL SNOW CONDITIONS

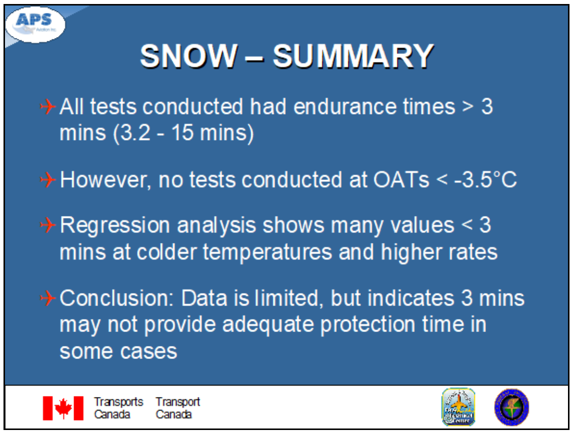


EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I - COMPOSITE SURFACES (-3°C Buffer)

NATURAL SNOW CONDITIONS

Note: Based on limited data



SNOW – SUMMARY

- All tests conducted had endurance times > 3 mins (3.2 - 15 mins)
- However, no tests conducted at OATs < -3.5°C
- Regression analysis shows many values < 3 mins at colder temperatures and higher rates
- Conclusion: Data is limited, but indicates 3 mins may not provide adequate protection time in some cases

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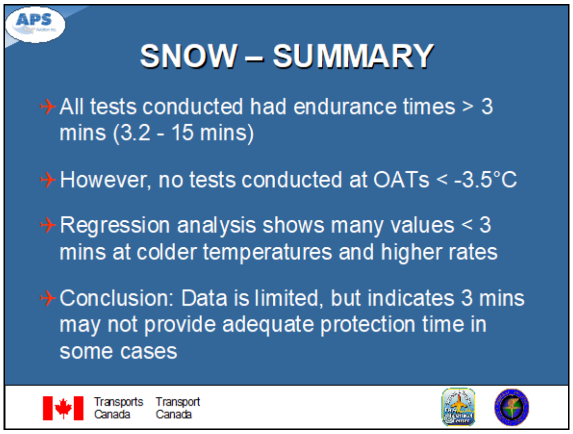

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- Conclusion: Data is limited, but indicates 3 mins may not provide adequate protection time in some cases

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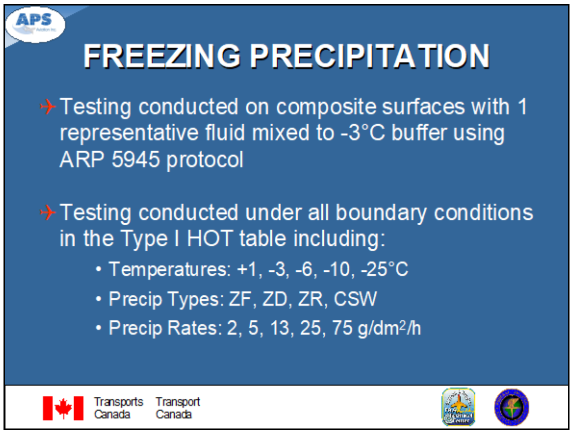
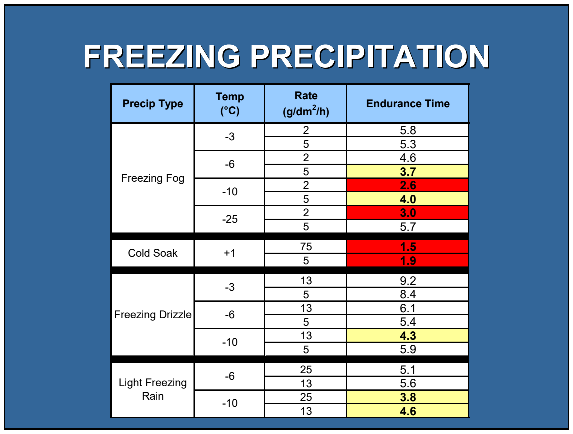


FREEZING PRECIPITATION

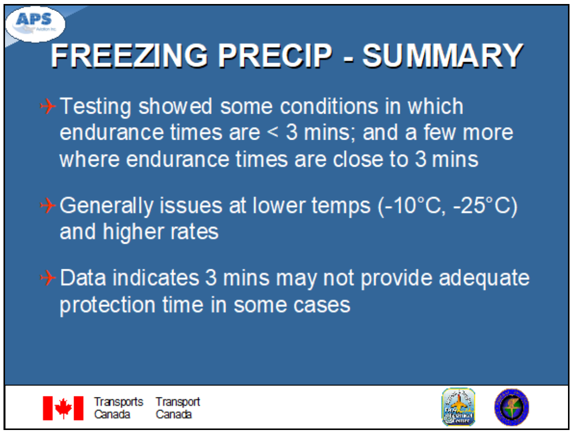
- Testing conducted on composite surfaces with 1 representative fluid mixed to -3°C buffer using ARP 5945 protocol
- Testing conducted under all boundary conditions in the Type I HOT table including:
  - Temperatures: +1, -3, -6, -10, -25°C
  - Precip Types: ZF, ZD, ZR, CSW
  - Precip Rates: 2, 5, 13, 25, 75 g/dm^2/h

Transports Canada Transport Canada



FREEZING PRECIPITATION

Precip Type	Temp (°C)	Rate (g/dm^2/h)	Endurance Time
Freezing Fog	-3	2	5.8
		5	5.3
	-6	2	4.6
		5	**3.7**
	-10	2	**2.6**
		5	**4.0**
	-25	2	**3.0**
		5	5.7
Cold Soak	+1	75	**1.5**
		5	**1.9**
Freezing Drizzle	-3	13	9.2
		5	8.4
	-6	13	6.1
		5	5.4
	-10	13	**4.3**
		5	5.9
Light Freezing Rain	-6	25	5.1
		13	5.6
	-10	25	**3.8**
		13	**4.6**



FREEZING PRECIP - SUMMARY

- Testing showed some conditions in which endurance times are < 3 mins; and a few more where endurance times are close to 3 mins
- Generally issues at lower temps (-10°C, -25°C) and higher rates
- Data indicates 3 mins may not provide adequate protection time in some cases

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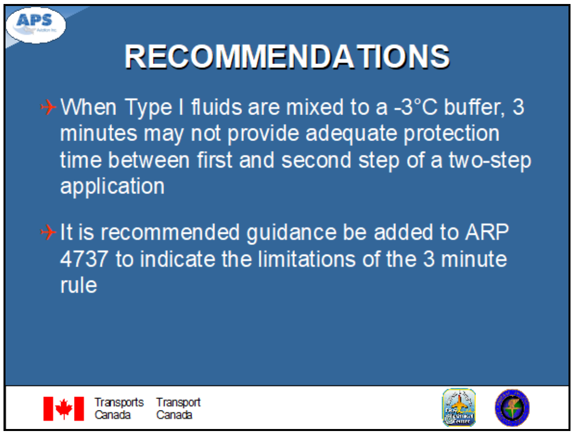

RECOMMENDATIONS

- When Type I fluids are mixed to a -3°C buffer, 3 minutes may not provide adequate protection time between first and second step of a two-step application
- It is recommended guidance be added to ARP 4737 to indicate the limitations of the 3 minute rule

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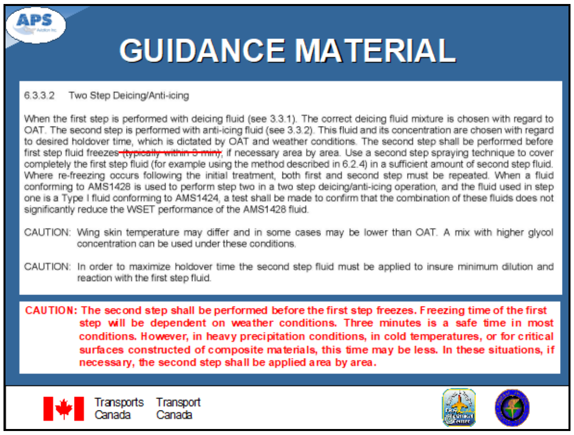

GUIDANCE MATERIAL

6.3.3.2 Two Step Deicing/Anti-icing

When the first step is performed with deicing fluid (see 3.3.1). The correct deicing fluid mixture is chosen with regard to OAT. The second step is performed with anti-icing fluid (see 3.3.2). This fluid and its concentration are chosen with regard to desired holdover time, which is dictated by OAT and weather conditions. The second step shall be performed before first step fluid freezes ~~(typically within 3 min)~~, if necessary area by area. Use a second step spraying technique to cover completely the first step fluid (for example using the method described in 6.2.4) in a sufficient amount of second step fluid. Where re-freezing occurs following the initial treatment, both first and second step must be repeated. When a fluid conforming to AMS1428 is used to perform step two in a two step deicing/anti-icing operation, and the fluid used in step one is a Type I fluid conforming to AMS1424, a test shall be made to confirm that the combination of these fluids does not significantly reduce the WSET performance of the AMS1428 fluid.

CAUTION: Wing skin temperature may differ and in some cases may be lower than OAT. A mix with higher glycol concentration can be used under these conditions.

CAUTION: In order to maximize holdover time the second step fluid must be applied to insure minimum dilution and reaction with the first step fluid.

CAUTION: The second step shall be performed before the first step freezes. Freezing time of the first step will be dependent on weather conditions. Three minutes is a safe time in most conditions. However, in heavy precipitation conditions, in cold temperatures, or for critical surfaces constructed of composite materials, this time may be less. In these situations, if necessary, the second step shall be applied area by area.

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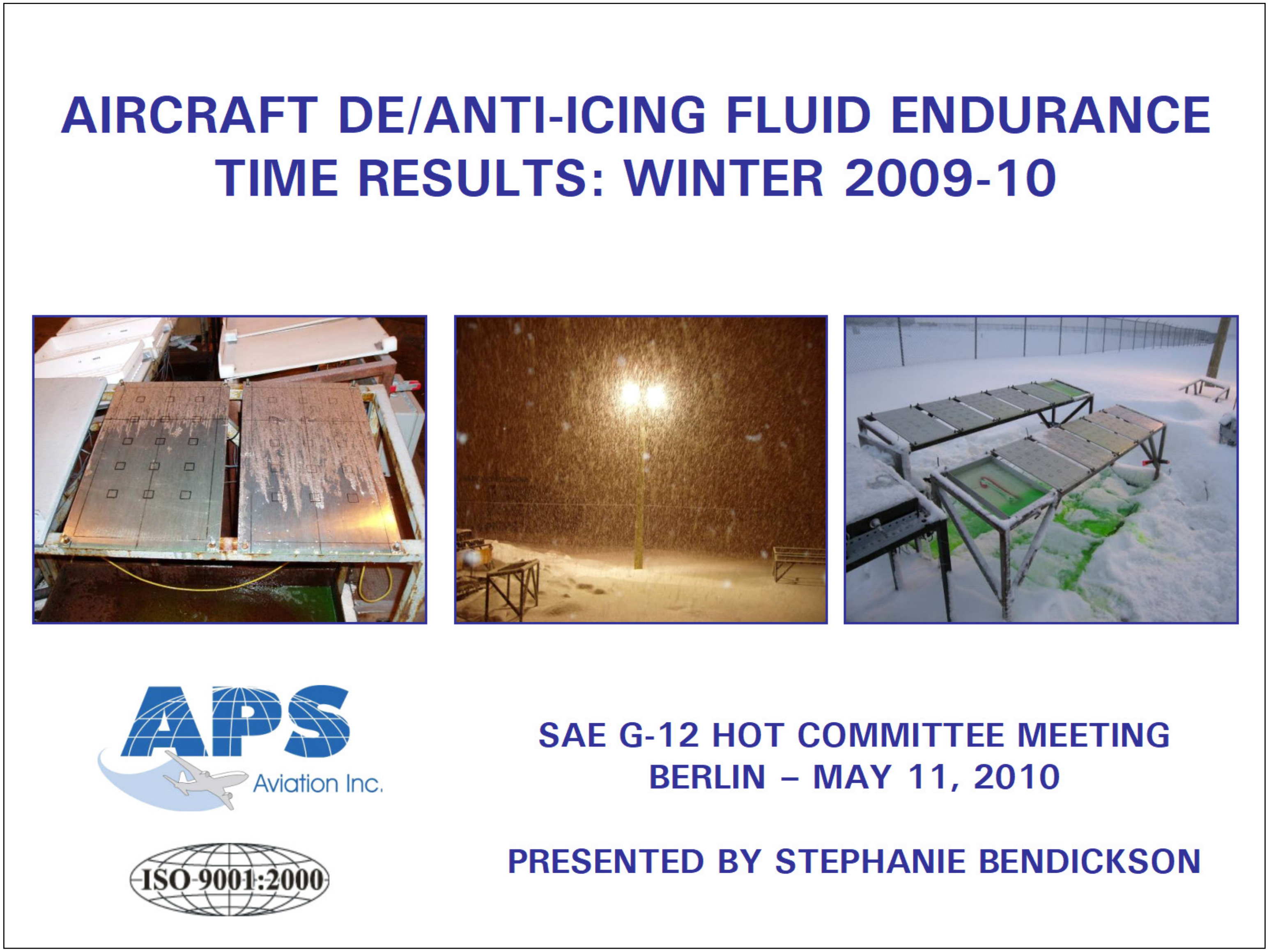


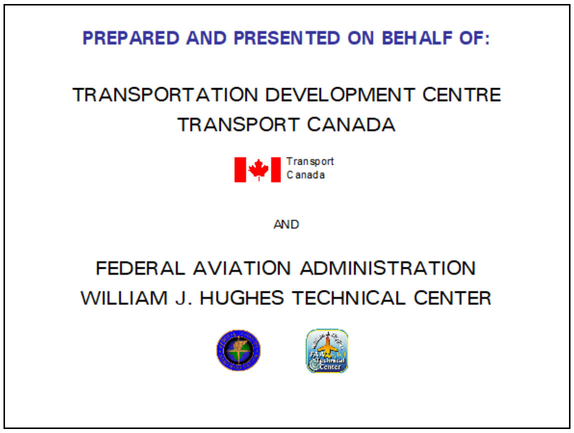
AIRCRAFT DE/ANTI-ICING FLUID ENDURANCE TIME RESULTS: WINTER 2009-10

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT COMMITTEE MEETING
BERLIN – MAY 11, 2010

PRESENTED BY STEPHANIE BENDICKSON



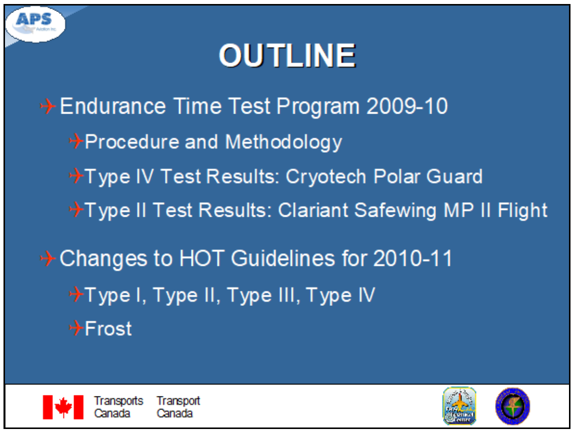
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Endurance Time Test Program 2009-10
  - Procedure and Methodology
  - Type IV Test Results: Cryotech Polar Guard
  - Type II Test Results: Clariant Safewing MP II Flight
- Changes to HOT Guidelines for 2010-11
  - Type I, Type II, Type III, Type IV
  - Frost

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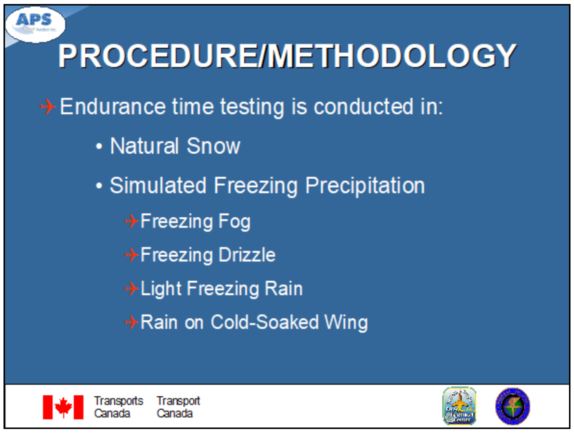
ENDURANCE TIME TEST PROGRAM

Winter 2009-10



PROCEDURE/METHODOLOGY

- Endurance time testing is conducted in:
  - Natural Snow
  - Simulated Freezing Precipitation
    - Freezing Fog
    - Freezing Drizzle
    - Light Freezing Rain
    - Rain on Cold-Soaked Wing

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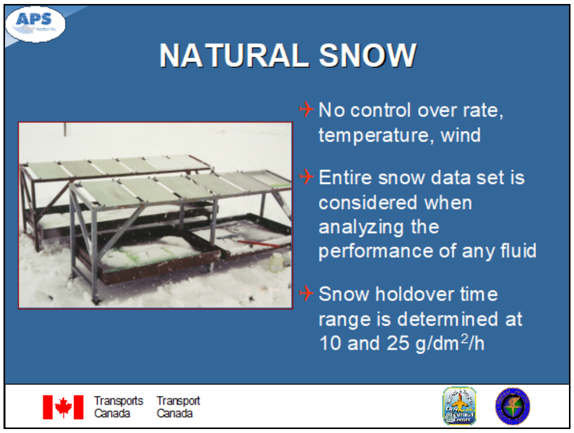

NATURAL SNOW

- 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^2/h

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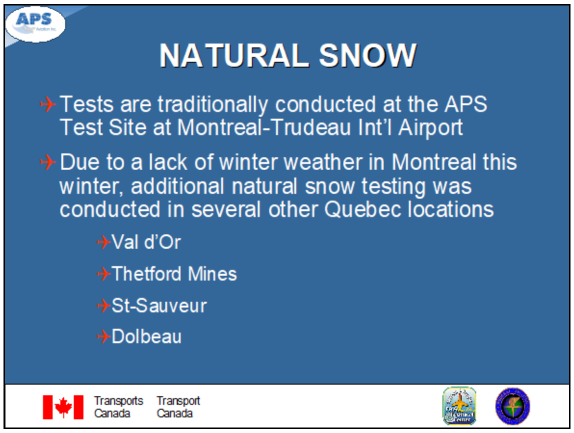

NATURAL SNOW

- Tests are traditionally conducted at the APS Test Site at Montreal-Trudeau Int'l Airport
- Due to a lack of winter weather in Montreal this winter, additional natural snow testing was conducted in several other Quebec locations
  - Val d'Or
  - Thetford Mines
  - St-Sauveur
  - Dolbeau

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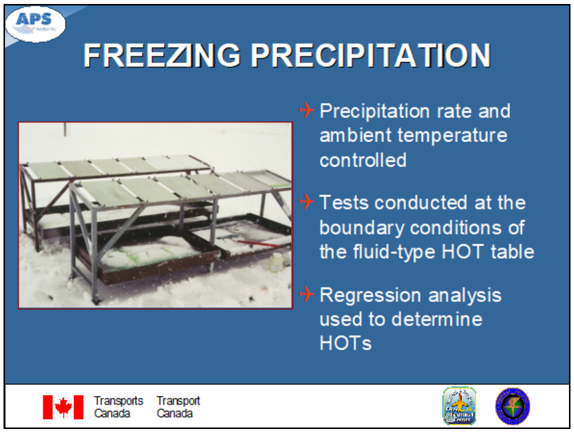
APS MONTREAL AIRPORT TEST SITE



FREEZING PRECIPITATION

- Precipitation rate and ambient temperature controlled
- Tests conducted at the boundary conditions of the fluid-type HOT table
- Regression analysis used to determine HOTs

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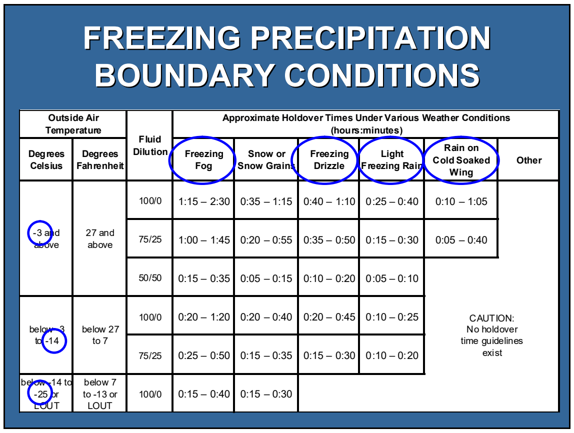
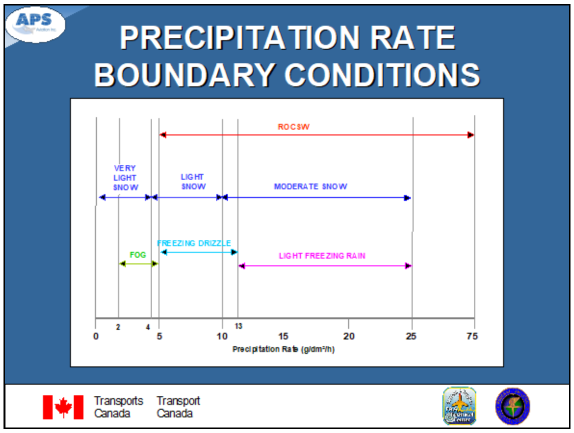


FREEZING PRECIPITATION BOUNDARY CONDITIONS

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45	0:10 – 0:25		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30	0:10 – 0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				



PRECIPITATION RATE BOUNDARY CONDITIONS

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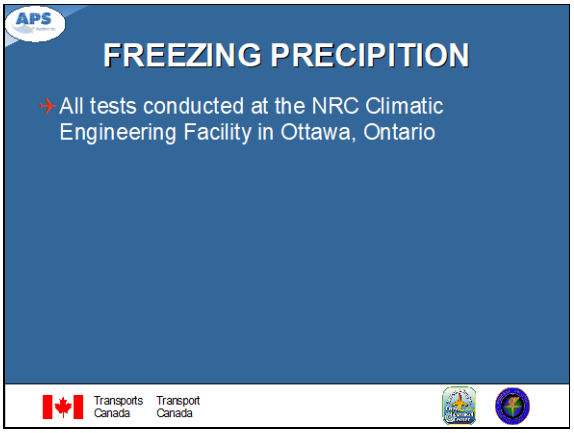

FREEZING PRECIPITION

- All tests conducted at the NRC Climatic Engineering Facility in Ottawa, Ontario

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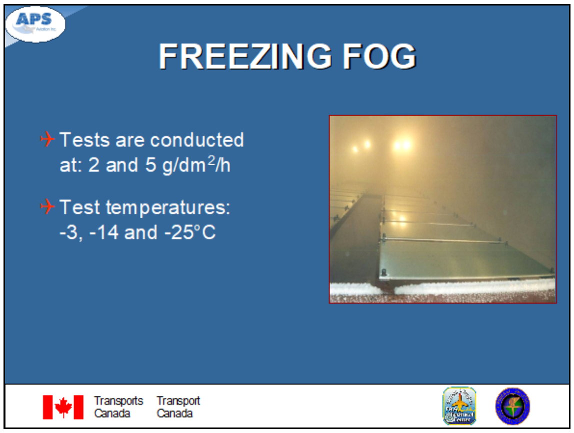
NRC CLIMATIC ENGINEERING FACILITY



FREEZING FOG

- Tests are conducted at: 2 and 5 g/dm^2/h
- Test temperatures: -3, -14 and -25°C

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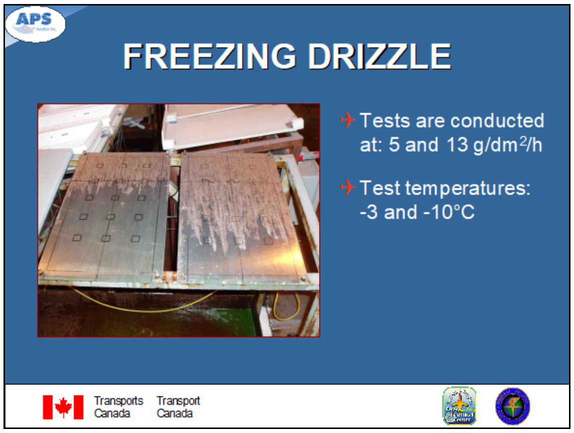

FREEZING DRIZZLE

- Tests are conducted at: 5 and 13 g/dm^2/h
- Test temperatures: -3 and -10°C

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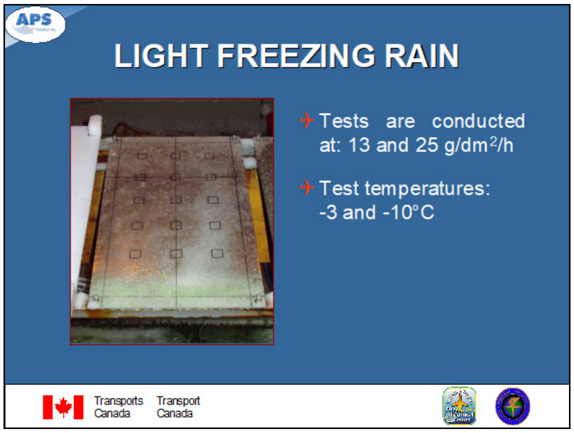

LIGHT FREEZING RAIN

- Tests are conducted at: 13 and 25 g/dm^2/h
- Test temperatures: -3 and -10°C

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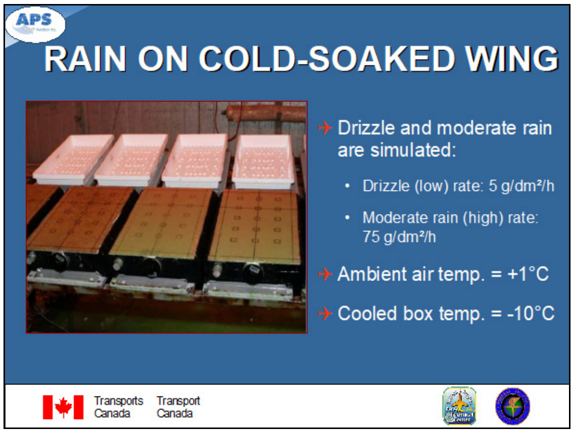

RAIN ON COLD-SOAKED WING

- Drizzle and moderate rain are simulated:
  - Drizzle (low) rate: 5 g/dm^2/h
  - Moderate rain (high) rate: 75 g/dm^2/h
- Ambient air temp. = +1°C
- Cooled box temp. = -10°C

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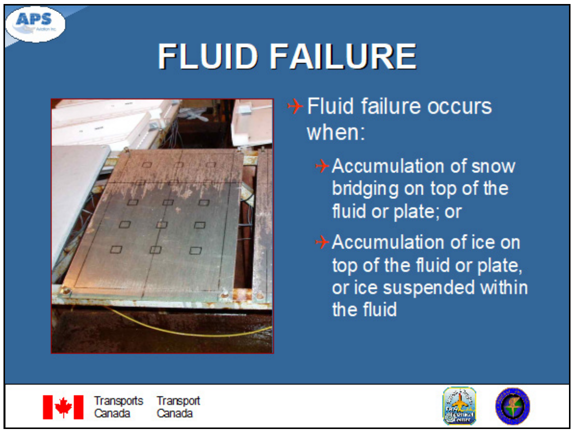

FLUID FAILURE

- Fluid failure occurs when:
  - Accumulation of snow bridging on top of the fluid or plate; or
  - Accumulation of ice on top of the fluid or plate, or ice suspended within the fluid

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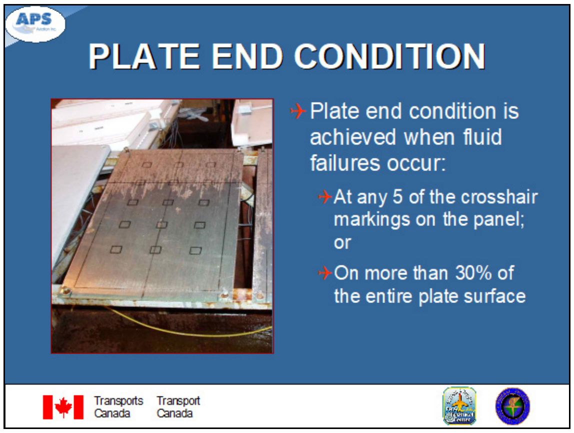

PLATE END CONDITION

- Plate end condition is achieved when fluid failures occur:
  - At any 5 of the crosshair markings on the panel; or
  - On more than 30% of the entire plate surface

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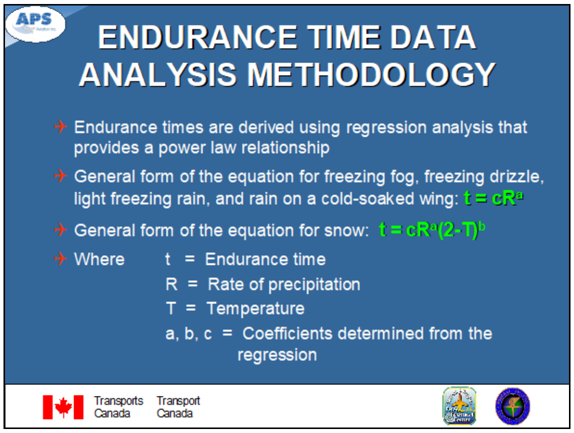

ENDURANCE TIME DATA ANALYSIS METHODOLOGY

- Endurance times are derived using regression analysis that provides a power law relationship
- General form of the equation for freezing fog, freezing drizzle, light freezing rain, and rain on a cold-soaked wing: $t = cR^a$
- General form of the equation for snow: $t = cR^a(2-T)^b$
- Where t = Endurance time

R = Rate of precipitation

T = Temperature

a, b, c = Coefficients determined from the regression

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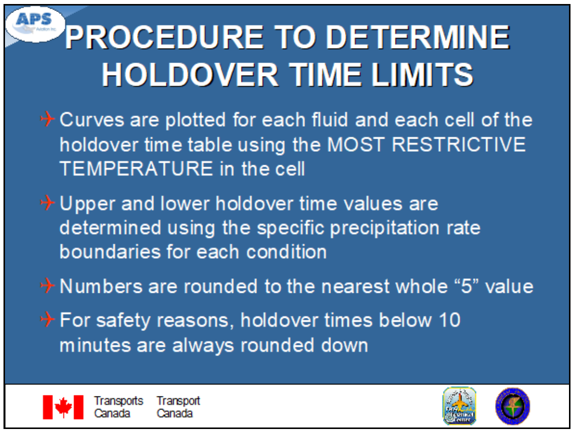

PROCEDURE TO DETERMINE HOLDOVER TIME LIMITS

- Curves are plotted for each fluid and each cell of the holdover time table using the MOST RESTRICTIVE TEMPERATURE in the cell
- Upper and lower holdover time values are determined using the specific precipitation rate boundaries for each condition
- Numbers are rounded to the nearest whole “5” value
- For safety reasons, holdover times below 10 minutes are always rounded down

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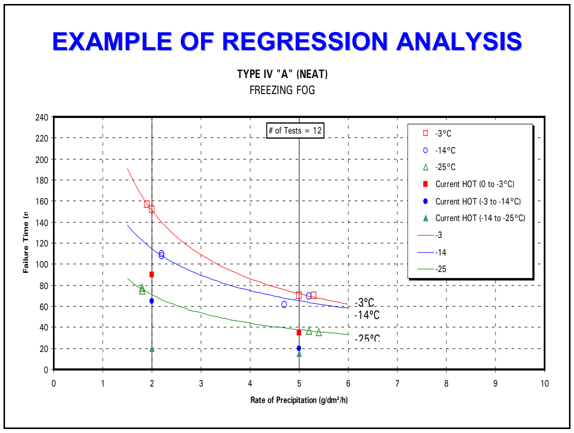
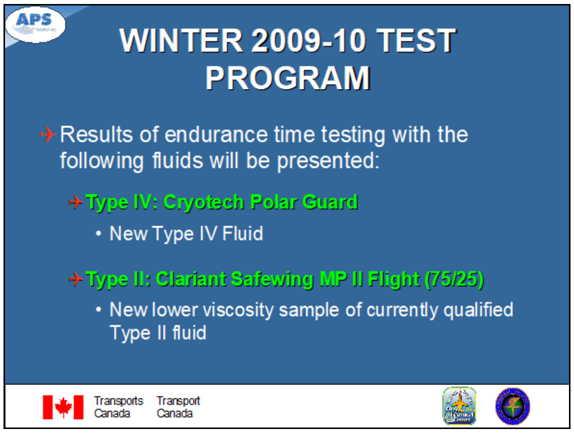


EXAMPLE OF REGRESSION ANALYSIS



WINTER 2009-10 TEST PROGRAM

- Results of endurance time testing with the following fluids will be presented:
  - **Type IV: Cryotech Polar Guard**
    - New Type IV Fluid
  - **Type II: Clariant Safewing MP II Flight (75/25)**
    - New lower viscosity sample of currently qualified Type II fluid

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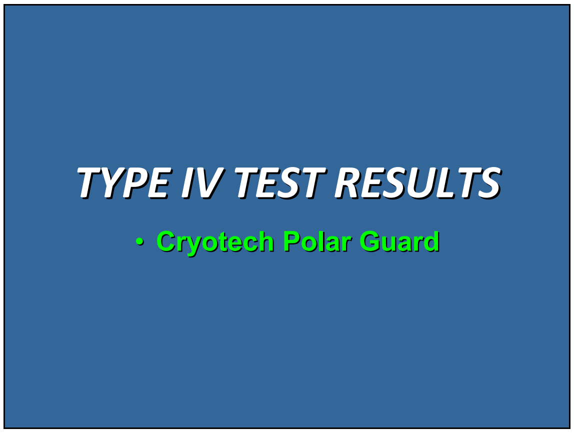
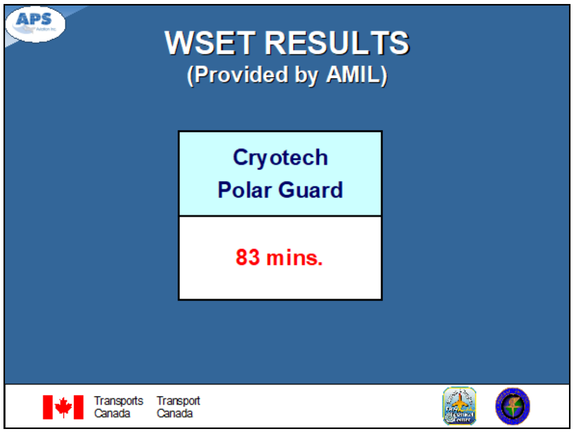


TYPE IV TEST RESULTS

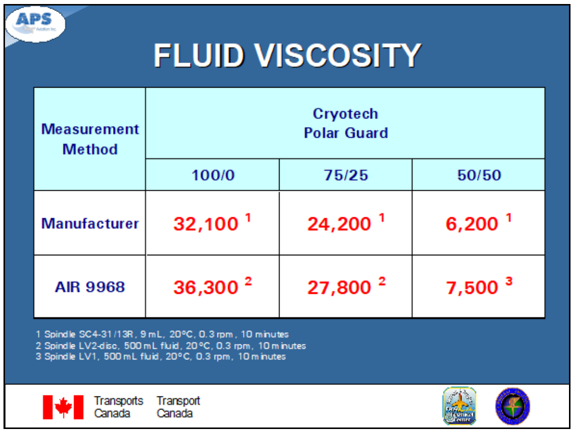
- **Cryotech Polar Guard**



WSET RESULTS
(Provided by AMIL)

Cryotech Polar Guard
83 mins.

Transports Canada Transport Canada



FLUID VISCOSITY

Measurement Method	Cryotech Polar Guard		
	100/0	75/25	50/50
Manufacturer	32,100 [1]	24,200 [1]	6,200 [1]
AIR 9968	36,300 [2]	27,800 [2]	7,500 [3]

1 Spindle SC4-31/13R, 9 mL, 20°C, 0.3 rpm, 10 minutes
2 Spindle LV2-disc, 500 mL fluid, 20°C, 0.3 rpm, 10 minutes
3 Spindle LV1, 500 mL fluid, 20°C, 0.3 rpm, 10 minutes

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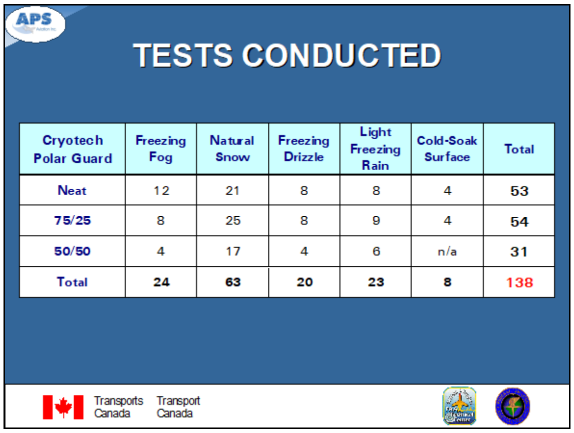

TESTS CONDUCTED

Cryotech Polar Guard	Freezing Fog	Natural Snow	Freezing Drizzle	Light Freezing Rain	Cold-Soak Surface	Total
Neat	12	21	8	8	4	53
75/25	8	25	8	9	4	54
50/50	4	17	4	6	n/a	31
Total	24	63	20	23	8	138

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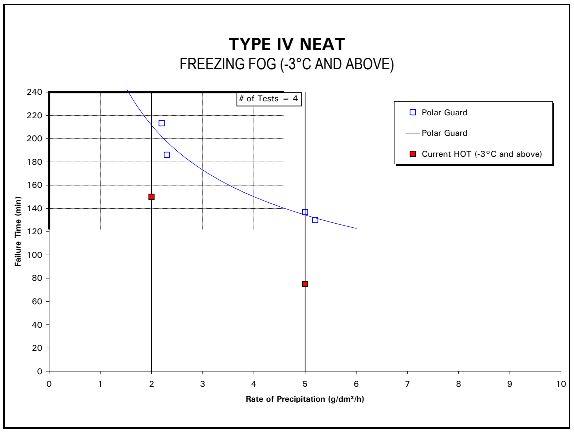
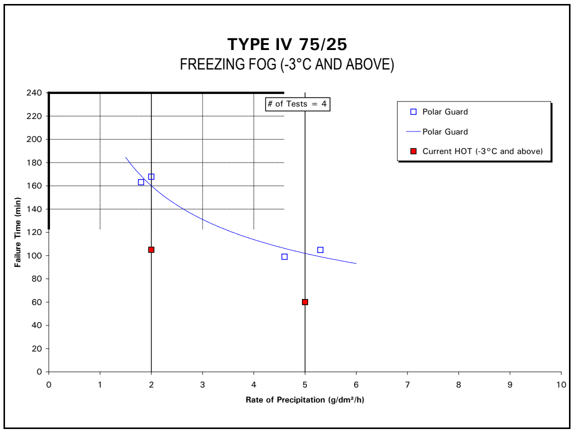
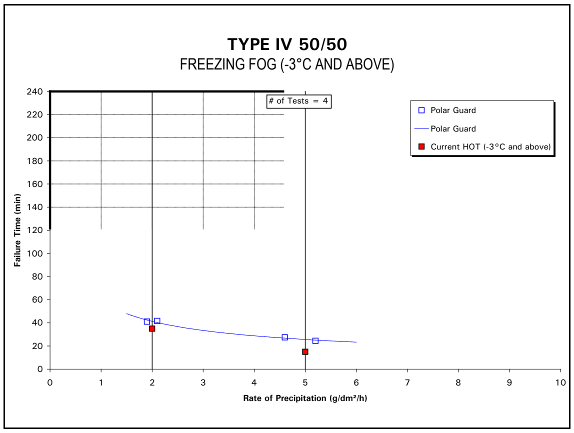
FREEZING FOG



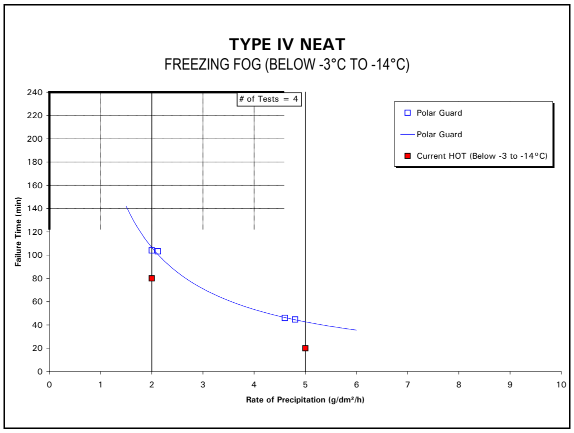
TYPE IV NEAT
FREEZING FOG (-3°C AND ABOVE)

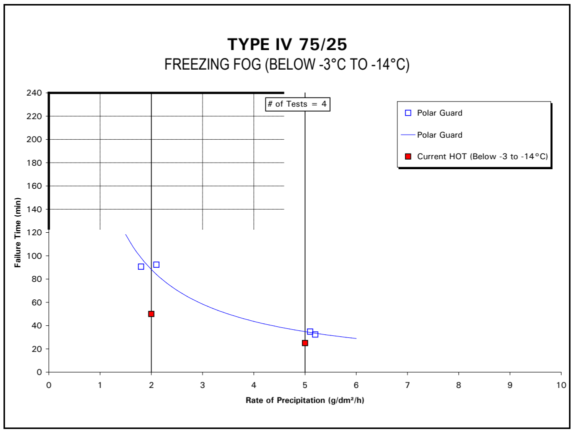


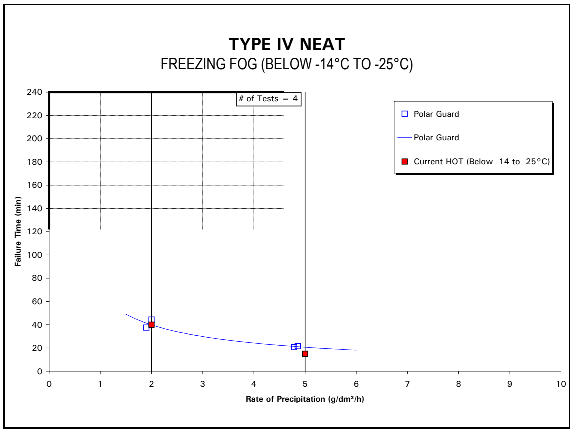
TYPE IV 75/25
FREEZING FOG (-3°C AND ABOVE)



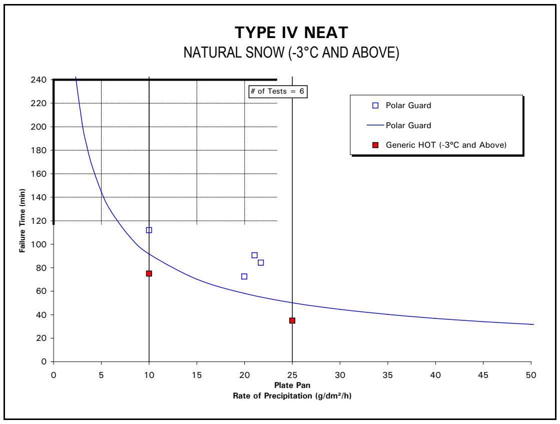
TYPE IV 50/50
FREEZING FOG (-3°C AND ABOVE)

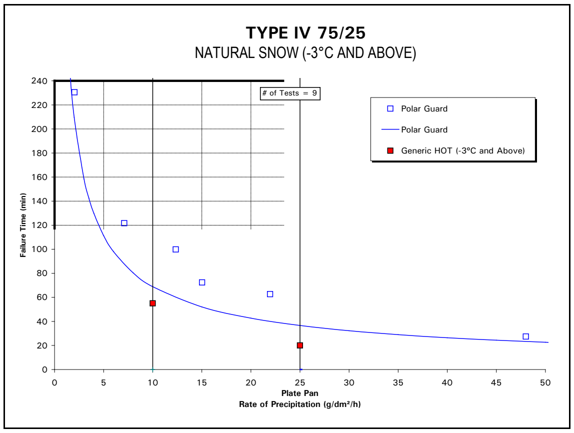

TYPE IV NEAT
FREEZING FOG (BELOW -3°C TO -14°C)
# of Tests = 4
Polar Guard
Polar Guard
Current HOT (Below -3 to -14°C)
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10

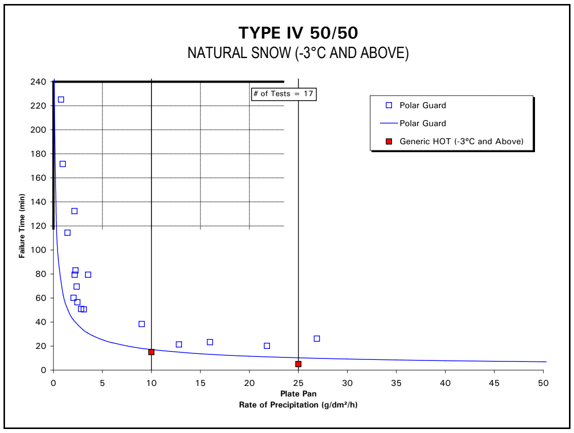

TYPE IV 75/25
FREEZING FOG (BELOW -3°C TO -14°C)
# of Tests = 4
Polar Guard
Polar Guard
Current HOT (Below -3 to -14°C)
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10


TYPE IV NEAT
FREEZING FOG (BELOW -14°C TO -25°C)
# of Tests = 4
Polar Guard
Polar Guard
Current HOT (Below -14 to -25°C)
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
Rate of Precipitation (g/dm²/h)
0
1
2
3
4
5
6
7
8
9
10

NATURAL SNOW
26 3:41

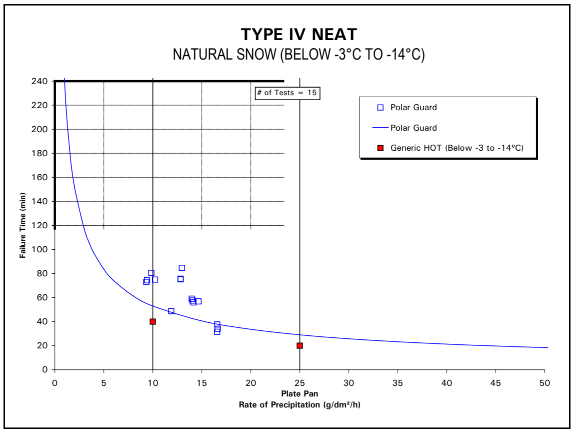

TYPE IV NEAT
NATURAL SNOW (-3°C AND ABOVE)
# of Tests = 6
Polar Guard
Polar Guard
Generic HOT (-3°C and Above)
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
Plate Pan
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
35
40
45
50


TYPE IV 75/25
NATURAL SNOW (-3°C AND ABOVE)
# of Tests = 9
Polar Guard
Polar Guard
Generic HOT (-3°C and Above)
Failure Time (min)
0
20
40
60
80
100
120
140
160
180
200
220
240
Plate Pan
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
35
40
45
50



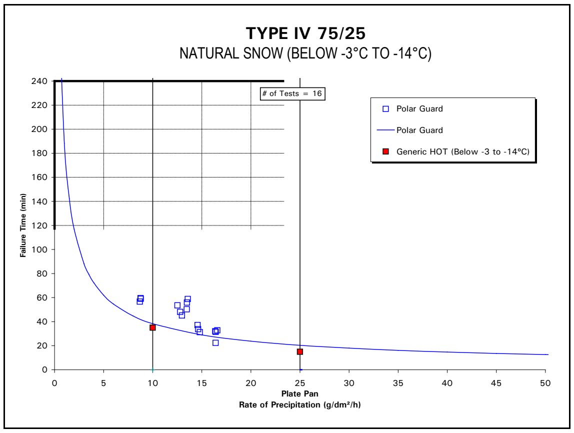
TYPE IV 50/50

NATURAL SNOW (-3°C AND ABOVE)



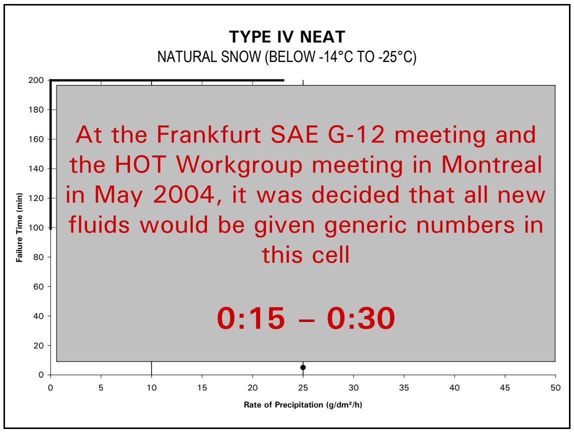
TYPE IV NEAT

NATURAL SNOW (BELOW -3°C TO -14°C)



TYPE IV 75/25

NATURAL SNOW (BELOW -3°C TO -14°C)



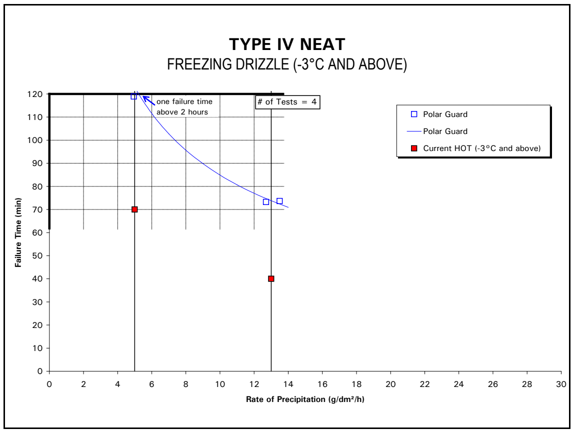
TYPE IV NEAT

NATURAL SNOW (BELOW -14°C TO -25°C)

At the Frankfurt SAE G-12 meeting and the HOT Workgroup meeting in Montreal in May 2004, it was decided that all new fluids would be given generic numbers in this cell

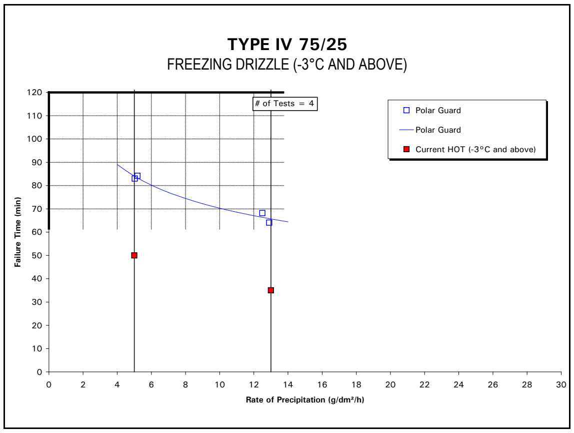
0:15 – 0:30

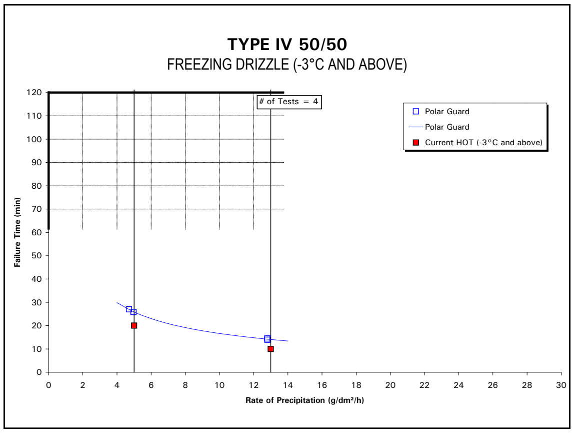
FREEZING DRIZZLE

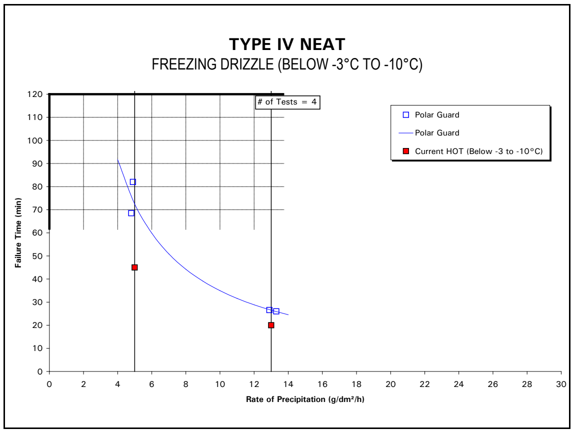


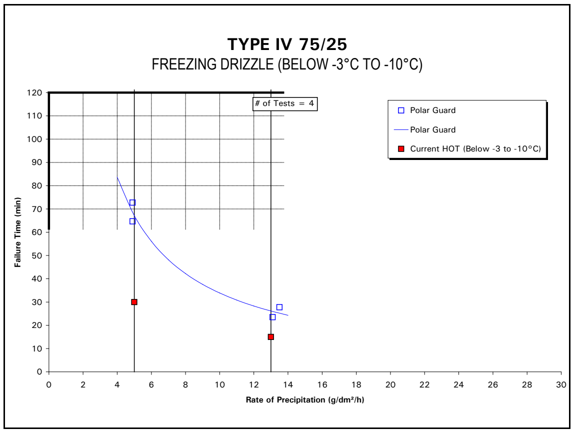
TYPE IV NEAT

FREEZING DRIZZLE (-3°C AND ABOVE)

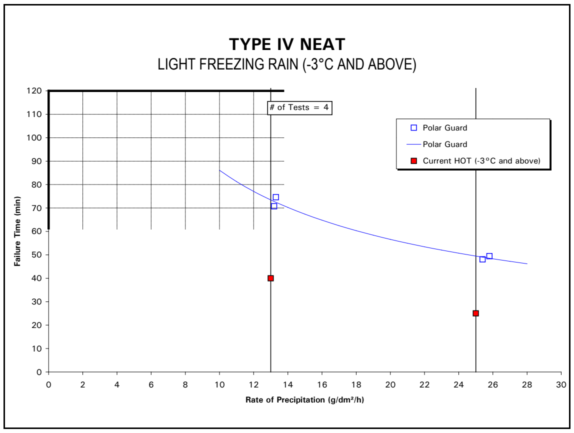

TYPE IV 75/25
FREEZING DRIZZLE (-3°C AND ABOVE)

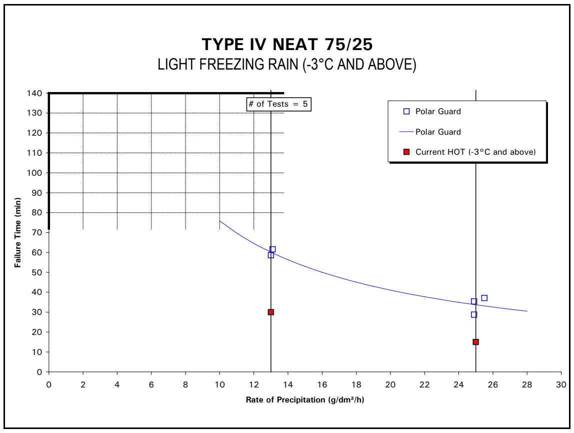

TYPE IV 50/50
FREEZING DRIZZLE (-3°C AND ABOVE)


TYPE IV NEAT
FREEZING DRIZZLE (BELOW -3°C TO -10°C)

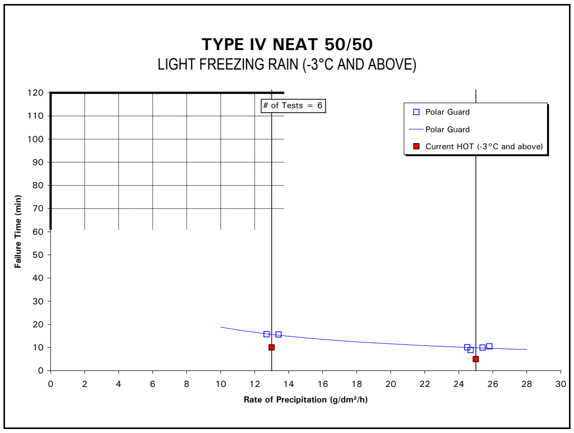

TYPE IV 75/25
FREEZING DRIZZLE (BELOW -3°C TO -10°C)

LIGHT FREEZING RAIN

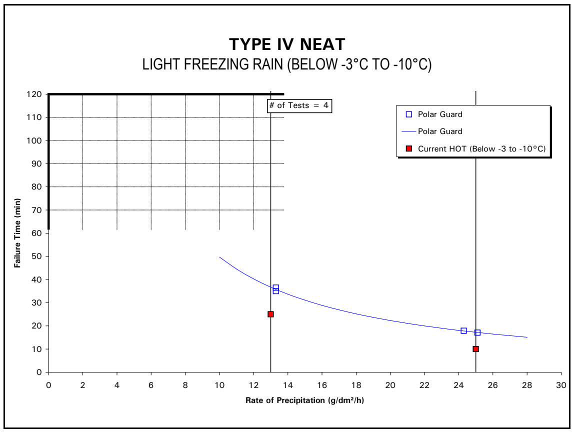

TYPE IV NEAT
LIGHT FREEZING RAIN (-3°C AND ABOVE)



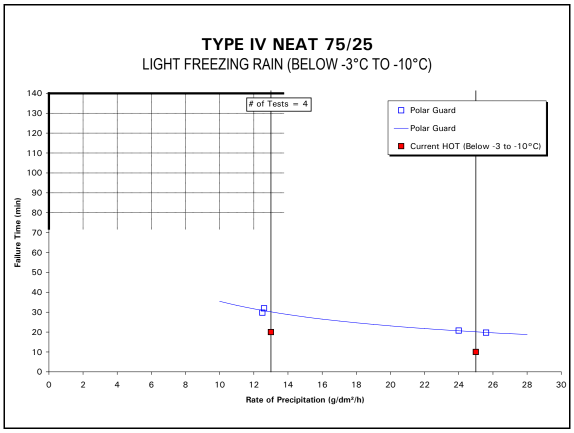
TYPE IV NEAT 75/25
LIGHT FREEZING RAIN (-3°C AND ABOVE)



TYPE IV NEAT 50/50
LIGHT FREEZING RAIN (-3°C AND ABOVE)

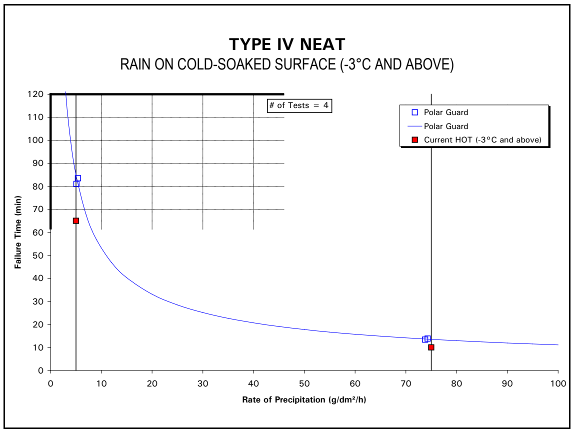


TYPE IV NEAT
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)

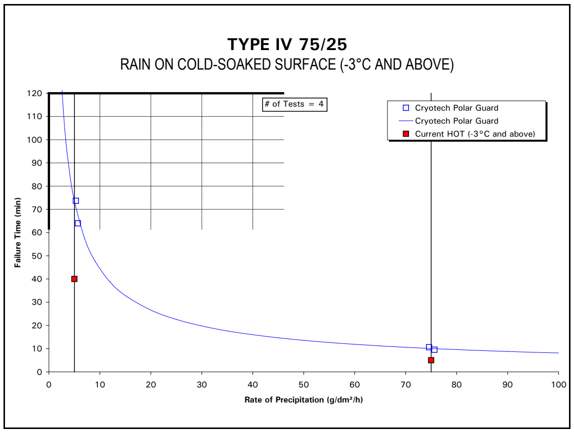


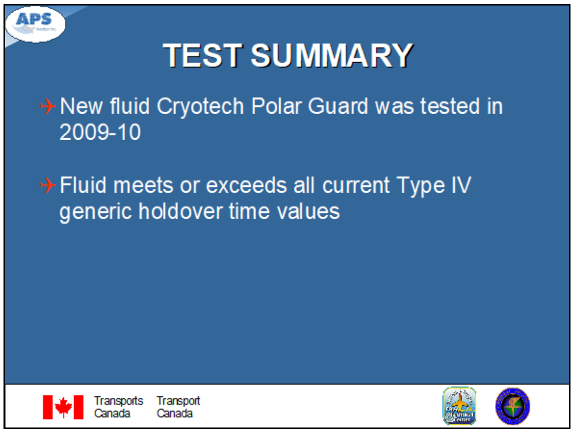
TYPE IV NEAT 75/25
LIGHT FREEZING RAIN (BELOW -3°C TO -10°C)

RAIN ON A COLD-SOAKED WING



TYPE IV NEAT
RAIN ON COLD-SOAKED SURFACE (-3°C AND ABOVE)





TEST SUMMARY

- New fluid Cryotech Polar Guard was tested in 2009-10
- Fluid meets or exceeds all current Type IV generic holdover time values

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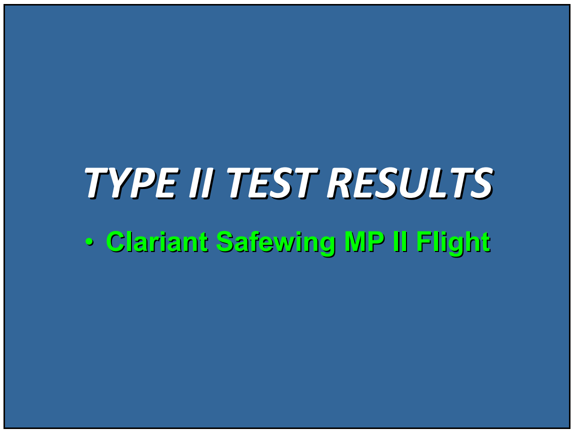
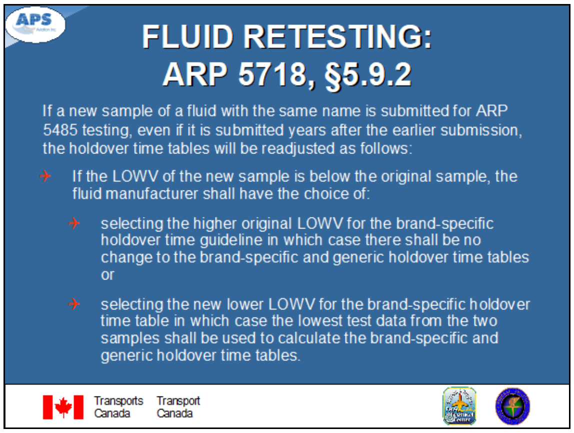


TYPE II TEST RESULTS

- **Clariant Safewing MP II Flight**

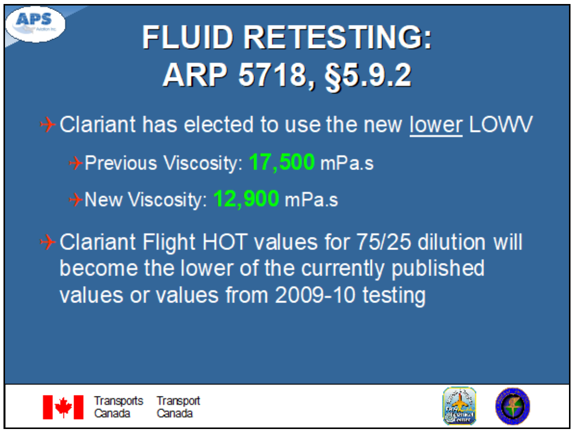


FLUID RETESTING: ARP 5718, §5.9.2

If a new sample of a fluid with the same name is submitted for ARP 5485 testing, even if it is submitted years after the earlier submission, the holdover time tables will be readjusted as follows:

- If the LOWV of the new sample is below the original sample, the fluid manufacturer shall have the choice of:
  - selecting the higher original LOWV for the brand-specific holdover time guideline in which case there shall be no change to the brand-specific and generic holdover time tables or
  - selecting the new lower LOWV for the brand-specific holdover time table in which case the lowest test data from the two samples shall be used to calculate the brand-specific and generic holdover time tables.

Transports Canada Transport Canada



FLUID RETESTING: ARP 5718, §5.9.2

- Clariant has elected to use the new lower LOWV
  - Previous Viscosity: 17,500 mPa.s
  - New Viscosity: 12,900 mPa.s
- Clariant Flight HOT values for 75/25 dilution will become the lower of the currently published values or values from 2009-10 testing

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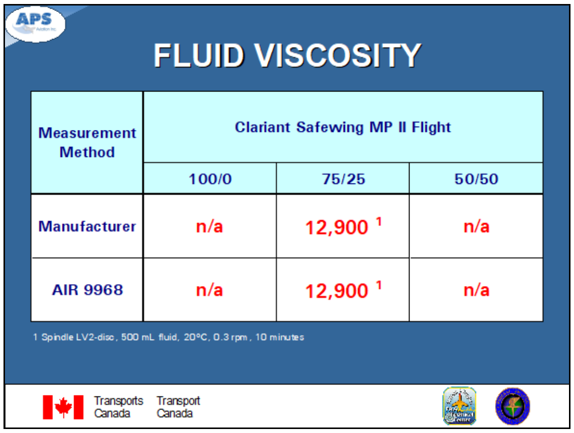
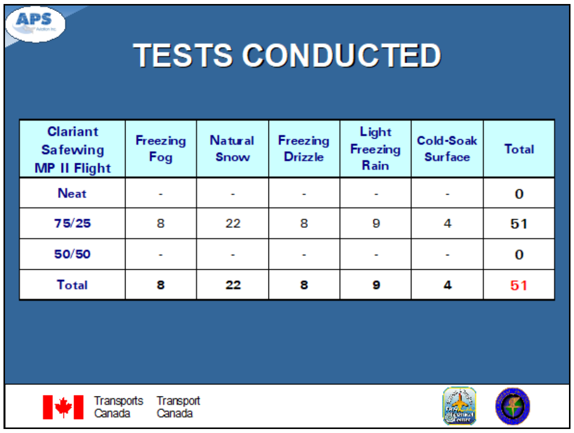


FLUID VISCOSITY

Measurement Method	Clariant Safewing MP II Flight		
	100/0	75/25	50/50
Manufacturer	n/a	12,900 [1]	n/a
AIR 9968	n/a	12,900 [1]	n/a

1 Spindle LV2-disc, 500 mL fluid, 20°C, 0.3 rpm, 10 minutes

Transports Canada Transport Canada

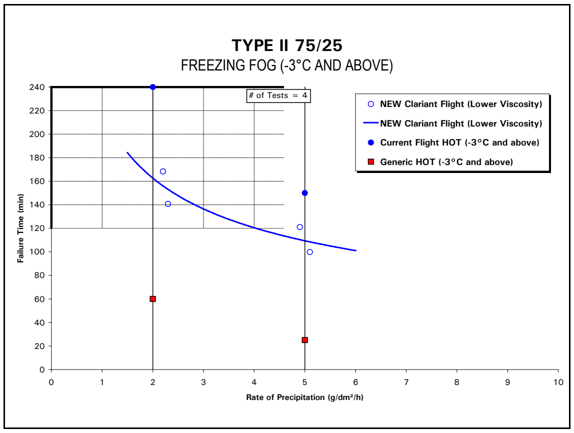


TESTS CONDUCTED

Clariant Safewing MP II Flight	Freezing Fog	Natural Snow	Freezing Drizzle	Light Freezing Rain	Cold-Soak Surface	Total
Neat	-	-	-	-	-	0
75/25	8	22	8	9	4	51
50/50	-	-	-	-	-	0
Total	8	22	8	9	4	51

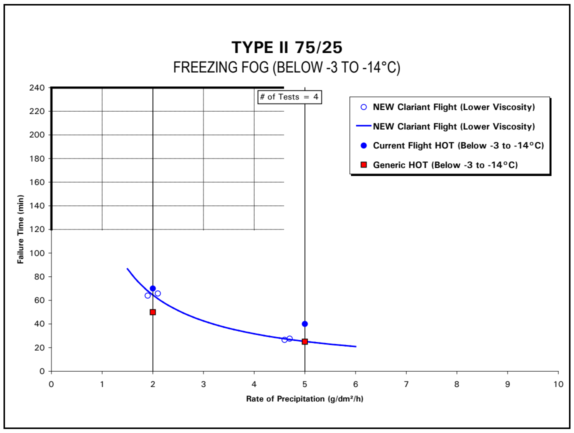
Transports Canada Transport Canada

FREEZING FOG



TYPE II 75/25

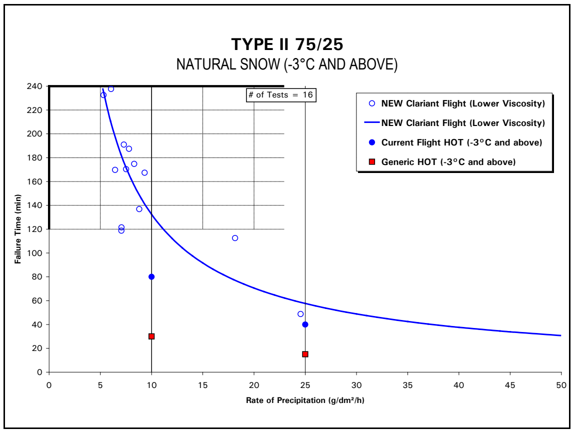
FREEZING FOG (-3°C AND ABOVE)



TYPE II 75/25

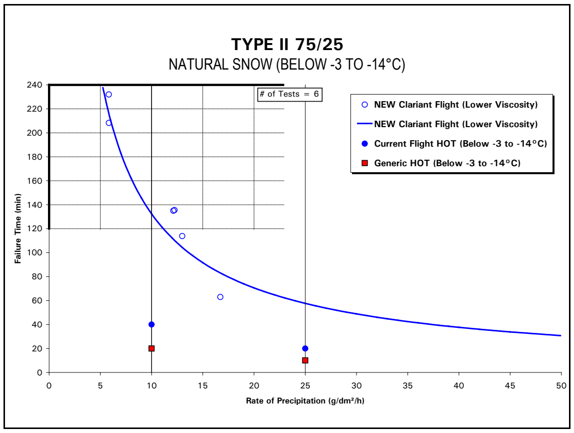
FREEZING FOG (BELOW -3 TO -14°C)

NATURAL SNOW



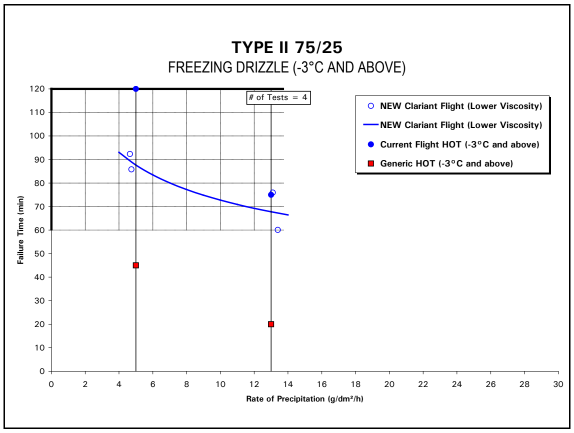
TYPE II 75/25

NATURAL SNOW (-3°C AND ABOVE)

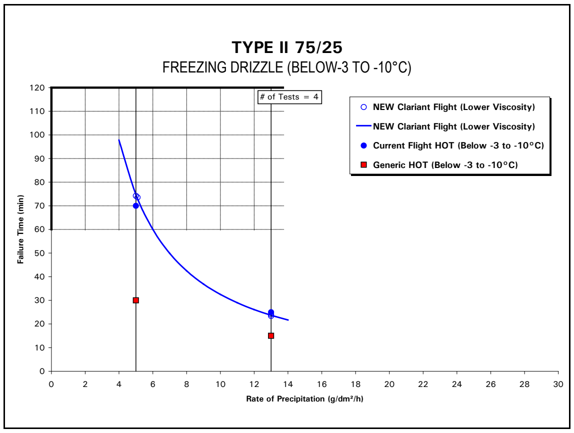


TYPE II 75/25
NATURAL SNOW (BELOW -3 TO -14°C)

FREEZING DRIZZLE

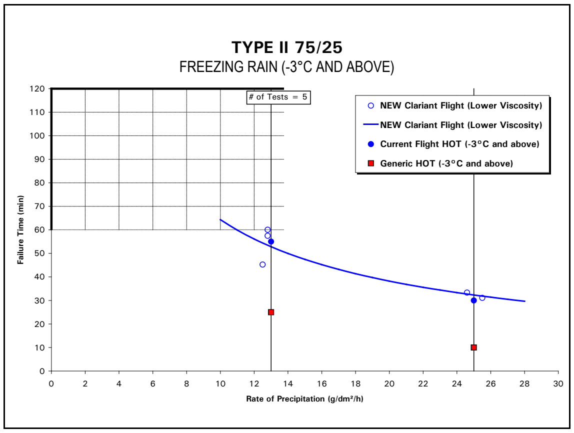


TYPE II 75/25
FREEZING DRIZZLE (-3°C AND ABOVE)

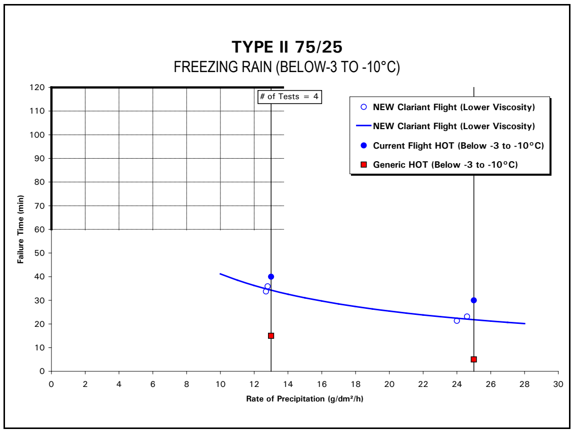


TYPE II 75/25
FREEZING DRIZZLE (BELOW-3 TO -10°C)

LIGHT FREEZING RAIN



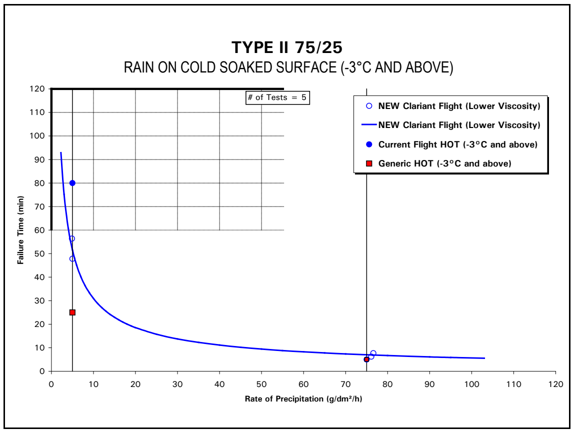
TYPE II 75/25
FREEZING RAIN (-3°C AND ABOVE)



TYPE II 75/25

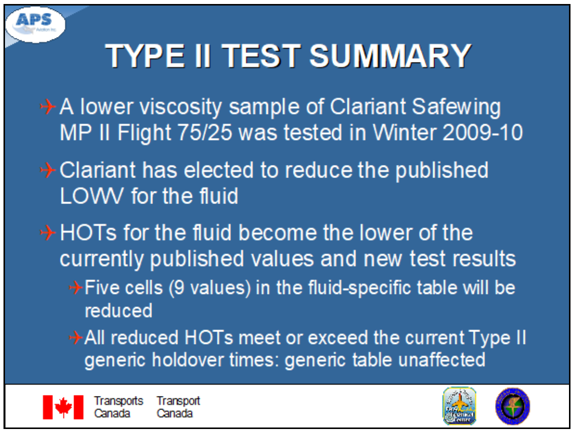
FREEZING RAIN (BELOW-3 TO -10°C)

RAIN ON A COLD-SOAKED WING



TYPE II 75/25

RAIN ON COLD SOAKED SURFACE (-3°C AND ABOVE)



TYPE II TEST SUMMARY

- A lower viscosity sample of Clariant Safewing MP II Flight 75/25 was tested in Winter 2009-10
- Clariant has elected to reduce the published LOWV for the fluid
- HOTs for the fluid become the lower of the currently published values and new test results
  - Five cells (9 values) in the fluid-specific table will be reduced
  - All reduced HOTs meet or exceed the current Type II generic holdover times: generic table unaffected

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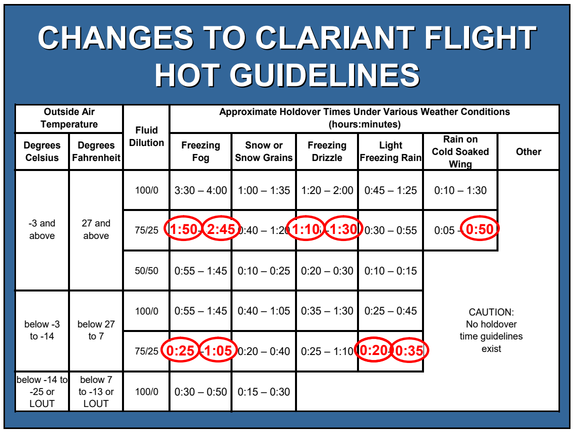
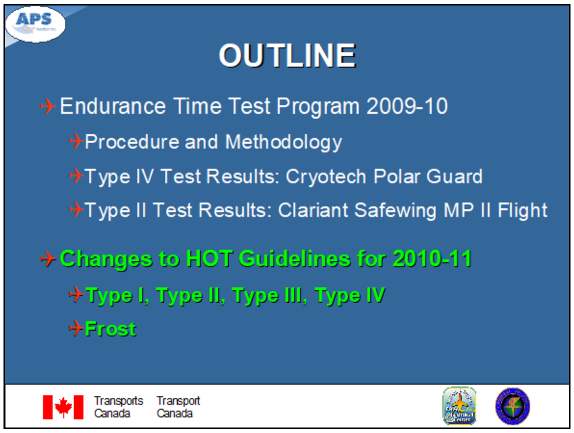


CHANGES TO CLARIANT FLIGHT HOT GUIDELINES

Outside Air Temperature		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	3:30 – 4:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	
		75/25	1:50 – 2:45	0:40 – 1:20	1:10 – 1:30	0:30 – 0:55	0:05 – 0:50	
		50/50	0:55 – 1:45	0:10 – 0:25	0:20 – 0:30	0:10 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55 – 1:45	0:40 – 1:05	0:35 – 1:30	0:25 – 0:45		
		75/25	0:25 – 1:05	0:20 – 0:40	0:25 – 1:10	0:20 – 0:35		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:30 – 0:50	0:15 – 0:30				



OUTLINE

- Endurance Time Test Program 2009-10
  - Procedure and Methodology
  - Type IV Test Results: Cryotech Polar Guard
  - Type II Test Results: Clariant Safewing MP II Flight
- **Changes to HOT Guidelines for 2010-11**
  - **Type I, Type II, Type III, Type IV**
  - **Frost**

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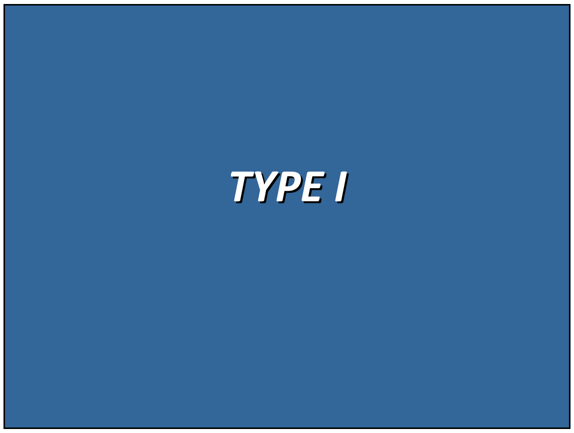
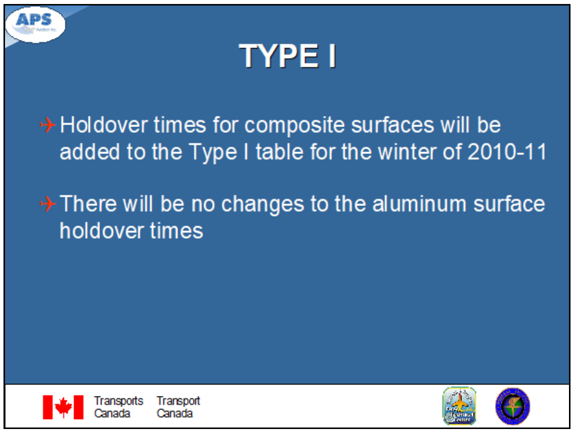
CHANGES TO HOT GUIDELINES

For the Winter 2010-11 Season



TYPE I



TYPE I

- Holdover times for composite surfaces will be added to the Type I table for the winter of 2010-11
- There will be no changes to the aluminum surface holdover times

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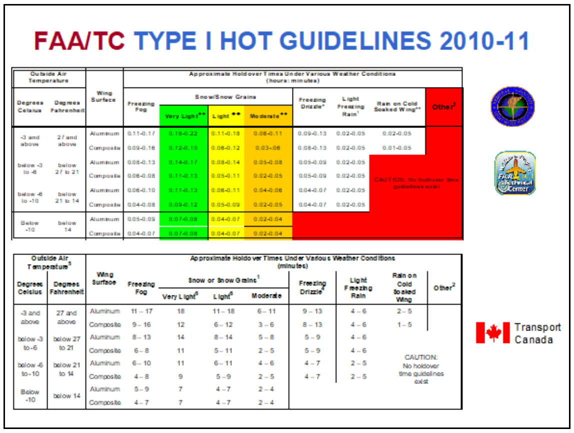
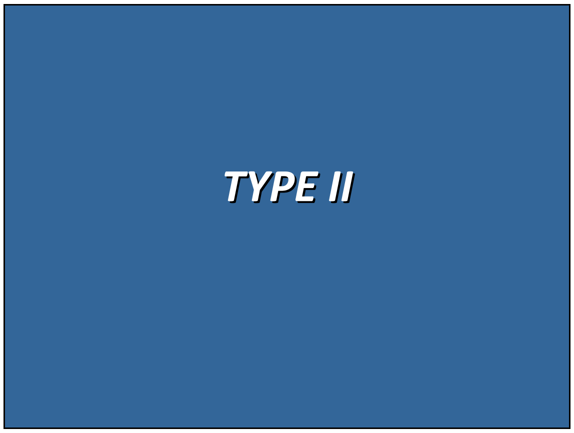


FAA/TC TYPE I HOT GUIDELINES 2010-11

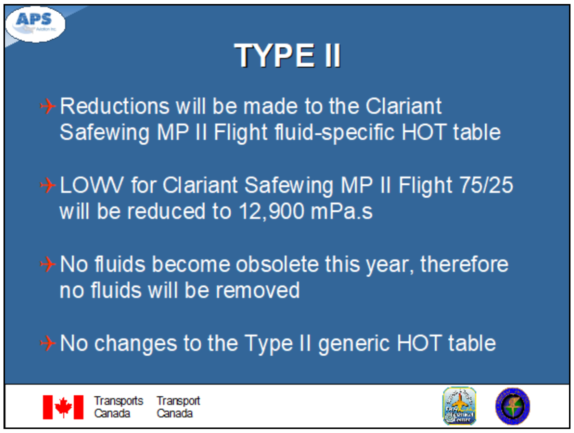
Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow/Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light**	Light **	Moderate **	Freezing Drizzle*	Light Freezing Rain[1]	Rain on Cold Soaked Wing**	Other[2]
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-.06	0:08-0:13	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05		
		Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
		Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				
		Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				

Outside Air Temperature[5]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
Below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

Transport Canada



TYPE II



TYPE II

- Reductions will be made to the Clariant Safewing MP II Flight fluid-specific HOT table
- LOWV for Clariant Safewing MP II Flight 75/25 will be reduced to 12,900 mPa.s
- No fluids become obsolete this year, therefore no fluids will be removed
- No changes to the Type II generic HOT table

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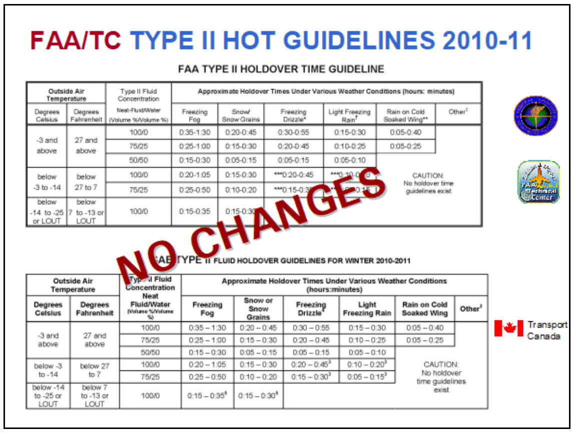


FAA/TC TYPE II HOT GUIDELINES 2010-11

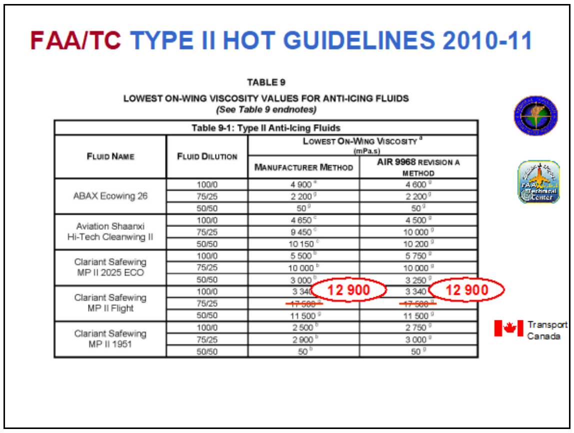
FAA TYPE II HOLDOVER TIME GUIDELINE

Outside Air Temperature		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow/ Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40	
		75/25	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	***0:20-0:45	[illegible]		
		75/25	0:25-0:50	0:10-0:20	[illegible]	[illegible]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:35	[illegible]				

NO CHANGES

[illegible]AE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011

Outside Air Temperature		Typ[illegible] Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				



FAA/TC TYPE II HOT GUIDELINES 2010-11

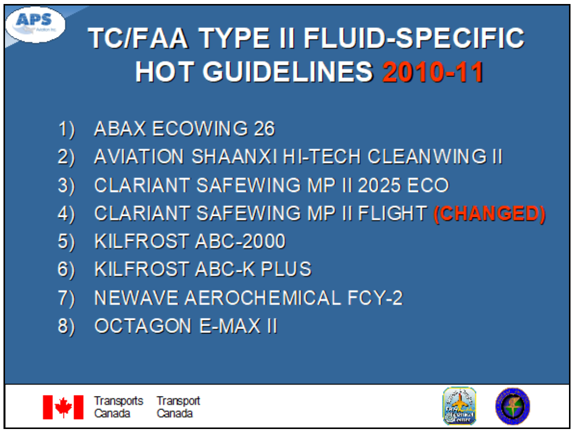
TABLE 9

LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS

(See Table 9 endnotes)

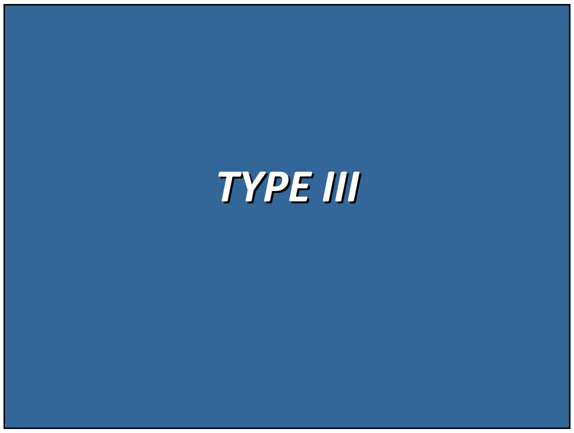
Table 9-1: Type II Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4 900 [a]	4 600 [g]
	75/25	2 200 [g]	2 200 [g]
	50/50	50 [g]	50 [g]
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 [c]	4 500 [g]
	75/25	9 450 [c]	10 000 [g]
	50/50	10 150 [c]	10 200 [g]
Clariant Safewing MP II 2025 ECO	100/0	5 500 [b]	5 750 [g]
	75/25	10 000 [b]	10 000 [g]
	50/50	3 000 [b]	3 250 [g]
Clariant Safewing MP II Flight	100/0	3 340	3 340
	75/25	~~17 500~~ [g] 12 900	~~17 500~~ [g] 12 900
	50/50	11 500 [g]	11 500 [g]
Clariant Safewing MP II 1951	100/0	2 500 [b]	2 750 [g]
	75/25	2 900 [b]	3 000 [g]
	50/50	50 [b]	50 [g]

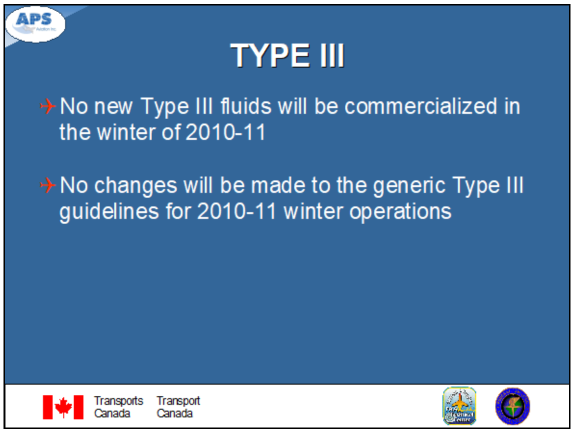


TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2010-11

1) ABAX ECOWING 26
2) AVIATION SHAANXI HI-TECH CLEANWING II
3) CLARIANT SAFEWING MP II 2025 ECO
4) CLARIANT SAFEWING MP II FLIGHT (CHANGED)
5) KILFROST ABC-2000
6) KILFROST ABC-K PLUS
7) NEWAVE AEROCHEMICAL FCY-2
8) OCTAGON E-MAX II

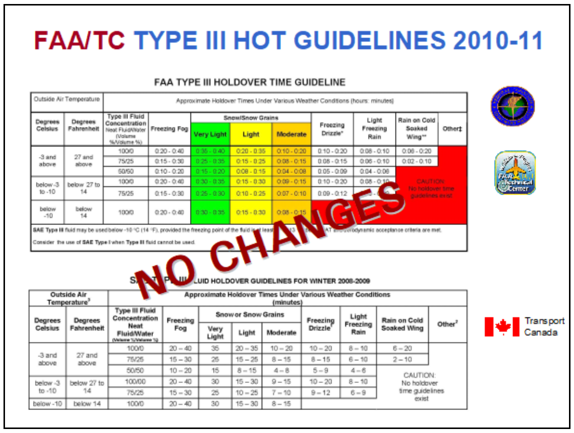


TYPE III



TYPE III

- No new Type III fluids will be commercialized in the winter of 2010-11
- No changes will be made to the generic Type III guidelines for 2010-11 winter operations



FAA/TC TYPE III HOT GUIDELINES 2010-11

FAA TYPE III HOLDOVER TIME GUIDELINE

Outside Air Temperature		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow/Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light	Light	Moderate	Freezing Drizzle*	Light Freezing Rain	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	0:20 - 0:40	0:35 - 0:40	0:20 - 0:35	0:10 - 0:20	0:10 - 0:20	0:08 - 0:10	0:06 - 0:20	
		75/25	0:15 - 0:30	0:25 - 0:35	0:15 - 0:25	0:08 - 0:15	0:08 - 0:15	0:06 - 0:10	0:02 - 0:10	
		50/50	0:10 - 0:20	0:15 - 0:20	0:08 - 0:15	0:04 - 0:08	0:05 - 0:09	0:04 - 0:06	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:09 - 0:15	0:10 - 0:20	0:08 - 0:10		
		75/25	0:15 - 0:30	0:25 - 0:30	0:10 - 0:25	0:07 - 0:10	0:09 - 0:12	[illegible]		
below -10	below 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:08 - 0:15				

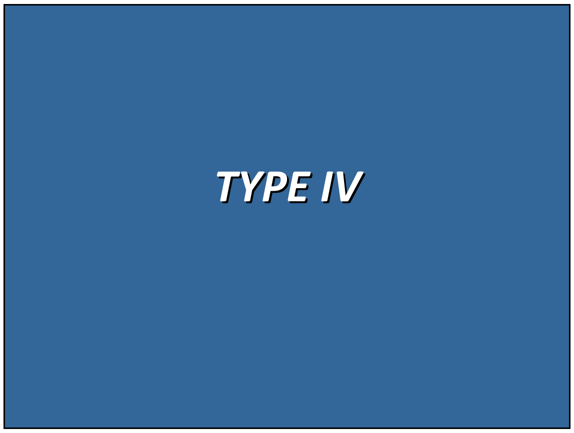
SAE Type III fluid may be used below -10 °C (14 °F), provided the freezing point of the fluid is [illegible] 13 [illegible] AT [illegible] aerodynamic acceptance criteria are met.

Consider the use of **SAE Type I** when **Type III** fluid cannot be used.

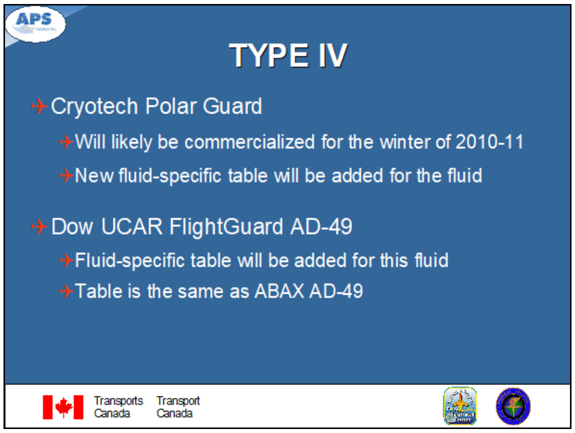
NO CHANGES

S[illegible] LUID HOLDOVER GUIDELINES FOR WINTER 2008-2009

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light	Light	Moderate	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/00	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				



TYPE IV



TYPE IV

- Cryotech Polar Guard
  - Will likely be commercialized for the winter of 2010-11
  - New fluid-specific table will be added for the fluid
- Dow UCAR FlightGuard AD-49
  - Fluid-specific table will be added for this fluid
  - Table is the same as ABAX AD-49

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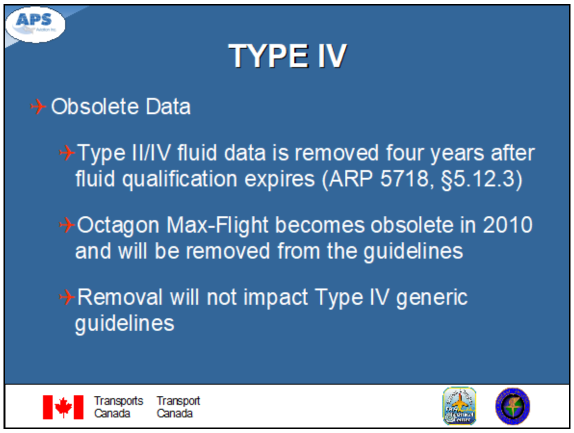

TYPE IV

- Obsolete Data
  - Type II/IV fluid data is removed four years after fluid qualification expires (ARP 5718, §5.12.3)
  - Octagon Max-Flight becomes obsolete in 2010 and will be removed from the guidelines
  - Removal will not impact Type IV generic guidelines

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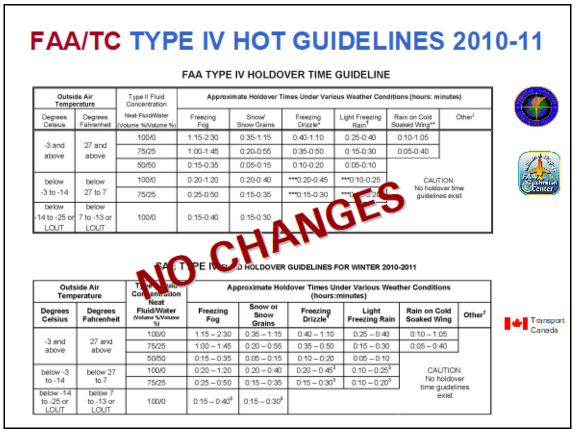


FAA/TC TYPE IV HOT GUIDELINES 2010-11

FAA TYPE IV HOLDOVER TIME GUIDELINE

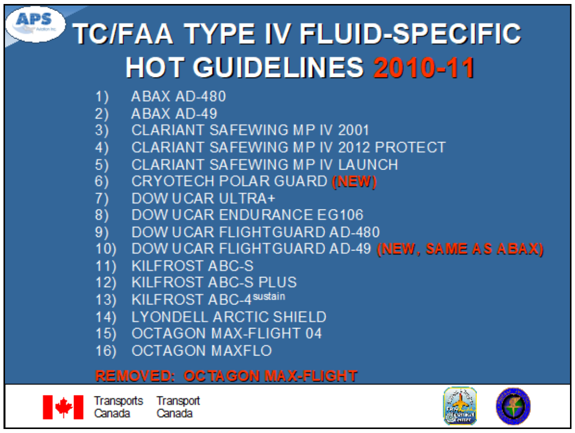
Outside Air Temperature		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit	Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog	Snow/ Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	[illegible]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

NO CHANGES

SAE TYPE IV [illegible] HOLDOVER GUIDELINES FOR WINTER 2010-2011

Outside Air Temperature		[illegible] Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

Transport Canada



TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2010-11

1) ABAX AD-480
2) ABAX AD-49
3) CLARIANT SAFEWING MP IV 2001
4) CLARIANT SAFEWING MP IV 2012 PROTECT
5) CLARIANT SAFEWING MP IV LAUNCH
6) CRYOTECH POLAR GUARD (NEW)
7) DOW UCAR ULTRA+
8) DOW UCAR ENDURANCE EG106
9) DOW UCAR FLIGHTGUARD AD-480
10) DOW UCAR FLIGHTGUARD AD-49 (NEW, SAME AS ABAX)
11) KILFROST ABC-S
12) KILFROST ABC-S PLUS
13) KILFROST ABC-4^{sustain}
14) LYONDELL ARCTIC SHIELD
15) OCTAGON MAX-FLIGHT 04
16) OCTAGON MAXFLO

REMOVED: OCTAGON MAX-FLIGHT

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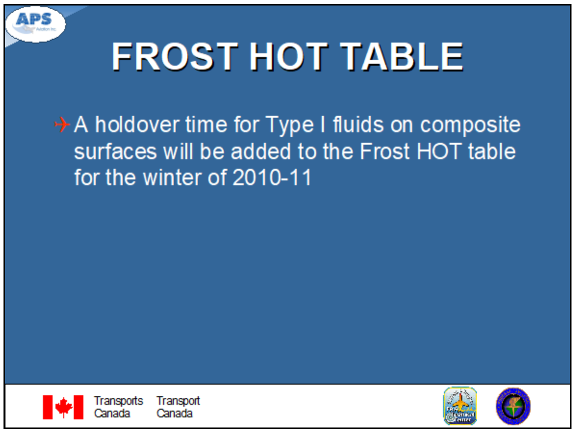
FROST TABLE



FROST HOT TABLE

- A holdover time for Type I fluids on composite surfaces will be added to the Frost HOT table for the winter of 2010-11

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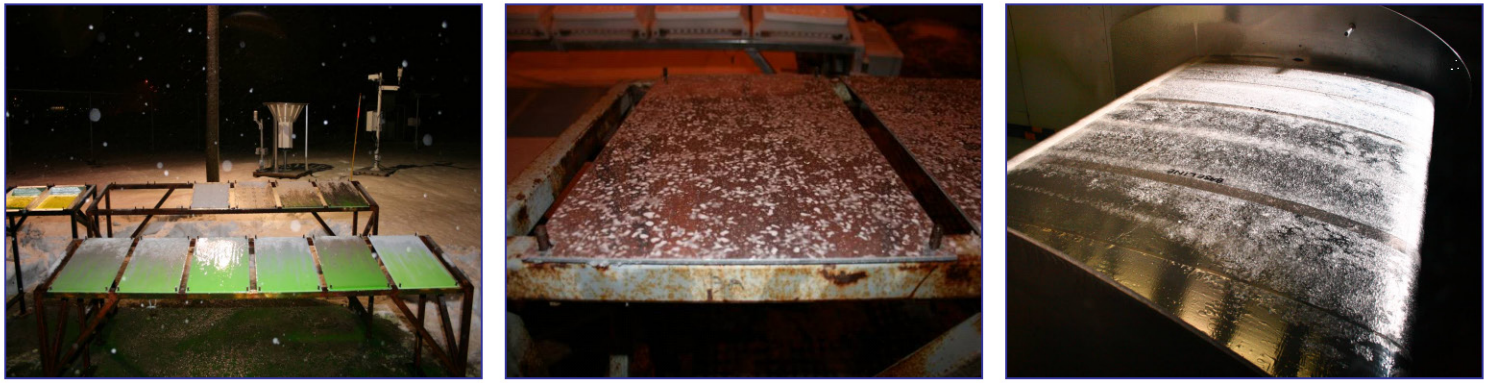
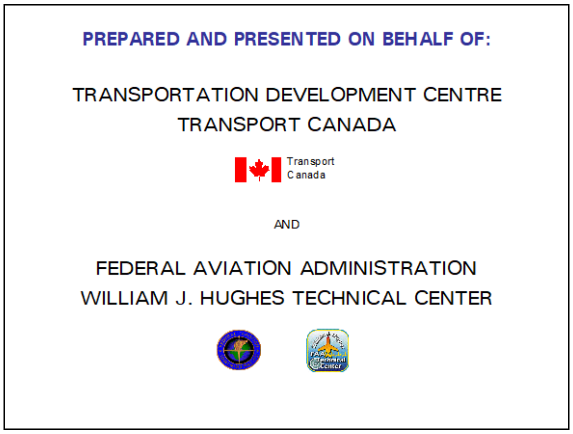
EFFECT OF ICE PHOBIC PRODUCTS ON DE/ANTI-ICING FLUID HOT'S



SAE G-12 – HOT COMMITEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI



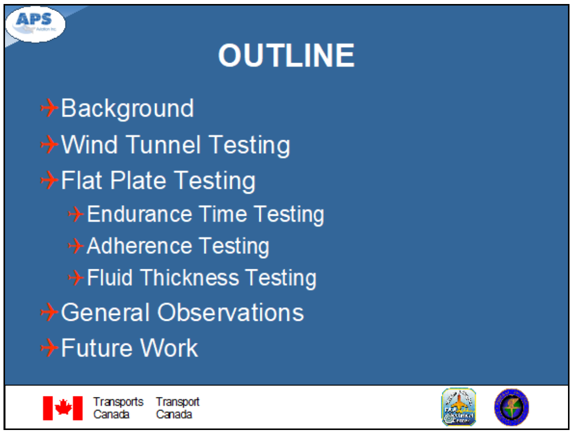
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Wind Tunnel Testing
- Flat Plate Testing
  - Endurance Time Testing
  - Adherence Testing
  - Fluid Thickness Testing
- General Observations
- Future Work

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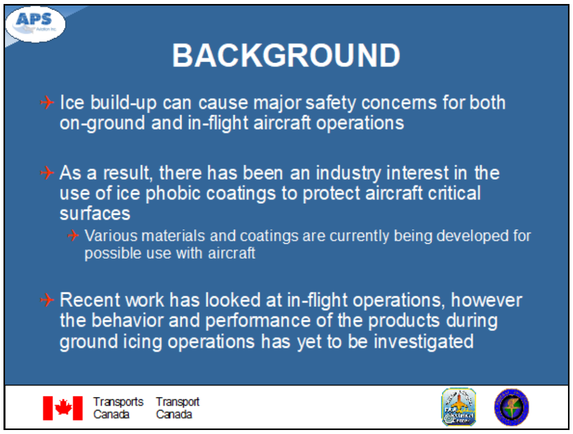

BACKGROUND

- Ice build-up can cause major safety concerns for both on-ground and in-flight aircraft operations
- As a result, there has been an industry interest in the use of ice phobic coatings to protect aircraft critical surfaces
  - Various materials and coatings are currently being developed for possible use with aircraft
- Recent work has looked at in-flight operations, however the behavior and performance of the products during ground icing operations has yet to be investigated

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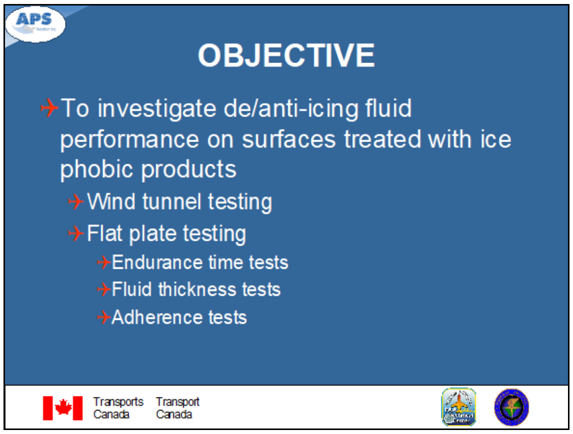

OBJECTIVE

- To investigate de/anti-icing fluid performance on surfaces treated with ice phobic products
  - Wind tunnel testing
  - Flat plate testing
    - Endurance time tests
    - Fluid thickness tests
    - Adherence tests

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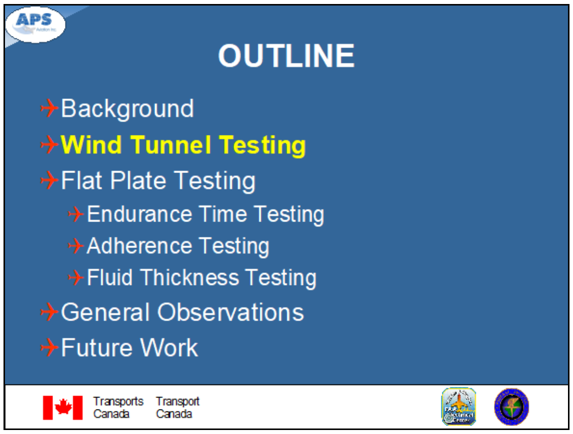

OUTLINE

- Background
- **Wind Tunnel Testing**
- Flat Plate Testing
  - Endurance Time Testing
  - Adherence Testing
  - Fluid Thickness Testing
- General Observations
- Future Work

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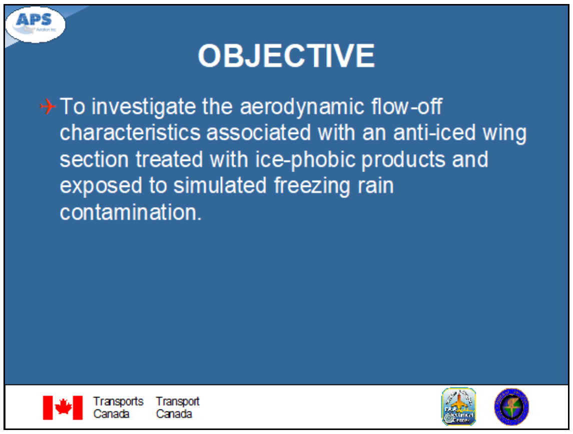

OBJECTIVE

- To investigate the aerodynamic flow-off characteristics associated with an anti-iced wing section treated with ice-phobic products and exposed to simulated freezing rain contamination.

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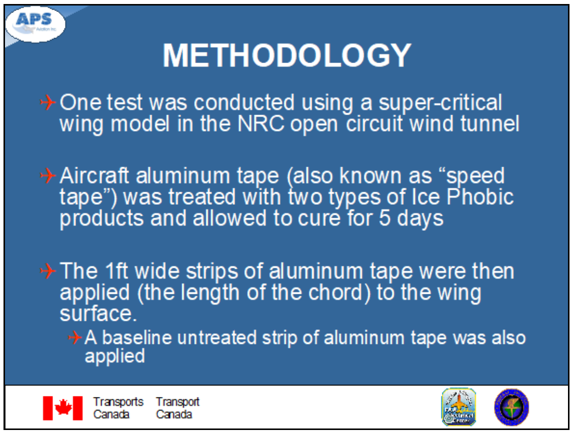

METHODOLOGY

- One test was conducted using a super-critical wing model in the NRC open circuit wind tunnel
- Aircraft aluminum tape (also known as "speed tape") was treated with two types of Ice Phobic products and allowed to cure for 5 days
- The 1ft wide strips of aluminum tape were then applied (the length of the chord) to the wing surface.
  - A baseline untreated strip of aluminum tape was also applied

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APPLICATION OF TREATED STRIPS OF SPEED TAPE

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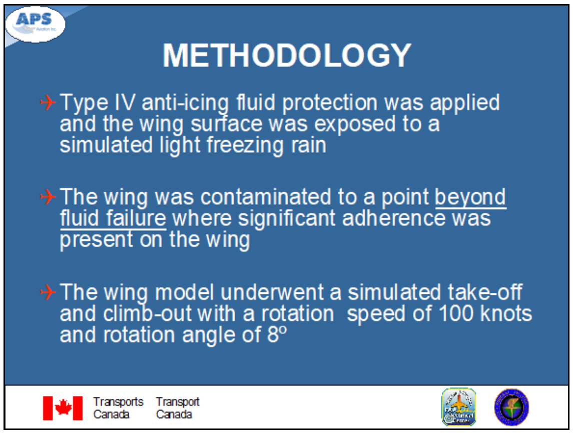

METHODOLOGY

- Type IV anti-icing fluid protection was applied and the wing surface was exposed to a simulated light freezing rain
- The wing was contaminated to a point beyond fluid failure where significant adherence was present on the wing
- The wing model underwent a simulated take-off and climb-out with a rotation speed of 100 knots and rotation angle of 8°

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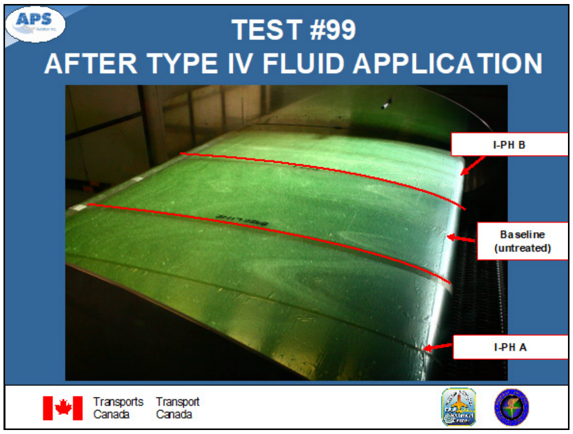

TEST #99
AFTER TYPE IV FLUID APPLICATION

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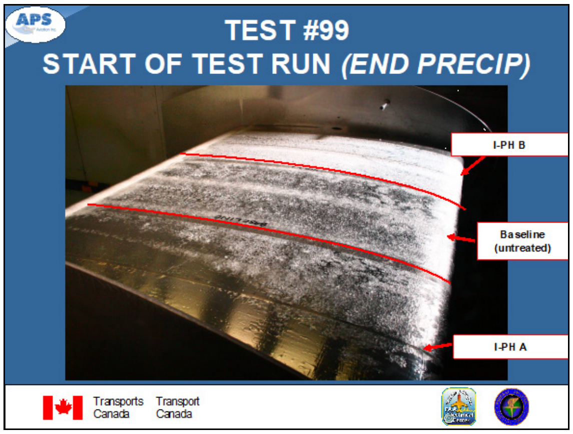

TEST #99
START OF TEST RUN *(END PRECIP)*

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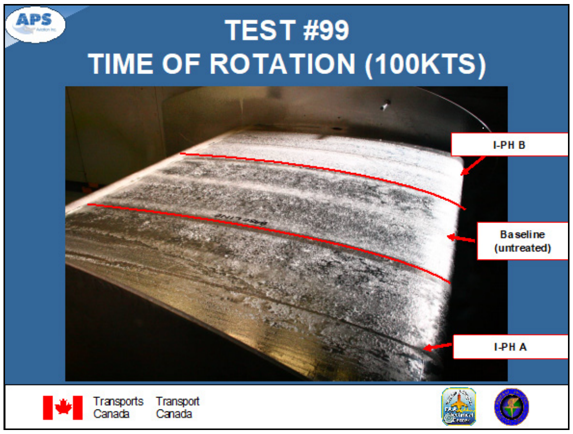

TEST #99
TIME OF ROTATION (100KTS)

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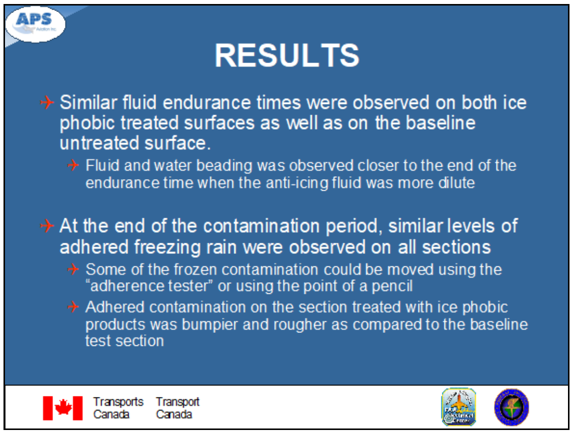
RUN #99

Transports Canada Transport Canada



RESULTS

- Similar fluid endurance times were observed on both ice phobic treated surfaces as well as on the baseline untreated surface.
  - Fluid and water beading was observed closer to the end of the endurance time when the anti-icing fluid was more dilute
- At the end of the contamination period, similar levels of adhered freezing rain were observed on all sections
  - Some of the frozen contamination could be moved using the "adherence tester" or using the point of a pencil
  - Adhered contamination on the section treated with ice phobic products was bumpier and rougher as compared to the baseline test section

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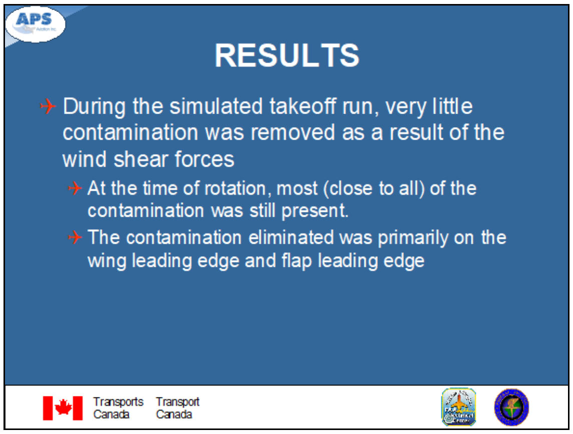

RESULTS

- During the simulated takeoff run, very little contamination was removed as a result of the wind shear forces
  - At the time of rotation, most (close to all) of the contamination was still present.
  - The contamination eliminated was primarily on the wing leading edge and flap leading edge

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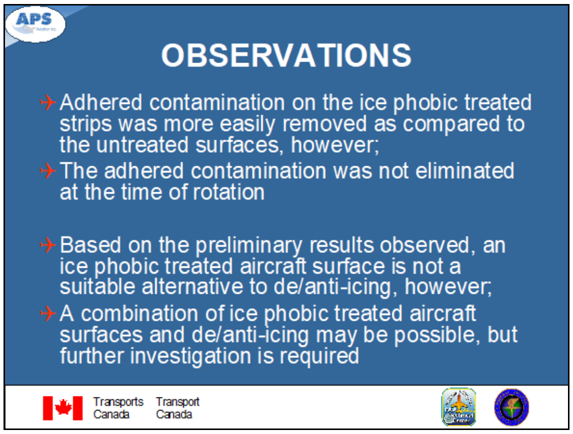

OBSERVATIONS

- Adhered contamination on the ice phobic treated strips was more easily removed as compared to the untreated surfaces, however;
- The adhered contamination was not eliminated at the time of rotation

- Based on the preliminary results observed, an ice phobic treated aircraft surface is not a suitable alternative to de/anti-icing, however;
- A combination of ice phobic treated aircraft surfaces and de/anti-icing may be possible, but further investigation is required

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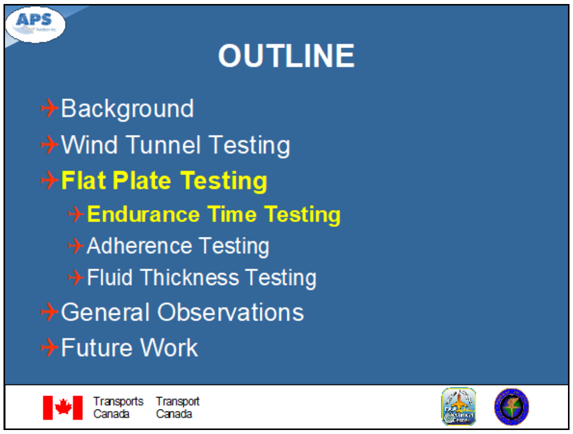
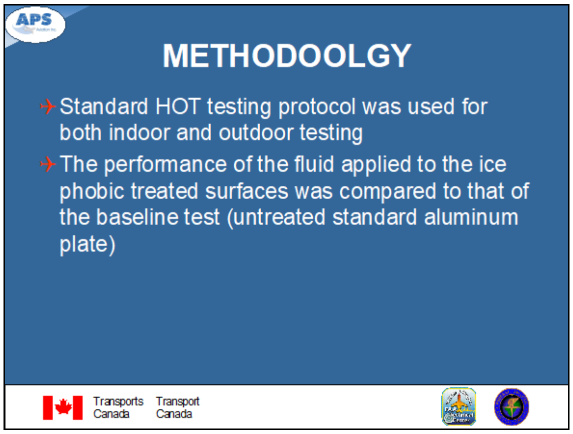


OUTLINE

- Background
- Wind Tunnel Testing
- **Flat Plate Testing**
  - **Endurance Time Testing**
  - Adherence Testing
  - Fluid Thickness Testing
- General Observations
- Future Work

Transports Canada Transport Canada



METHODOOLGY

- Standard HOT testing protocol was used for both indoor and outdoor testing
- The performance of the fluid applied to the ice phobic treated surfaces was compared to that of the baseline test (untreated standard aluminum plate)

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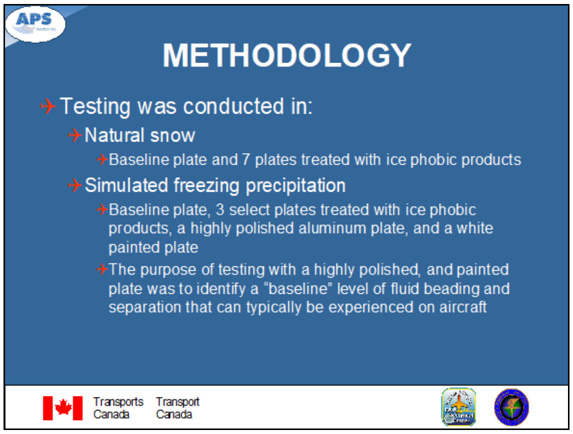

METHODOLOGY

- Testing was conducted in:
  - Natural snow
    - Baseline plate and 7 plates treated with ice phobic products
  - Simulated freezing precipitation
    - Baseline plate, 3 select plates treated with ice phobic products, a highly polished aluminum plate, and a white painted plate
    - The purpose of testing with a highly polished, and painted plate was to identify a "baseline" level of fluid beading and separation that can typically be experienced on aircraft

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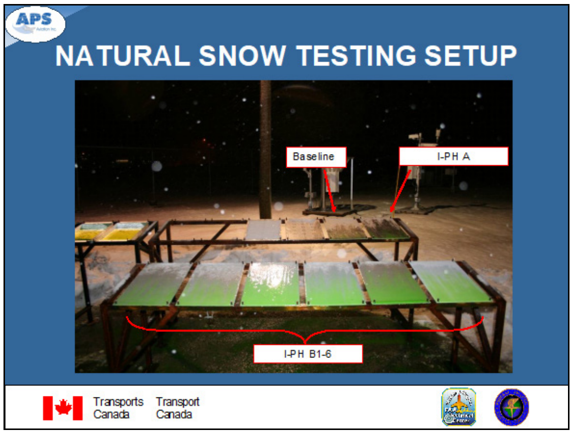
NATURAL SNOW TESTING



NATURAL SNOW TESTING SETUP

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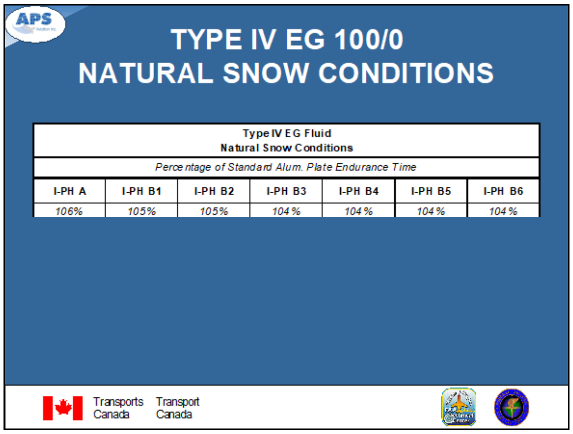

TYPE IV EG 100/0
NATURAL SNOW CONDITIONS

Type IV EG Fluid
Natural Snow Conditions

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B1	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
106%	*105%*	*105%*	*104%*	*104%*	*104%*	*104%*

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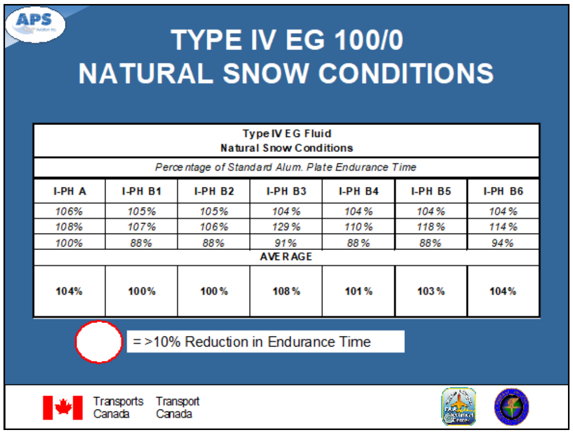

TYPE IV EG 100/0
NATURAL SNOW CONDITIONS

Type IV EG Fluid
Natural Snow Conditions

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B1	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
106%	*105%*	*105%*	*104%*	*104%*	*104%*	*104%*
108%	*107%*	*106%*	*129%*	*110%*	*118%*	*114%*
100%	*88%*	*88%*	*91%*	*88%*	*88%*	*94%*
AVERAGE						
104%	**100%**	**100%**	**108%**	**101%**	**103%**	**104%**

○ = >10% Reduction in Endurance Time

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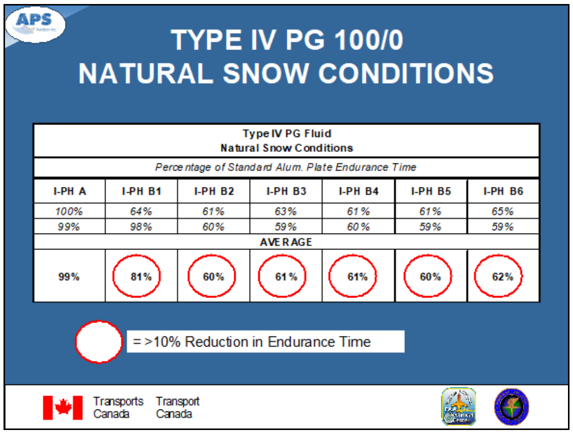

TYPE IV PG 100/0
NATURAL SNOW CONDITIONS

Type IV PG Fluid
Natural Snow Conditions

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B1	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
100%	*64%*	*61%*	*63%*	*61%*	*61%*	*65%*
99%	*98%*	*60%*	*59%*	*60%*	*59%*	*59%*
AVERAGE						
99%	**81%**	**60%**	**61%**	**61%**	**60%**	**62%**

○ = >10% Reduction in Endurance Time

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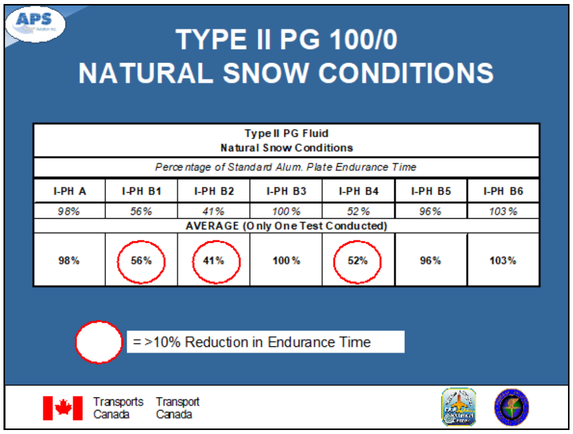

TYPE II PG 100/0 NATURAL SNOW CONDITIONS

Type II PG Fluid
Natural Snow Conditions

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B1	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
98%	*56%*	*41%*	*100%*	*52%*	*96%*	*103%*
AVERAGE (Only One Test Conducted)						
98%	**56%**	**41%**	**100%**	**52%**	**96%**	**103%**

○ = >10% Reduction in Endurance Time

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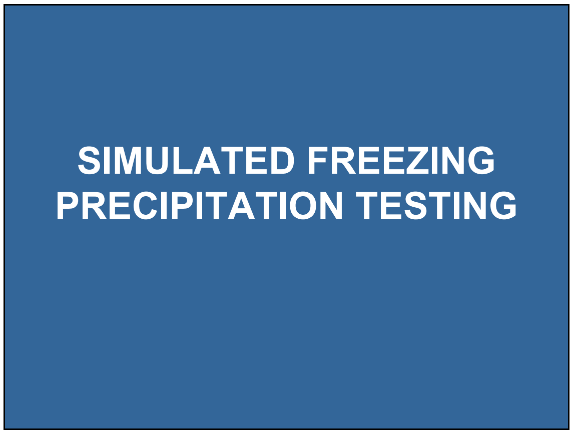
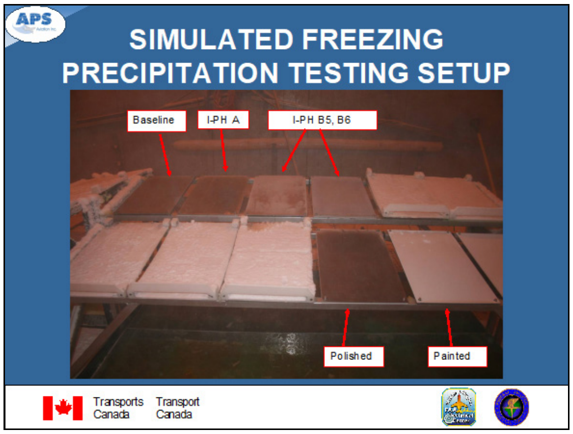


SIMULATED FREEZING PRECIPITATION TESTING



SIMULATED FREEZING PRECIPITATION TESTING SETUP

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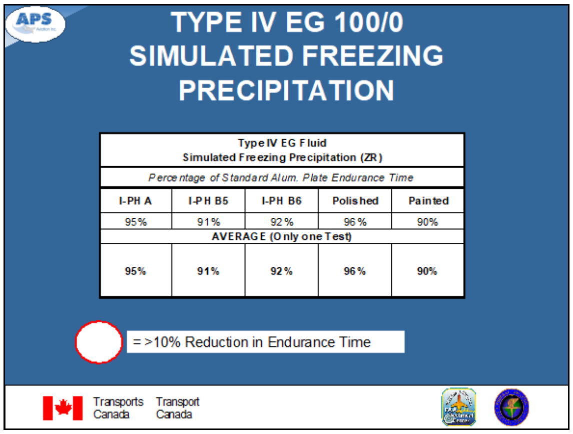


TYPE IV EG 100/0 SIMULATED FREEZING PRECIPITATION

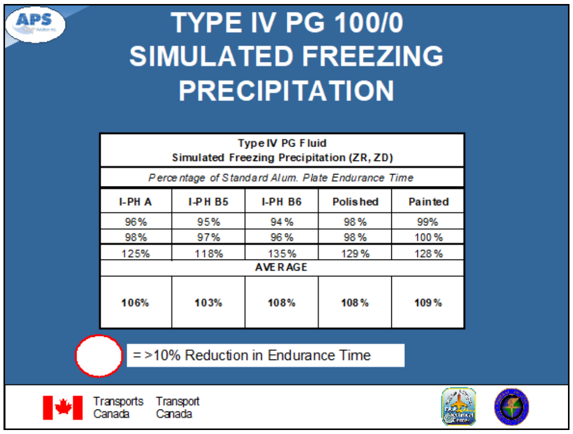
Type IV EG Fluid
Simulated Freezing Precipitation (ZR)

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B5	I-PH B6	Polished	Painted
95%	91%	92%	96%	90%
AVERAGE (Only one Test)				
95%	**91%**	**92%**	**96%**	**90%**

○ = >10% Reduction in Endurance Time

Transports Canada Transport Canada



TYPE IV PG 100/0 SIMULATED FREEZING PRECIPITATION

Type IV PG Fluid
Simulated Freezing Precipitation (ZR, ZD)

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B5	I-PH B6	Polished	Painted
96%	95%	94%	98%	99%
98%	97%	96%	98%	100%
125%	118%	135%	129%	128%
AVERAGE				
106%	**103%**	**108%**	**108%**	**109%**

○ = >10% Reduction in Endurance Time

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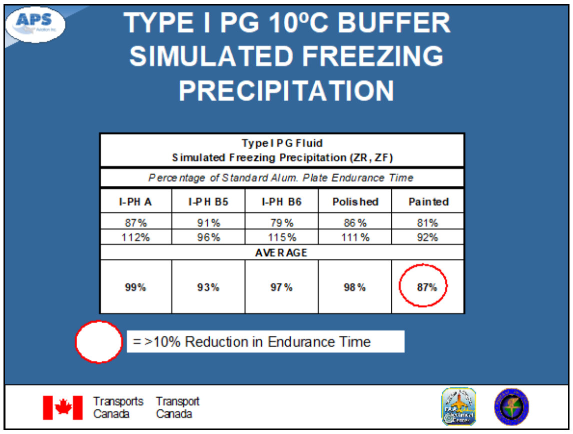

TYPE I PG 10ºC BUFFER SIMULATED FREEZING PRECIPITATION

Type I PG Fluid
Simulated Freezing Precipitation (ZR, ZF)

Percentage of Standard Alum. Plate Endurance Time

I-PH A	I-PH B5	I-PH B6	Polished	Painted
87%	91%	79%	86%	81%
112%	96%	115%	111%	92%
AVERAGE				
99%	**93%**	**97%**	**98%**	**87%**

○ = >10% Reduction in Endurance Time

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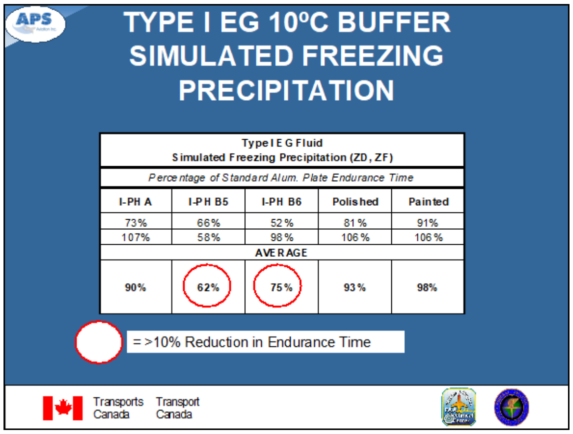

TYPE I EG 10°C BUFFER SIMULATED FREEZING PRECIPITATION

Type I E G Fluid Simulated Freezing Precipitation (ZD, ZF)				
Percentage of Standard Alum. Plate Endurance Time				
I-PH A	**I-PH B5**	**I-PH B6**	**Polished**	**Painted**
73%	66%	52%	81%	91%
107%	58%	98%	106%	106%
AVERAGE				
90%	**62%**	**75%**	**93%**	**98%**

○ = >10% Reduction in Endurance Time

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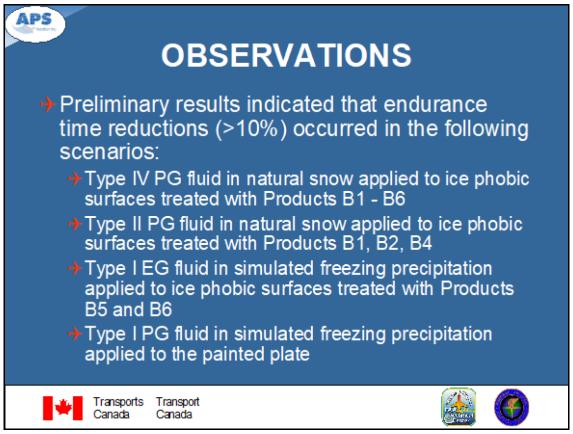

OBSERVATIONS

- Preliminary results indicated that endurance time reductions (>10%) occurred in the following scenarios:
  - Type IV PG fluid in natural snow applied to ice phobic surfaces treated with Products B1 - B6
  - Type II PG fluid in natural snow applied to ice phobic surfaces treated with Products B1, B2, B4
  - Type I EG fluid in simulated freezing precipitation applied to ice phobic surfaces treated with Products B5 and B6
  - Type I PG fluid in simulated freezing precipitation applied to the painted plate

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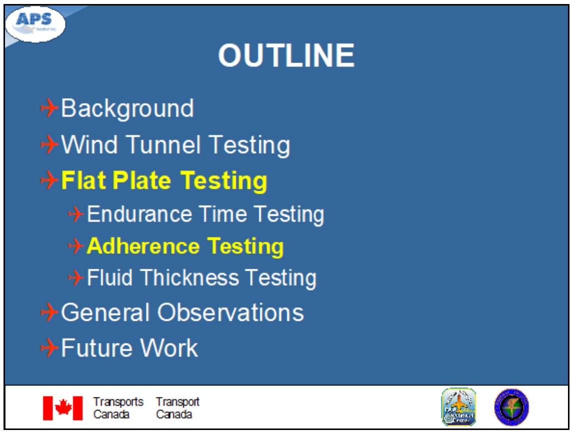

OUTLINE

- Background
- Wind Tunnel Testing
- **Flat Plate Testing**
  - Endurance Time Testing
  - **Adherence Testing**
  - Fluid Thickness Testing
- General Observations
- Future Work

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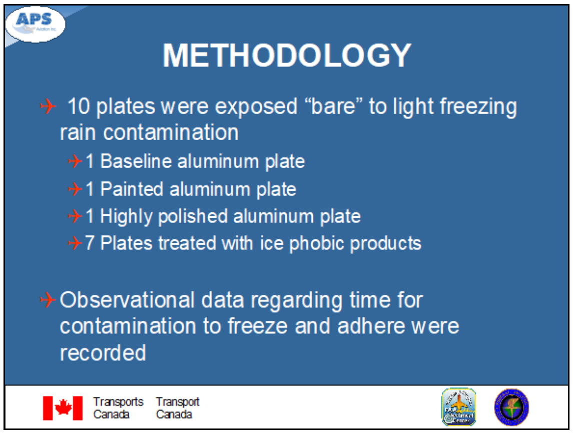

METHODOLOGY

- 10 plates were exposed "bare" to light freezing rain contamination
  - 1 Baseline aluminum plate
  - 1 Painted aluminum plate
  - 1 Highly polished aluminum plate
  - 7 Plates treated with ice phobic products
- Observational data regarding time for contamination to freeze and adhere were recorded

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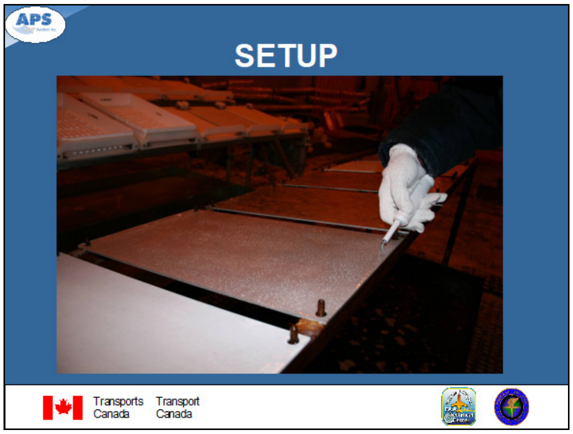

SETUP

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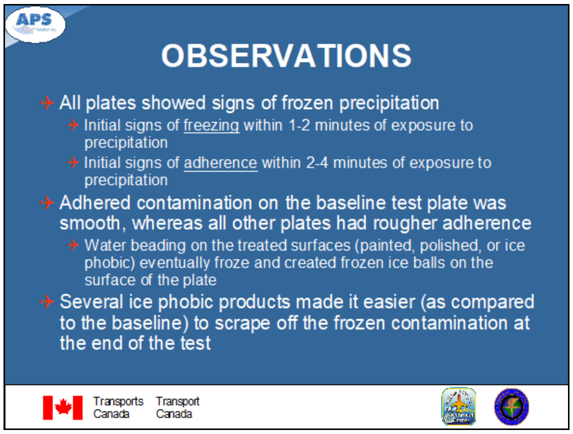

OBSERVATIONS

- All plates showed signs of frozen precipitation
  - Initial signs of freezing within 1-2 minutes of exposure to precipitation
  - Initial signs of adherence within 2-4 minutes of exposure to precipitation
- Adhered contamination on the baseline test plate was smooth, whereas all other plates had rougher adherence
  - Water beading on the treated surfaces (painted, polished, or ice phobic) eventually froze and created frozen ice balls on the surface of the plate
- Several ice phobic products made it easier (as compared to the baseline) to scrape off the frozen contamination at the end of the test

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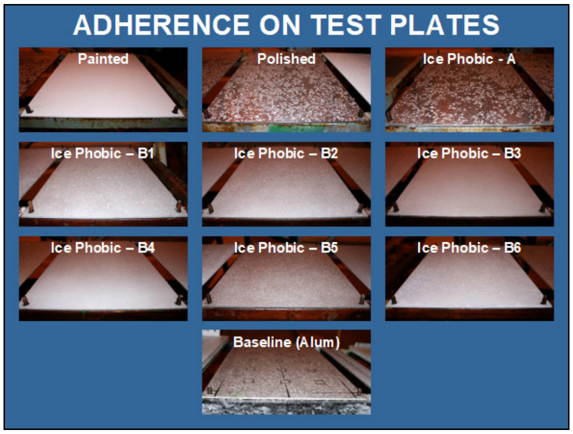
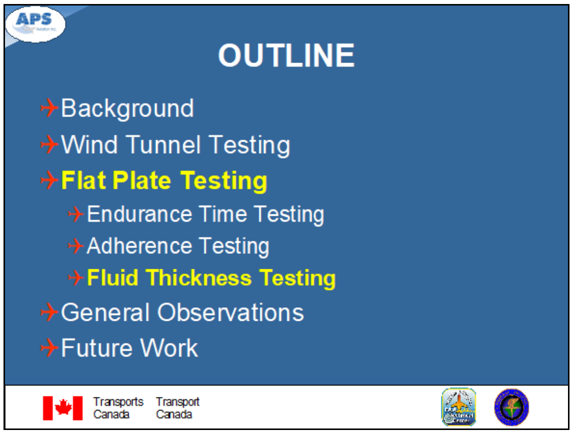


ADHERENCE ON TEST PLATES



OUTLINE

- Background
- Wind Tunnel Testing
- **Flat Plate Testing**
  - Endurance Time Testing
  - Adherence Testing
  - **Fluid Thickness Testing**
- General Observations
- Future Work

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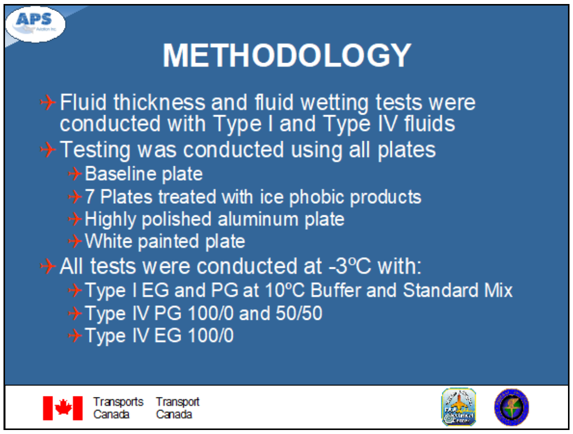

METHODOLOGY

- Fluid thickness and fluid wetting tests were conducted with Type I and Type IV fluids
- Testing was conducted using all plates
  - Baseline plate
  - 7 Plates treated with ice phobic products
  - Highly polished aluminum plate
  - White painted plate
- All tests were conducted at -3°C with:
  - Type I EG and PG at 10°C Buffer and Standard Mix
  - Type IV PG 100/0 and 50/50
  - Type IV EG 100/0

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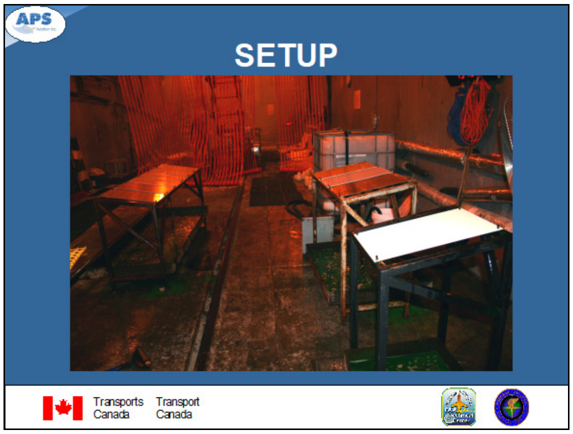
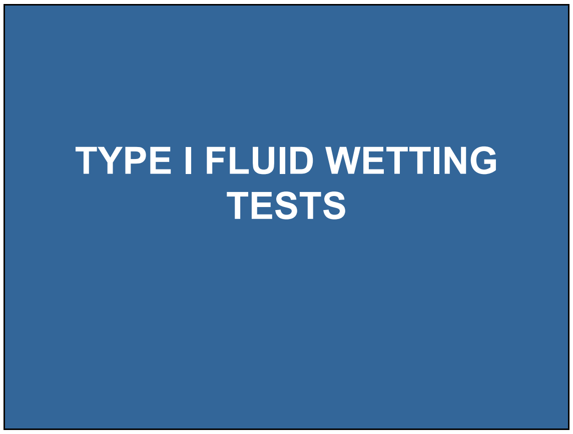
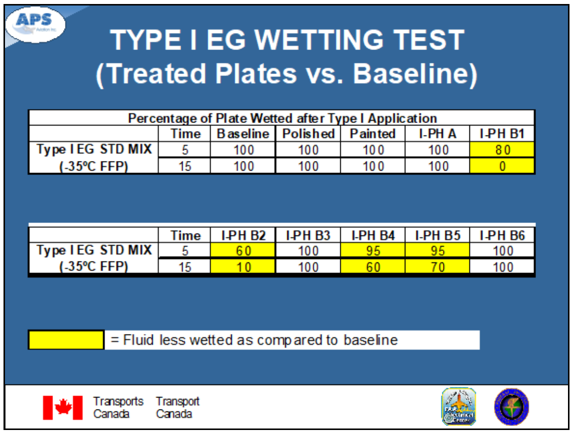


SETUP

Transports Canada Transport Canada



TYPE I FLUID WETTING TESTS



TYPE I EG WETTING TEST (Treated Plates vs. Baseline)

Percentage of Plate Wetted after Type I Application

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type I EG STD MIX (-35°C FFP)	5	100	100	100	100	80
	15	100	100	100	100	0

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type I EG STD MIX (-35°C FFP)	5	60	100	95	95	100
	15	10	100	60	70	100

🟨 = Fluid less wetted as compared to baseline

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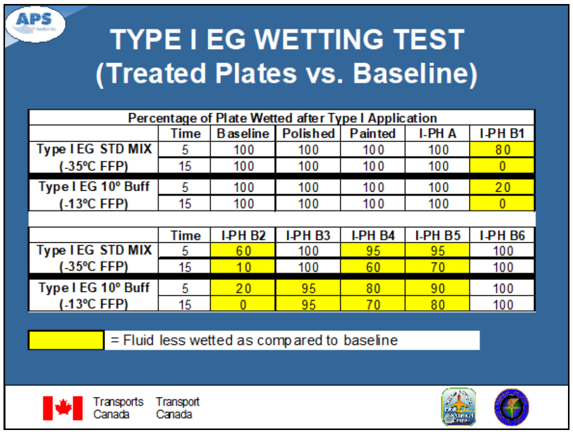

TYPE I EG WETTING TEST (Treated Plates vs. Baseline)

Percentage of Plate Wetted after Type I Application

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type I EG STD MIX (-35°C FFP)	5	100	100	100	100	80
	15	100	100	100	100	0
Type I EG 10° Buff (-13°C FFP)	5	100	100	100	100	20
	15	100	100	100	100	0

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type I EG STD MIX (-35°C FFP)	5	60	100	95	95	100
	15	10	100	60	70	100
Type I EG 10° Buff (-13°C FFP)	5	20	95	80	90	100
	15	0	95	70	80	100

🟨 = Fluid less wetted as compared to baseline

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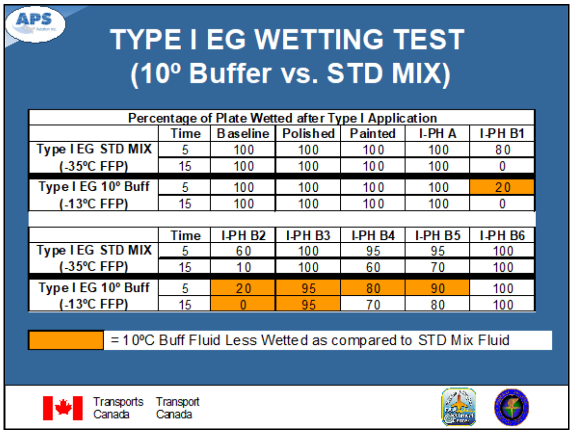

TYPE I EG WETTING TEST (10° Buffer vs. STD MIX)

Percentage of Plate Wetted after Type I Application

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type I EG STD MIX (-35°C FFP)	5	100	100	100	100	80
	15	100	100	100	100	0
Type I EG 10° Buff (-13°C FFP)	5	100	100	100	100	20
	15	100	100	100	100	0

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type I EG STD MIX (-35°C FFP)	5	60	100	95	95	100
	15	10	100	60	70	100
Type I EG 10° Buff (-13°C FFP)	5	20	95	80	90	100
	15	0	95	70	80	100

🟧 = 10°C Buff Fluid Less Wetted as compared to STD Mix Fluid

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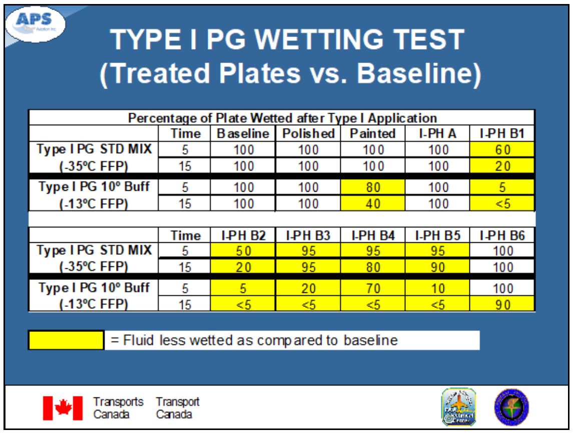


TYPE I PG WETTING TEST (Treated Plates vs. Baseline)

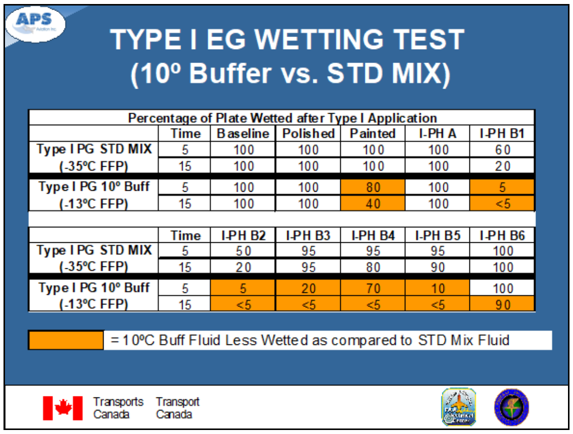
Percentage of Plate Wetted after Type I Application

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type I PG STD MIX (-35°C FFP)	5	100	100	100	100	60
	15	100	100	100	100	20
Type I PG 10° Buff (-13°C FFP)	5	100	100	80	100	5
	15	100	100	40	100	<5

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type I PG STD MIX (-35°C FFP)	5	50	95	95	95	100
	15	20	95	80	90	100
Type I PG 10° Buff (-13°C FFP)	5	5	20	70	10	100
	15	<5	<5	<5	<5	90

🟨 = Fluid less wetted as compared to baseline

Transports Canada Transport Canada



TYPE I EG WETTING TEST (10° Buffer vs. STD MIX)

Percentage of Plate Wetted after Type I Application

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type I PG STD MIX (-35°C FFP)	5	100	100	100	100	60
	15	100	100	100	100	20
Type I PG 10° Buff (-13°C FFP)	5	100	100	80	100	5
	15	100	100	40	100	<5

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type I PG STD MIX (-35°C FFP)	5	50	95	95	95	100
	15	20	95	80	90	100
Type I PG 10° Buff (-13°C FFP)	5	5	20	70	10	100
	15	<5	<5	<5	<5	90

🟧 = 10°C Buff Fluid Less Wetted as compared to STD Mix Fluid

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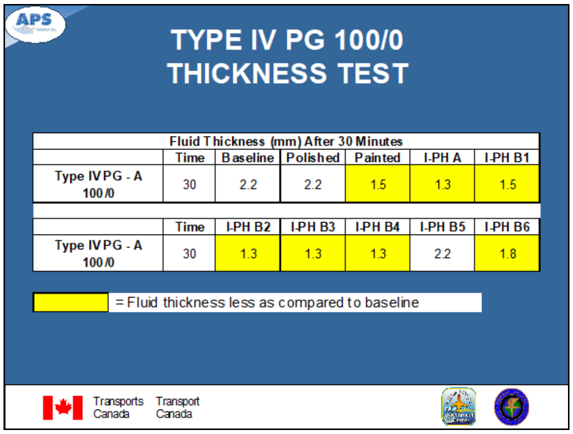
TYPE IV FLUID THICKNESS TESTS



TYPE IV PG 100/0 THICKNESS TEST

Fluid Thickness (mm) After 30 Minutes

	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type IV PG - A 100/0	30	2.2	2.2	1.5	1.3	1.5

	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type IV PG - A 100/0	30	1.3	1.3	1.3	2.2	1.8

🟨 = Fluid thickness less as compared to baseline

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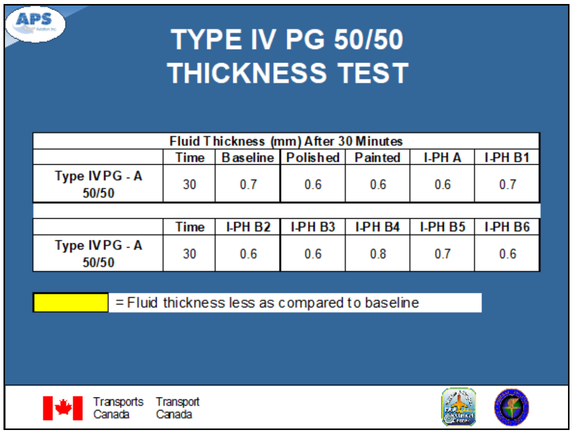

TYPE IV PG 50/50 THICKNESS TEST

Fluid Thickness (mm) After 30 Minutes						
	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type IV PG - A 50/50	30	0.7	0.6	0.6	0.6	0.7
	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type IV PG - A 50/50	30	0.6	0.6	0.8	0.7	0.6

🟨 = Fluid thickness less as compared to baseline

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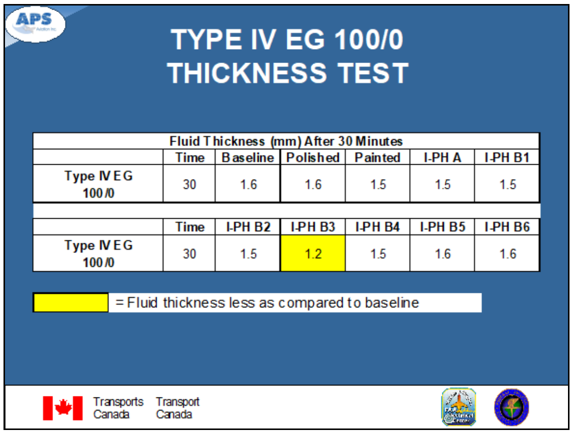

TYPE IV EG 100/0 THICKNESS TEST

Fluid Thickness (mm) After 30 Minutes						
	Time	Baseline	Polished	Painted	I-PH A	I-PH B1
Type IV EG 100/0	30	1.6	1.6	1.5	1.5	1.5
	Time	I-PH B2	I-PH B3	I-PH B4	I-PH B5	I-PH B6
Type IV EG 100/0	30	1.5	🟨 1.2	1.5	1.6	1.6

🟨 = Fluid thickness less as compared to baseline

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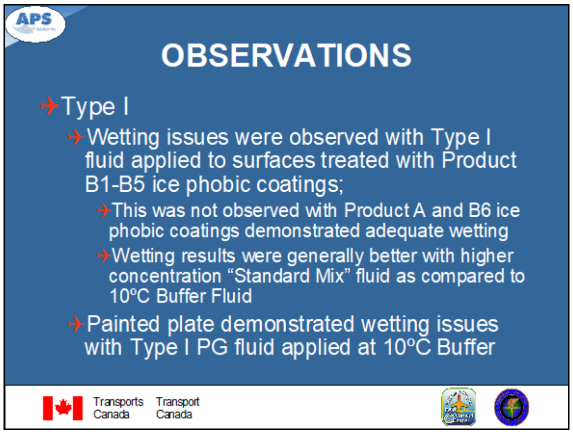

OBSERVATIONS

- Type I
  - Wetting issues were observed with Type I fluid applied to surfaces treated with Product B1-B5 ice phobic coatings;
    - This was not observed with Product A and B6 ice phobic coatings demonstrated adequate wetting
    - Wetting results were generally better with higher concentration "Standard Mix" fluid as compared to 10°C Buffer Fluid
  - Painted plate demonstrated wetting issues with Type I PG fluid applied at 10°C Buffer

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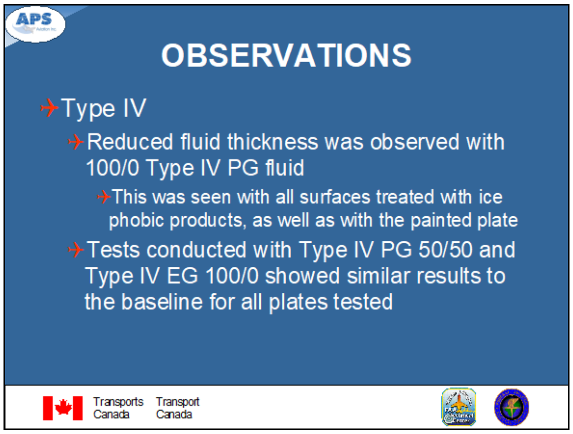

OBSERVATIONS

- Type IV
  - Reduced fluid thickness was observed with 100/0 Type IV PG fluid
    - This was seen with all surfaces treated with ice phobic products, as well as with the painted plate
  - Tests conducted with Type IV PG 50/50 and Type IV EG 100/0 showed similar results to the baseline for all plates tested

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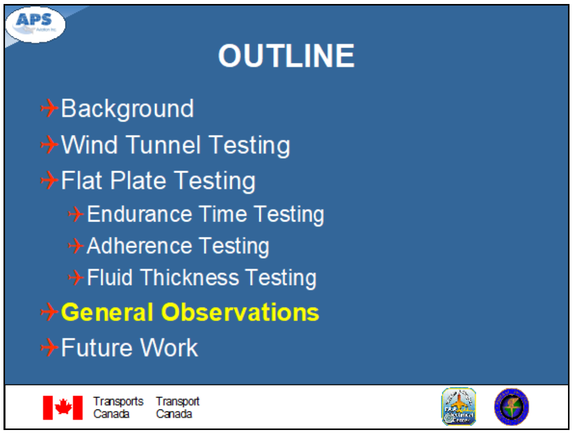

OUTLINE

- Background
- Wind Tunnel Testing
- Flat Plate Testing
  - Endurance Time Testing
  - Adherence Testing
  - Fluid Thickness Testing
- **General Observations**
- Future Work

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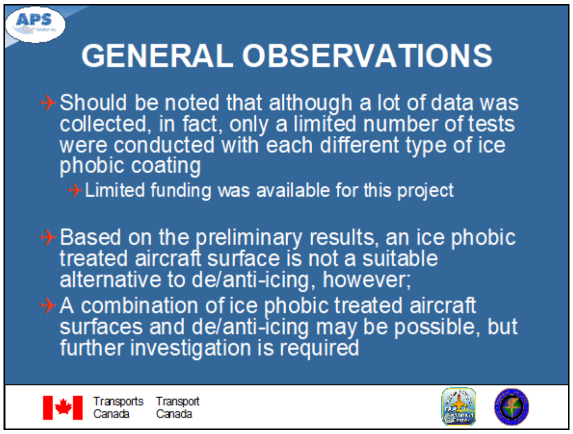

GENERAL OBSERVATIONS

- Should be noted that although a lot of data was collected, in fact, only a limited number of tests were conducted with each different type of ice phobic coating
  - Limited funding was available for this project
- Based on the preliminary results, an ice phobic treated aircraft surface is not a suitable alternative to de/anti-icing, however;
- A combination of ice phobic treated aircraft surfaces and de/anti-icing may be possible, but further investigation is required

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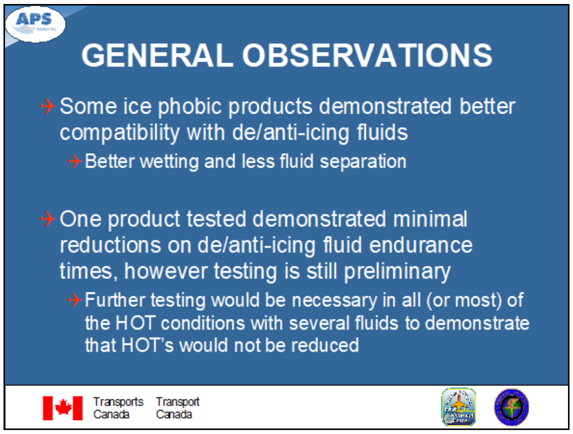

GENERAL OBSERVATIONS

- Some ice phobic products demonstrated better compatibility with de/anti-icing fluids
  - Better wetting and less fluid separation
- One product tested demonstrated minimal reductions on de/anti-icing fluid endurance times, however testing is still preliminary
  - Further testing would be necessary in all (or most) of the HOT conditions with several fluids to demonstrate that HOT's would not be reduced

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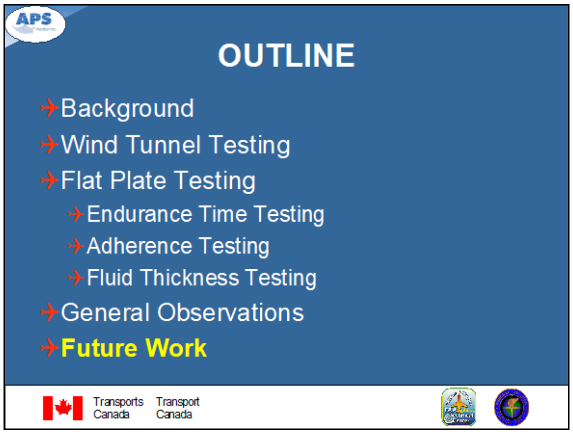

OUTLINE

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  - Fluid Thickness Testing
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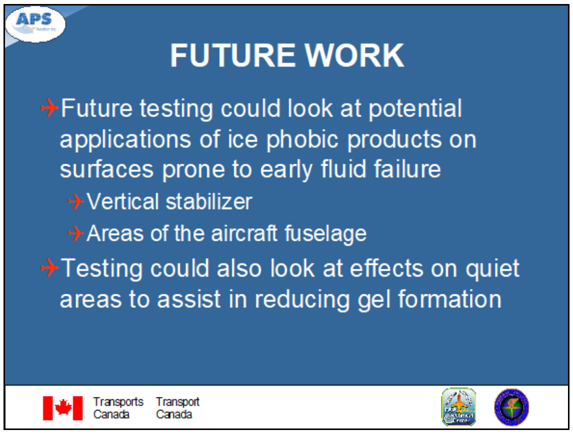
Transports Canada Transport Canada



FUTURE WORK

- Future testing could look at potential applications of ice phobic products on surfaces prone to early fluid failure
  - Vertical stabilizer
  - Areas of the aircraft fuselage
- Testing could also look at effects on quiet areas to assist in reducing gel formation

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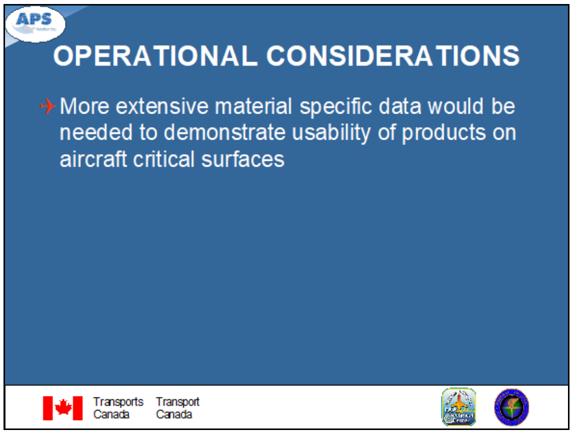

OPERATIONAL CONSIDERATIONS

- More extensive material specific data would be needed to demonstrate usability of products on aircraft critical surfaces

Transports Canada Transport Canada

Marco Ruggi
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APS
Aviation Inc.

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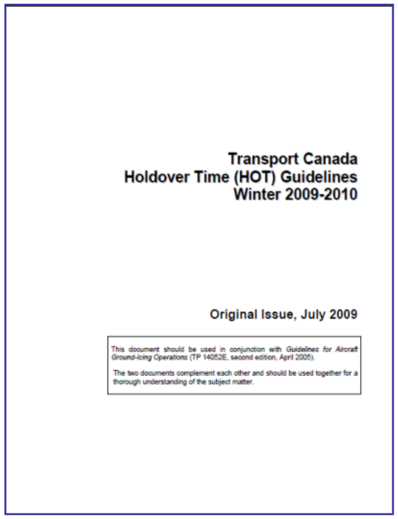
POTENTIAL FUTURE CHANGES TO THE HOT GUIDELINE TABLE FORMAT

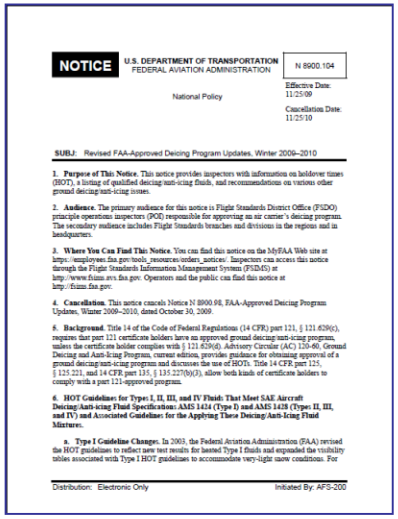


Transport Canada
Holdover Time (HOT) Guidelines
Winter 2009-2010

Original Issue, July 2009

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

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



NOTICE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

N 8900.104

National Policy

Effective Date:
11/25/09

Cancellation Date:
11/25/10

SUBJ: Revised FAA-Approved Deicing Program Updates, Winter 2009–2010

1. **Purpose of This Notice.** This notice provides inspectors with information on holdover times (HOT), a listing of qualified deicing/anti-icing fluids, and recommendations on various other ground deicing/anti-icing issues.

2. **Audience.** The primary audience for this notice is Flight Standards District Office (FSDO) principle operations inspectors (POI) responsible for approving an air carrier's deicing program. The secondary audience includes Flight Standards branches and divisions in the regions and in headquarters.

3. **Where You Can Find This Notice.** You can find this notice on the MyFAA Web site at https://employees.faa.gov/tools_resources/orders_notices/. Inspectors can access this notice through the Flight Standards Information Management System (FSIMS) at http://www.fsims.avs.faa.gov. Operators and the public can find this notice at http://fsims.faa.gov.

4. **Cancellation.** This notice cancels Notice N 8900.98, FAA-Approved Deicing Program Updates, Winter 2009–2010, dated October 30, 2009.

5. **Background.** Title 14 of the Code of Federal Regulations (14 CFR) part 121, § 121.629(c), requires that part 121 certificate holders have an approved ground deicing/anti-icing program, unless the certificate holder complies with § 121.629(d). Advisory Circular (AC) 120-60, Ground Deicing and Anti-Icing Program, current edition, provides guidance for obtaining approval of a ground deicing/anti-icing program and discusses the use of HOTs. Title 14 CFR part 125, § 125.221, and 14 CFR part 135, § 135.227(b)(3), allow both kinds of certificate holders to comply with a part 121-approved program.

6. **HOT Guidelines for Types I, II, III, and IV Fluids That Meet SAE Aircraft Deicing/Anti-icing Fluid Specifications AMS 1424 (Type I) and AMS 1428 (Types II, III, and IV) and Associated Guidelines for the Applying These Deicing/Anti-Icing Fluid Mixtures.**

   a. **Type I Guideline Changes.** In 2003, the Federal Aviation Administration (FAA) revised the HOT guidelines to reflect new test results for heated Type I fluids and expanded the visibility tables associated with Type I HOT guidelines to accommodate very-light snow conditions. For

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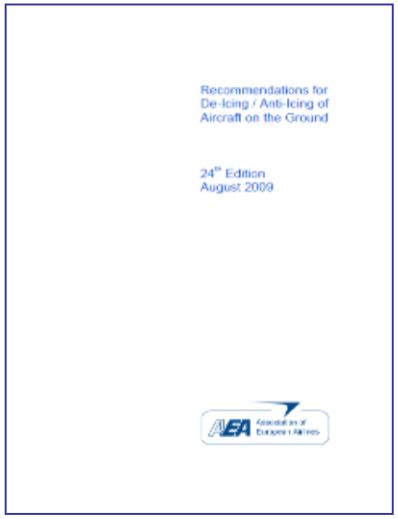


Recommendations for
De-Icing / Anti-Icing of
Aircraft on the Ground

24th Edition
August 2009

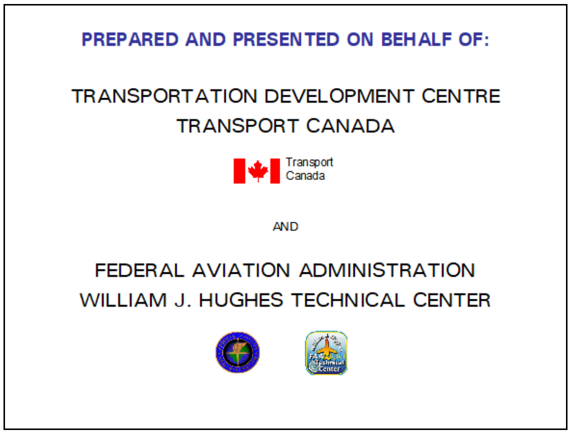
AEA Association of European Airlines

APS Aviation Inc.

ISO 9001:2000

SAE G-12 – HOT COMMITEE
BERLIN – MAY 11, 2010

PRESENTED BY MARCO RUGGI



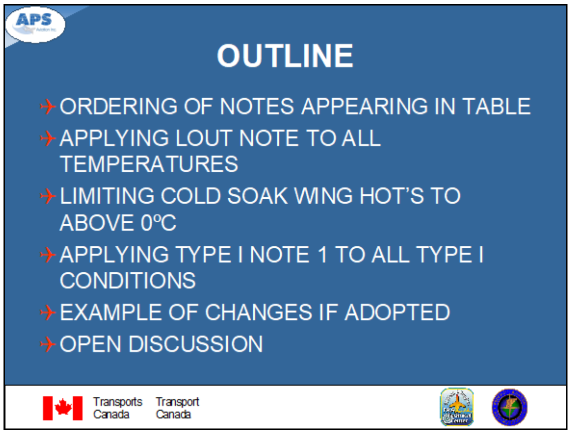
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

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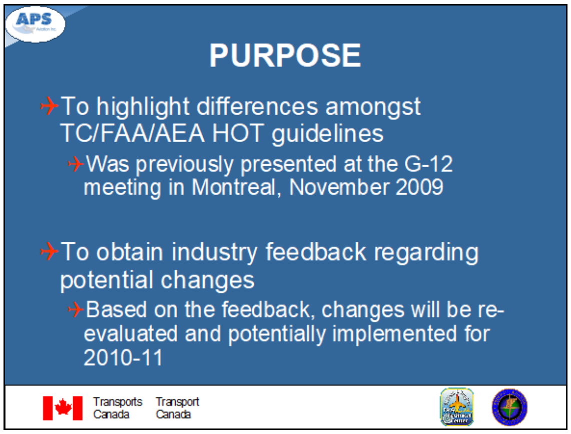

PURPOSE

- To highlight differences amongst TC/FAA/AEA HOT guidelines
  - Was previously presented at the G-12 meeting in Montreal, November 2009
- To obtain industry feedback regarding potential changes
  - Based on the feedback, changes will be re-evaluated and potentially implemented for 2010-11

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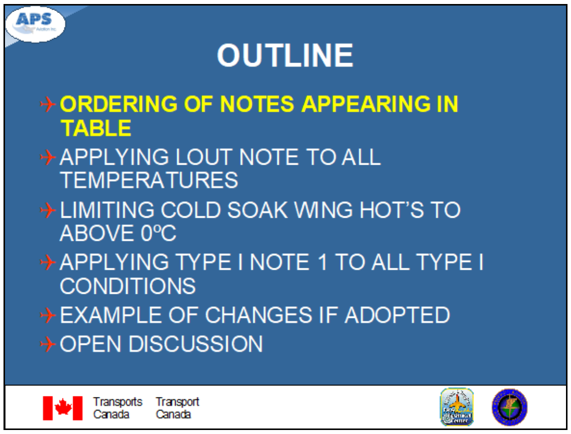

OUTLINE

- **ORDERING OF NOTES APPEARING IN TABLE**
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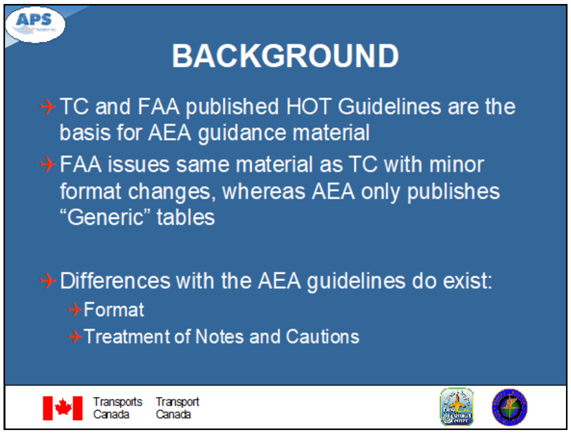

BACKGROUND

- TC and FAA published HOT Guidelines are the basis for AEA guidance material
- FAA issues same material as TC with minor format changes, whereas AEA only publishes "Generic" tables
- Differences with the AEA guidelines do exist:
  - Format
  - Treatment of Notes and Cautions

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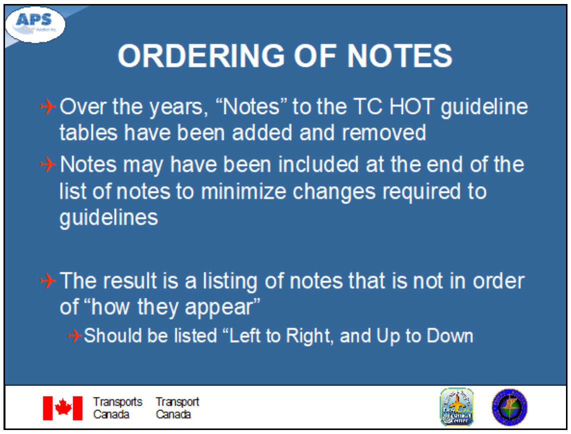

ORDERING OF NOTES

- Over the years, "Notes" to the TC HOT guideline tables have been added and removed
- Notes may have been included at the end of the list of notes to minimize changes required to guidelines
- The result is a listing of notes that is not in order of "how they appear"
  - Should be listed "Left to Right, and Up to Down

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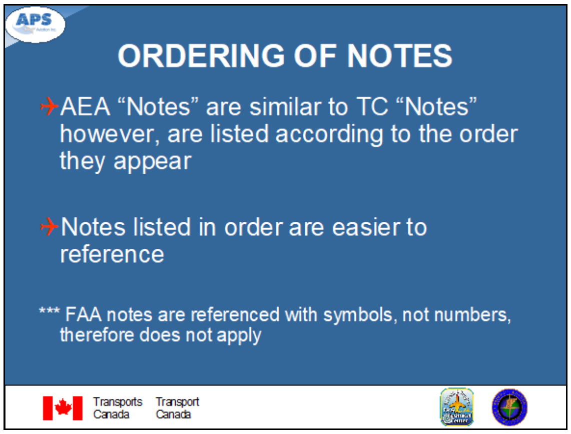

ORDERING OF NOTES

- AEA “Notes” are similar to TC “Notes” however, are listed according to the order they appear
- Notes listed in order are easier to reference

*** FAA notes are referenced with symbols, not numbers, therefore does not apply

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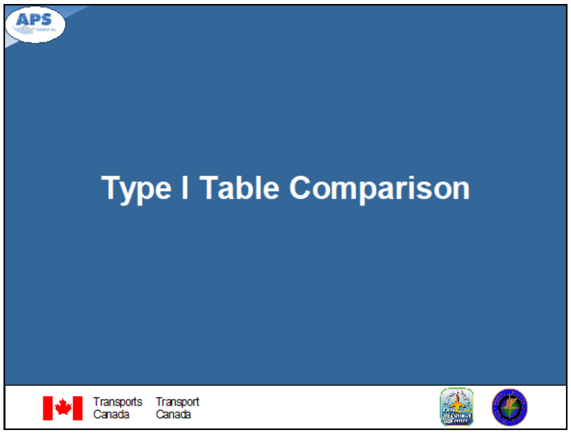

Type I Table Comparison

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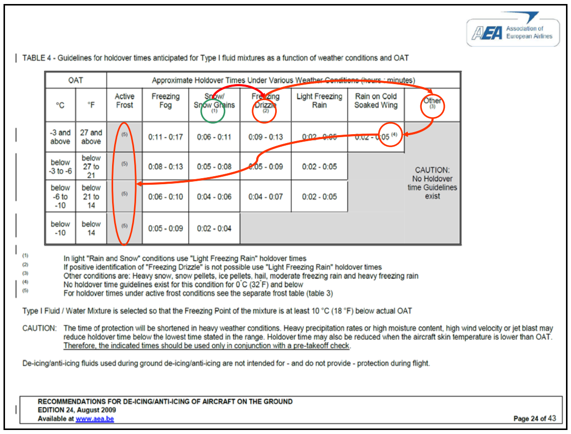

AEA Association of European Airlines

TABLE 4 - Guidelines for holdover times anticipated for Type I fluid mixtures as a function of weather conditions and OAT

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	(5)	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05 (4)	CAUTION: No Holdover time Guidelines exist
below -3 to -6	below 27 to 21	(5)	0:08 - 0:13	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05		
below -6 to -10	below 21 to 14	(5)	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05		
below -10	below 14	(5)	0:05 - 0:09	0:02 - 0:04				

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
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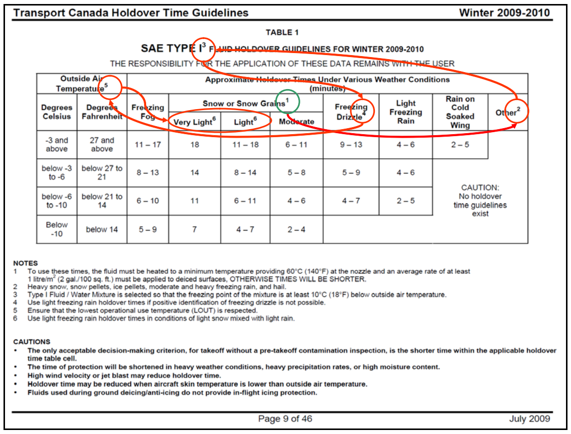

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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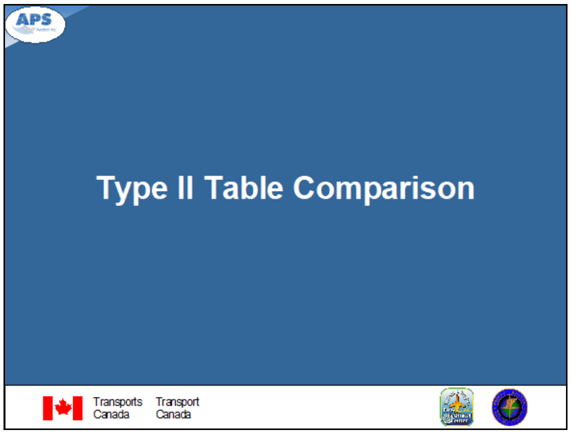

Type II Table Comparison

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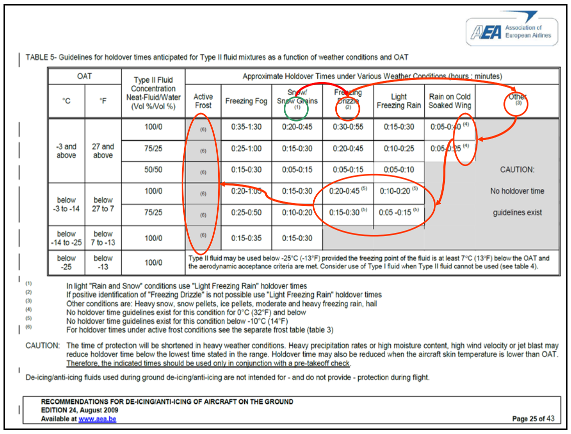

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TABLE 5- Guidelines for holdover times anticipated for Type II fluid mixtures as a function of weather conditions and OAT

OAT		Type II Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	100/0	(6)	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:05-0:40 (4)	CAUTION: No holdover time guidelines exist
		75/25	(6)	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25 (4)	
		50/50	(6)	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	(6)	0:20-1:05	0:15-0:30	0:20-0:45 (5)	0:10-0:20 (5)		
		75/25	(6)	0:25-0:50	0:10-0:20	0:15-0:30 (5)	0:05 -0:15 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:35	0:15-0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type II fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) No holdover time guidelines exist for this condition below -10°C (14°F)
(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
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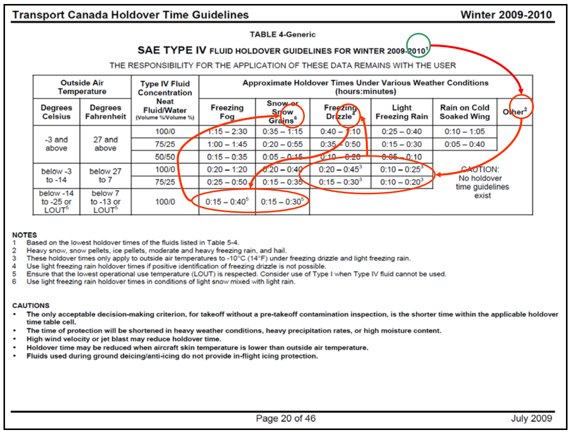

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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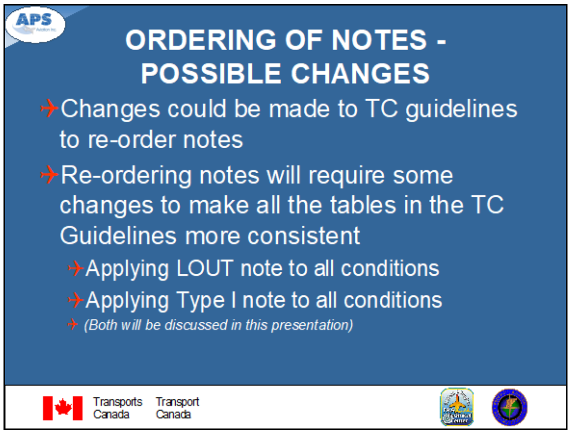

ORDERING OF NOTES - POSSIBLE CHANGES

- Changes could be made to TC guidelines to re-order notes
- Re-ordering notes will require some changes to make all the tables in the TC Guidelines more consistent
  - Applying LOUT note to all conditions
  - Applying Type I note to all conditions
  - *(Both will be discussed in this presentation)*

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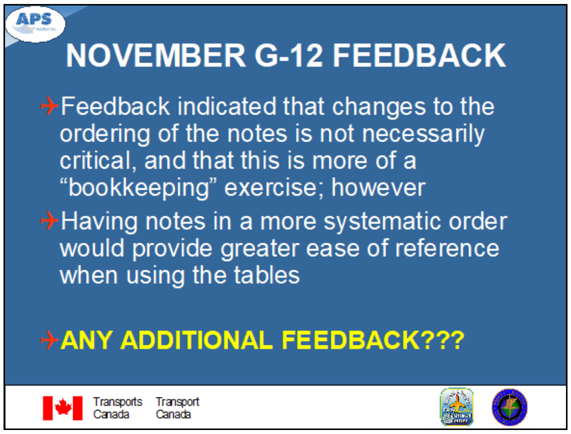

NOVEMBER G-12 FEEDBACK

- Feedback indicated that changes to the ordering of the notes is not necessarily critical, and that this is more of a "bookkeeping" exercise; however
- Having notes in a more systematic order would provide greater ease of reference when using the tables
- **ANY ADDITIONAL FEEDBACK???**

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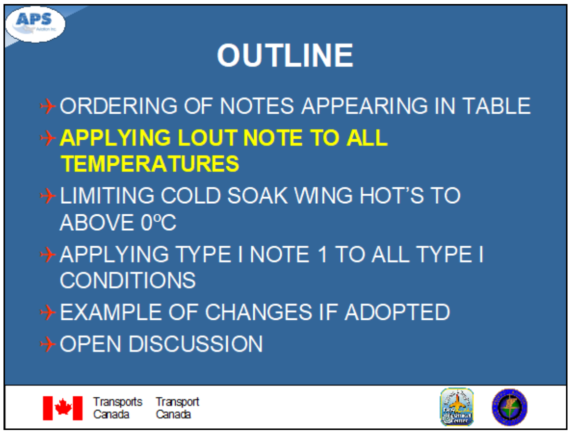

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- **APPLYING LOUT NOTE TO ALL TEMPERATURES**
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

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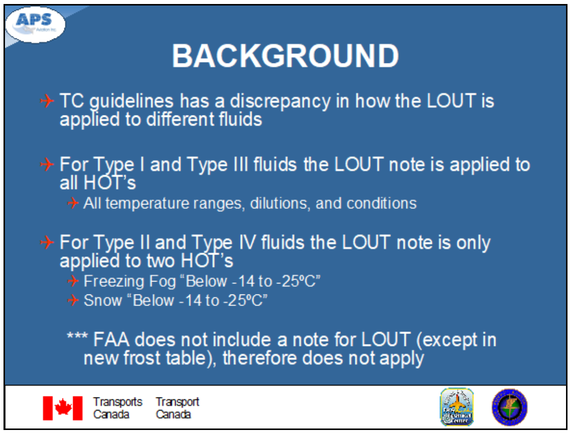

BACKGROUND

- TC guidelines has a discrepancy in how the LOUT is applied to different fluids
- For Type I and Type III fluids the LOUT note is applied to all HOT's
  - All temperature ranges, dilutions, and conditions
- For Type II and Type IV fluids the LOUT note is only applied to two HOT's
  - Freezing Fog "Below -14 to -25ºC"
  - Snow "Below -14 to -25ºC"

*** FAA does not include a note for LOUT (except in new frost table), therefore does not apply

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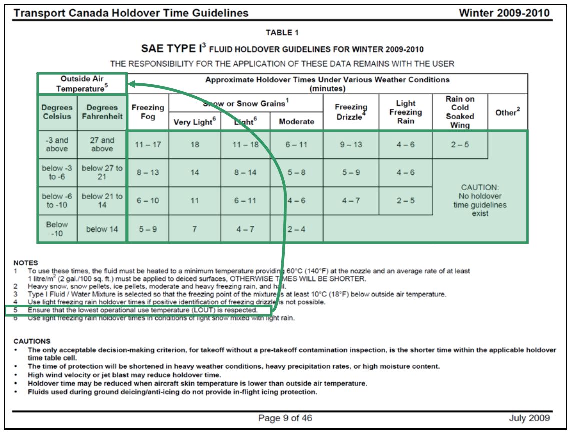

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^{2} (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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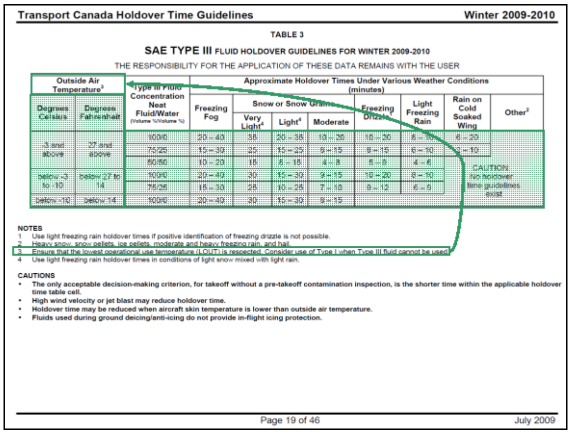

Transport Canada Holdover Time Guidelines Winter 2009-2010

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature^3		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains: Very Light^4	Snow or Snow Grains: Light^4	Snow or Snow Grains: Moderate	Freezing Drizzle^1	Light Freezing Rain	Rain on Cold Soaked Wing	Other^2
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	9 – 15				

NOTES
1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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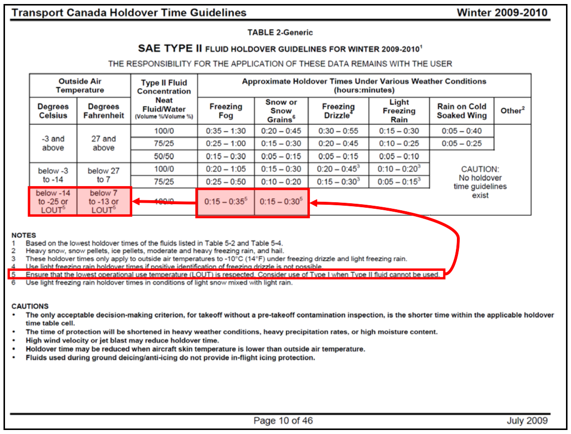

Transport Canada Holdover Time Guidelines Winter 2009-2010

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains^6	Freezing Drizzle^4	Light Freezing Rain	Rain on Cold Soaked Wing	Other^2
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45^3	0:10 – 0:20^3		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30^3	0:05 – 0:15^3		
below -14 to -25 or LOUT^5	below 7 to -13 or LOUT^5	100/0	0:15 – 0:35^5	0:15 – 0:30^5				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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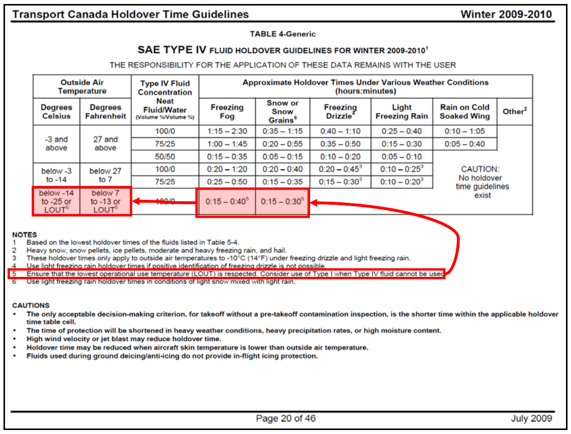

Transport Canada Holdover Time Guidelines Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains^6	Freezing Drizzle^4	Light Freezing Rain	Rain on Cold Soaked Wing	Other^2
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45^3	0:10 – 0:25^3		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30^3	0:10 – 0:20^3		
below -14 to -25 or LOUT^5	below 7 to -13 or LOUT^5	100/0	0:15 – 0:40^5	0:15 – 0:30^5				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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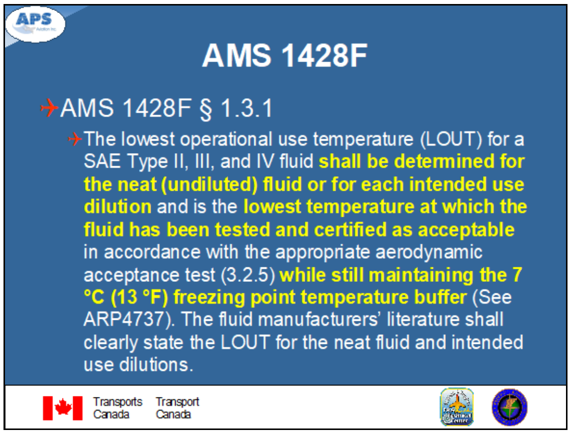

AMS 1428F

- AMS 1428F § 1.3.1
  - The lowest operational use temperature (LOUT) for a SAE Type II, III, and IV fluid **shall be determined for the neat (undiluted) fluid or for each intended use dilution** and is the **lowest temperature at which the fluid has been tested and certified as acceptable** in accordance with the appropriate aerodynamic acceptance test (3.2.5) **while still maintaining the 7 °C (13 °F) freezing point temperature buffer** (See ARP4737). The fluid manufacturers' literature shall clearly state the LOUT for the neat fluid and intended use dilutions.

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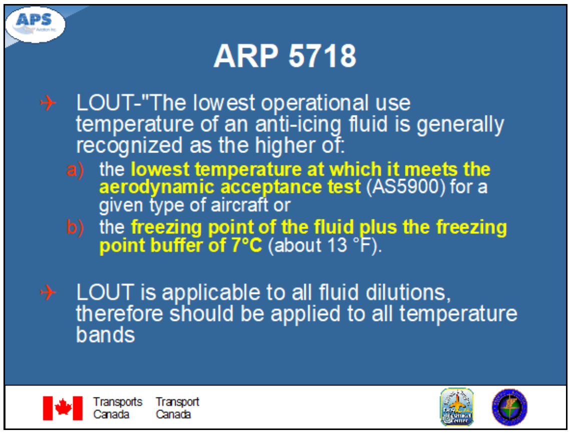

ARP 5718

- LOUT-"The lowest operational use temperature of an anti-icing fluid is generally recognized as the higher of:
  - a) the **lowest temperature at which it meets the aerodynamic acceptance test** (AS5900) for a given type of aircraft or
  - b) the **freezing point of the fluid plus the freezing point buffer of 7°C** (about 13 °F).
- LOUT is applicable to all fluid dilutions, therefore should be applied to all temperature bands

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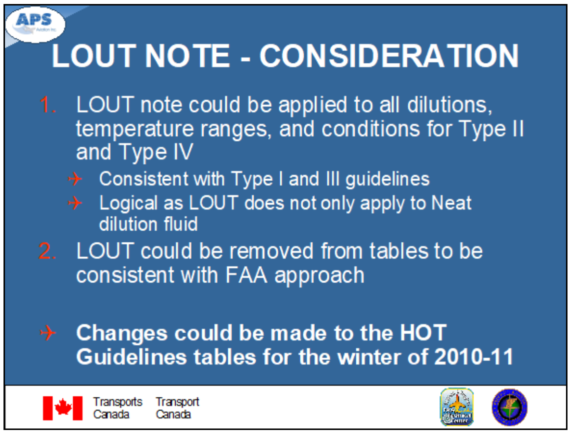

LOUT NOTE - CONSIDERATION

1. LOUT note could be applied to all dilutions, temperature ranges, and conditions for Type II and Type IV
   - Consistent with Type I and III guidelines
   - Logical as LOUT does not only apply to Neat dilution fluid
2. LOUT could be removed from tables to be consistent with FAA approach

- **Changes could be made to the HOT Guidelines tables for the winter of 2010-11**

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NOVEMBER G-12 FEEDBACK

- Feedback indicated that applying the LOUT to all temperature bands in the TC Guidelines (similar to Type I and Type III) would be more appropriate
- **ANY ADDITIONAL FEEDBACK???**

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LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST

BACKGROUND

- New separate frost table format was adopted for 2009-10 HOT Guidelines
- New frost table indicates that Type I fluid may be used below -25ºC if LOUT is respected; however
- Restrictions for use of Type II, III, and IV below -25ºC were included based on fluid freeze point issues (not directly linked to LOUT)

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BACKGROUND

- TC guidelines restricts use of Type II, III, and IV below -25ºC based on temperature bands limits
- FAA guidelines have included an additional note (Note 3) to emphasize this point

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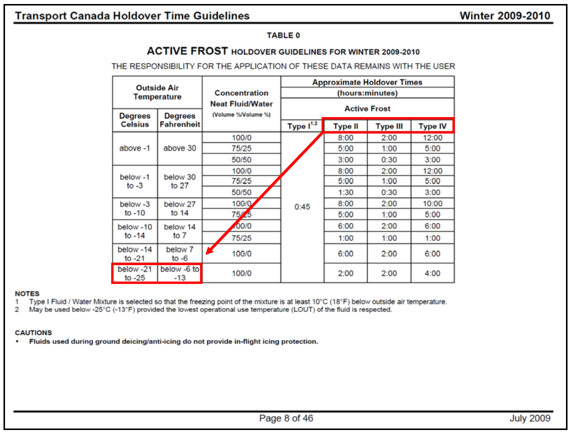

Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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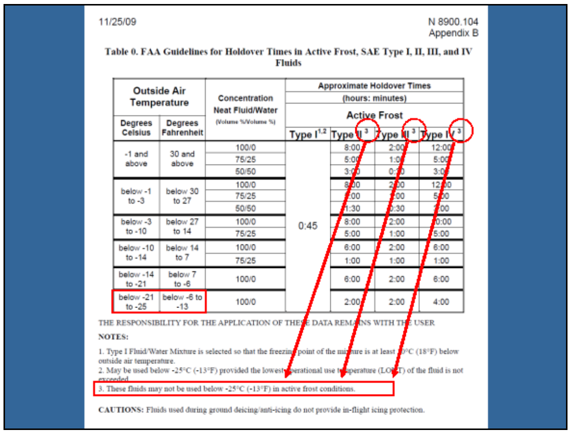

11/25/09

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Appendix B

Table 0. FAA Guidelines for Holdover Times in Active Frost, SAE Type I, II, III, and IV Fluids

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

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

NOTES:

1. Type I Fluid/Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2. May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is not exceeded.
3. These fluids may not be used below -25°C (-13°F) in active frost conditions.

CAUTIONS: Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

FROST LOUT NOTE - CONSIDERATION

- Note related to lowest applicable temperature could be included in TC Guidelines to be consistent with FAA guidelines
- **Changes could be made to the HOT Guidelines tables for the winter of 2010-11**
- **ANY ADDITIONAL FEEDBACK???**

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OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- **LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC**
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

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BACKGROUND

- Both FAA and AEA include an additional note in HOT guidance material for Rain on a Cold Soaked Wing "RCSW"
  - Note restricts use of RCSW HOT's to "Above 0ºC"
- Discrepancy with TC Guidance material
  - TC RCSW HOT's are applicable to "-3ºC and above"
- When developing HOT tables, RCSW is tested at +1ºC
  - Methodology uses +1ºC to ensure "Rain" and not "Freezing Rain"

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BACKGROUND

- Prior to 2005-06, HOT tables had an "Above 0ºC" row
- RCSW HOT's were only applied to "Above 0ºC" conditions
- When "Above 0ºC" row was removed, RCSW condition was extended to include "Above -3ºC"
  - Logic for keeping RCSW for "above -3ºC" was:
    - Rain only occurs above 0ºC
    - Won't clutter table with another caution note

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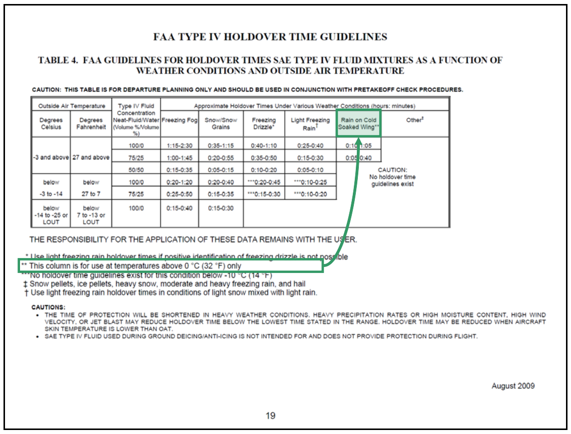

FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

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

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

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

August 2009

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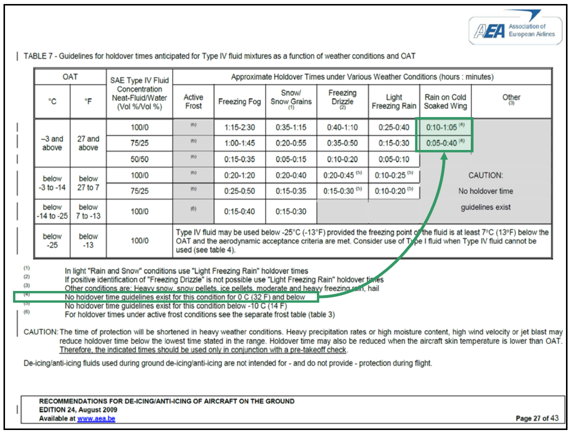

AEA Association of European Airlines

TABLE 7 - Guidelines for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
–3 and above	27 and above	100/0	(6)	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	CAUTION: No holdover time guidelines exist
		75/25	(6)	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	(6)	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	(6)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)		
		75/25	(6)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type IV fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0 C (32 F) and below
(5) No holdover time guidelines exist for this condition below -10 C (14 F)
(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
EDITION 24, August 2009
Available at www.aea.be
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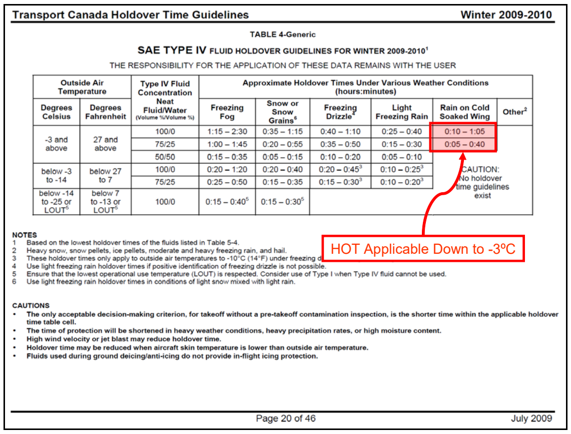

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

HOT Applicable Down to -3ºC

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing d
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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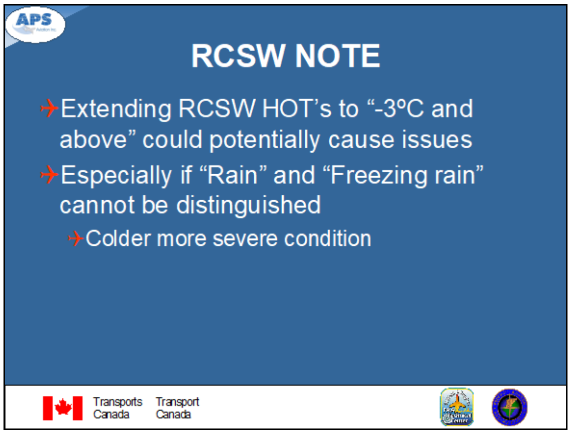

RCSW NOTE

- Extending RCSW HOT's to "-3ºC and above" could potentially cause issues
- Especially if "Rain" and "Freezing rain" cannot be distinguished
  - Colder more severe condition

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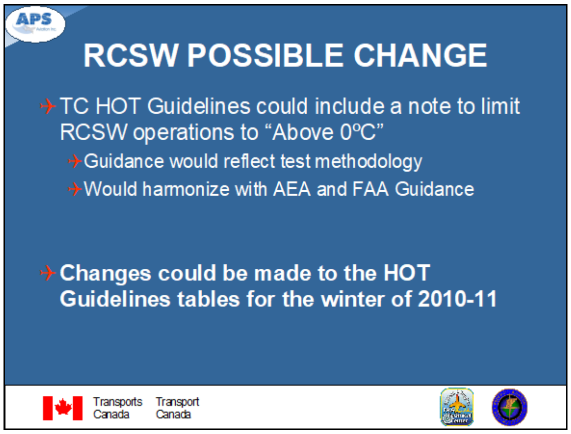

RCSW POSSIBLE CHANGE

- TC HOT Guidelines could include a note to limit RCSW operations to "Above 0ºC"
  - Guidance would reflect test methodology
  - Would harmonize with AEA and FAA Guidance
- **Changes could be made to the HOT Guidelines tables for the winter of 2010-11**

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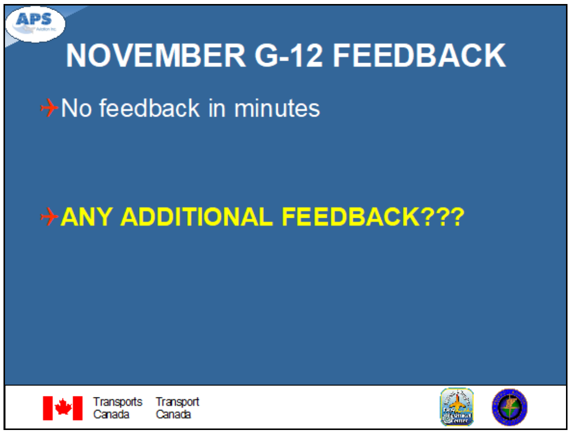

NOVEMBER G-12 FEEDBACK

- No feedback in minutes
- **ANY ADDITIONAL FEEDBACK???**

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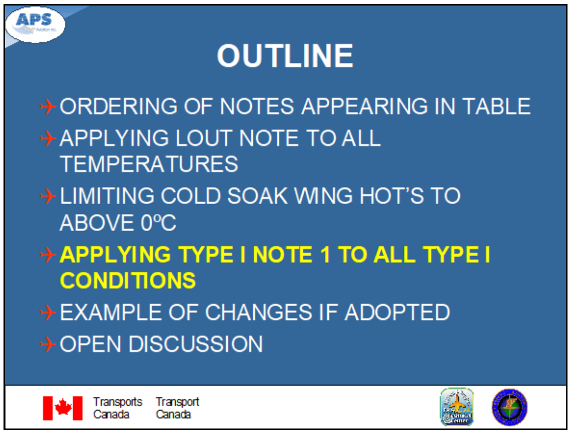
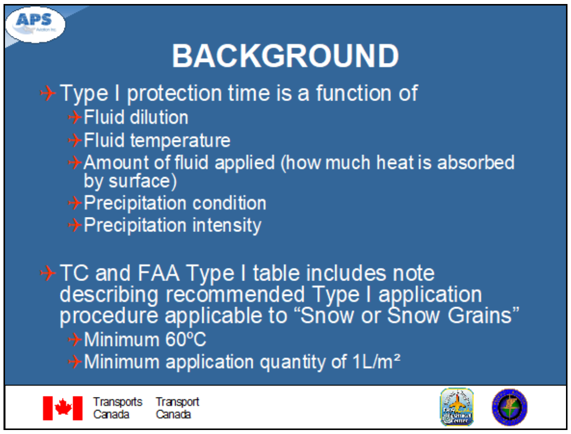


OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- **APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS**
- EXAMPLE OF CHANGES IF ADOPTED
- OPEN DISCUSSION

Transports Canada Transport Canada



BACKGROUND

- Type I protection time is a function of
  - Fluid dilution
  - Fluid temperature
  - Amount of fluid applied (how much heat is absorbed by surface)
  - Precipitation condition
  - Precipitation intensity
- TC and FAA Type I table includes note describing recommended Type I application procedure applicable to "Snow or Snow Grains"
  - Minimum 60ºC
  - Minimum application quantity of 1L/m²

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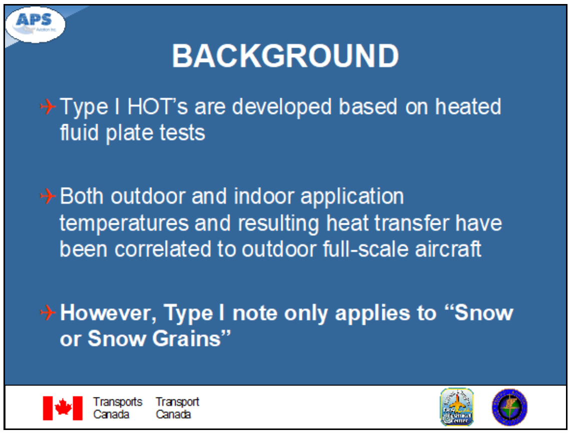

BACKGROUND

- Type I HOT's are developed based on heated fluid plate tests
- Both outdoor and indoor application temperatures and resulting heat transfer have been correlated to outdoor full-scale aircraft
- **However, Type I note only applies to "Snow or Snow Grains"**

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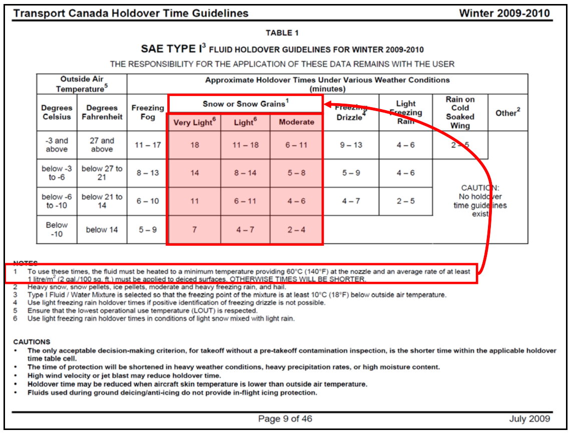

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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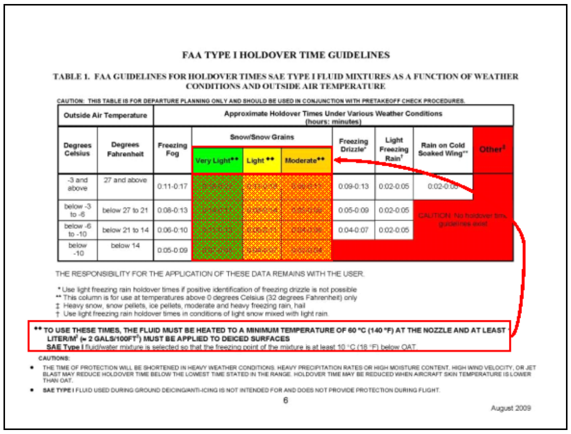

FAA TYPE I HOLDOVER TIME GUIDELINES

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
			Very Light**	Light **	Moderate**				
-3 and above	27 and above	0:11-0:17	[illegible]	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	0:08-0:13	[illegible]	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	0:06-0:10	[illegible]	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
below -10	below 14	0:05-0:09	[illegible]	0:04-0:07	0:02-0:04				

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

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

**** TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M² (≈ 2 GALS/100FT²) MUST BE APPLIED TO DEICED SURFACES**
SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE I** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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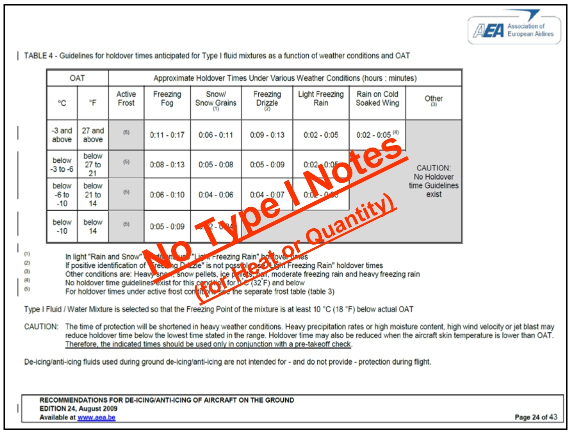

Association of European Airlines

TABLE 4 - Guidelines for holdover times anticipated for Type I fluid mixtures as a function of weather conditions and OAT

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	(5)	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05 (4)	CAUTION: No Holdover time Guidelines exist
below -3 to -6	below 27 to 21	(5)	0:08 - 0:13	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05		
below -6 to -10	below 21 to 14	(5)	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	[illegible]		
below -10	below 14	(5)	0:05 - 0:09	[illegible]				

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

RECOMMENDATIONS FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND
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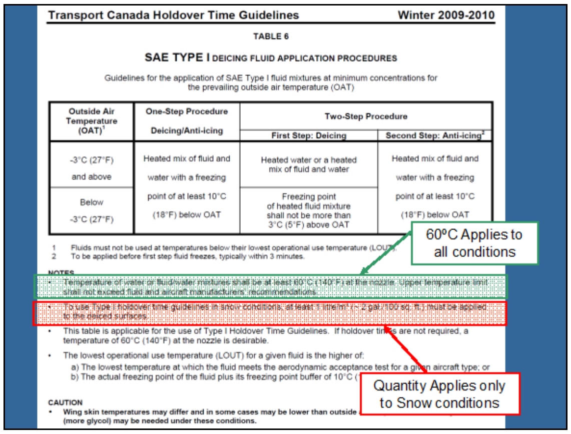


Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
2 To be applied before first step fluid freezes, typically within 3 minutes.

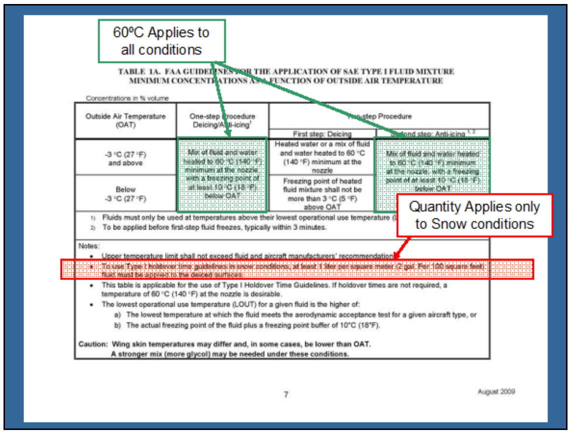
NOTES

- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in snow conditions, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  - b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside**
(more glycol) may be needed under these conditions.

60ºC Applies to all conditions
Quantity Applies only to Snow conditions



60ºC Applies to all conditions

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

Concentrations in % volume

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing [1, 2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

1) Fluids must only be used at temperatures above their lowest operational use temperature (L
2) To be applied before first-step fluid freezes, typically within 3 minutes.

Notes:

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendation
- To use Type I holdover time guidelines in snow conditions, at least 1 liter per square meter (2 gal. Per 100 square feet) fluid must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  - b) The actual freezing point of the fluid plus a freezing point buffer of 10°C (18°F).

Caution: Wing skin temperatures may differ and, in some cases, be lower than OAT.
A stronger mix (more glycol) may be needed under these conditions.

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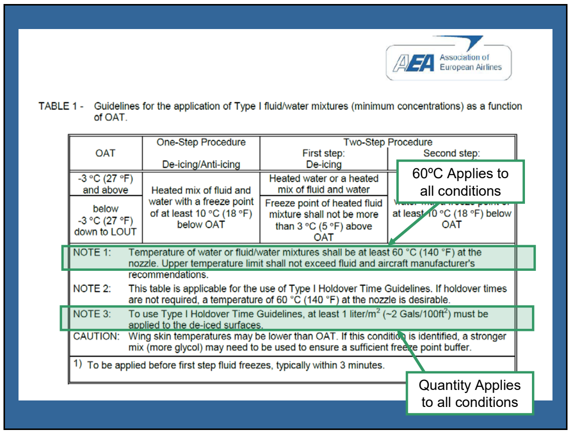


Association of European Airlines

TABLE 1 - Guidelines for the application of Type I fluid/water mixtures (minimum concentrations) as a function of OAT.

OAT	One-Step Procedure De-icing/Anti-icing	Two-Step Procedure First step: De-icing	 Second step:
-3 °C (27 °F) and above	Heated mix of fluid and water with a freeze point of at least 10 °C (18 °F) below OAT	Heated water or a heated mix of fluid and water	water with a freeze point of at least 10 °C (18 °F) below OAT
below -3 °C (27 °F) down to LOUT		Freeze point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

NOTE 1: 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 manufacturer's recommendations.

NOTE 2: 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.

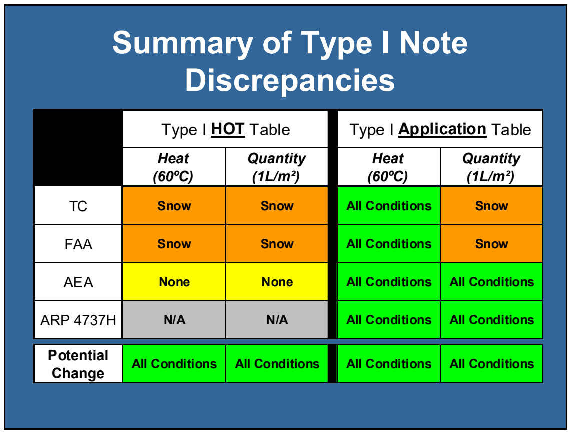
NOTE 3: To use Type I Holdover Time Guidelines, at least 1 liter/m^2 (~2 Gals/100ft^2) must be applied to the de-iced surfaces.

CAUTION: Wing skin temperatures may be lower than OAT. If this condition is identified, a stronger mix (more glycol) may need to be used to ensure a sufficient freeze point buffer.

1) To be applied before first step fluid freezes, typically within 3 minutes.

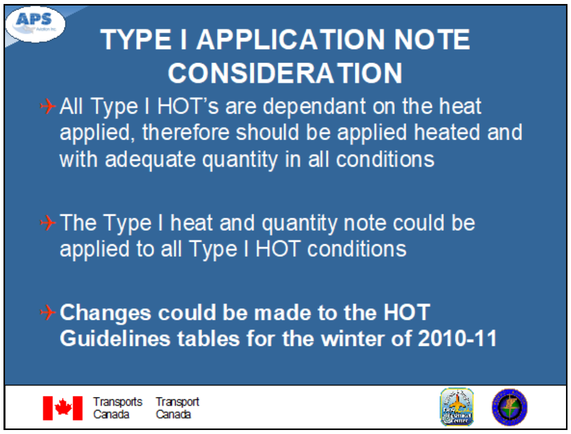
60ºC Applies to all conditions

Quantity Applies to all conditions



Summary of Type I Note Discrepancies

	Type I **HOT** Table		Type I **Application** Table	
	Heat (60ºC)	***Quantity (1L/m²)***	***Heat (60ºC)***	***Quantity (1L/m²)***
TC	**Snow**	**Snow**	**All Conditions**	**Snow**
FAA	**Snow**	**Snow**	**All Conditions**	**Snow**
AEA	**None**	**None**	**All Conditions**	**All Conditions**
ARP 4737H	**N/A**	**N/A**	**All Conditions**	**All Conditions**
Potential Change	**All Conditions**	**All Conditions**	**All Conditions**	**All Conditions**



TYPE I APPLICATION NOTE CONSIDERATION

- All Type I HOT's are dependant on the heat applied, therefore should be applied heated and with adequate quantity in all conditions
- The Type I heat and quantity note could be applied to all Type I HOT conditions
- **Changes could be made to the HOT Guidelines tables for the winter of 2010-11**

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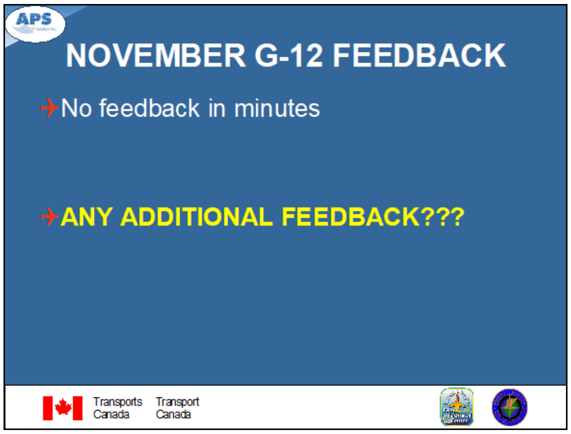

NOVEMBER G-12 FEEDBACK

- No feedback in minutes
- **ANY ADDITIONAL FEEDBACK???**

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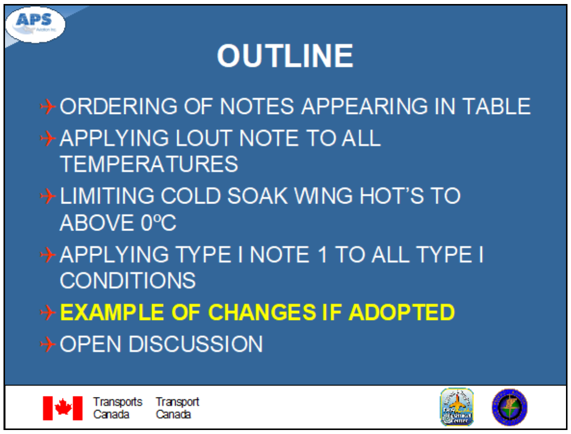

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- **EXAMPLE OF CHANGES IF ADOPTED**
- OPEN DISCUSSION

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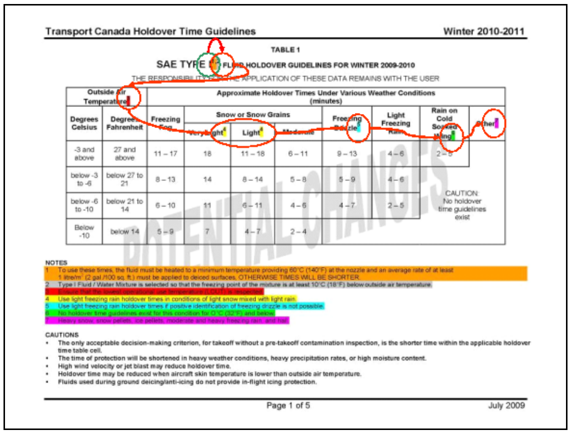

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains Very Light[4]	 Light[4]	 Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

POTENTIAL CHANGES

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 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.
3 Ensure that the lowest operational use temperature (LOUT) is respected.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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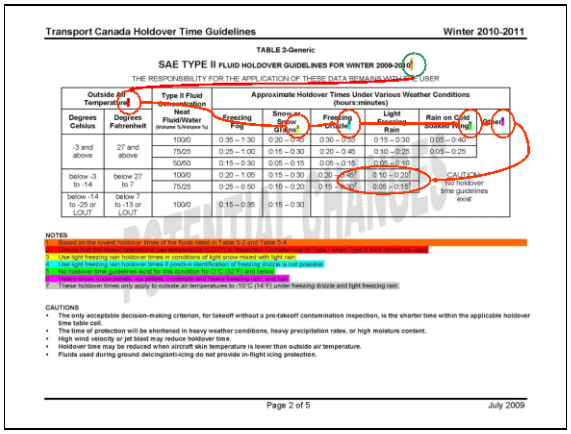
POTENTIAL CHANGES

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[7]	0:10 – 0:20[7]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[7]	0:05 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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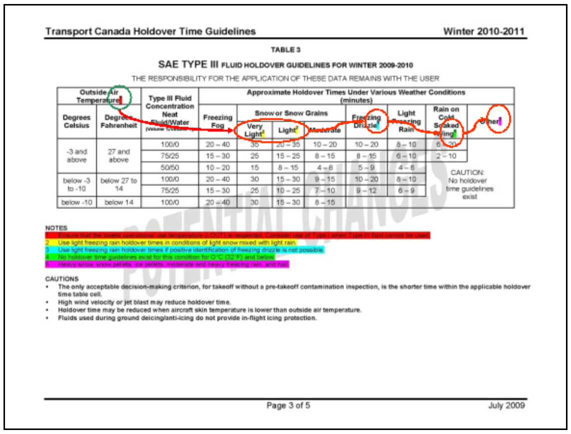
POTENTIAL CHANGES

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[1]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[2]	Light[2]	Moderate	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
2 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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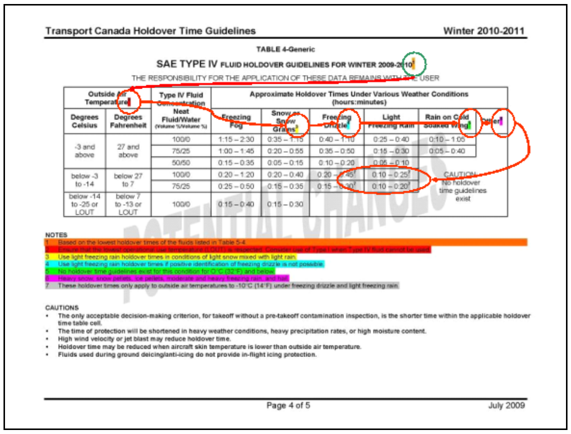
POTENTIAL CHANGES

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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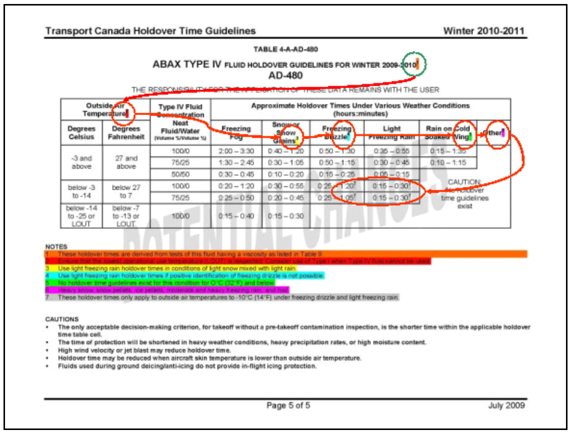
POTENTIAL CHANGES

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-A-AD-480

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]
AD-480

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -25 or LOUT	below -7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.
- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.
- High wind velocity or jet blast may reduce holdover time.
- Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.
- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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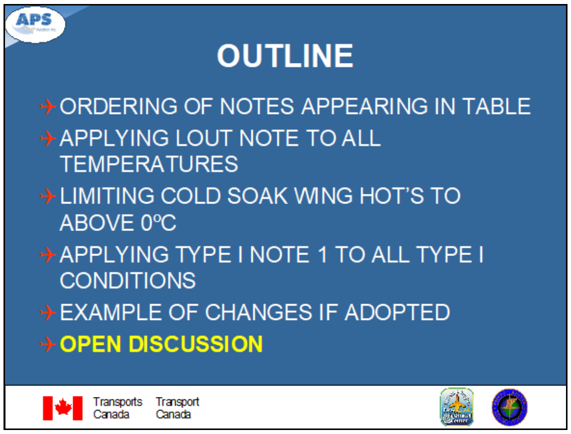
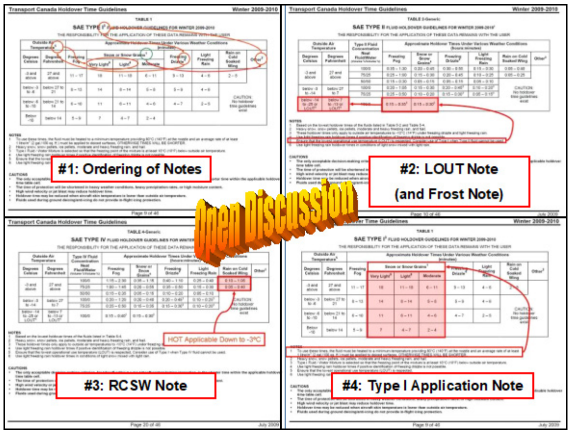

APS
Transports Canada
Transport Canada

OUTLINE

- ORDERING OF NOTES APPEARING IN TABLE
- APPLYING LOUT NOTE TO ALL TEMPERATURES
- LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
- APPLYING TYPE I NOTE 1 TO ALL TYPE I CONDITIONS
- EXAMPLE OF CHANGES IF ADOPTED
- **OPEN DISCUSSION**


Transport Canada Holdover Time Guidelines

HOT Applicable Down to -3ºC

#1: Ordering of Notes

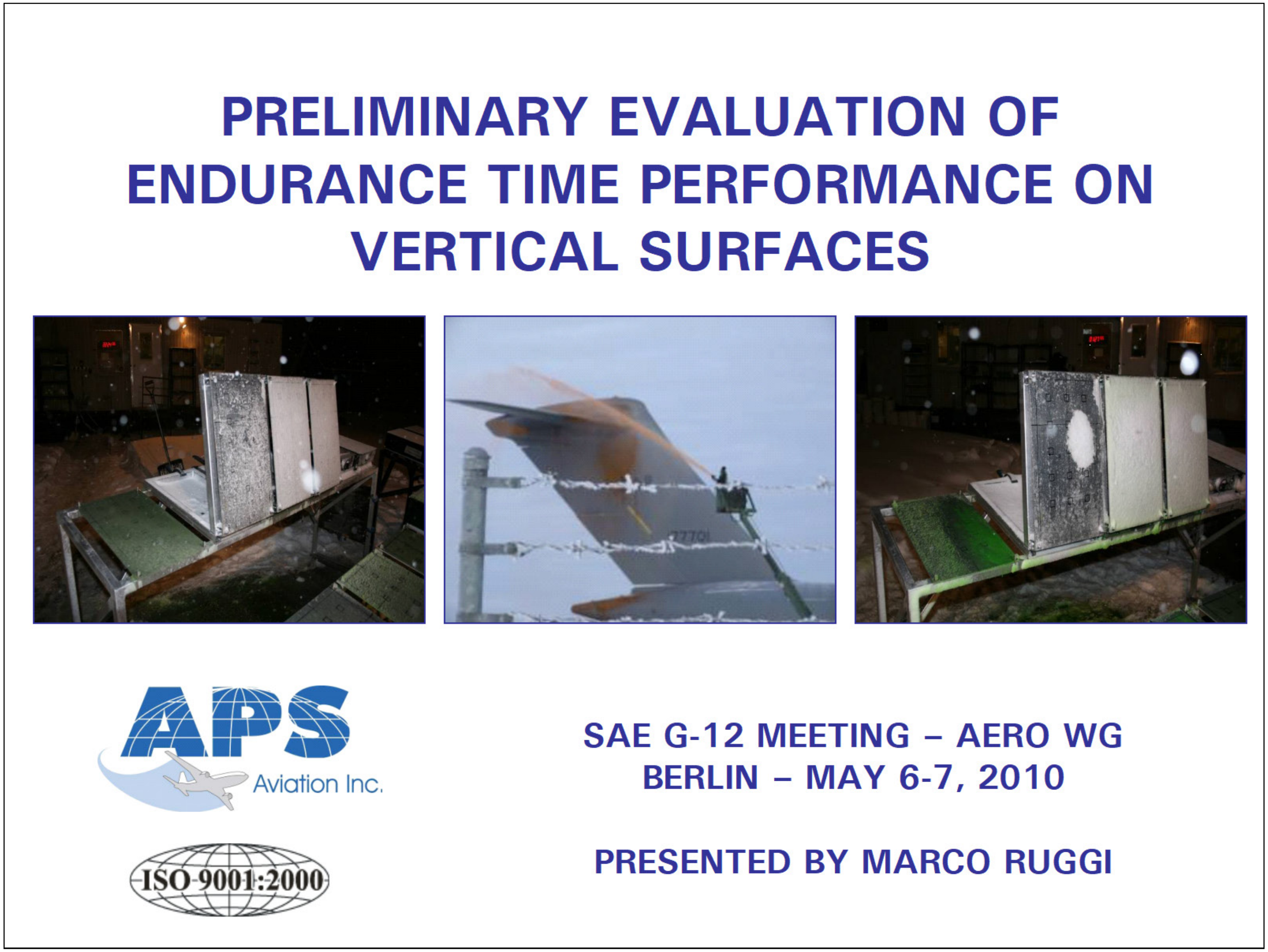
#2: LOUT Note
(and Frost Note)

Open Discussion

#3: RCSW Note

#4: Type I Application Note

Marco Ruggi
mruggi@adga.ca



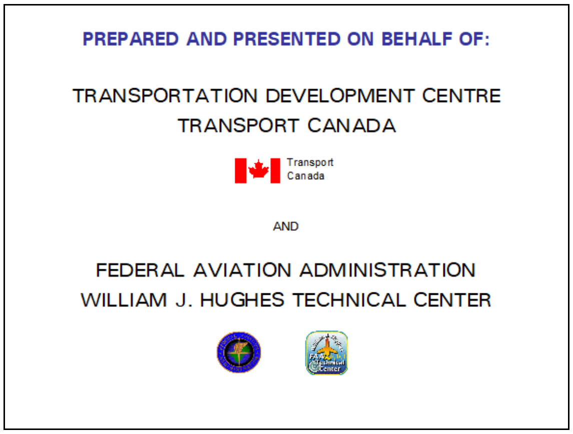
PRELIMINARY EVALUATION OF ENDURANCE TIME PERFORMANCE ON VERTICAL SURFACES

APS
Aviation Inc.

ISO 9001:2000

SAE G-12 MEETING – AERO WG
BERLIN – MAY 6-7, 2010

PRESENTED BY MARCO RUGGI



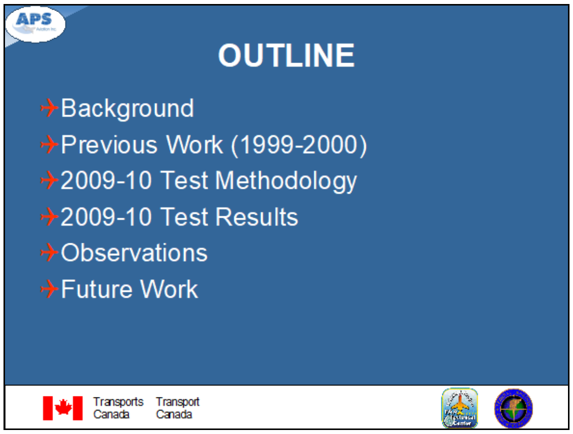
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Background
- Previous Work (1999-2000)
- 2009-10 Test Methodology
- 2009-10 Test Results
- Observations
- Future Work

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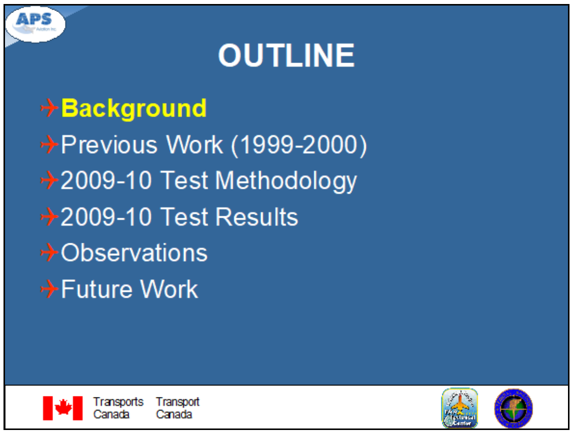

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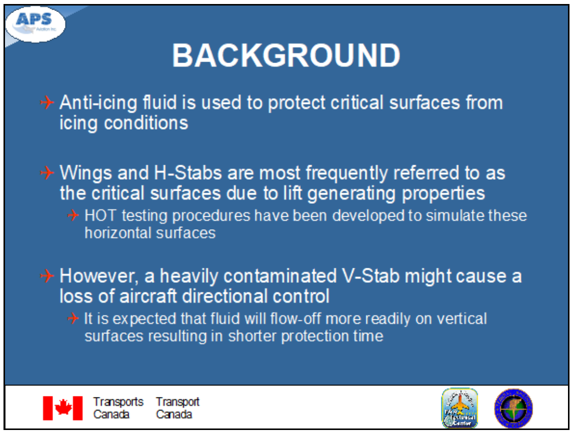

BACKGROUND

- Anti-icing fluid is used to protect critical surfaces from icing conditions
- Wings and H-Stabs are most frequently referred to as the critical surfaces due to lift generating properties
  - HOT testing procedures have been developed to simulate these horizontal surfaces
- However, a heavily contaminated V-Stab might cause a loss of aircraft directional control
  - It is expected that fluid will flow-off more readily on vertical surfaces resulting in shorter protection time

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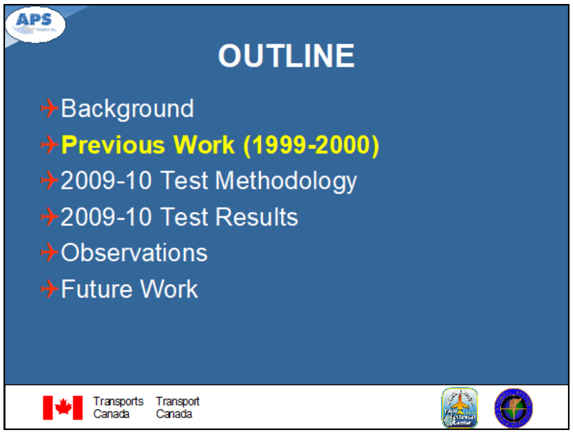

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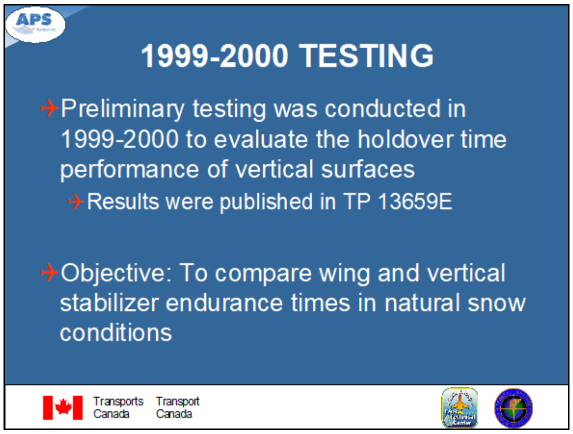
Transports Canada Transport Canada



1999-2000 TESTING

- Preliminary testing was conducted in 1999-2000 to evaluate the holdover time performance of vertical surfaces
  - Results were published in TP 13659E
- Objective: To compare wing and vertical stabilizer endurance times in natural snow conditions

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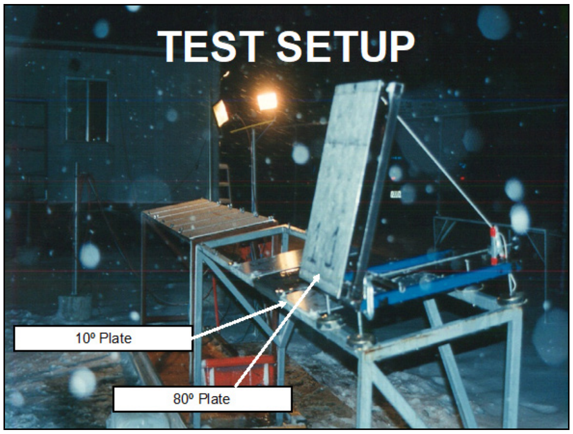
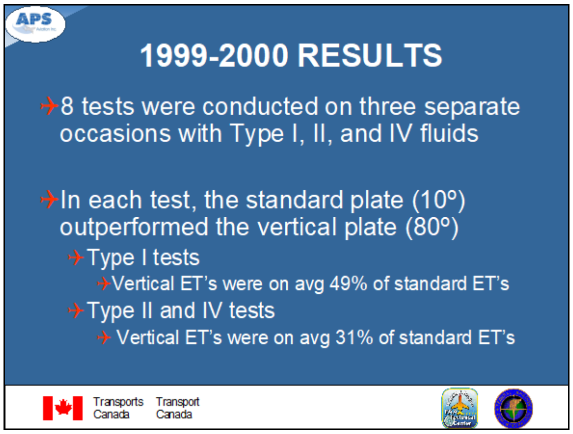


TEST SETUP



1999-2000 RESULTS

- 8 tests were conducted on three separate occasions with Type I, II, and IV fluids
- In each test, the standard plate (10º) outperformed the vertical plate (80º)
  - Type I tests
    - Vertical ET's were on avg 49% of standard ET's
  - Type II and IV tests
    - Vertical ET's were on avg 31% of standard ET's

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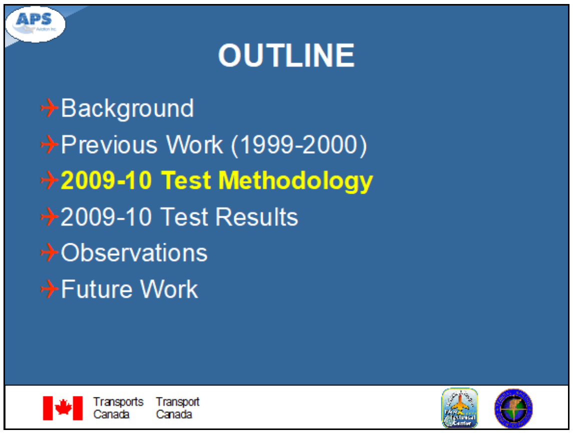

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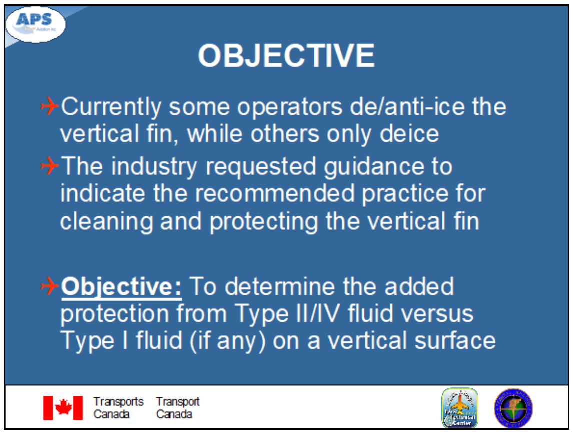

OBJECTIVE

- Currently some operators de/anti-ice the vertical fin, while others only deice
- The industry requested guidance to indicate the recommended practice for cleaning and protecting the vertical fin
- **Objective:** To determine the added protection from Type II/IV fluid versus Type I fluid (if any) on a vertical surface

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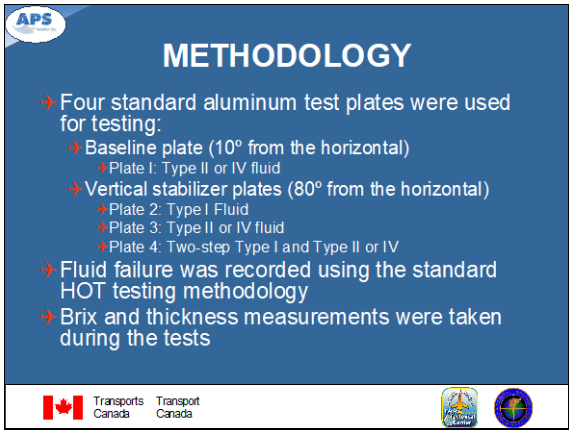

METHODOLOGY

- Four standard aluminum test plates were used for testing:
  - Baseline plate (10º from the horizontal)
    - Plate I: Type II or IV fluid
  - Vertical stabilizer plates (80º from the horizontal)
    - Plate 2: Type I Fluid
    - Plate 3: Type II or IV fluid
    - Plate 4: Two-step Type I and Type II or IV
- Fluid failure was recorded using the standard HOT testing methodology
- Brix and thickness measurements were taken during the tests

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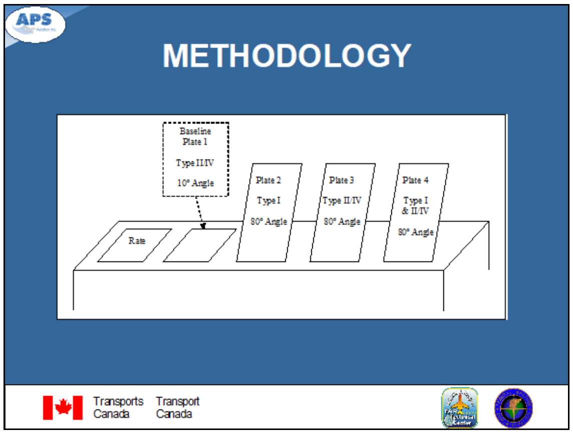
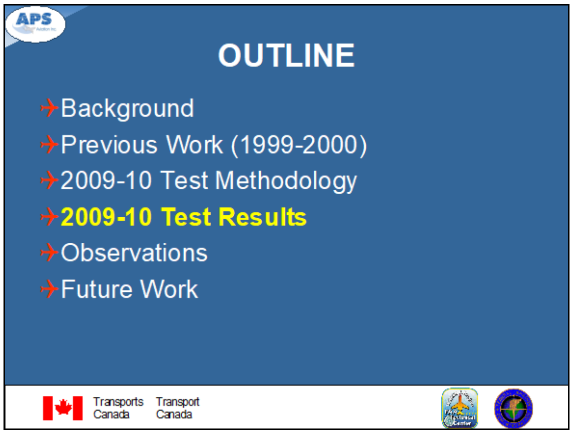


METHODOLOGY

Transports Canada Transport Canada



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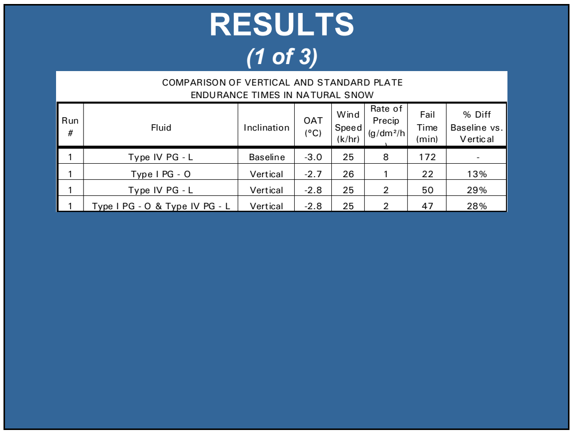
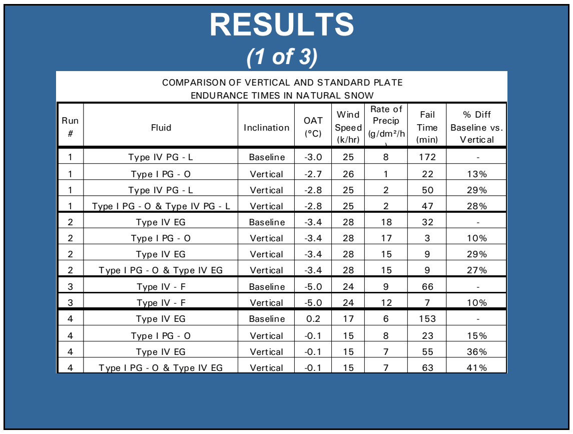


RESULTS

(1 of 3)

COMPARISON OF VERTICAL AND STANDARD PLATE
ENDURANCE TIMES IN NATURAL SNOW

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h	Fail Time (min)	% Diff Baseline vs. Vertical
1	Type IV PG - L	Baseline	-3.0	25	8	172	-
1	Type I PG - O	Vertical	-2.7	26	1	22	13%
1	Type IV PG - L	Vertical	-2.8	25	2	50	29%
1	Type I PG - O & Type IV PG - L	Vertical	-2.8	25	2	47	28%



RESULTS

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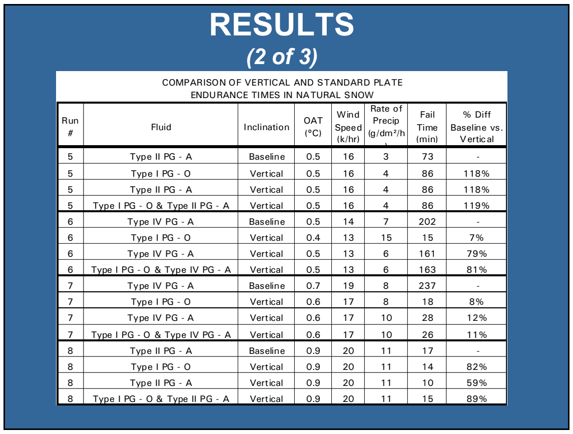
1	Type IV PG - L	Vertical	-2.8	25	2	50	29%
1	Type I PG - O & Type IV PG - L	Vertical	-2.8	25	2	47	28%
2	Type IV EG	Baseline	-3.4	28	18	32	-
2	Type I PG - O	Vertical	-3.4	28	17	3	10%
2	Type IV EG	Vertical	-3.4	28	15	9	29%
2	Type I PG - O & Type IV EG	Vertical	-3.4	28	15	9	27%
3	Type IV - F	Baseline	-5.0	24	9	66	-
3	Type IV - F	Vertical	-5.0	24	12	7	10%
4	Type IV EG	Baseline	0.2	17	6	153	-
4	Type I PG - O	Vertical	-0.1	15	8	23	15%
4	Type IV EG	Vertical	-0.1	15	7	55	36%
4	Type I PG - O & Type IV EG	Vertical	-0.1	15	7	63	41%

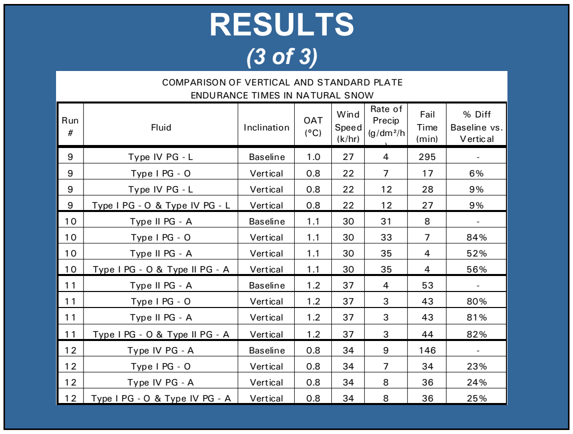


RESULTS

(2 of 3)

COMPARISON OF VERTICAL AND STANDARD PLATE
ENDURANCE TIMES IN NATURAL SNOW

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h	Fail Time (min)	% Diff Baseline vs. Vertical
5	Type II PG - A	Baseline	0.5	16	3	73	-
5	Type I PG - O	Vertical	0.5	16	4	86	118%
5	Type II PG - A	Vertical	0.5	16	4	86	118%
5	Type I PG - O & Type II PG - A	Vertical	0.5	16	4	86	119%
6	Type IV PG - A	Baseline	0.5	14	7	202	-
6	Type I PG - O	Vertical	0.4	13	15	15	7%
6	Type IV PG - A	Vertical	0.5	13	6	161	79%
6	Type I PG - O & Type IV PG - A	Vertical	0.5	13	6	163	81%
7	Type IV PG - A	Baseline	0.7	19	8	237	-
7	Type I PG - O	Vertical	0.6	17	8	18	8%
7	Type IV PG - A	Vertical	0.6	17	10	28	12%
7	Type I PG - O & Type IV PG - A	Vertical	0.6	17	10	26	11%
8	Type II PG - A	Baseline	0.9	20	11	17	-
8	Type I PG - O	Vertical	0.9	20	11	14	82%
8	Type II PG - A	Vertical	0.9	20	11	10	59%
8	Type I PG - O & Type II PG - A	Vertical	0.9	20	11	15	89%

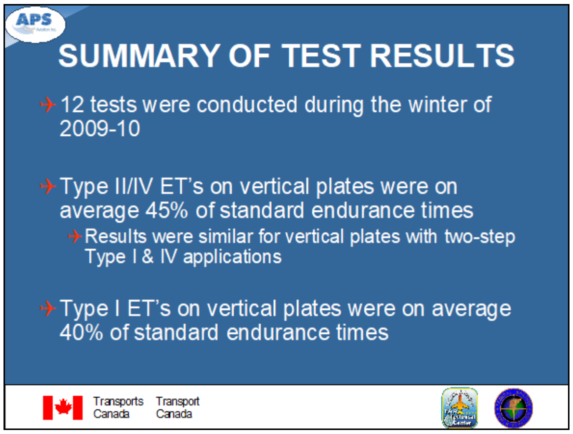


RESULTS

(3 of 3)

COMPARISON OF VERTICAL AND STANDARD PLATE
ENDURANCE TIMES IN NATURAL SNOW

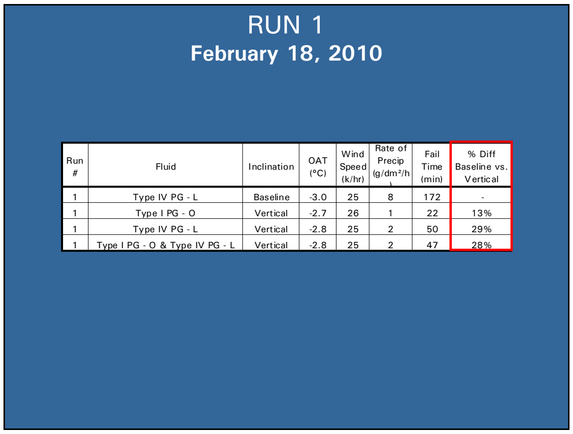
Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h	Fail Time (min)	% Diff Baseline vs. Vertical
9	Type IV PG - L	Baseline	1.0	27	4	295	-
9	Type I PG - O	Vertical	0.8	22	7	17	6%
9	Type IV PG - L	Vertical	0.8	22	12	28	9%
9	Type I PG - O & Type IV PG - L	Vertical	0.8	22	12	27	9%
10	Type II PG - A	Baseline	1.1	30	31	8	-
10	Type I PG - O	Vertical	1.1	30	33	7	84%
10	Type II PG - A	Vertical	1.1	30	35	4	52%
10	Type I PG - O & Type II PG - A	Vertical	1.1	30	35	4	56%
11	Type II PG - A	Baseline	1.2	37	4	53	-
11	Type I PG - O	Vertical	1.2	37	3	43	80%
11	Type II PG - A	Vertical	1.2	37	3	43	81%
11	Type I PG - O & Type II PG - A	Vertical	1.2	37	3	44	82%
12	Type IV PG - A	Baseline	0.8	34	9	146	-
12	Type I PG - O	Vertical	0.8	34	7	34	23%
12	Type IV PG - A	Vertical	0.8	34	8	36	24%
12	Type I PG - O & Type IV PG - A	Vertical	0.8	34	8	36	25%



SUMMARY OF TEST RESULTS

- 12 tests were conducted during the winter of 2009-10
- Type II/IV ET's on vertical plates were on average 45% of standard endurance times
  - Results were similar for vertical plates with two-step Type I & IV applications
- Type I ET's on vertical plates were on average 40% of standard endurance times

Photo Examples



RUN 1

February 18, 2010

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h)	Fail Time (min)	% Diff Baseline vs. Vertical
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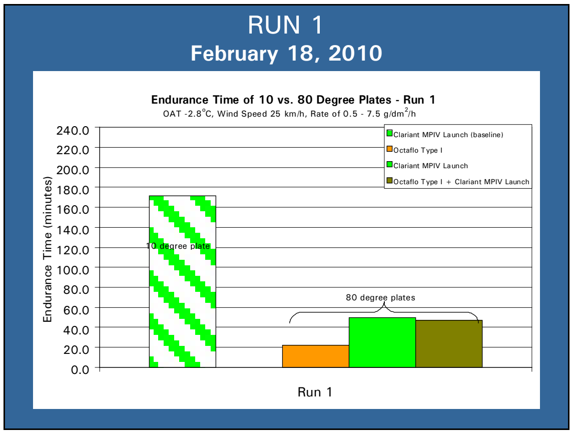
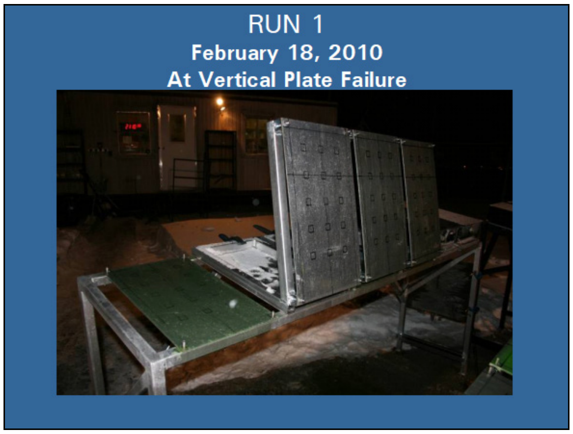


RUN 1

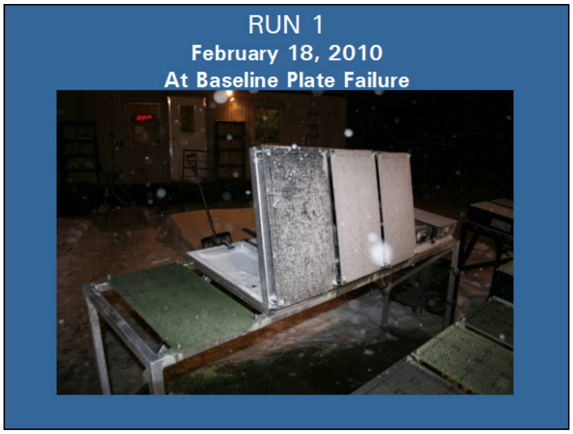
February 18, 2010



RUN 1

February 18, 2010

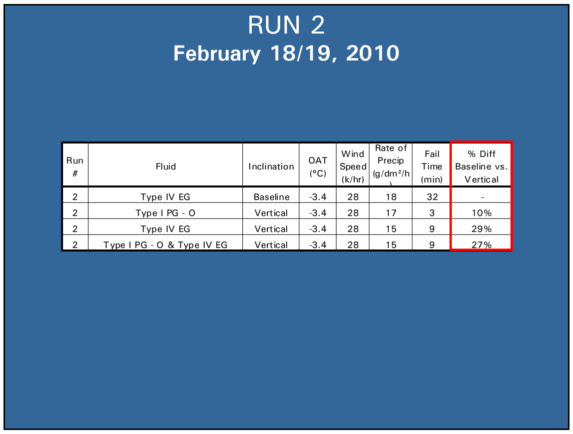
At Vertical Plate Failure



RUN 1

February 18, 2010

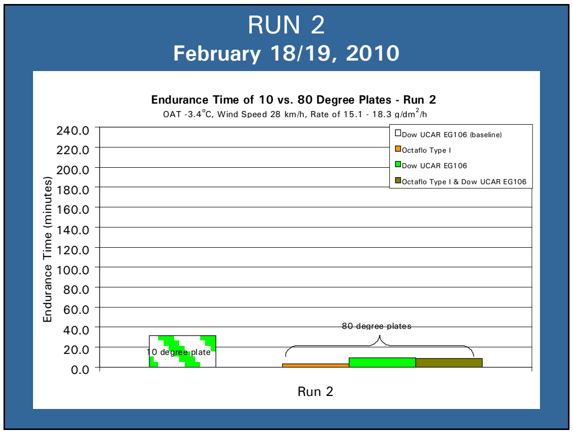
At Baseline Plate Failure



RUN 2

February 18/19, 2010

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h)	Fail Time (min)	% Diff Baseline vs. Vertical
2	Type IV EG	Baseline	-3.4	28	18	32	-
2	Type I PG - O	Vertical	-3.4	28	17	3	10%
2	Type IV EG	Vertical	-3.4	28	15	9	29%
2	Type I PG - O & Type IV EG	Vertical	-3.4	28	15	9	27%

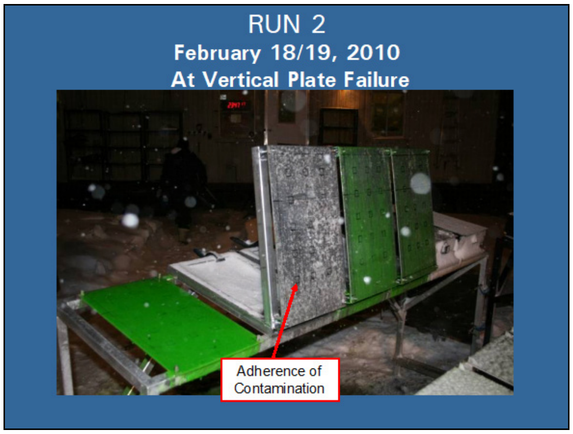


RUN 2

February 18/19, 2010

Endurance Time of 10 vs. 80 Degree Plates - Run 2

OAT -3.4°C, Wind Speed 28 km/h, Rate of 15.1 - 18.3 $g/dm^2/h$

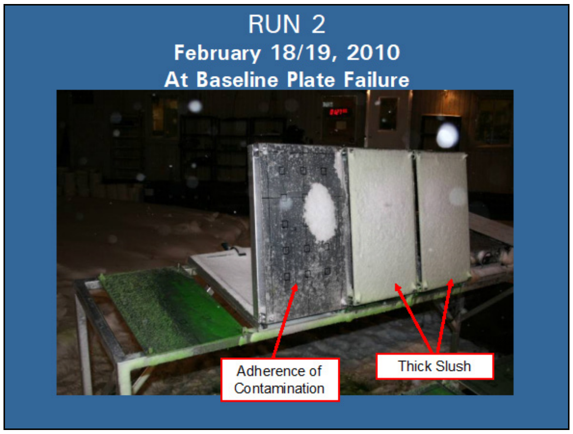


RUN 2

February 18/19, 2010

At Vertical Plate Failure

Adherence of Contamination



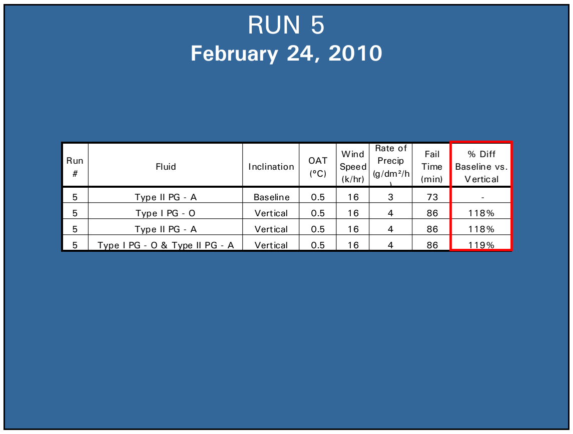
RUN 2

February 18/19, 2010

At Baseline Plate Failure

Adherence of Contamination

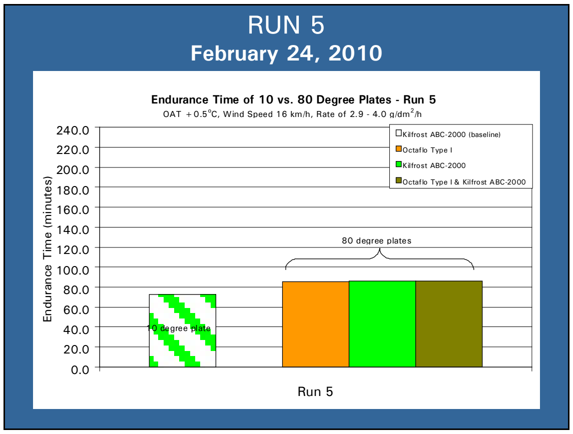
Thick Slush



RUN 5

February 24, 2010

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip ($g/dm^2/h$)	Fail Time (min)	% Diff Baseline vs. Vertical
5	Type II PG - A	Baseline	0.5	16	3	73	-
5	Type I PG - O	Vertical	0.5	16	4	86	118%
5	Type II PG - A	Vertical	0.5	16	4	86	118%
5	Type I PG - O & Type II PG - A	Vertical	0.5	16	4	86	119%



RUN 5

February 24, 2010

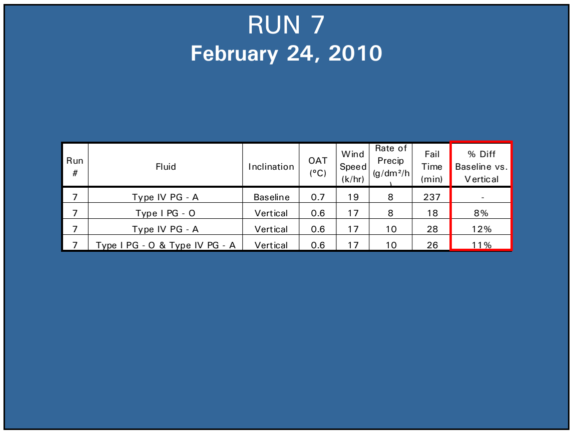
Endurance Time of 10 vs. 80 Degree Plates - Run 5

OAT +0.5°C, Wind Speed 16 km/h, Rate of 2.9 - 4.0 $g/dm^2/h$

RUN 5

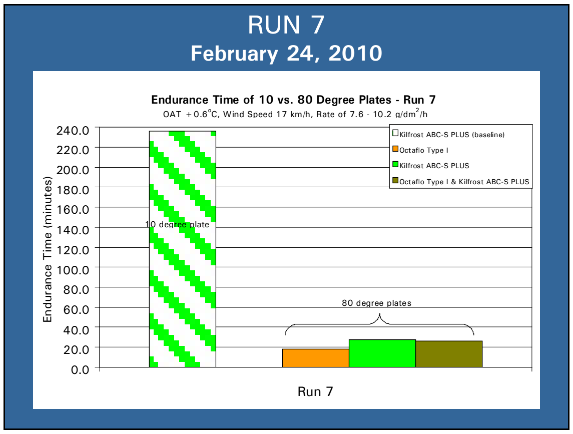
February 24, 2010

At Vertical & Baseline Plate Failure

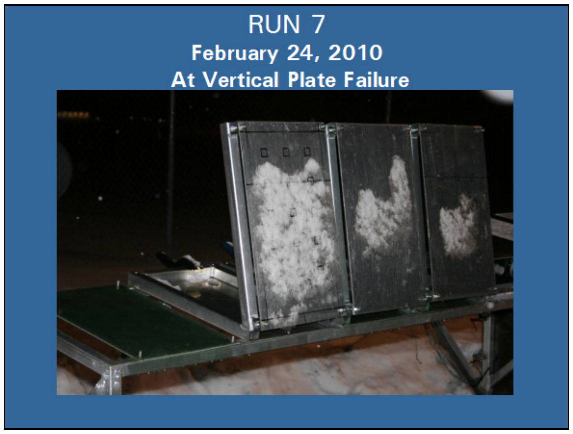


RUN 7
February 24, 2010

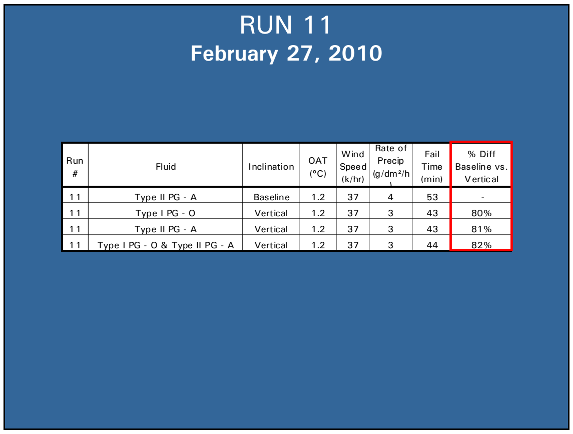
Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h)	Fail Time (min)	% Diff Baseline vs. Vertical
7	Type IV PG - A	Baseline	0.7	19	8	237	-
7	Type I PG - O	Vertical	0.6	17	8	18	8%
7	Type IV PG - A	Vertical	0.6	17	10	28	12%
7	Type I PG - O & Type IV PG - A	Vertical	0.6	17	10	26	11%



RUN 7
February 24, 2010

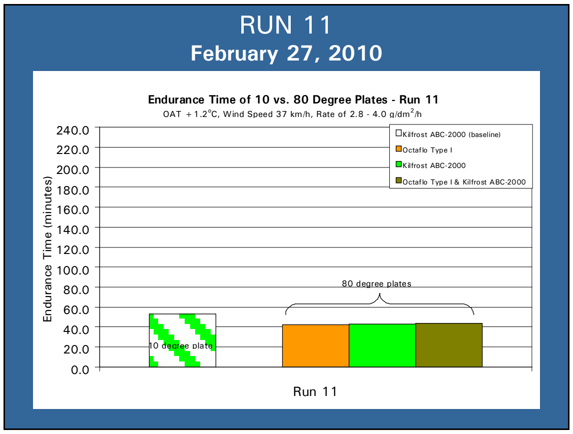


RUN 7
February 24, 2010
At Vertical Plate Failure

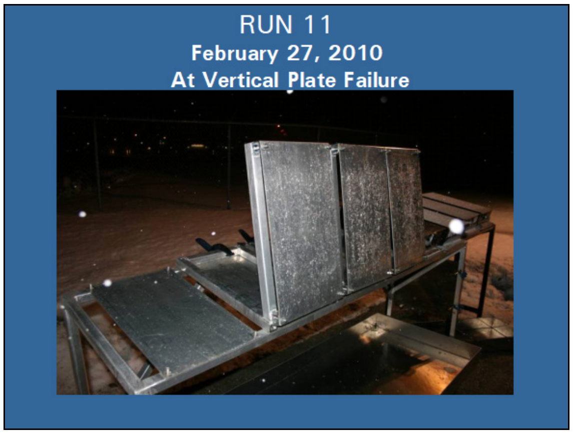


RUN 11
February 27, 2010

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h)	Fail Time (min)	% Diff Baseline vs. Vertical
11	Type II PG - A	Baseline	1.2	37	4	53	-
11	Type I PG - O	Vertical	1.2	37	3	43	80%
11	Type II PG - A	Vertical	1.2	37	3	43	81%
11	Type I PG - O & Type II PG - A	Vertical	1.2	37	3	44	82%

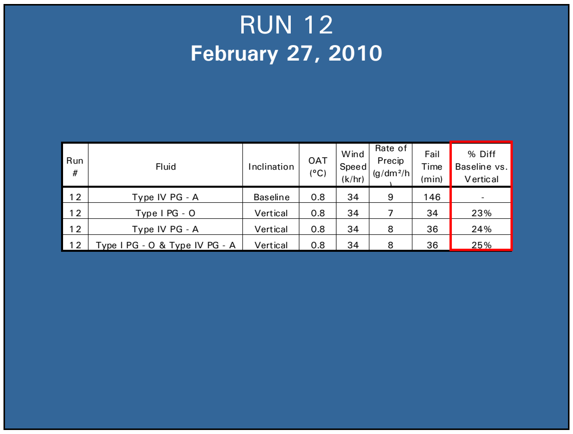


RUN 11
February 27, 2010



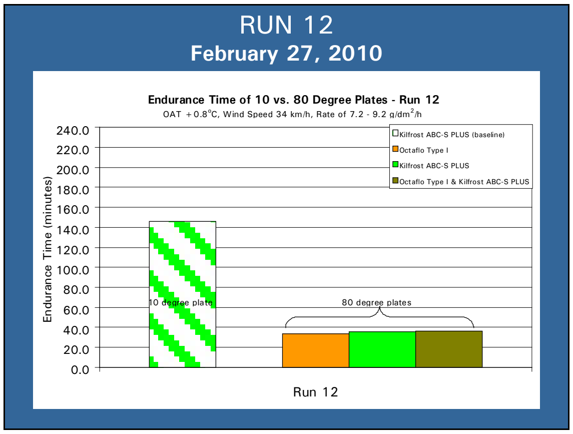
RUN 11
February 27, 2010
At Vertical Plate Failure

RUN 11
February 27, 2010
At Baseline Plate Failure



RUN 12
February 27, 2010

Run #	Fluid	Inclination	OAT (°C)	Wind Speed (k/hr)	Rate of Precip (g/dm²/h)	Fail Time (min)	% Diff Baseline vs. Vertical
12	Type IV PG - A	Baseline	0.8	34	9	146	-
12	Type I PG - O	Vertical	0.8	34	7	34	23%
12	Type IV PG - A	Vertical	0.8	34	8	36	24%
12	Type I PG - O & Type IV PG - A	Vertical	0.8	34	8	36	25%



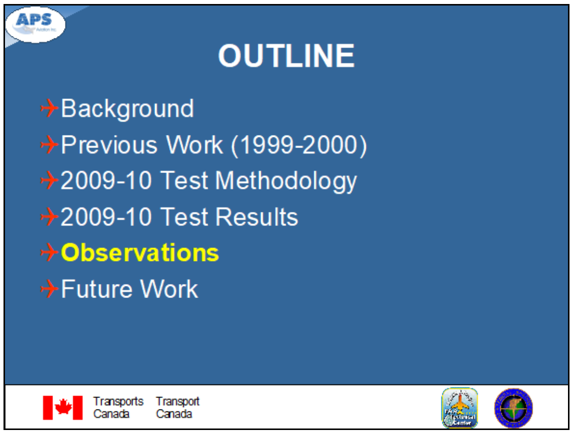
RUN 12
February 27, 2010

Endurance Time of 10 vs. 80 Degree Plates - Run 12

OAT +0.8°C, Wind Speed 34 km/h, Rate of 7.2 - 9.2 g/dm²/h

RUN 12
February 27, 2010
At Vertical Plate Failure

RUN 12
February 27, 2010
At Baseline Plate Failure



OUTLINE

- Background
- Previous Work (1999-2000)
- 2009-10 Test Methodology
- 2009-10 Test Results
- **Observations**
- Future Work

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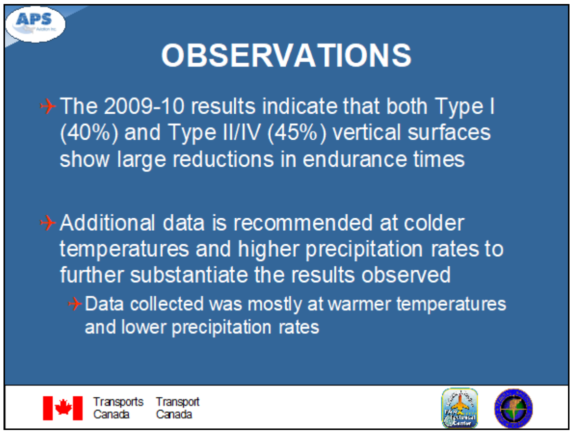

OBSERVATIONS

- The 2009-10 results indicate that both Type I (40%) and Type II/IV (45%) vertical surfaces show large reductions in endurance times
- Additional data is recommended at colder temperatures and higher precipitation rates to further substantiate the results observed
  - Data collected was mostly at warmer temperatures and lower precipitation rates

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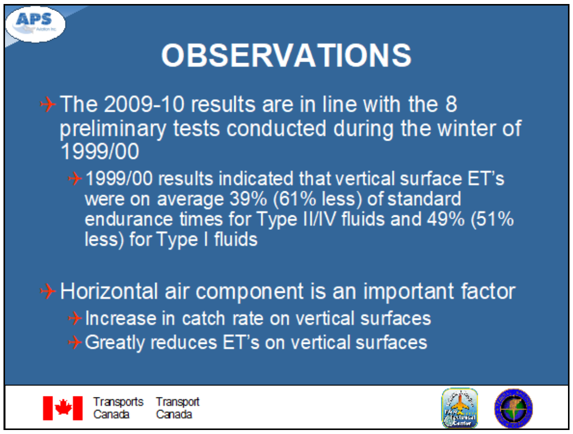

OBSERVATIONS

- The 2009-10 results are in line with the 8 preliminary tests conducted during the winter of 1999/00
  - 1999/00 results indicated that vertical surface ET's were on average 39% (61% less) of standard endurance times for Type II/IV fluids and 49% (51% less) for Type I fluids
- Horizontal air component is an important factor
  - Increase in catch rate on vertical surfaces
  - Greatly reduces ET's on vertical surfaces

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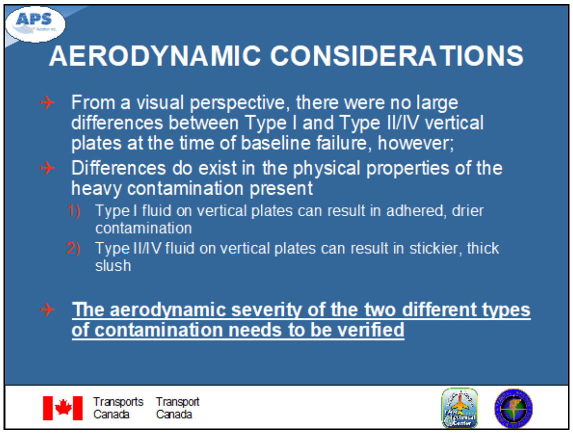

AERODYNAMIC CONSIDERATIONS

- From a visual perspective, there were no large differences between Type I and Type II/IV vertical plates at the time of baseline failure, however;
- Differences do exist in the physical properties of the heavy contamination present
  1) Type I fluid on vertical plates can result in adhered, drier contamination
  2) Type II/IV fluid on vertical plates can result in stickier, thick slush
- **The aerodynamic severity of the two different types of contamination needs to be verified**

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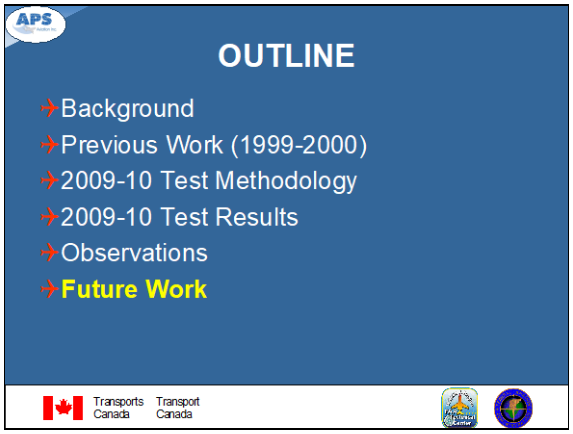

OUTLINE

- Background
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- **Future Work**

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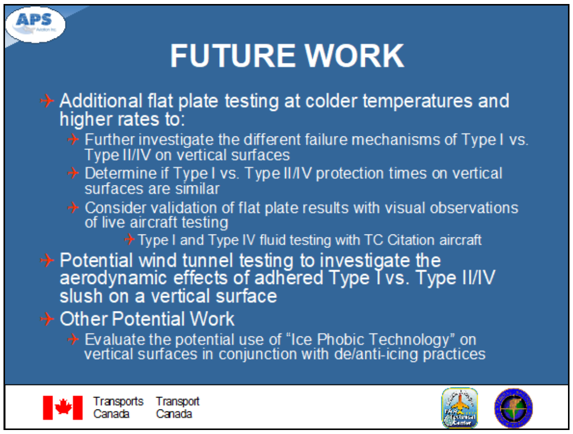

FUTURE WORK

- Additional flat plate testing at colder temperatures and higher rates to:
  - Further investigate the different failure mechanisms of Type I vs. Type II/IV on vertical surfaces
  - Determine if Type I vs. Type II/IV protection times on vertical surfaces are similar
  - Consider validation of flat plate results with visual observations of live aircraft testing
    - Type I and Type IV fluid testing with TC Citation aircraft
- Potential wind tunnel testing to investigate the aerodynamic effects of adhered Type I vs. Type II/IV slush on a vertical surface
- Other Potential Work
  - Evaluate the potential use of "Ice Phobic Technology" on vertical surfaces in conjunction with de/anti-icing practices

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APS Aviation Inc.

Marco Ruggi
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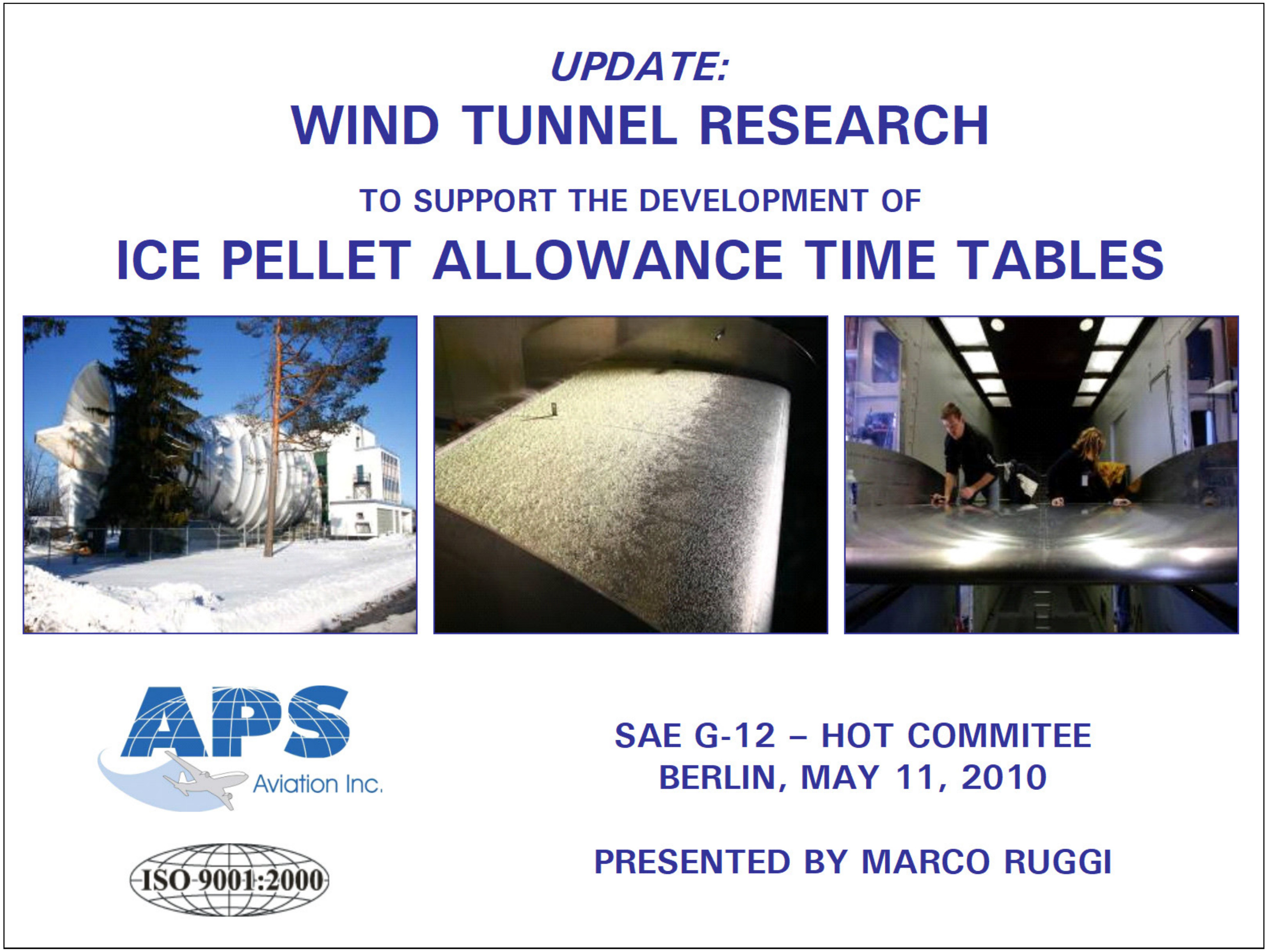


UPDATE:

WIND TUNNEL RESEARCH

TO SUPPORT THE DEVELOPMENT OF

ICE PELLET ALLOWANCE TIME TABLES

APS
Aviation Inc.
ISO 9001:2000

SAE G-12 – HOT COMMITEE
BERLIN, MAY 11, 2010

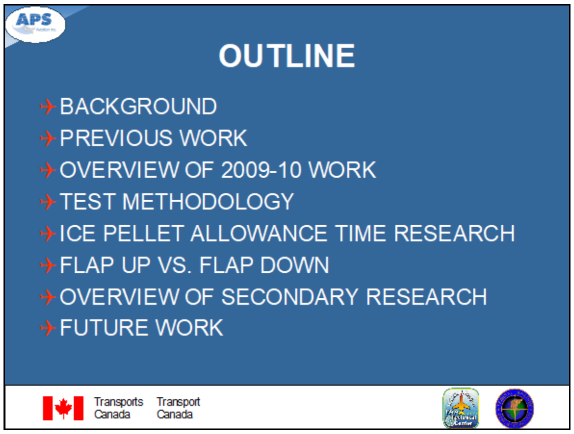
PRESENTED BY MARCO RUGGI

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

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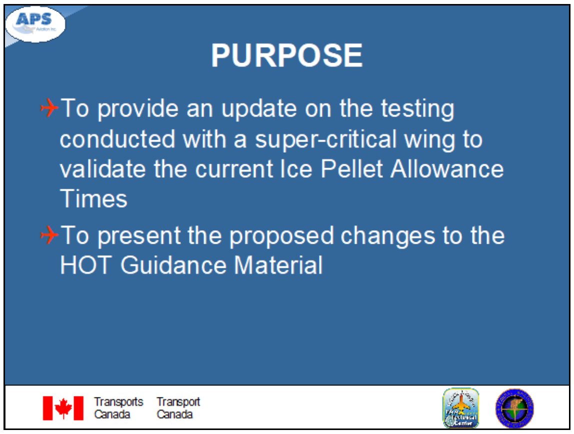
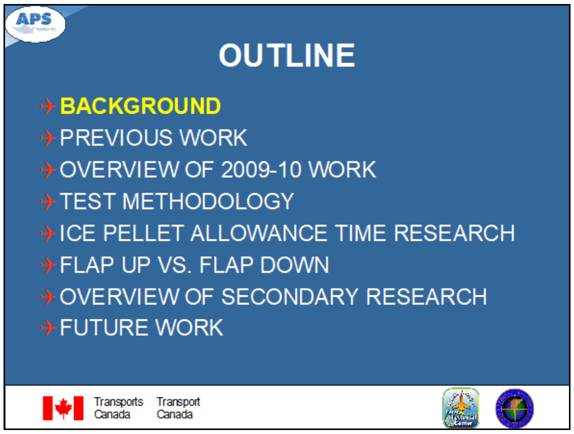
- OVERVIEW OF 2009-10 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
- FLAP UP VS. FLAP DOWN
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK



PURPOSE

- To provide an update on the testing conducted with a super-critical wing to validate the current Ice Pellet Allowance Times
- To present the proposed changes to the HOT Guidance Material



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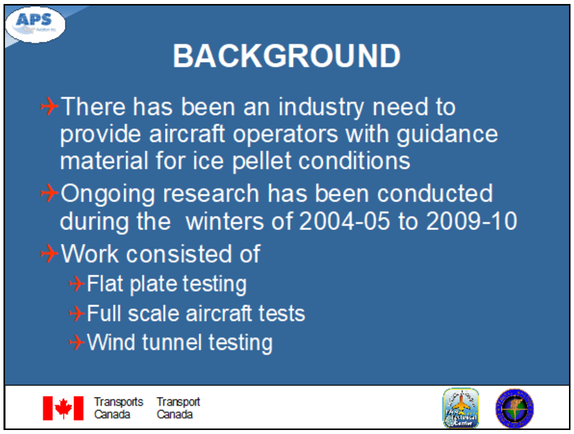
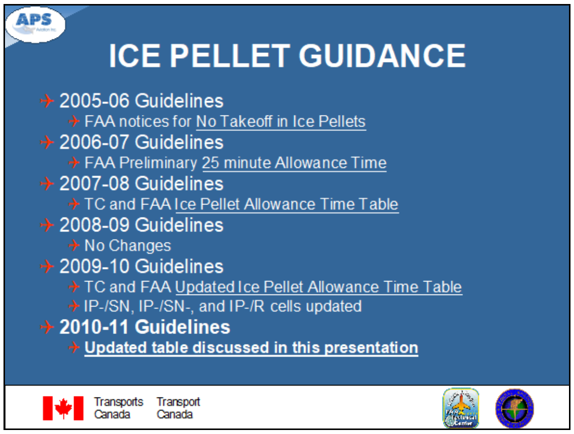


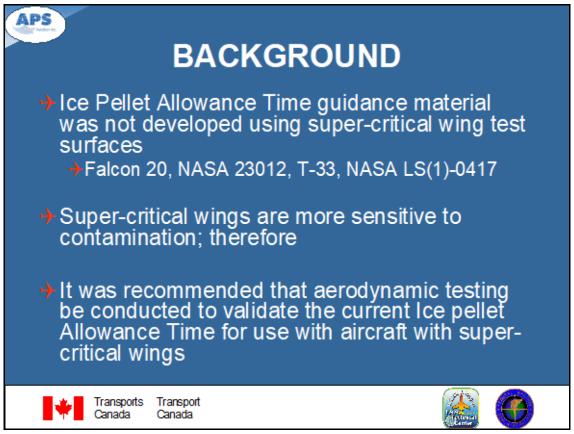
BACKGROUND

- There has been an industry need to provide aircraft operators with guidance material for ice pellet conditions
- Ongoing research has been conducted during the winters of 2004-05 to 2009-10
- Work consisted of
  - Flat plate testing
  - Full scale aircraft tests
  - Wind tunnel testing



ICE PELLET GUIDANCE

- 2005-06 Guidelines
  - FAA notices for No Takeoff in Ice Pellets
- 2006-07 Guidelines
  - FAA Preliminary 25 minute Allowance Time
- 2007-08 Guidelines
  - TC and FAA Ice Pellet Allowance Time Table
- 2008-09 Guidelines
  - No Changes
- 2009-10 Guidelines
  - TC and FAA Updated Ice Pellet Allowance Time Table
  - IP-/SN, IP-/SN-, and IP-/R cells updated
- **2010-11 Guidelines**
  - **Updated table discussed in this presentation**



BACKGROUND

- Ice Pellet Allowance Time guidance material was not developed using super-critical wing test surfaces
  - Falcon 20, NASA 23012, T-33, NASA LS(1)-0417
- Super-critical wings are more sensitive to contamination; therefore
- It was recommended that aerodynamic testing be conducted to validate the current Ice pellet Allowance Time for use with aircraft with super-critical wings

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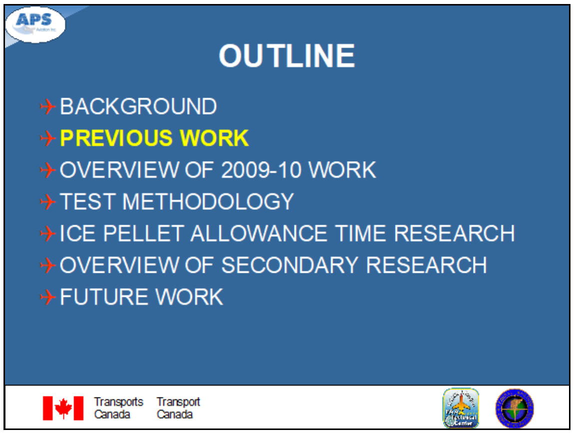

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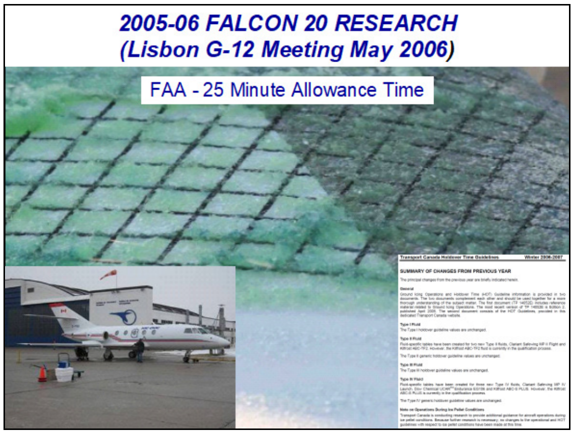


2005-06 FALCON 20 RESEARCH (Lisbon G-12 Meeting May 2006)

FAA - 25 Minute Allowance Time

Transport Canada Holdover Time Guidelines **Winter 2006-2007**

SUMMARY OF CHANGES FROM PREVIOUS YEAR

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

General

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

Type I Fluid

The Type I holdover guideline values are unchanged.

Type II Fluid

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

The Type II generic holdover guideline values are unchanged.

Type III Fluid

The Type III holdover guideline values are unchanged.

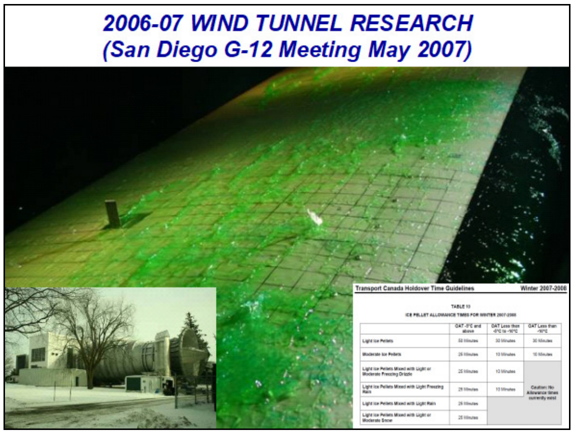
Type IV Fluid

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

The Type IV generic holdover guideline values are unchanged.

Note on Operations During Ice Pellet Conditions

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



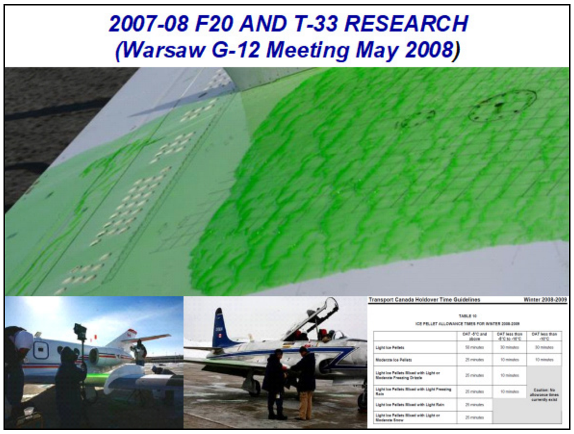
2006-07 WIND TUNNEL RESEARCH (San Diego G-12 Meeting May 2007)

Transport Canada Holdover Time Guidelines **Winter 2007-2008**

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		



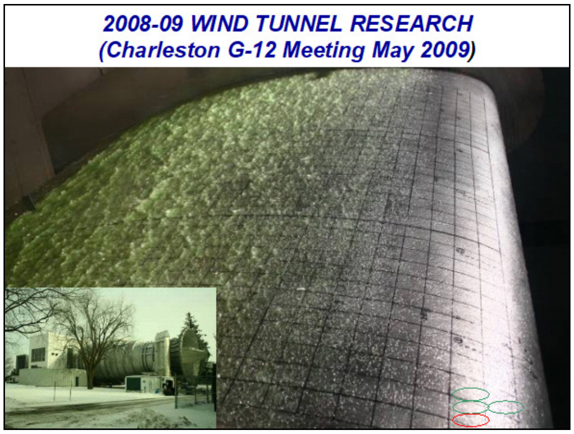
2007-08 F20 AND T-33 RESEARCH (Warsaw G-12 Meeting May 2008)

Transport Canada Holdover Time Guidelines **Winter 2008-2009**

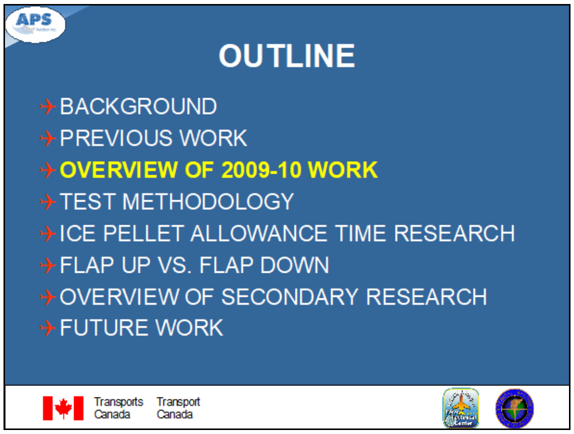
TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		



2008-09 WIND TUNNEL RESEARCH (Charleston G-12 Meeting May 2009)



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2009-10 TEST PLAN

- Primary Research Objectives
  - Validation of Current Allowance Times for super critical wing
  - Expansion of Allowance Times
- Secondary Research Objectives
  - Type III Allowance Times
  - Heavy Snow
  - Snow on a Dry Wing
  - Effect of Ice Phobic Products
  - Effect of Runway Deicer
  - Surface Roughness Tests
  - Effect of Contaminated Flap
  - ZR-/SN

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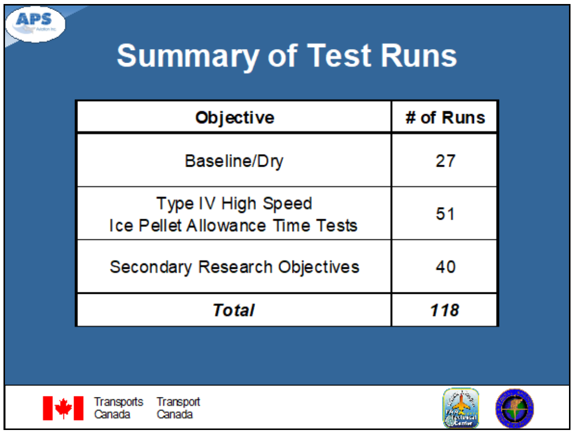

Summary of Test Runs

Objective	# of Runs
Baseline/Dry	27
Type IV High Speed Ice Pellet Allowance Time Tests	51
Secondary Research Objectives	40
Total	***118***

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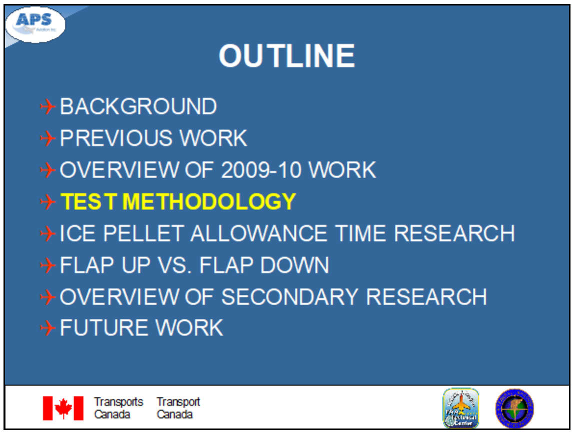
2009-10 RESEARCH TEAM



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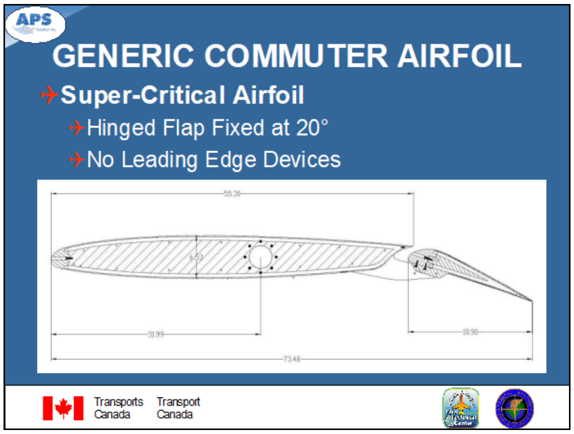

GENERIC COMMUTER AIRFOIL

- **Super-Critical Airfoil**
  - Hinged Flap Fixed at 20°
  - No Leading Edge Devices

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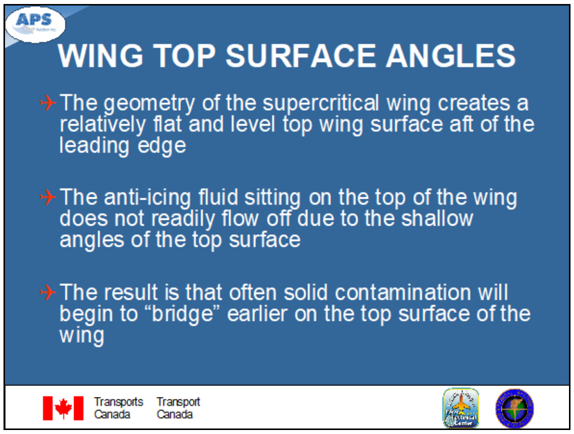

WING TOP SURFACE ANGLES

- The geometry of the supercritical wing creates a relatively flat and level top wing surface aft of the leading edge
- The anti-icing fluid sitting on the top of the wing does not readily flow off due to the shallow angles of the top surface
- The result is that often solid contamination will begin to “bridge” earlier on the top surface of the wing

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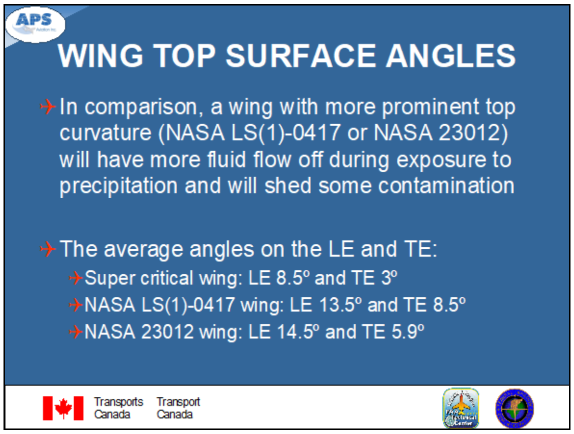

WING TOP SURFACE ANGLES

- In comparison, a wing with more prominent top curvature (NASA LS(1)-0417 or NASA 23012) will have more fluid flow off during exposure to precipitation and will shed some contamination
- The average angles on the LE and TE:
  - Super critical wing: LE 8.5º and TE 3º
  - NASA LS(1)-0417 wing: LE 13.5º and TE 8.5º
  - NASA 23012 wing: LE 14.5º and TE 5.9º

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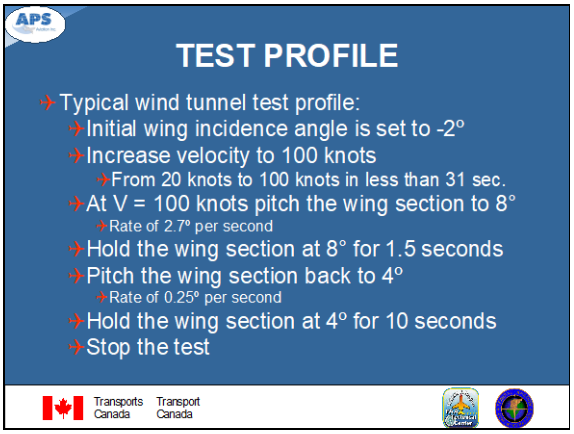

TEST PROFILE

- Typical wind tunnel test profile:
  - Initial wing incidence angle is set to -2º
  - Increase velocity to 100 knots
    - From 20 knots to 100 knots in less than 31 sec.
  - At V = 100 knots pitch the wing section to 8°
    - Rate of 2.7º per second
  - Hold the wing section at 8° for 1.5 seconds
  - Pitch the wing section back to 4º
    - Rate of 0.25º per second
  - Hold the wing section at 4º for 10 seconds
  - Stop the test

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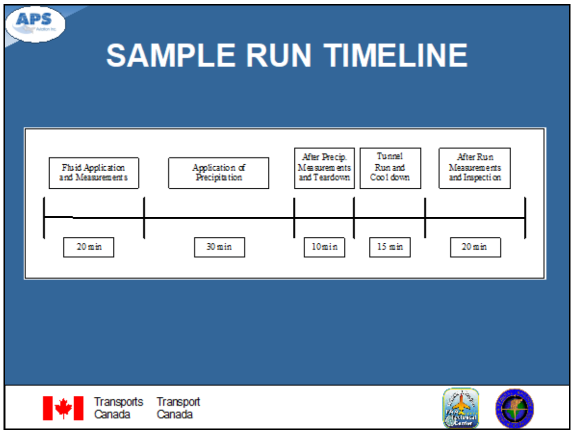

SAMPLE RUN TIMELINE

Fluid Application and Measurements
Application of Precipitation
After Precip. Measurements and Teardown
Tunnel Run and Cool down
After Run Measurements and Inspection

20 min
30 min
10min
15 min
20 min

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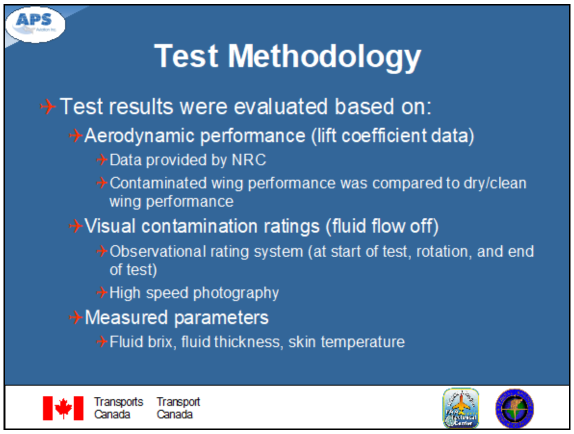

Test Methodology

- Test results were evaluated based on:
  - Aerodynamic performance (lift coefficient data)
    - Data provided by NRC
    - Contaminated wing performance was compared to dry/clean wing performance
  - Visual contamination ratings (fluid flow off)
    - Observational rating system (at start of test, rotation, and end of test)
    - High speed photography
  - Measured parameters
    - Fluid brix, fluid thickness, skin temperature

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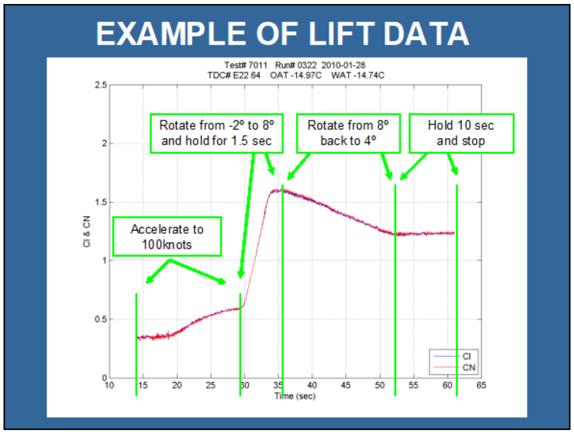
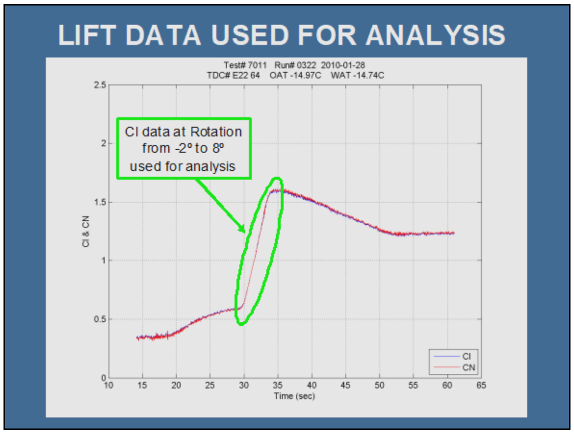
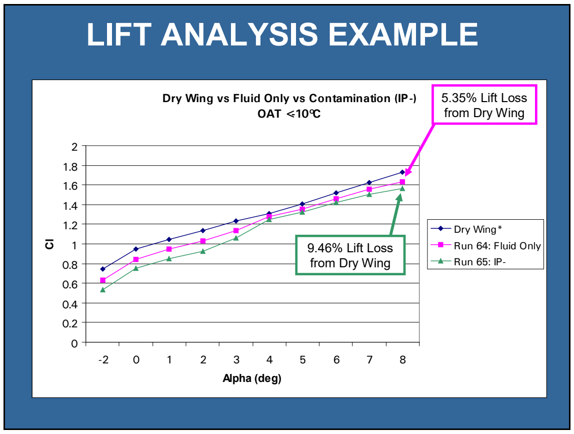


EXAMPLE OF LIFT DATA



LIFT DATA USED FOR ANALYSIS

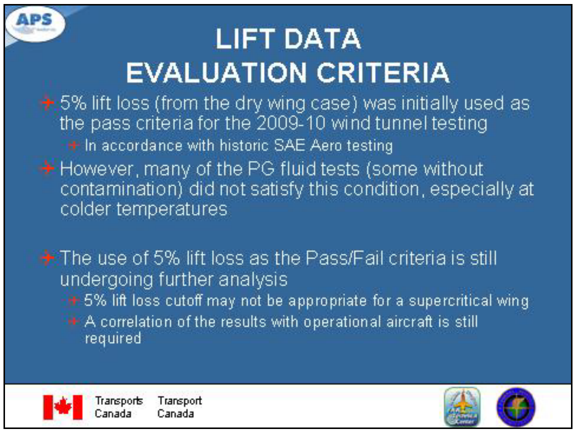
Cl data at Rotation from -2° to 8° used for analysis



LIFT ANALYSIS EXAMPLE

5.35% Lift Loss from Dry Wing

9.46% Lift Loss from Dry Wing



LIFT DATA EVALUATION CRITERIA

- 5% lift loss (from the dry wing case) was initially used as the pass criteria for the 2009-10 wind tunnel testing
  - In accordance with historic SAE Aero testing
- However, many of the PG fluid tests (some without contamination) did not satisfy this condition, especially at colder temperatures
- The use of 5% lift loss as the Pass/Fail criteria is still undergoing further analysis
  - 5% lift loss cutoff may not be appropriate for a supercritical wing
  - A correlation of the results with operational aircraft is still required

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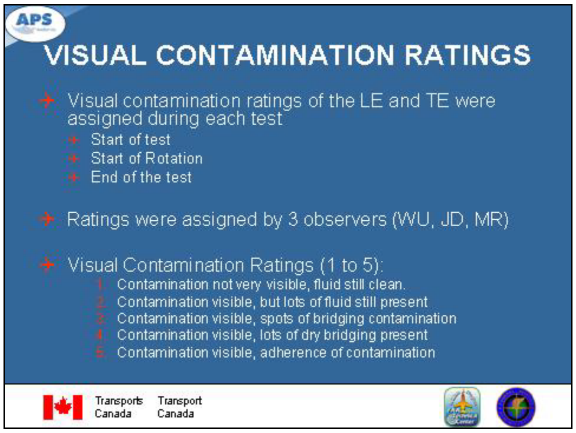

VISUAL CONTAMINATION RATINGS

- Visual contamination ratings of the LE and TE were assigned during each test
  - Start of test
  - Start of Rotation
  - End of the test
- Ratings were assigned by 3 observers (WU, JD, MR)
- Visual Contamination Ratings (1 to 5):
  1. Contamination not very visible, fluid still clean.
  2. Contamination visible, but lots of fluid still present
  3. Contamination visible, spots of bridging contamination
  4. Contamination visible, lots of dry bridging present
  5. Contamination visible, adherence of contamination

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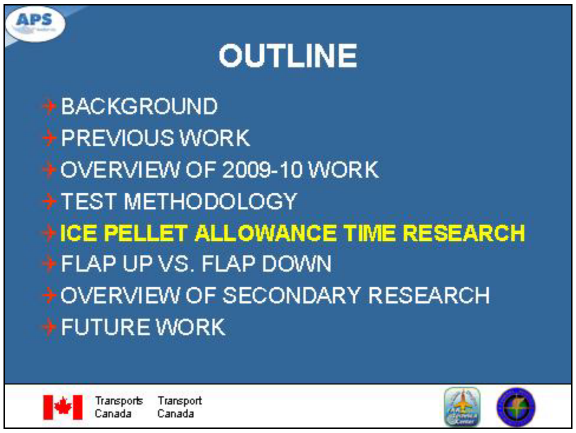

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- OVERVIEW OF 2009-10 WORK
- TEST METHODOLOGY
- **ICE PELLET ALLOWANCE TIME RESEARCH**
- FLAP UP VS. FLAP DOWN
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK

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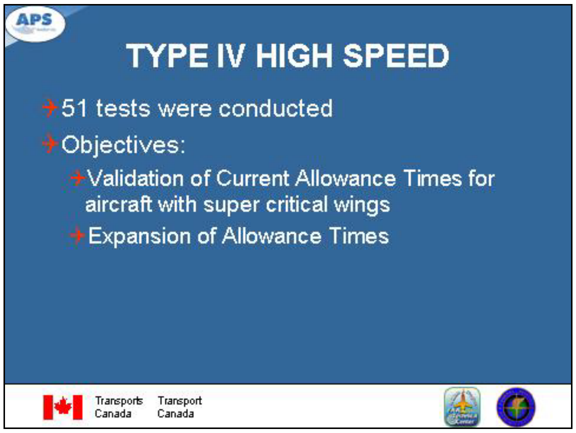

TYPE IV HIGH SPEED

- 51 tests were conducted
- Objectives:
  - Validation of Current Allowance Times for aircraft with super critical wings
  - Expansion of Allowance Times

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RESULTS

- EG Fluid Type IV
  - Generally performed well in all IP allowance time conditions
  - Typically lift losses were less than 5% from the dry wing in most conditions
- PG fluid Type IV
  - Potential fluid flow-off issues observed below -5ºC
    - Lift losses >5% from the dry wing for some fluid only cases
    - Increasingly larger lift losses for some contamination cases (close to 10% from the dry wing)
  - Larger lift losses were observed below -10ºC

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Example: Type IV EG Validation Test - Light Ice Pellets

Run #	Test Condition	Fluid Name	Target Temp.	Actual Temp.	IP Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
75	Fluid Only	Type IV EG	<-10°C	-18.1°C	N/A	1/1/1	1/1/1	1.651	4.37
80	IP-	Type IV EG	<-10°C	-17.0°C	25	2.5/2.2/3	1/1.25/1.7	1.67	3.27

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2009-10 ICE PELLET ALLOWANCE TIME TABLE

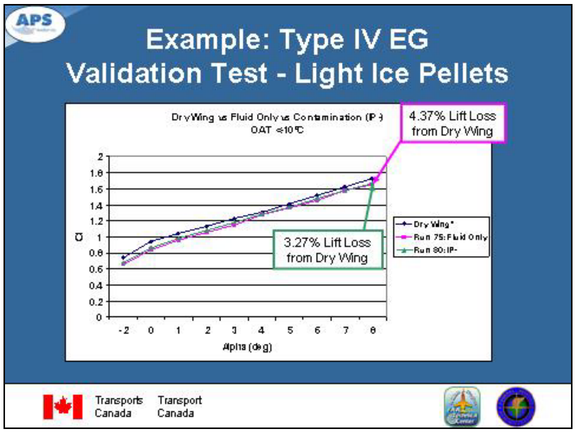
Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

Example: Type IV EG Validation Test - Light Ice Pellets



RUN #80

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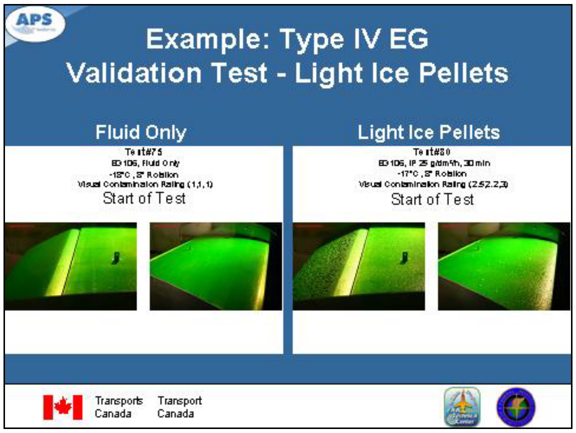
Example: Type IV EG Validation Test - Light Ice Pellets

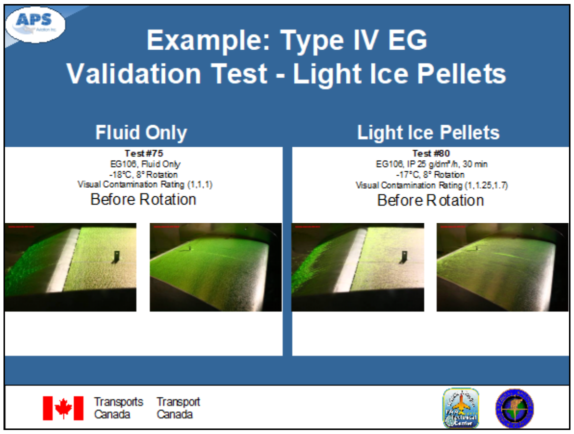


Fluid Only

Test#75
EG106, Fluid Only
-18°C, 8° Rotation
Visual Contamination Rating (1,1,1)
Start of Test

Light Ice Pellets

Test#80
EG106, IP 25 g/dm²/h, 30 min
-17°C, 8° Rotation
Visual Contamination Rating (2.5,2.2,3)
Start of Test



Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test #75
EG106, Fluid Only
-18°C, 8° Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

Light Ice Pellets

Test #80
EG106, IP 25 g/dm²/h, 30 min
-17°C, 8° Rotation
Visual Contamination Rating (1,1.25,1.7)
Before Rotation

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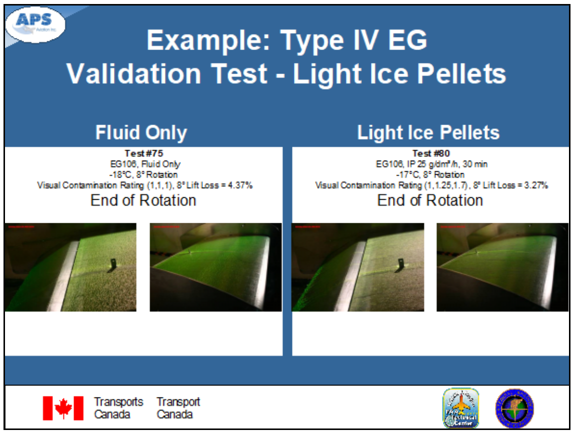

Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test #75
EG106, Fluid Only
-18°C, 8° Rotation
Visual Contamination Rating (1,1,1), 8° Lift Loss = 4.37%
End of Rotation

Light Ice Pellets

Test #80
EG106, IP 25 g/dm²/h, 30 min
-17°C, 8° Rotation
Visual Contamination Rating (1,1.25,1.7), 8° Lift Loss = 3.27%
End of Rotation

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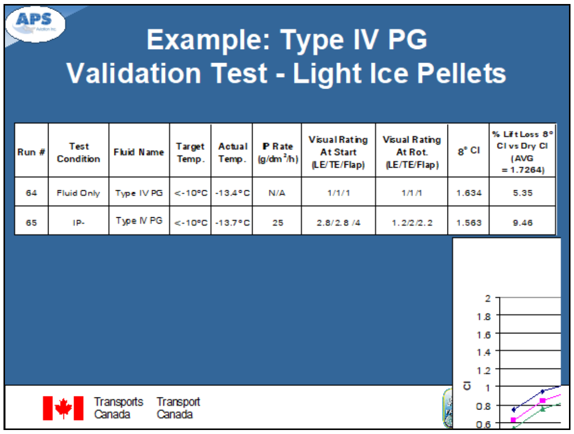

Example: Type IV PG Validation Test - Light Ice Pellets

Run #	Test Condition	Fluid Name	Target Temp.	Actual Temp.	IP Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
64	Fluid Only	Type IV PG	<-10°C	-13.4°C	N/A	1/1/1	1/1/1	1.634	5.35
65	IP-	Type IV PG	<-10°C	-13.7°C	25	2.8/2.8 /4	1.2/2/2.2	1.563	9.46

2
1.8
1.6
1.4
1.2
1
0.8
0.6
Cl

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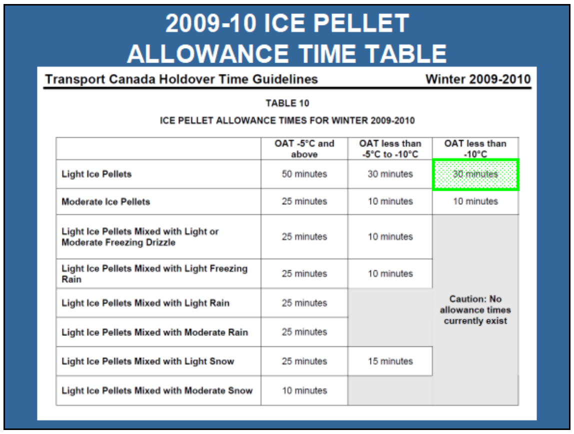


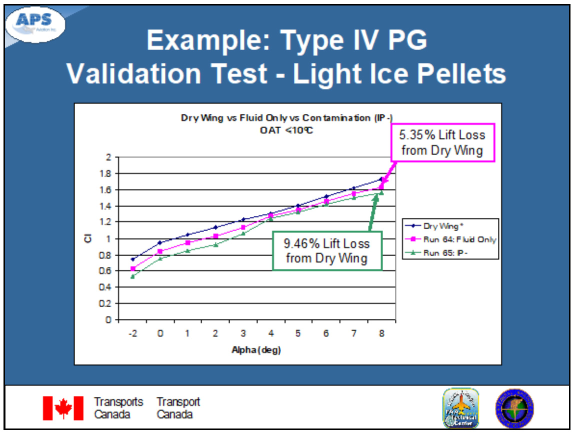
2009-10 ICE PELLET ALLOWANCE TIME TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		



Example: Type IV PG Validation Test - Light Ice Pellets

5.35% Lift Loss from Dry Wing

9.46% Lift Loss from Dry Wing

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RUN #65

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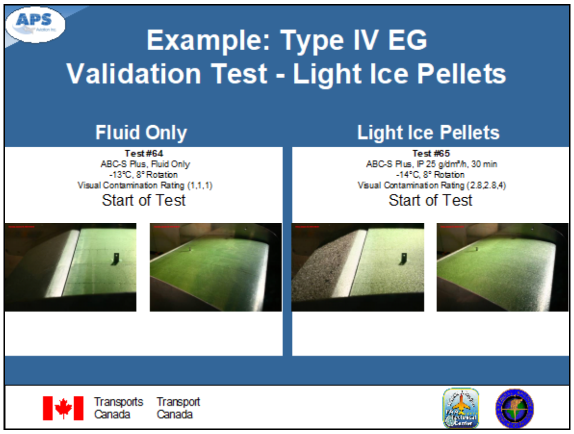

Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test #64
ABC-S Plus, Fluid Only
-13°C, 8° Rotation
Visual Contamination Rating (1,1,1)
Start of Test

Light Ice Pellets

Test #65
ABC-S Plus, IP 25 $g/dm^2/h$, 30 min
-14°C, 8° Rotation
Visual Contamination Rating (2.8,2.8,4)
Start of Test

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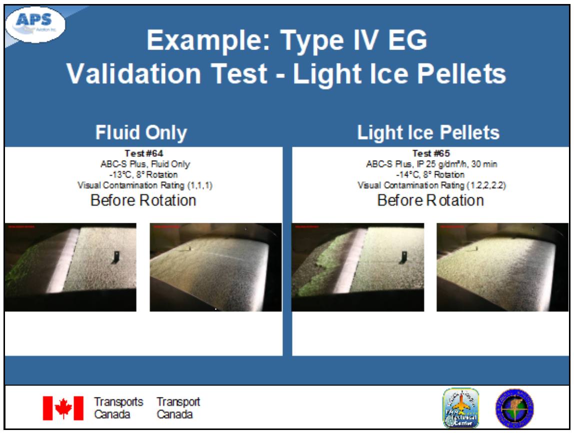

Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test #64
ABC-S Plus, Fluid Only
-13°C, 8° Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

Light Ice Pellets

Test #65
ABC-S Plus, IP 25 $g/dm^2/h$, 30 min
-14°C, 8° Rotation
Visual Contamination Rating (1.2,2,2.2)
Before Rotation

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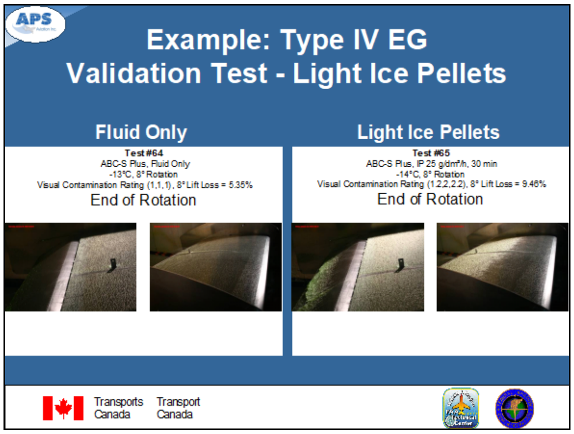

Example: Type IV EG Validation Test - Light Ice Pellets

Fluid Only

Test #64
ABC-S Plus, Fluid Only
-13°C, 8° Rotation
Visual Contamination Rating (1,1,1), 8° Lift Loss = 5.35%
End of Rotation

Light Ice Pellets

Test #65
ABC-S Plus, IP 25 $g/dm^2/h$, 30 min
-14°C, 8° Rotation
Visual Contamination Rating (1.2,2,2.2), 8° Lift Loss = 9.46%
End of Rotation

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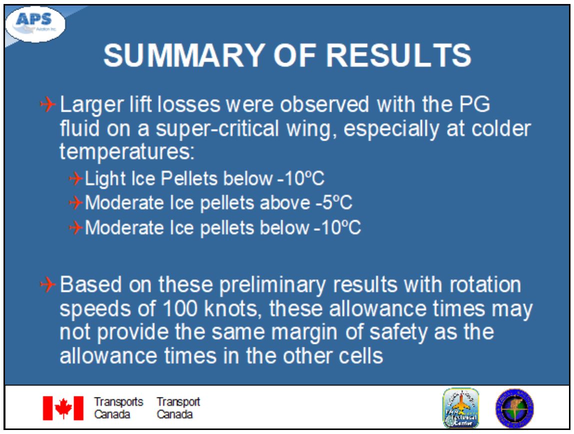

SUMMARY OF RESULTS

- Larger lift losses were observed with the PG fluid on a super-critical wing, especially at colder temperatures:
  - Light Ice Pellets below -10°C
  - Moderate Ice pellets above -5°C
  - Moderate Ice pellets below -10°C
- Based on these preliminary results with rotation speeds of 100 knots, these allowance times may not provide the same margin of safety as the allowance times in the other cells

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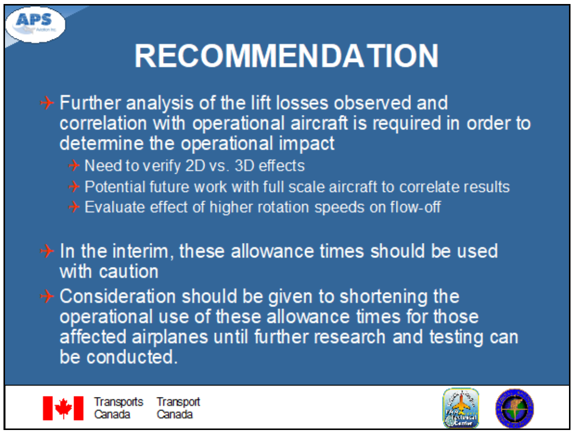

RECOMMENDATION

- Further analysis of the lift losses observed and correlation with operational aircraft is required in order to determine the operational impact
  - Need to verify 2D vs. 3D effects
  - Potential future work with full scale aircraft to correlate results
  - Evaluate effect of higher rotation speeds on flow-off
- In the interim, these allowance times should be used with caution
- Consideration should be given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted.

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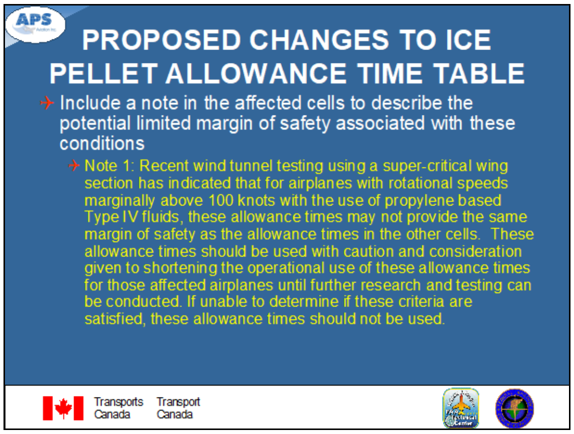

PROPOSED CHANGES TO ICE PELLET ALLOWANCE TIME TABLE

- Include a note in the affected cells to describe the potential limited margin of safety associated with these conditions
  - Note 1: Recent wind tunnel testing using a super-critical wing section has indicated that for airplanes with rotational speeds marginally above 100 knots with the use of propylene based Type IV fluids, these allowance times may not provide the same margin of safety as the allowance times in the other cells. These allowance times should be used with caution and consideration given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted. If unable to determine if these criteria are satisfied, these allowance times should not be used.

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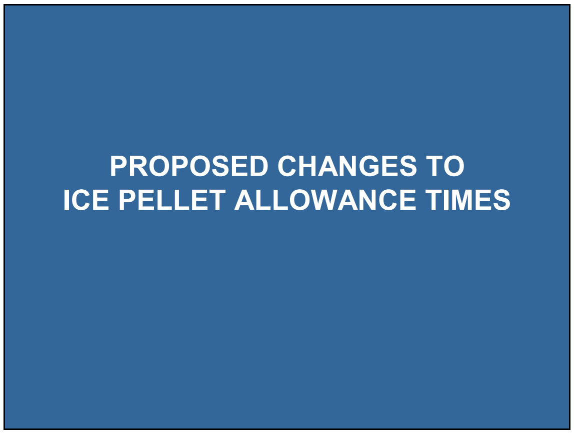
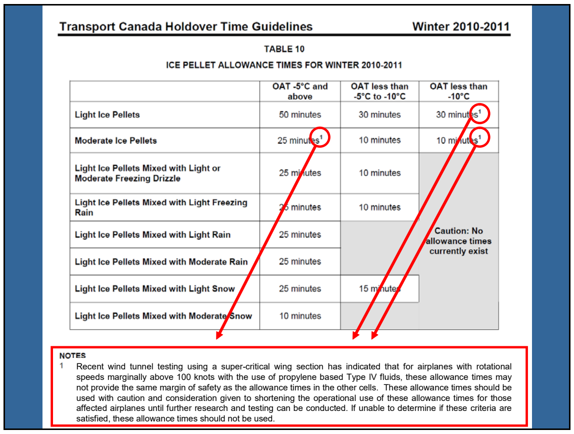


PROPOSED CHANGES TO ICE PELLET ALLOWANCE TIMES



Transport Canada Holdover Time Guidelines Winter 2010-2011

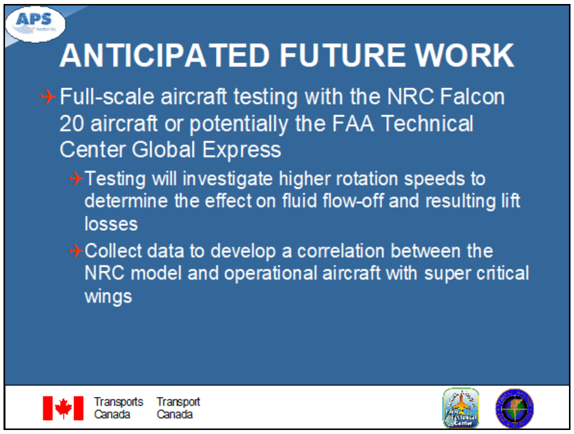
TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[1]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

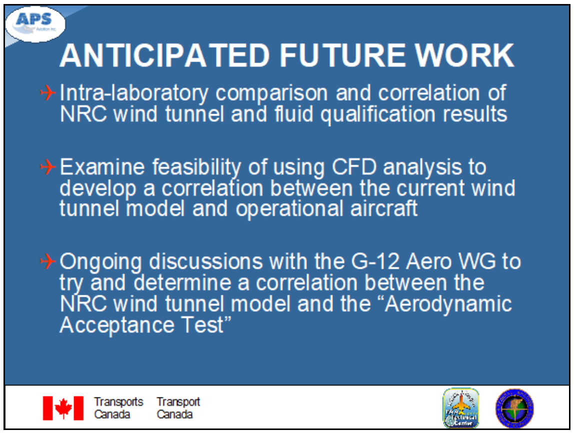
NOTES

[1] Recent wind tunnel testing using a super-critical wing section has indicated that for airplanes with rotational speeds marginally above 100 knots with the use of propylene based Type IV fluids, these allowance times may not provide the same margin of safety as the allowance times in the other cells. These allowance times should be used with caution and consideration given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted. If unable to determine if these criteria are satisfied, these allowance times should not be used.



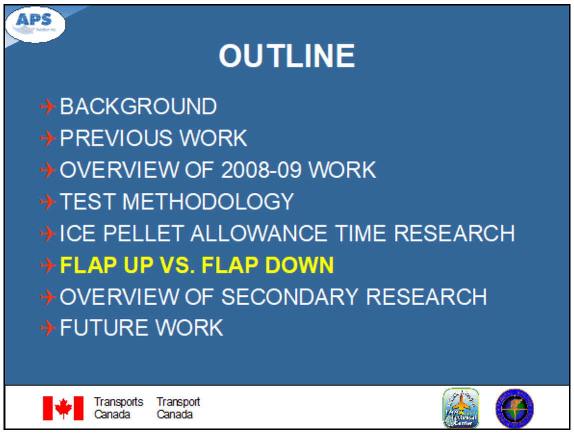
ANTICIPATED FUTURE WORK

- Full-scale aircraft testing with the NRC Falcon 20 aircraft or potentially the FAA Technical Center Global Express
  - Testing will investigate higher rotation speeds to determine the effect on fluid flow-off and resulting lift losses
  - Collect data to develop a correlation between the NRC model and operational aircraft with super critical wings



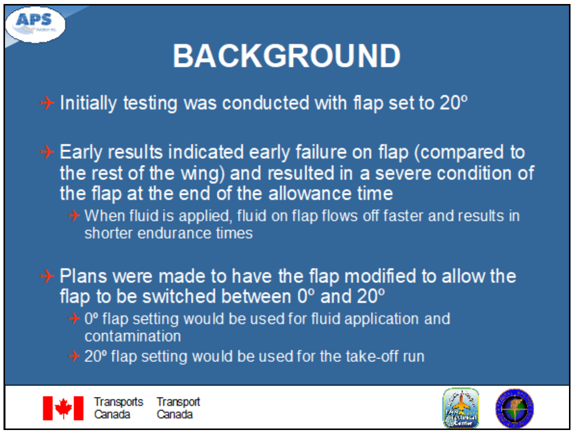
ANTICIPATED FUTURE WORK

- Intra-laboratory comparison and correlation of NRC wind tunnel and fluid qualification results
- Examine feasibility of using CFD analysis to develop a correlation between the current wind tunnel model and operational aircraft
- Ongoing discussions with the G-12 Aero WG to try and determine a correlation between the NRC wind tunnel model and the “Aerodynamic Acceptance Test”



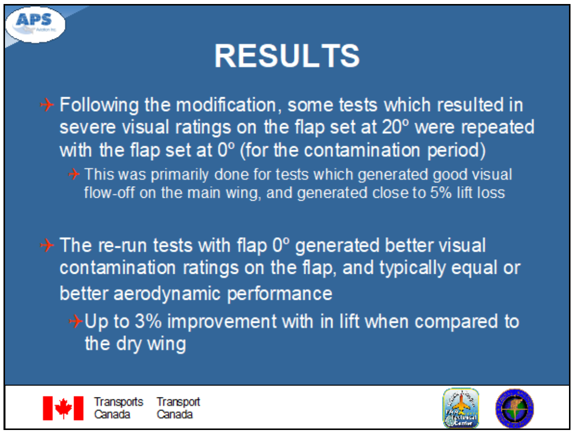
OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
- **FLAP UP VS. FLAP DOWN**
- OVERVIEW OF SECONDARY RESEARCH
- FUTURE WORK



BACKGROUND

- Initially testing was conducted with flap set to 20º
- Early results indicated early failure on flap (compared to the rest of the wing) and resulted in a severe condition of the flap at the end of the allowance time
  - When fluid is applied, fluid on flap flows off faster and results in shorter endurance times
- Plans were made to have the flap modified to allow the flap to be switched between 0º and 20º
  - 0º flap setting would be used for fluid application and contamination
  - 20º flap setting would be used for the take-off run



RESULTS

- Following the modification, some tests which resulted in severe visual ratings on the flap set at 20° were repeated with the flap set at 0° (for the contamination period)
  - This was primarily done for tests which generated good visual flow-off on the main wing, and generated close to 5% lift loss
- The re-run tests with flap 0° generated better visual contamination ratings on the flap, and typically equal or better aerodynamic performance
  - Up to 3% improvement with in lift when compared to the dry wing

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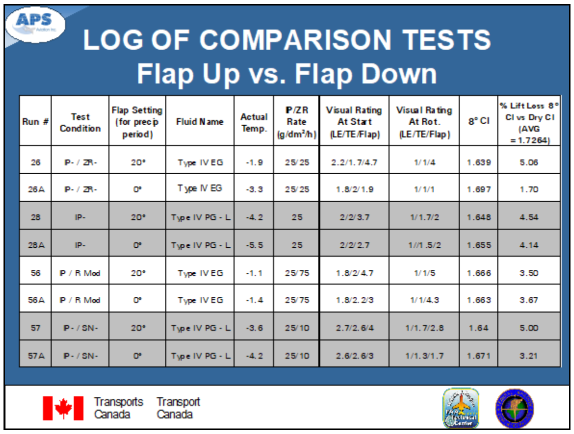

LOG OF COMPARISON TESTS
Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	IP/ZR Rate ($g/dm^2/h$)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
26	IP- / ZR-	20°	Type IV EG	-1.9	25/25	2.2/1.7/4.7	1/1/4	1.639	5.06
26A	IP- / ZR-	0°	Type IV EG	-3.3	25/25	1.8/2/1.9	1/1/1	1.697	1.70
28	IP-	20°	Type IV PG - L	-4.2	25	2/2/3.7	1/1.7/2	1.648	4.54
28A	IP-	0°	Type IV PG - L	-5.5	25	2/2/2.7	1//1.5/2	1.655	4.14
56	IP / R Mod	20°	Type IV EG	-1.1	25/75	1.8/2/4.7	1/1/5	1.666	3.50
56A	IP / R Mod	0°	Type IV EG	-1.4	25/75	1.8/2.2/3	1/1/4.3	1.663	3.67
57	IP- / SN-	20°	Type IV PG - L	-3.6	25/10	2.7/2.6/4	1/1.7/2.8	1.64	5.00
57A	IP- / SN-	0°	Type IV PG - L	-4.2	25/10	2.6/2.6/3	1/1.3/1.7	1.671	3.21

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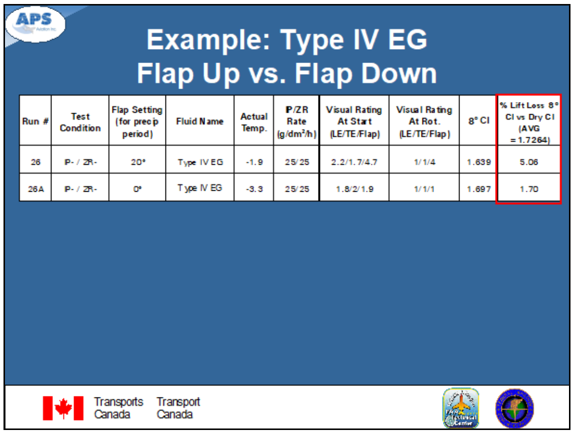

Example: Type IV EG
Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	IP/ZR Rate ($g/dm^2/h$)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
26	IP- / ZR-	20°	Type IV EG	-1.9	25/25	2.2/1.7/4.7	1/1/4	1.639	5.06
26A	IP- / ZR-	0°	Type IV EG	-3.3	25/25	1.8/2/1.9	1/1/1	1.697	1.70

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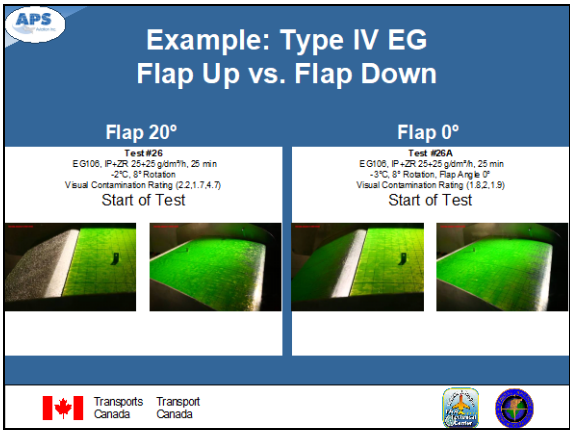


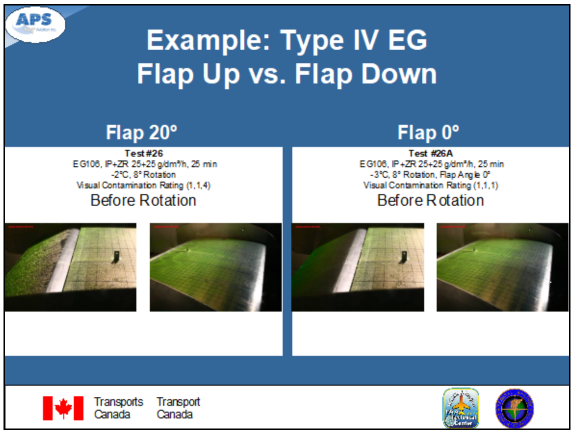
Example: Type IV EG
Flap Up vs. Flap Down

Flap 20°

Test #26
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (2.2,1.7,4.7)
Start of Test

Flap 0°

Test #26A
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1.8,2,1.9)
Start of Test



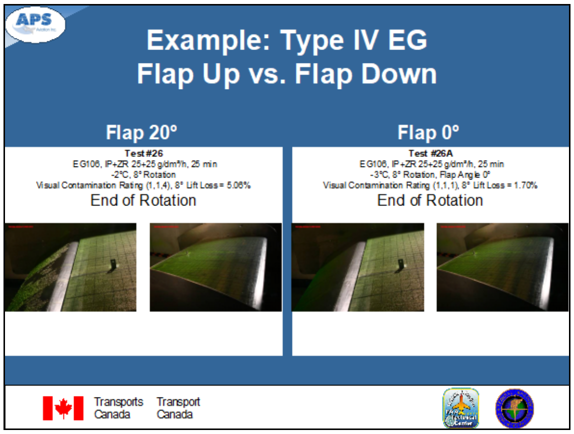
Example: Type IV EG
Flap Up vs. Flap Down

Flap 20°

Test #26
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (1,1,4)
Before Rotation

Flap 0°

Test #26A
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1,1,1)
Before Rotation



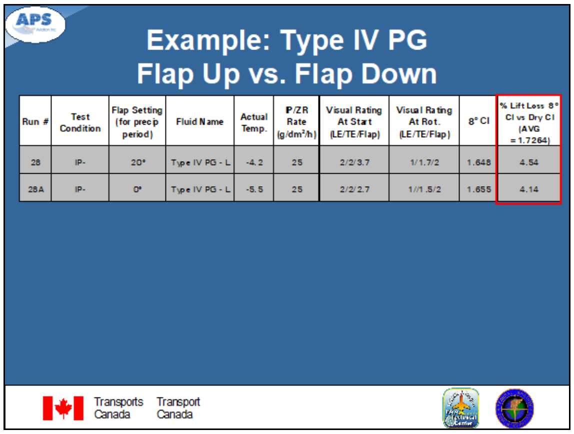
Example: Type IV EG
Flap Up vs. Flap Down

Flap 20°

Test #26
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (1,1,4), 8° Lift Loss = 5.06%
End of Rotation

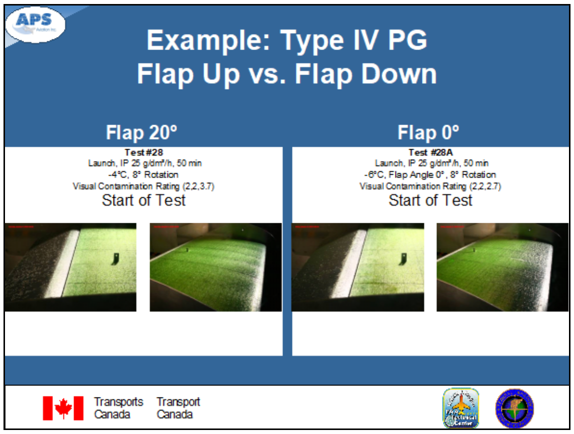
Flap 0°

Test #26A
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1,1,1), 8° Lift Loss = 1.70%
End of Rotation



Example: Type IV PG Flap Up vs. Flap Down

Run #	Test Condition	Flap Setting (for precip period)	Fluid Name	Actual Temp.	P/ZR Rate (g/dm²/h)	Visual Rating At Start (LE/TE/Flap)	Visual Rating At Rot. (LE/TE/Flap)	8° Cl	% Lift Loss 8° Cl vs Dry Cl (AVG = 1.7264)
28	IP-	20°	Type IV PG - L	-4.2	25	2/2/3.7	1/1.7/2	1.648	4.54
28A	IP-	0°	Type IV PG - L	-5.5	25	2/2/2.7	1//1.5/2	1.655	4.14



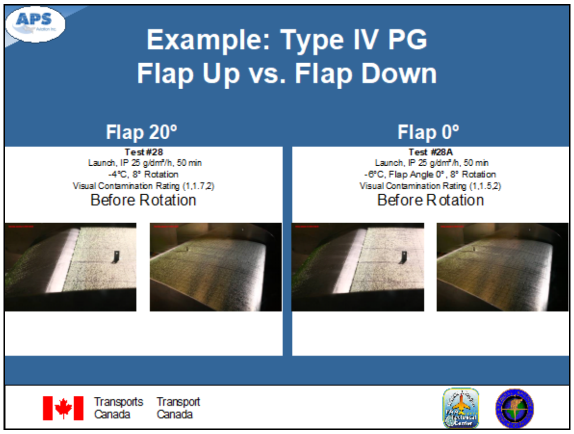
Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (2,2,3.7)
Start of Test

Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (2,2,2.7)
Start of Test



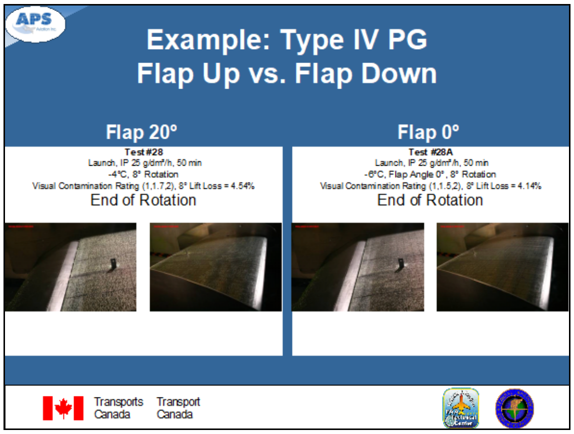
Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.7,2)
Before Rotation

Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (1,1.5,2)
Before Rotation



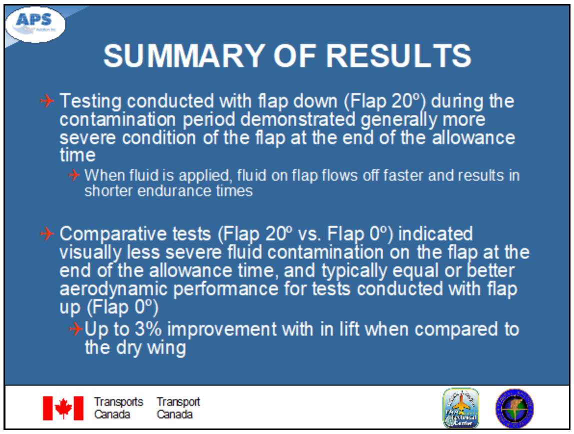
Example: Type IV PG Flap Up vs. Flap Down

Flap 20°

Test #28
Launch, IP 25 g/dm²/h, 50 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.7,2), 8° Lift Loss = 4.54%
End of Rotation

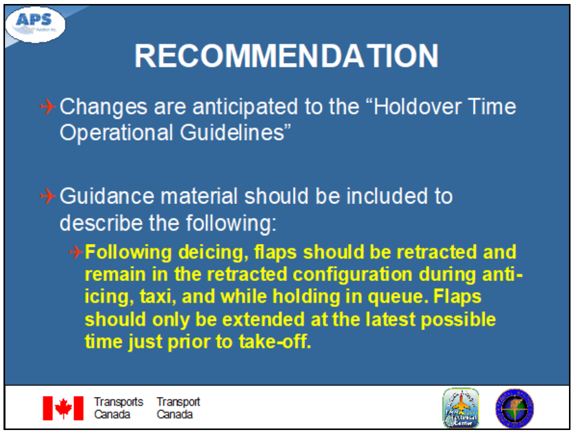
Flap 0°

Test #28A
Launch, IP 25 g/dm²/h, 50 min
-6°C, Flap Angle 0°, 8° Rotation
Visual Contamination Rating (1,1.5,2), 8° Lift Loss = 4.14%
End of Rotation



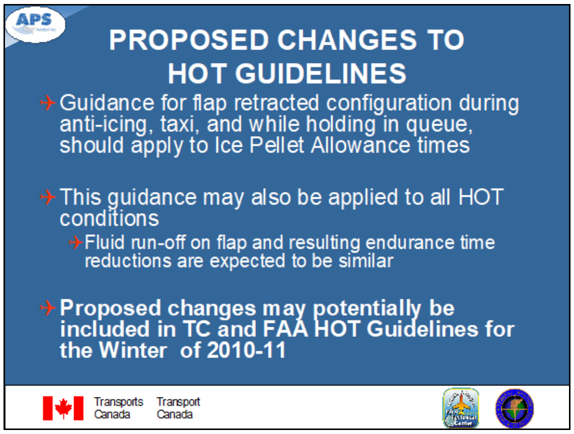
SUMMARY OF RESULTS

- Testing conducted with flap down (Flap 20°) during the contamination period demonstrated generally more severe condition of the flap at the end of the allowance time
  - When fluid is applied, fluid on flap flows off faster and results in shorter endurance times
- Comparative tests (Flap 20° vs. Flap 0°) indicated visually less severe fluid contamination on the flap at the end of the allowance time, and typically equal or better aerodynamic performance for tests conducted with flap up (Flap 0°)
  - Up to 3% improvement with in lift when compared to the dry wing



RECOMMENDATION

- Changes are anticipated to the “Holdover Time Operational Guidelines”
- Guidance material should be included to describe the following:
  - **Following deicing, flaps should be retracted and remain in the retracted configuration during anti-icing, taxi, and while holding in queue. Flaps should only be extended at the latest possible time just prior to take-off.**



PROPOSED CHANGES TO HOT GUIDELINES

- Guidance for flap retracted configuration during anti-icing, taxi, and while holding in queue, should apply to Ice Pellet Allowance times
- This guidance may also be applied to all HOT conditions
  - Fluid run-off on flap and resulting endurance time reductions are expected to be similar
- **Proposed changes may potentially be included in TC and FAA HOT Guidelines for the Winter of 2010-11**

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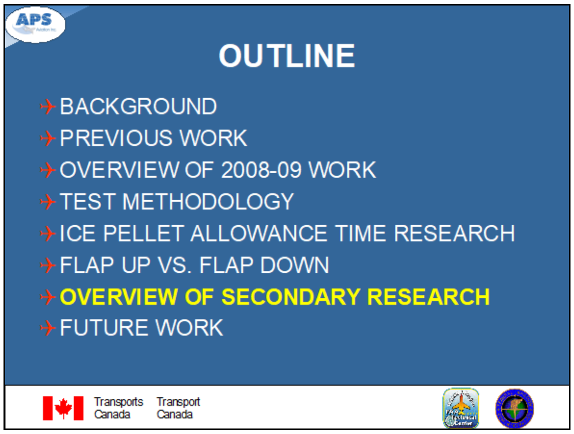

OUTLINE

- BACKGROUND
- PREVIOUS WORK
- OVERVIEW OF 2008-09 WORK
- TEST METHODOLOGY
- ICE PELLET ALLOWANCE TIME RESEARCH
- FLAP UP VS. FLAP DOWN
- **OVERVIEW OF SECONDARY RESEARCH**
- FUTURE WORK

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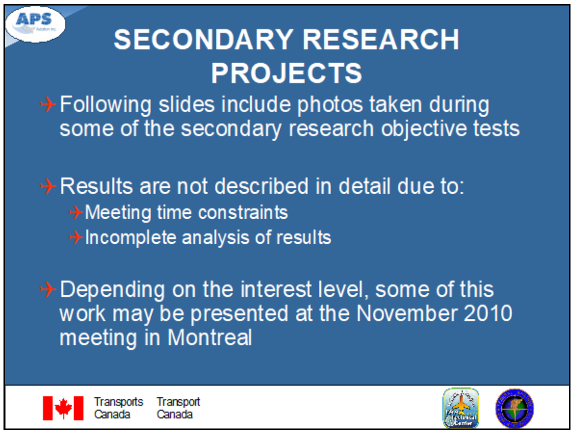

SECONDARY RESEARCH PROJECTS

- Following slides include photos taken during some of the secondary research objective tests
- Results are not described in detail due to:
  - Meeting time constraints
  - Incomplete analysis of results
- Depending on the interest level, some of this work may be presented at the November 2010 meeting in Montreal

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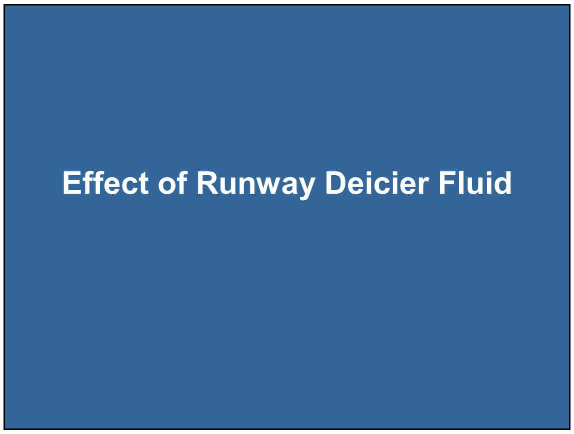
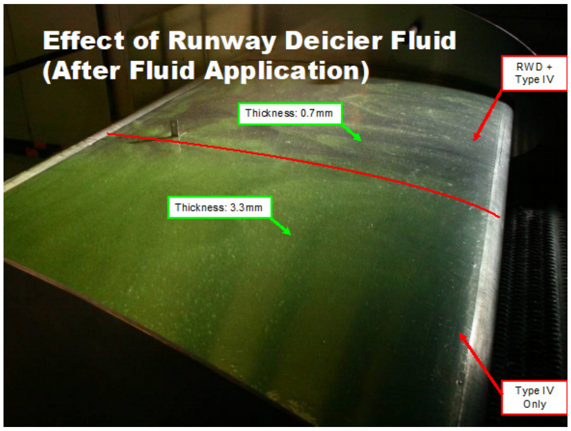
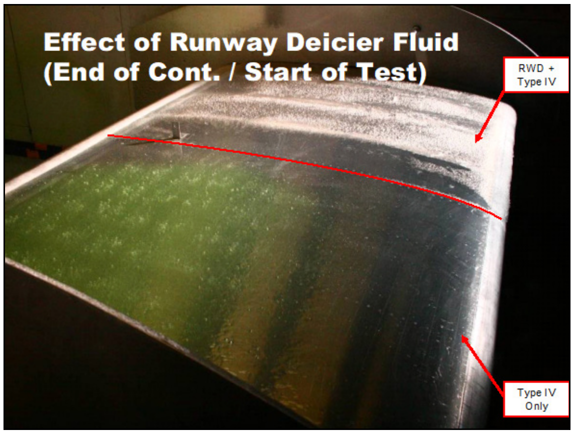


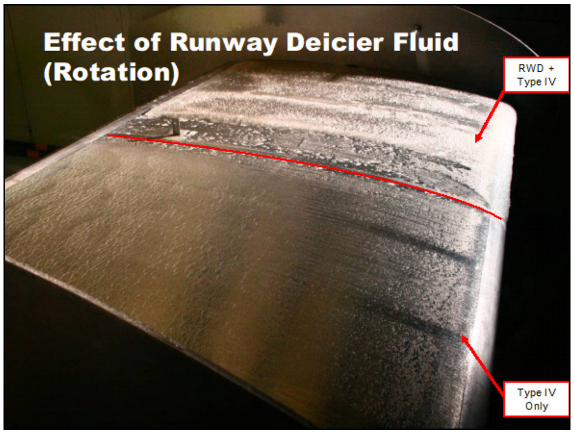
Effect of Runway Deicier Fluid



Effect of Runway Deicier Fluid (After Fluid Application)



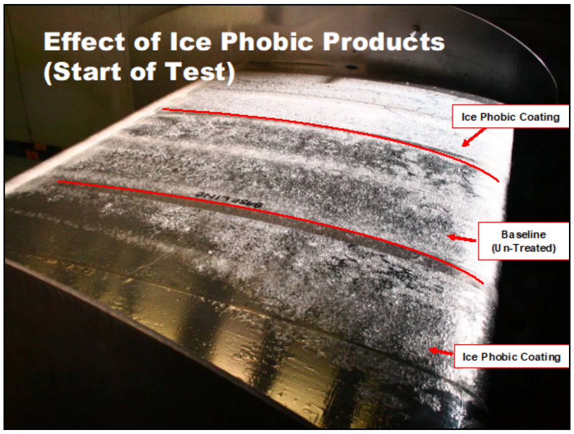
Effect of Runway Deicier Fluid (End of Cont. / Start of Test)



Effect of Runway Deicier Fluid (Rotation)

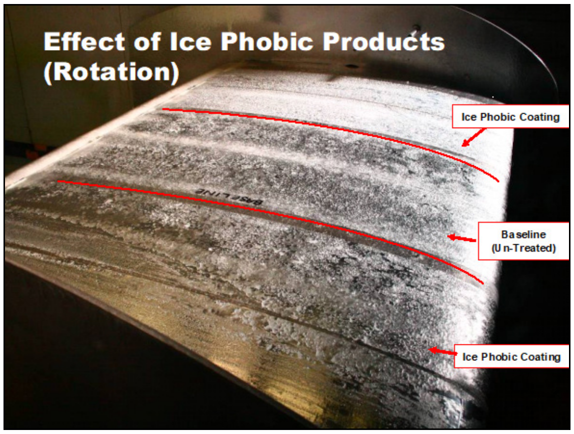
RWD + Type IV
Type IV Only

Effect of Ice Phobic Products



Effect of Ice Phobic Products (Start of Test)

Ice Phobic Coating
Baseline (Un-Treated)
Ice Phobic Coating



Effect of Ice Phobic Products (Rotation)

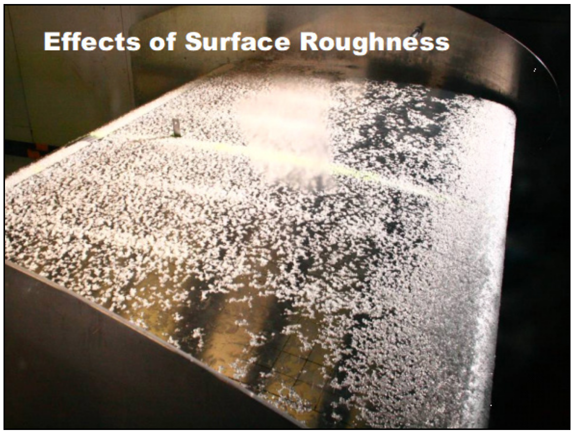
Ice Phobic Coating
Baseline (Un-Treated)
Ice Phobic Coating

Snow on an Un-Protected Wing

Snow on an Un-Protected Wing (Start of Test)

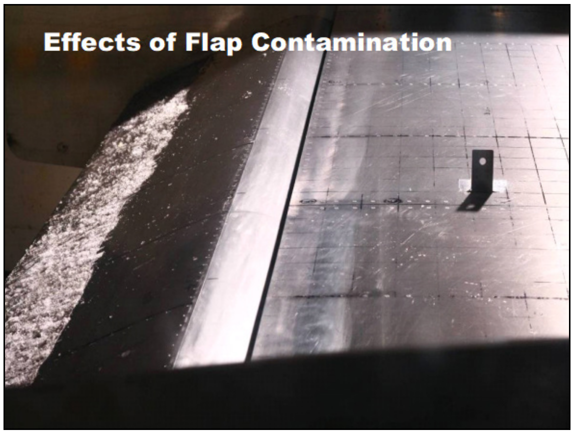
Snow on an Un-Protected Wing (Rotation)

Effects of Surface Roughness



Effects of Surface Roughness

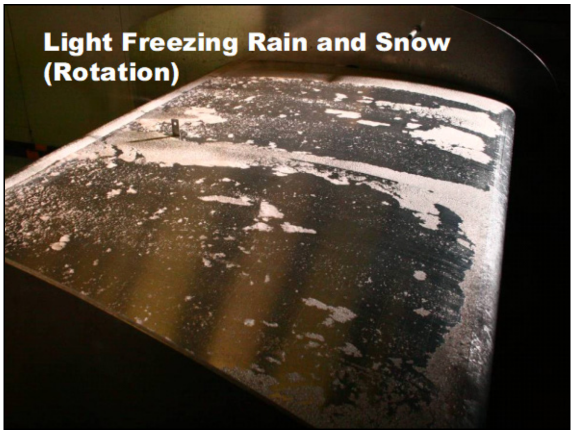
Effects of Flap Contamination



Effects of Flap Contamination

Light Freezing Rain and Snow

Light Freezing Rain and Snow (Start of Test)

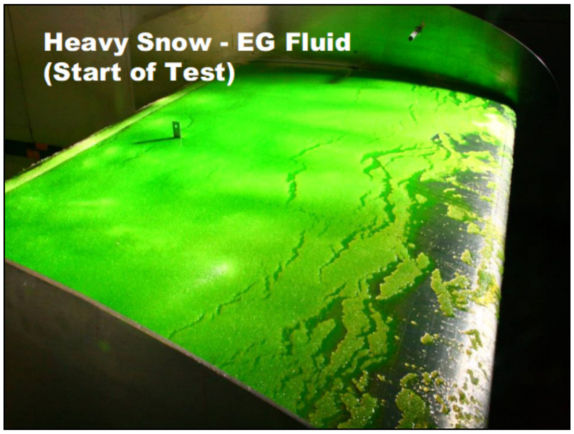


Light Freezing Rain and Snow (Rotation)

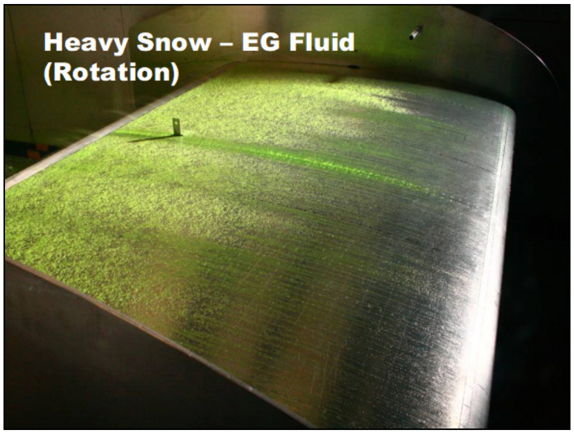
Heavy Snow

Heavy Snow - PG Fluid (Start of Test)

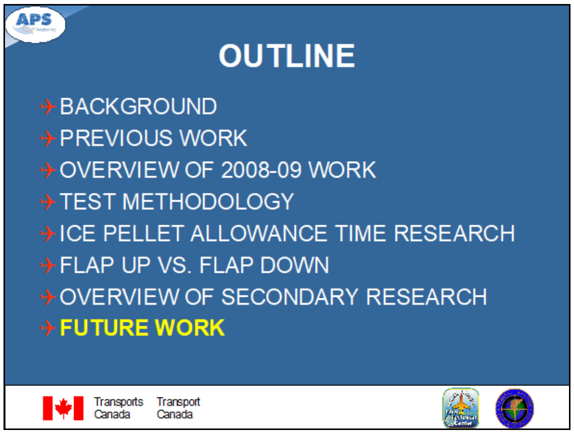
Heavy Snow – PG Fluid (Rotation)



Heavy Snow - EG Fluid (Start of Test)



Heavy Snow – EG Fluid (Rotation)



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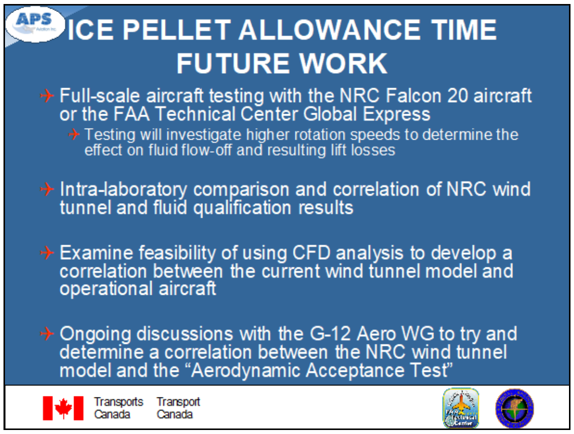

ICE PELLET ALLOWANCE TIME FUTURE WORK

- Full-scale aircraft testing with the NRC Falcon 20 aircraft or the FAA Technical Center Global Express
  - Testing will investigate higher rotation speeds to determine the effect on fluid flow-off and resulting lift losses
- Intra-laboratory comparison and correlation of NRC wind tunnel and fluid qualification results
- Examine feasibility of using CFD analysis to develop a correlation between the current wind tunnel model and operational aircraft
- Ongoing discussions with the G-12 Aero WG to try and determine a correlation between the NRC wind tunnel model and the "Aerodynamic Acceptance Test"

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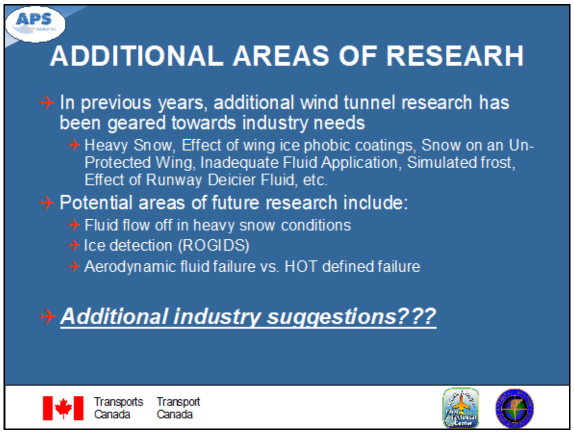

ADDITIONAL AREAS OF RESEARCH

- In previous years, additional wind tunnel research has been geared towards industry needs
  - Heavy Snow, Effect of wing ice phobic coatings, Snow on an Un-Protected Wing, Inadequate Fluid Application, Simulated frost, Effect of Runway Deicier Fluid, etc.
- Potential areas of future research include:
  - Fluid flow off in heavy snow conditions
  - Ice detection (ROGIDS)
  - Aerodynamic fluid failure vs. HOT defined failure
- ***Additional industry suggestions???***

Transports Canada Transport Canada

APS Aviation Inc

Marco Ruggi
mruggi@adga.ca

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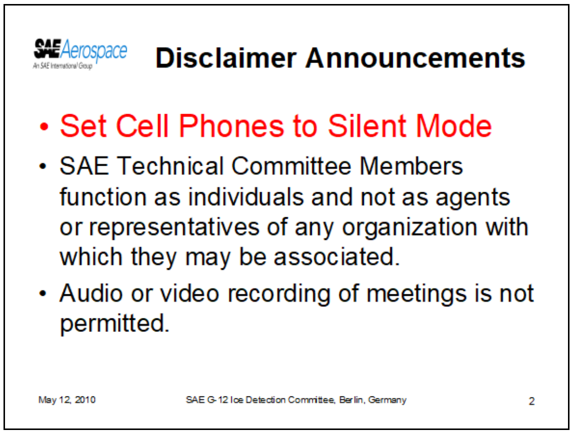
SAE Aerospace
An SAE International Group

SAE Committee G-12

Ice Detection Committee Meeting

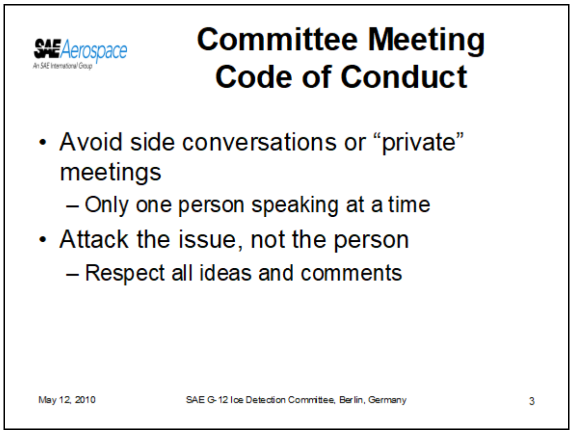
Berlin, Germany

May 12, 2010



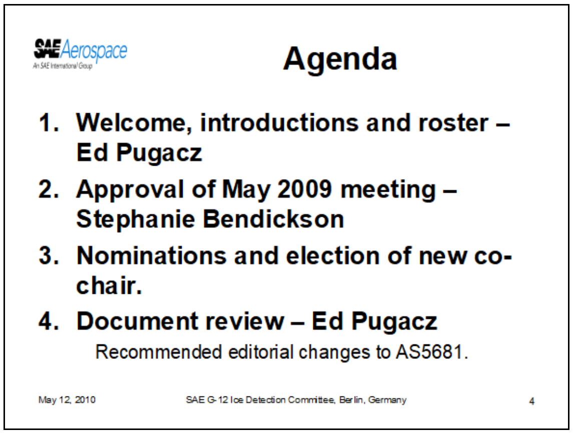
Disclaimer Announcements

- Set Cell Phones to Silent Mode
- SAE Technical Committee Members function as individuals and not as agents or representatives of any organization with which they may be associated.
- Audio or video recording of meetings is not permitted.



Committee Meeting Code of Conduct

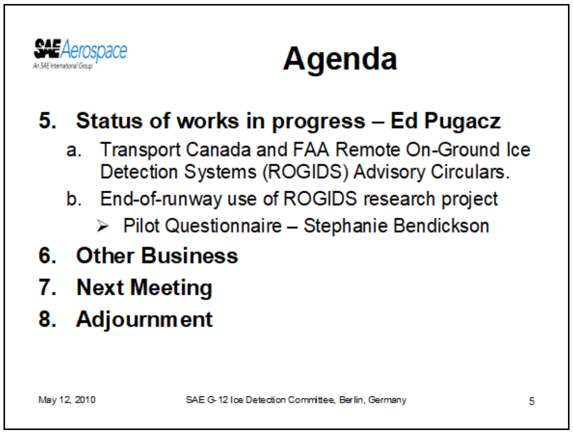
- Avoid side conversations or "private" meetings
  - Only one person speaking at a time
- Attack the issue, not the person
  - Respect all ideas and comments



Agenda

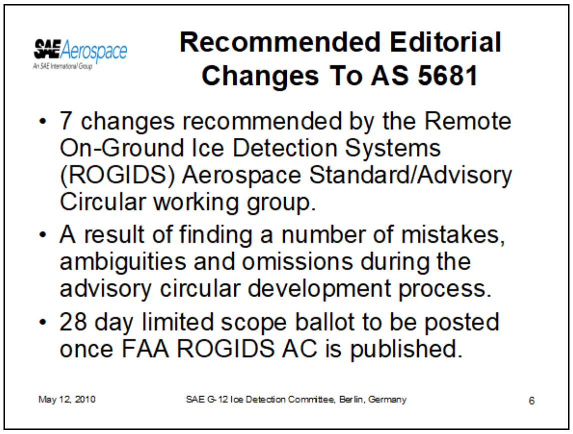
1. **Welcome, introductions and roster – Ed Pugacz**
2. **Approval of May 2009 meeting – Stephanie Bendickson**
3. **Nominations and election of new co-chair.**
4. **Document review – Ed Pugacz**

   Recommended editorial changes to AS5681.



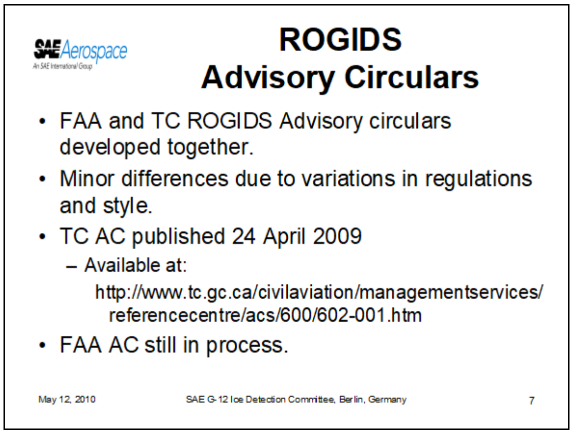
Agenda

5. **Status of works in progress – Ed Pugacz**
   a. Transport Canada and FAA Remote On-Ground Ice Detection Systems (ROGIDS) Advisory Circulars.
   b. End-of-runway use of ROGIDS research project
      ➢ Pilot Questionnaire – Stephanie Bendickson
6. **Other Business**
7. **Next Meeting**
8. **Adjournment**



Recommended Editorial Changes To AS 5681

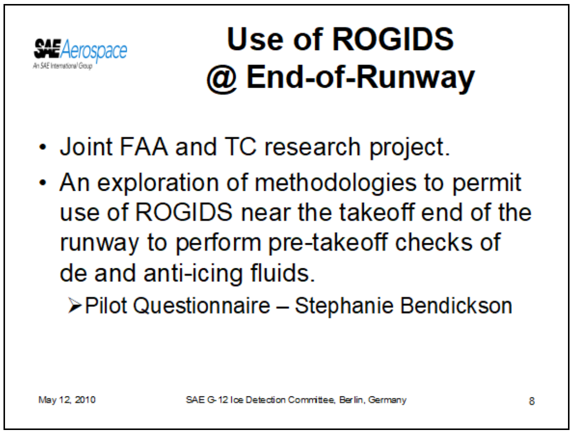
- 7 changes recommended by the Remote On-Ground Ice Detection Systems (ROGIDS) Aerospace Standard/Advisory Circular working group.
- A result of finding a number of mistakes, ambiguities and omissions during the advisory circular development process.
- 28 day limited scope ballot to be posted once FAA ROGIDS AC is published.



ROGIDS Advisory Circulars

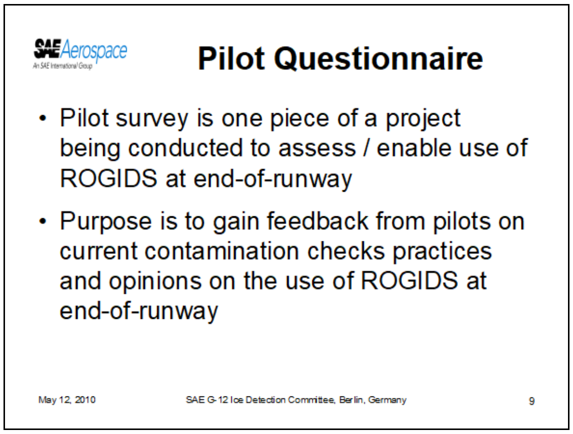
- FAA and TC ROGIDS Advisory circulars developed together.
- Minor differences due to variations in regulations and style.
- TC AC published 24 April 2009
  - Available at:

    http://www.tc.gc.ca/civilaviation/managementservices/referencecentre/acs/600/602-001.htm
- FAA AC still in process.



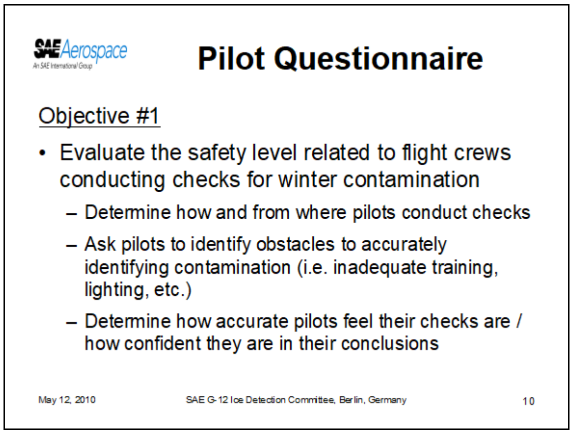
Use of ROGIDS @ End-of-Runway

- Joint FAA and TC research project.
- An exploration of methodologies to permit use of ROGIDS near the takeoff end of the runway to perform pre-takeoff checks of de and anti-icing fluids.
  - ➢Pilot Questionnaire – Stephanie Bendickson



Pilot Questionnaire

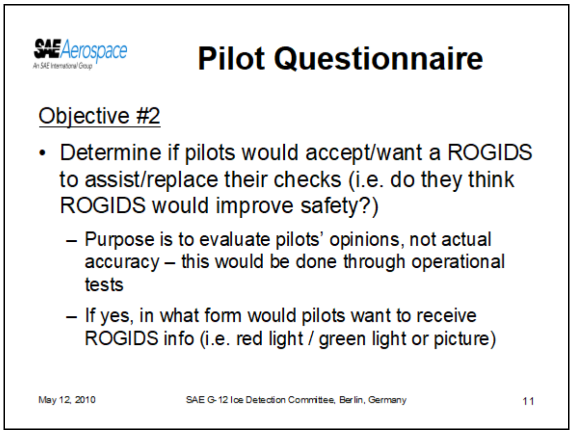
- Pilot survey is one piece of a project being conducted to assess / enable use of ROGIDS at end-of-runway
- Purpose is to gain feedback from pilots on current contamination checks practices and opinions on the use of ROGIDS at end-of-runway



Pilot Questionnaire

Objective #1

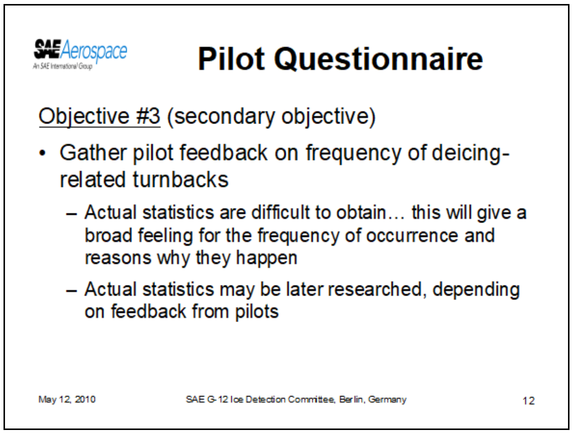
- Evaluate the safety level related to flight crews conducting checks for winter contamination
  - Determine how and from where pilots conduct checks
  - Ask pilots to identify obstacles to accurately identifying contamination (i.e. inadequate training, lighting, etc.)
  - Determine how accurate pilots feel their checks are / how confident they are in their conclusions



Pilot Questionnaire

Objective #2

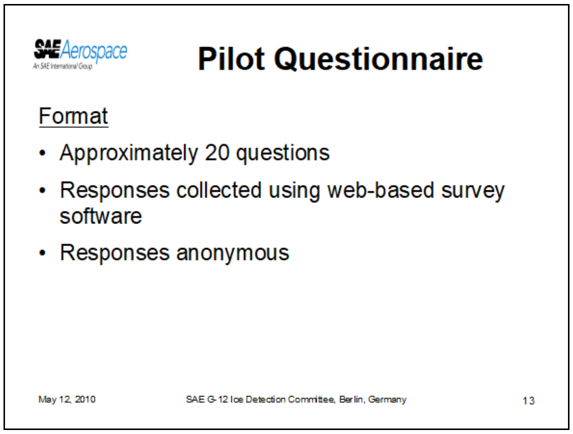
- Determine if pilots would accept/want a ROGIDS to assist/replace their checks (i.e. do they think ROGIDS would improve safety?)
  - Purpose is to evaluate pilots' opinions, not actual accuracy – this would be done through operational tests
  - If yes, in what form would pilots want to receive ROGIDS info (i.e. red light / green light or picture)



Pilot Questionnaire

Objective #3 (secondary objective)

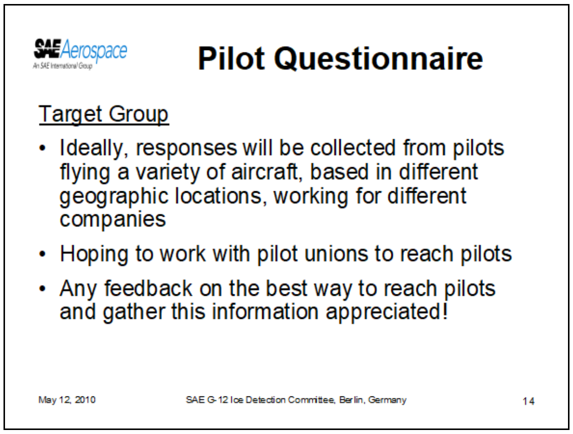
- Gather pilot feedback on frequency of deicing-related turnbacks
  - Actual statistics are difficult to obtain… this will give a broad feeling for the frequency of occurrence and reasons why they happen
  - Actual statistics may be later researched, depending on feedback from pilots



Pilot Questionnaire

Format

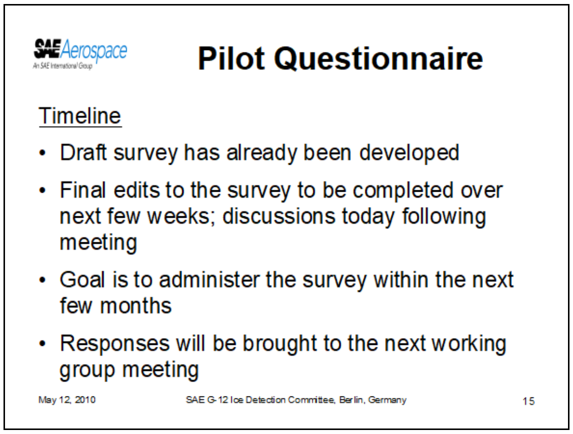
- Approximately 20 questions
- Responses collected using web-based survey software
- Responses anonymous



Pilot Questionnaire

Target Group

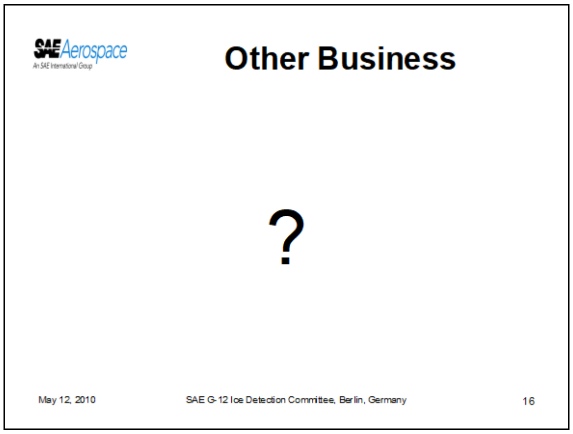
- Ideally, responses will be collected from pilots flying a variety of aircraft, based in different geographic locations, working for different companies
- Hoping to work with pilot unions to reach pilots
- Any feedback on the best way to reach pilots and gather this information appreciated!



Pilot Questionnaire

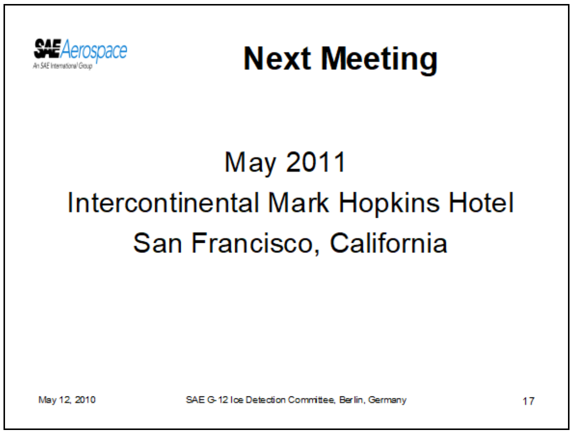
Timeline

- Draft survey has already been developed
- Final edits to the survey to be completed over next few weeks; discussions today following meeting
- Goal is to administer the survey within the next few months
- Responses will be brought to the next working group meeting



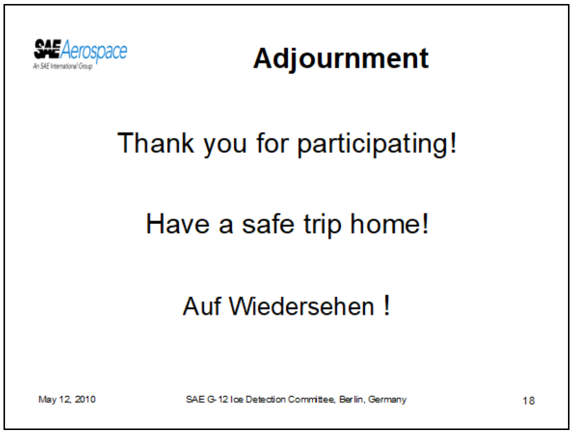
Other Business

?



Next Meeting

May 2011
Intercontinental Mark Hopkins Hotel
San Francisco, California



Adjournment

Thank you for participating!

Have a safe trip home!

Auf Wiedersehen !

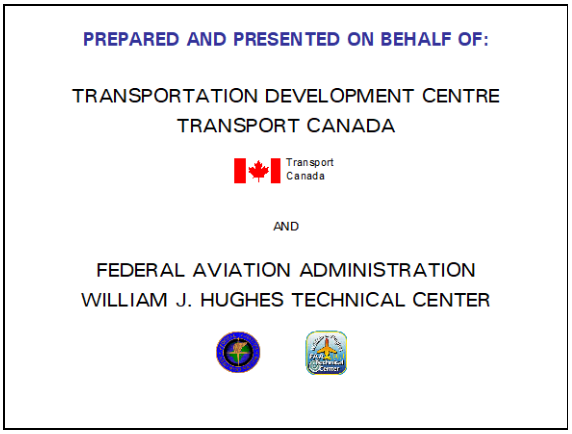
DEGRADED ANTI-ICING FLUID PERFORMANCE
FOLLOWING CONTAMINATION WITH
RUNWAY DEICING FLUID

APS Aviation Inc.

ISO 9001:2000

SAE G-12 – RESIDUES WORKING GROUP
MONTREAL – NOVEMBER 2, 2010

PRESENTED BY MARCO RUGGI



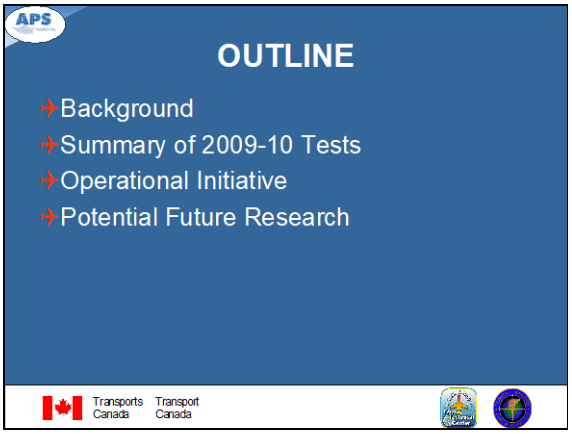
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



APS

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- Background
- Summary of 2009-10 Tests
- Operational Initiative
- Potential Future Research

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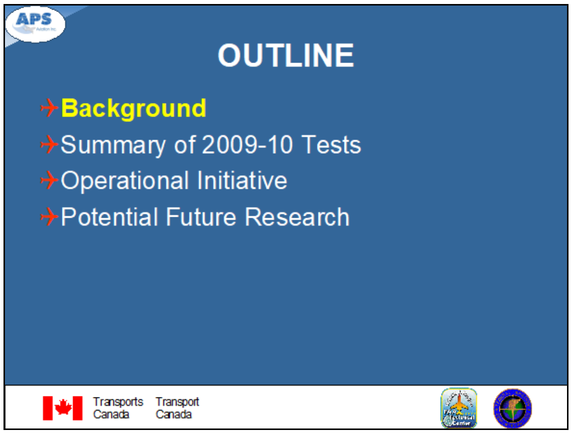

APS

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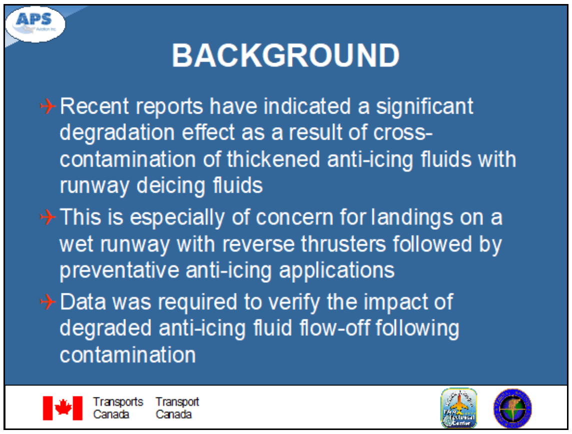

APS

BACKGROUND

- Recent reports have indicated a significant degradation effect as a result of cross-contamination of thickened anti-icing fluids with runway deicing fluids
- This is especially of concern for landings on a wet runway with reverse thrusters followed by preventative anti-icing applications
- Data was required to verify the impact of degraded anti-icing fluid flow-off following contamination

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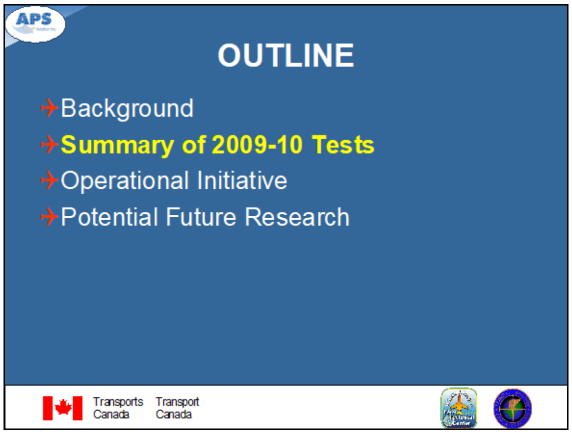

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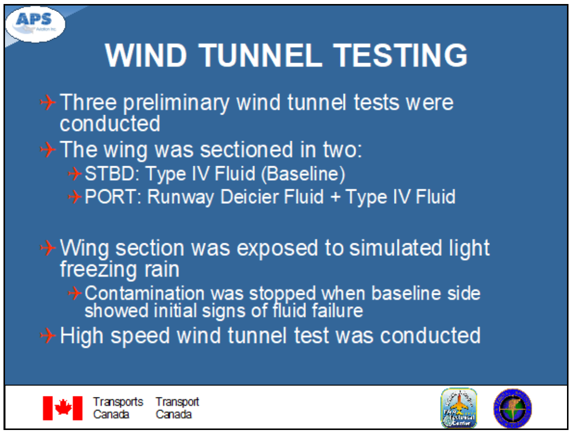
WIND TUNNEL TESTING



WIND TUNNEL TESTING

- Three preliminary wind tunnel tests were conducted
- The wing was sectioned in two:
  - STBD: Type IV Fluid (Baseline)
  - PORT: Runway Deicier Fluid + Type IV Fluid
- Wing section was exposed to simulated light freezing rain
  - Contamination was stopped when baseline side showed initial signs of fluid failure
- High speed wind tunnel test was conducted

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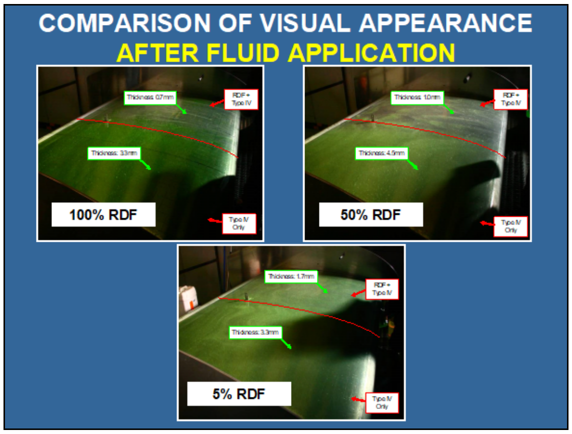
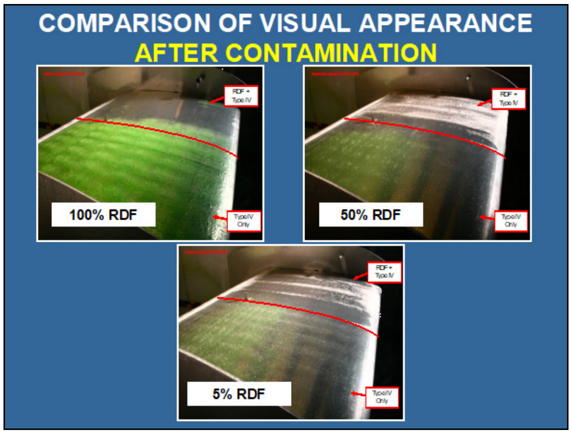


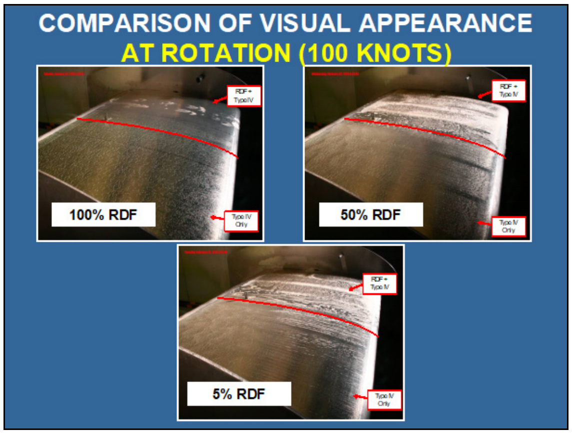
COMPARISON OF VISUAL APPEARANCE AFTER FLUID APPLICATION

Thickness: 0.7mm
RDF + Type IV
Thickness: 3.3mm
100% RDF
Type IV Only
Thickness: 1.0mm
RDF + Type IV
Thickness: 4.5mm
50% RDF
Type IV Only
Thickness: 1.7mm
RDF + Type IV
Thickness: 3.3mm
5% RDF
Type IV Only



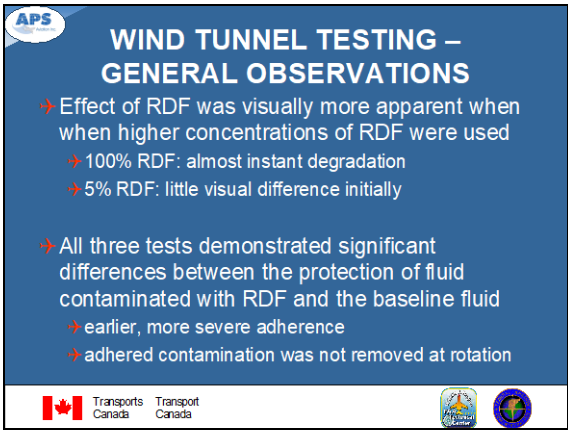
COMPARISON OF VISUAL APPEARANCE AFTER CONTAMINATION

RDF + Type IV
100% RDF
Type IV Only
RDF + Type IV
50% RDF
Type IV Only
RDF + Type IV
5% RDF
Type IV Only



COMPARISON OF VISUAL APPEARANCE AT ROTATION (100 KNOTS)

RDF + Type IV
100% RDF
Type IV Only
RDF + Type IV
50% RDF
Type IV Only
RDF + Type IV
5% RDF
Type IV Only



WIND TUNNEL TESTING – GENERAL OBSERVATIONS

- Effect of RDF was visually more apparent when when higher concentrations of RDF were used
  - 100% RDF: almost instant degradation
  - 5% RDF: little visual difference initially
- All three tests demonstrated significant differences between the protection of fluid contaminated with RDF and the baseline fluid
  - earlier, more severe adherence
  - adhered contamination was not removed at rotation

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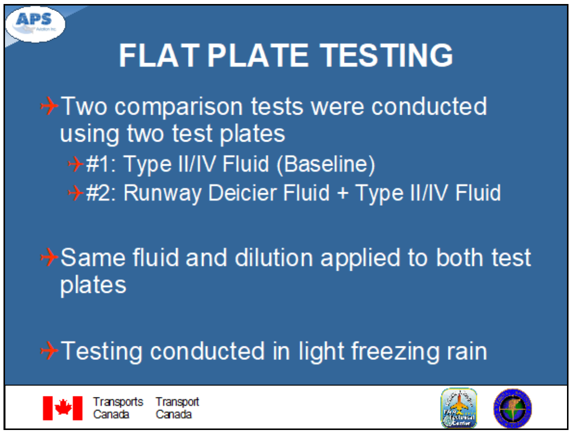
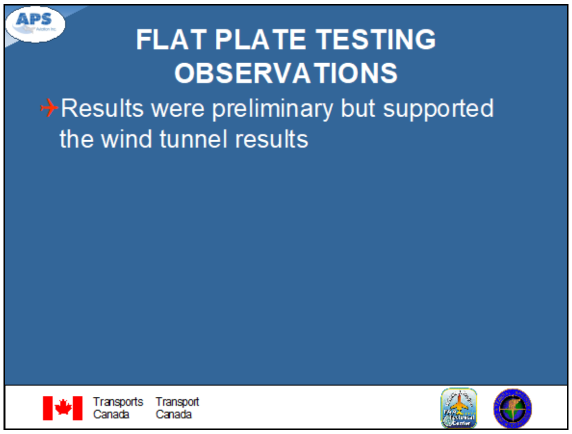
FLAT PLATE TESTING



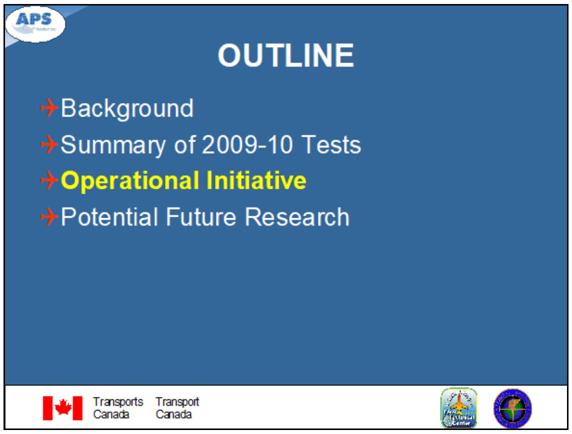
FLAT PLATE TESTING

- Two comparison tests were conducted using two test plates
  - #1: Type II/IV Fluid (Baseline)
  - #2: Runway Deicier Fluid + Type II/IV Fluid
- Same fluid and dilution applied to both test plates
- Testing conducted in light freezing rain



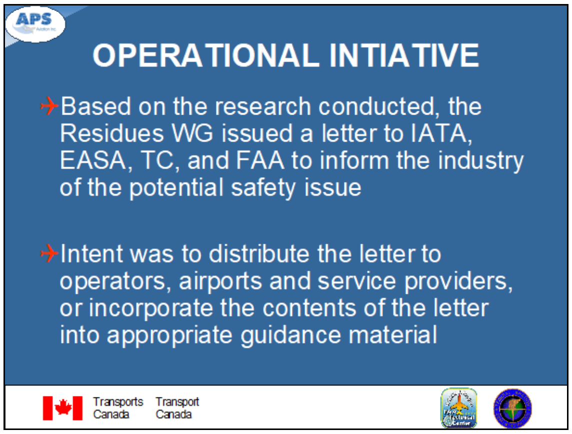
FLAT PLATE TESTING OBSERVATIONS

- Results were preliminary but supported the wind tunnel results



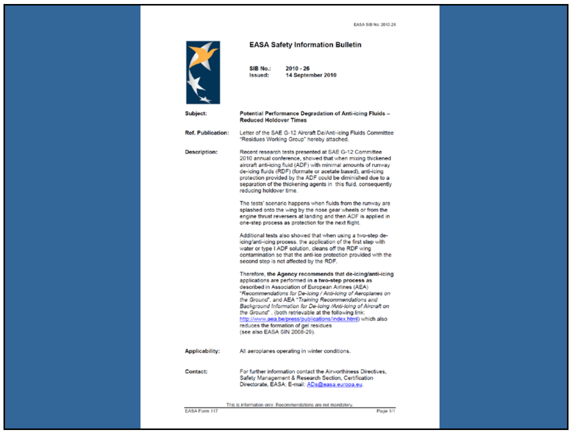
OUTLINE

- Background
- Summary of 2009-10 Tests
- **Operational Initiative**
- Potential Future Research



OPERATIONAL INTIATIVE

- Based on the research conducted, the Residues WG issued a letter to IATA, EASA, TC, and FAA to inform the industry of the potential safety issue
- Intent was to distribute the letter to operators, airports and service providers, or incorporate the contents of the letter into appropriate guidance material



EASA SIB No: 2010-26

EASA Safety Information Bulletin

SIB No.: **2010 - 26**
Issued: **14 September 2010**

Subject: **Potential Performance Degradation of Anti-icing Fluids – Reduced Holdover Times**

Ref. Publication: Letter of the SAE G-12 Aircraft De/Anti-icing Fluids Committee "Residues Working Group" hereby attached.

Description: Recent research tests presented at SAE G-12 Committee 2010 annual conference, showed that when mixing thickened aircraft anti-icing fluid (ADF) with minimal amounts of runway de-icing fluids (RDF) (formate or acetate based), anti-icing protection provided by the ADF could be diminished due to a separation of the thickening agents in this fluid, consequently reducing holdover time.

The tests' scenario happens when fluids from the runway are splashed onto the wing by the nose gear wheels or from the engine thrust reversers at landing and then ADF is applied in one-step process as protection for the next flight.

Additional tests also showed that when using a two-step de-icing/anti-icing process, the application of the first step with water or type I ADF solution, cleans off the RDF wing contamination so that the anti-ice protection provided with the second step is not affected by the RDF.

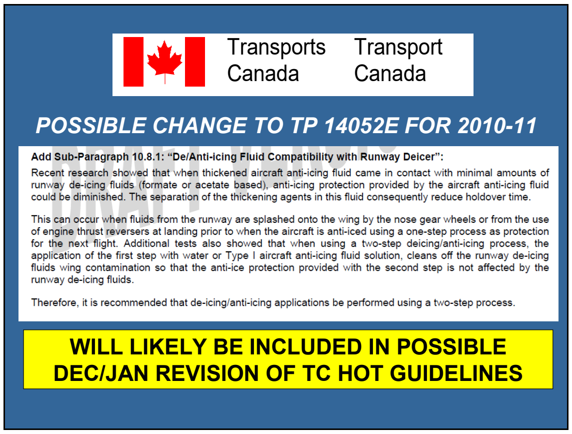
Therefore, **the Agency recommends** that **de-icing/anti-icing** applications are performed **in a two-step process as** described in Association of European Airlines (AEA) "*Recommendations for De-Icing / Anti-Icing of Aeroplanes on the Ground*", and AEA "*Training Recommendations and Background Information for De-Icing /Anti-Icing of Aircraft on the Ground*" , (both retrievable at the following link: http://www.aea.be/press/publications/index.html) which also reduces the formation of gel residues (see also EASA SIN 2008-29).

Applicability: All aeroplanes operating in winter conditions.

Contact: For further information contact the Airworthiness Directives, Safety Management & Research Section, Certification Directorate, EASA; E-mail: ADs@easa.europa.eu.

This is information only. Recommendations are not mandatory.

EASA Form 117 Page 1/1



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POSSIBLE CHANGE TO TP 14052E FOR 2010-11

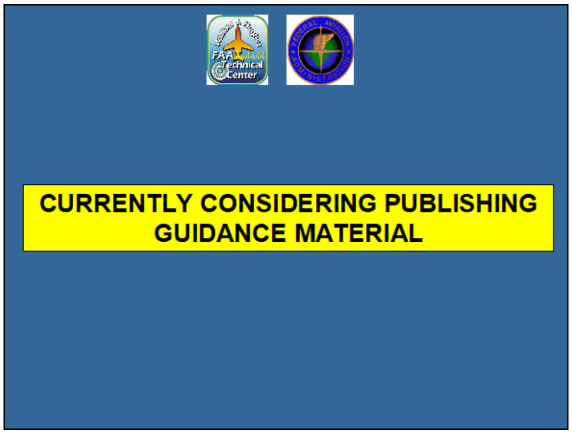
Add Sub-Paragraph 10.8.1: "De/Anti-icing Fluid Compatibility with Runway Deicer":

Recent research showed that when thickened aircraft anti-icing fluid came in contact with minimal amounts of runway de-icing fluids (formate or acetate based), anti-icing protection provided by the aircraft anti-icing fluid could be diminished. The separation of the thickening agents in this fluid consequently reduce holdover time.

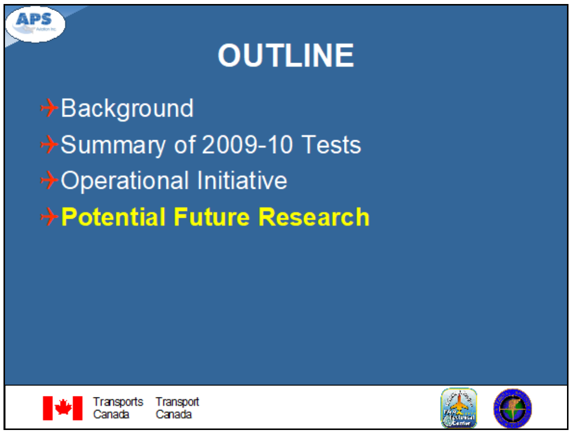
This can occur when fluids from the runway are splashed onto the wing by the nose gear wheels or from the use of engine thrust reversers at landing prior to when the aircraft is anti-iced using a one-step process as protection for the next flight. Additional tests also showed that when using a two-step deicing/anti-icing process, the application of the first step with water or Type I aircraft anti-icing fluid solution, cleans off the runway de-icing fluids wing contamination so that the anti-ice protection provided with the second step is not affected by the runway de-icing fluids.

Therefore, it is recommended that de-icing/anti-icing applications be performed using a two-step process.

WILL LIKELY BE INCLUDED IN POSSIBLE DEC/JAN REVISION OF TC HOT GUIDELINES



CURRENTLY CONSIDERING PUBLISHING GUIDANCE MATERIAL



OUTLINE

- Background
- Summary of 2009-10 Tests
- Operational Initiative
- **Potential Future Research**

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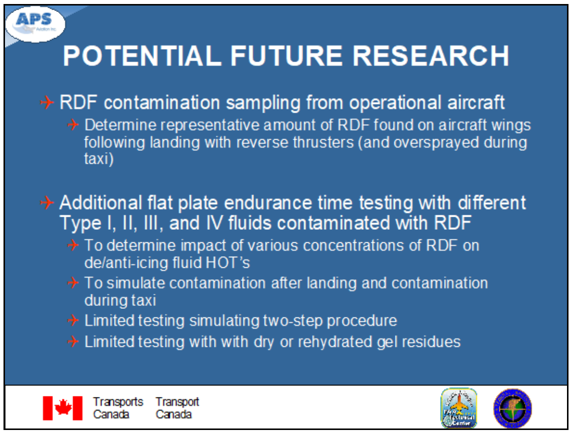

POTENTIAL FUTURE RESEARCH

- RDF contamination sampling from operational aircraft
  - Determine representative amount of RDF found on aircraft wings following landing with reverse thrusters (and oversprayed during taxi)
- Additional flat plate endurance time testing with different Type I, II, III, and IV fluids contaminated with RDF
  - To determine impact of various concentrations of RDF on de/anti-icing fluid HOT's
  - To simulate contamination after landing and contamination during taxi
  - Limited testing simulating two-step procedure
  - Limited testing with with dry or rehydrated gel residues

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APS Aviation Inc.

Marco Ruggi
mruggi@adga.ca

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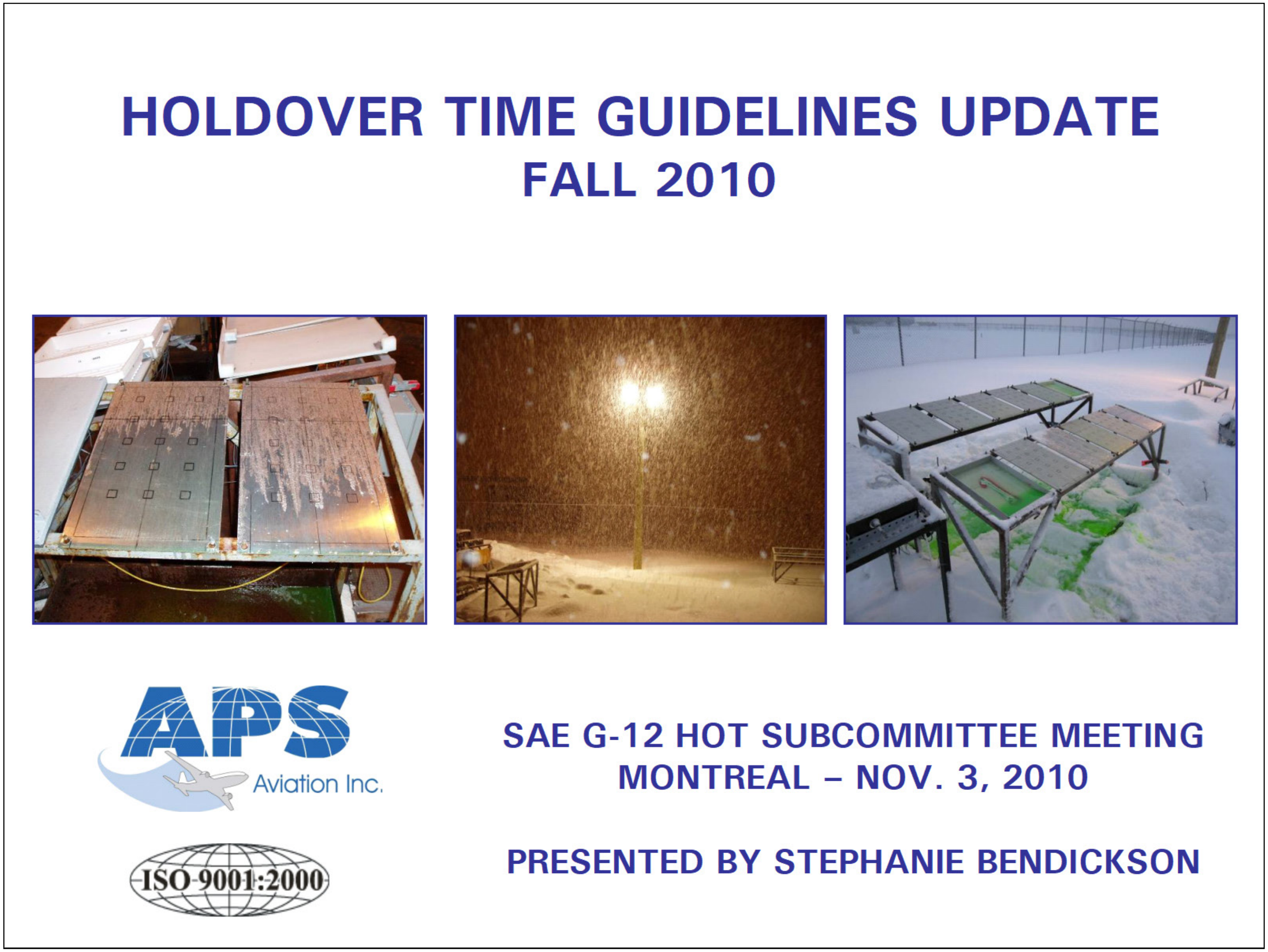
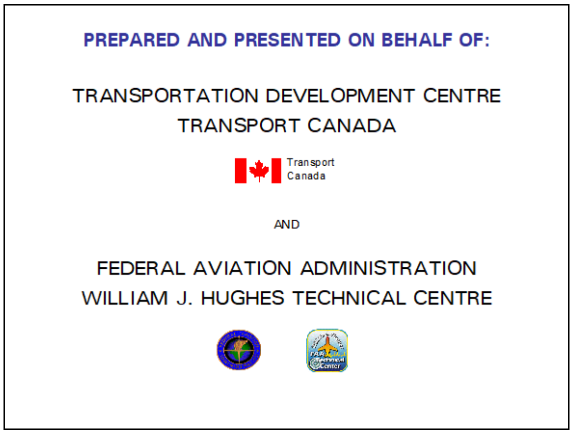


HOLDOVER TIME GUIDELINES UPDATE
FALL 2010

SAE G-12 HOT SUBCOMMITTEE MEETING
MONTREAL – NOV. 3, 2010

PRESENTED BY STEPHANIE BENDICKSON

APS
Aviation Inc.
ISO 9001:2000



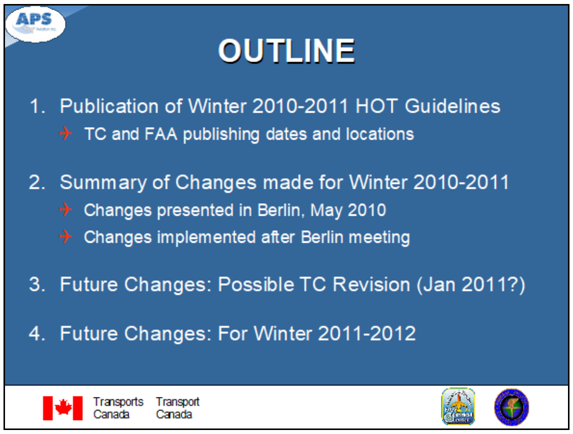
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

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   - TC and FAA publishing dates and locations
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4. Future Changes: For Winter 2011-2012

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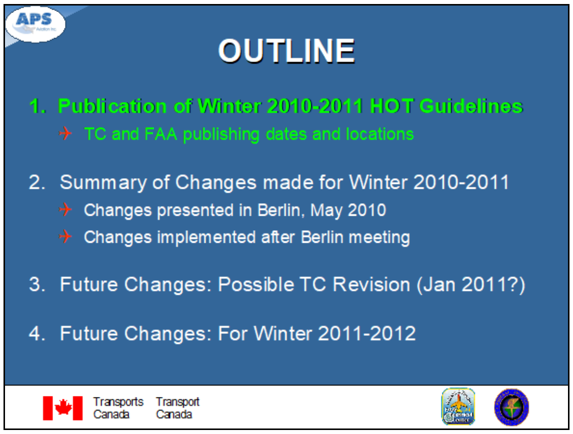

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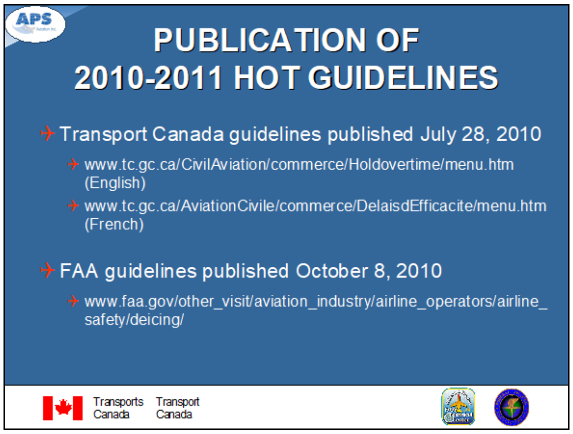

PUBLICATION OF 2010-2011 HOT GUIDELINES

- Transport Canada guidelines published July 28, 2010
  - www.tc.gc.ca/CivilAviation/commerce/Holdovertime/menu.htm (English)
  - www.tc.gc.ca/AviationCivile/commerce/DelaisdEfficacite/menu.htm (French)
- FAA guidelines published October 8, 2010
  - www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/

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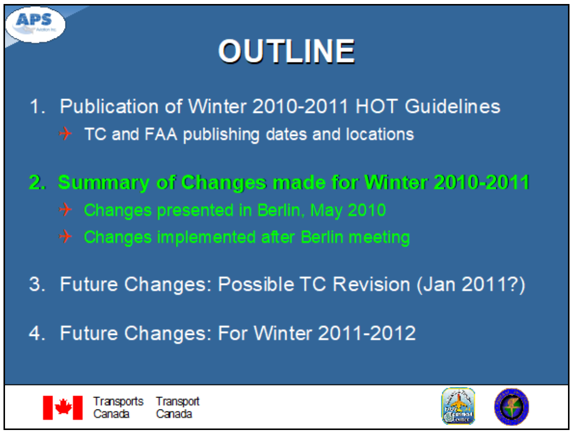

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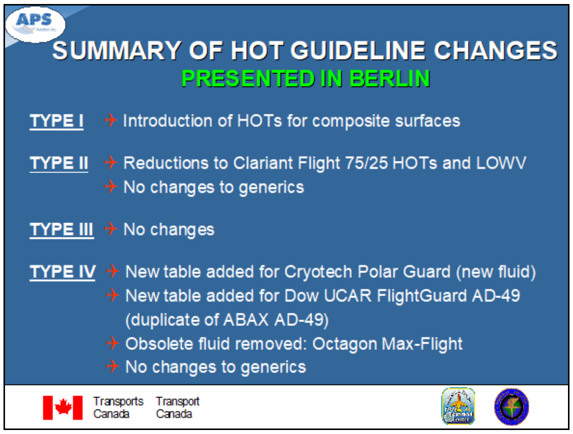

SUMMARY OF HOT GUIDELINE CHANGES PRESENTED IN BERLIN

TYPE I	Introduction of HOTs for composite surfaces
TYPE II	Reductions to Clariant Flight 75/25 HOTs and LOWV No changes to generics
TYPE III	No changes
TYPE IV	New table added for Cryotech Polar Guard (new fluid) New table added for Dow UCAR FlightGuard AD-49 (duplicate of ABAX AD-49) Obsolete fluid removed: Octagon Max-Flight No changes to generics

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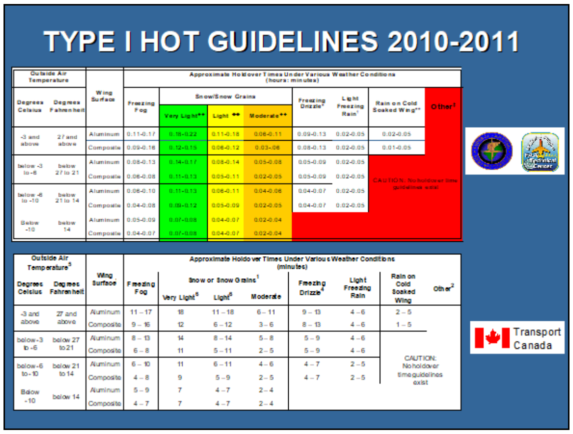
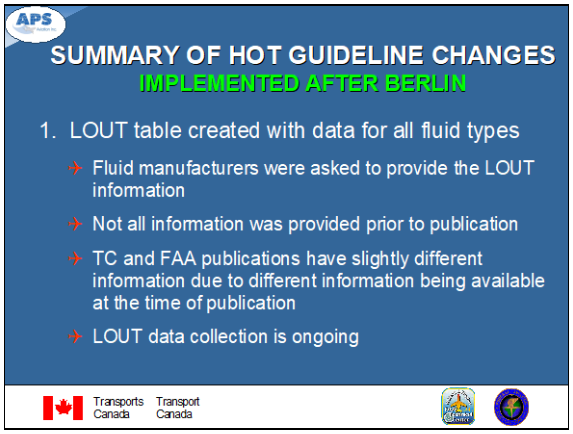


TYPE I HOT GUIDELINES 2010-2011

Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow/Snow Grains						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light**	Light **	Moderate**	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-:06	0:08-0:13	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05		
		Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
		Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				
		Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				

Outside Air Temperature[5]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (minutes)							
				Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
Below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

Transport Canada



SUMMARY OF HOT GUIDELINE CHANGES
IMPLEMENTED AFTER BERLIN

1. LOUT table created with data for all fluid types
   - Fluid manufacturers were asked to provide the LOUT information
   - Not all information was provided prior to publication
   - TC and FAA publications have slightly different information due to different information being available at the time of publication
   - LOUT data collection is ongoing

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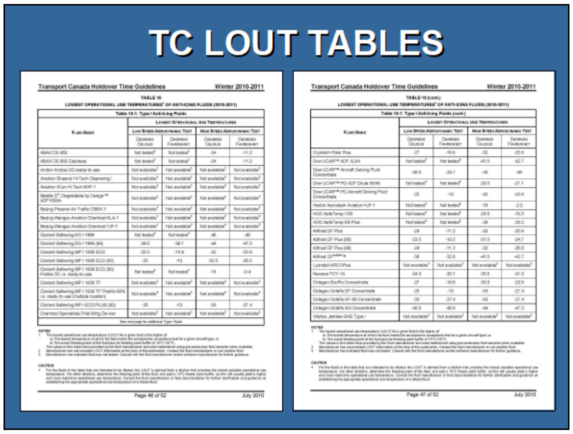
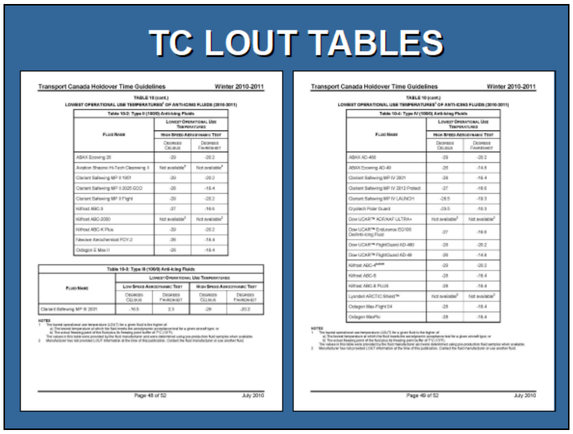
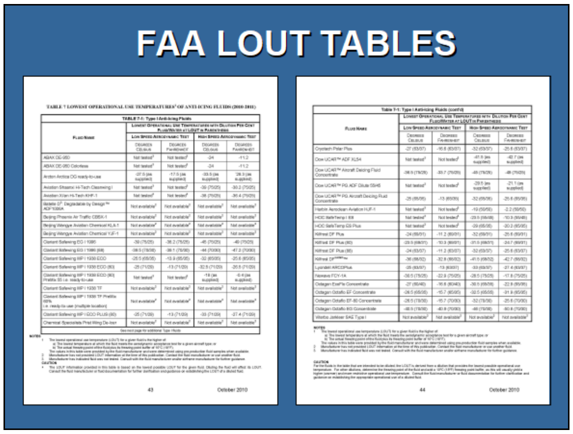


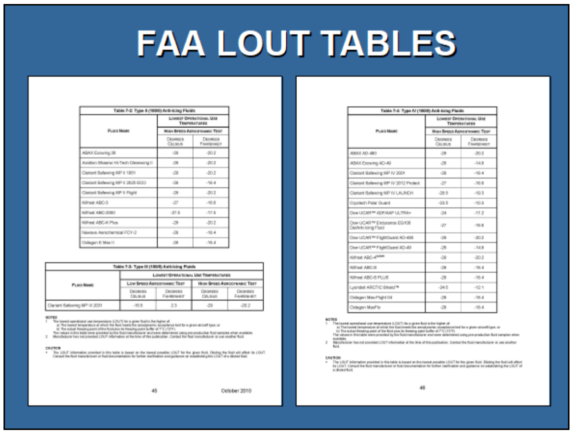
TC LOUT TABLES



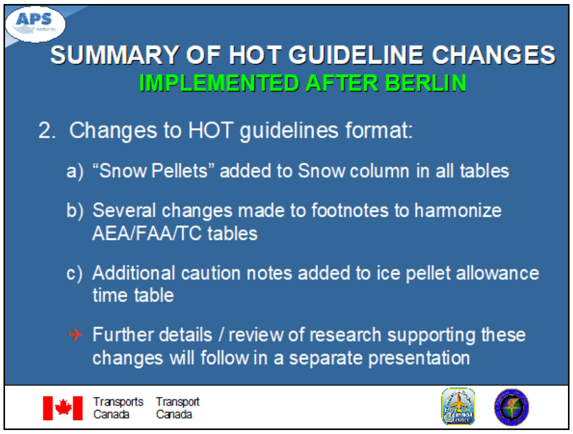
TC LOUT TABLES



FAA LOUT TABLES



FAA LOUT TABLES



SUMMARY OF HOT GUIDELINE CHANGES
IMPLEMENTED AFTER BERLIN

2. Changes to HOT guidelines format:
   - a) “Snow Pellets” added to Snow column in all tables
   - b) Several changes made to footnotes to harmonize AEA/FAA/TC tables
   - c) Additional caution notes added to ice pellet allowance time table
   - Further details / review of research supporting these changes will follow in a separate presentation

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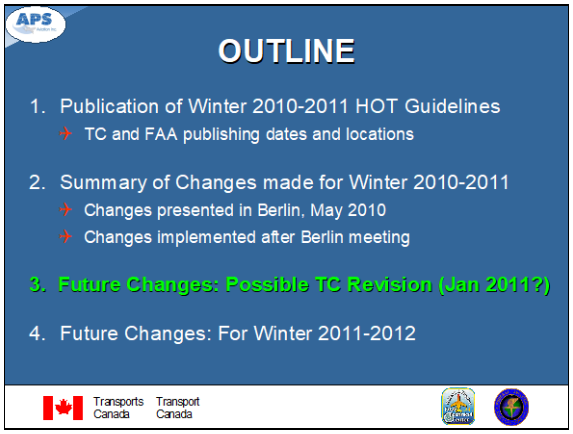

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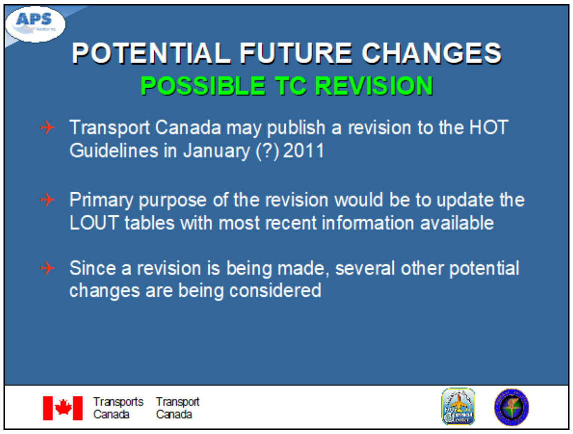

POTENTIAL FUTURE CHANGES
POSSIBLE TC REVISION

- Transport Canada may publish a revision to the HOT Guidelines in January (?) 2011
- Primary purpose of the revision would be to update the LOUT tables with most recent information available
- Since a revision is being made, several other potential changes are being considered

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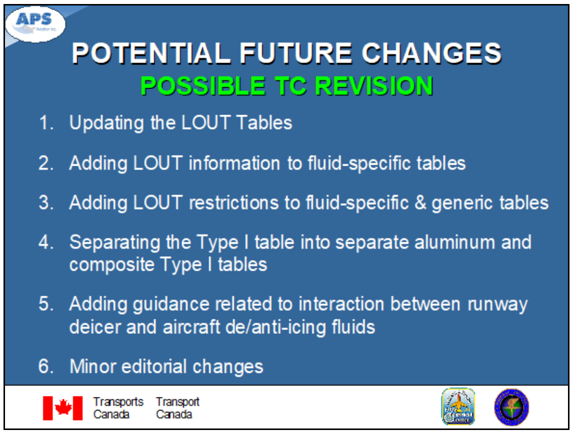

POTENTIAL FUTURE CHANGES
POSSIBLE TC REVISION

1. Updating the LOUT Tables
2. Adding LOUT information to fluid-specific tables
3. Adding LOUT restrictions to fluid-specific & generic tables
4. Separating the Type I table into separate aluminum and composite Type I tables
5. Adding guidance related to interaction between runway deicer and aircraft de/anti-icing fluids
6. Minor editorial changes

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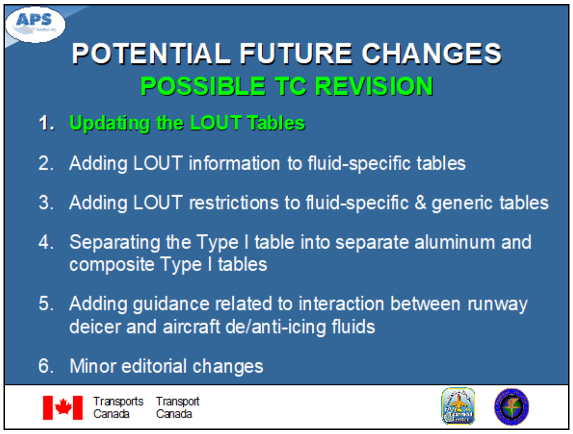

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POSSIBLE TC REVISION

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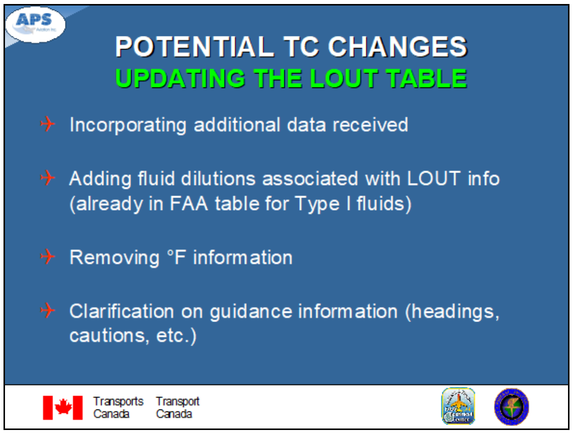

POTENTIAL TC CHANGES
UPDATING THE LOUT TABLE

- Incorporating additional data received
- Adding fluid dilutions associated with LOUT info (already in FAA table for Type I fluids)
- Removing °F information
- Clarification on guidance information (headings, cautions, etc.)

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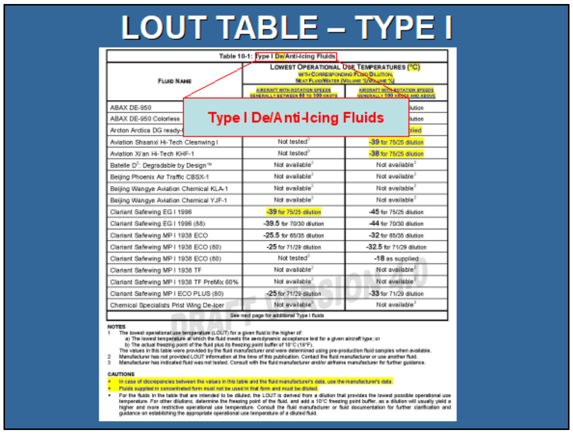
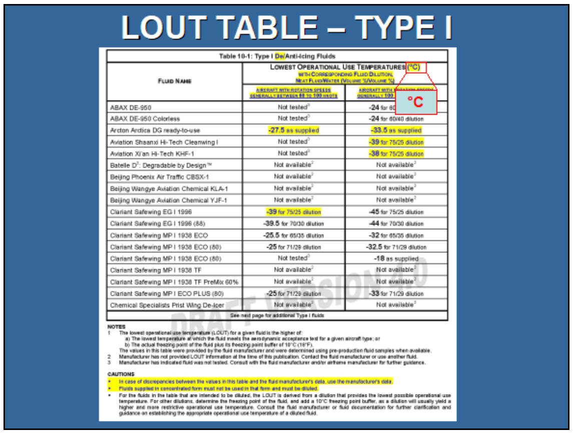


LOUT TABLE – TYPE I

Type I De/Anti-Icing Fluids



LOUT TABLE – TYPE I

°C

Table 10-1: Type I De/Anti-Icing Fluids

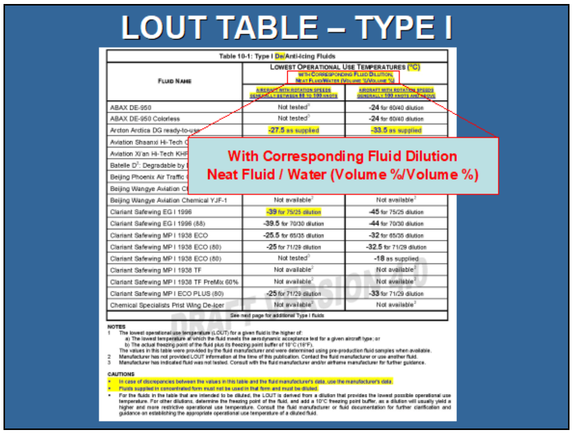
Fluid Name	Lowest Operational Use Temperatures (°C) with Corresponding Fluid Dilution, Neat Fluid/Water (Volume %/Volume %)	
	Aircraft with rotation speeds generally between 60 to 100 knots	Aircraft with rotation speeds generally 100 knots and above
ABAX DE-950	Not tested[3]	-24 for 60
ABAX DE-950 Colorless	Not tested[3]	-24 for 60/40 dilution
Arcton Arctica DG ready-to-use	-27.5 as supplied	-33.5 as supplied
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[3]	-39 for 75/25 dilution
Aviation Xi'an Hi-Tech KHF-1	Not tested[3]	-38 for 75/25 dilution
Batelle D[3]: Degradable by Design™	Not available[2]	Not available[2]
Beijing Phoenix Air Traffic CBSX-1	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical KLA-1	Not available[2]	Not available[2]
Beijing Wangye Aviation Chemical YJF-1	Not available[2]	Not available[2]
Clariant Safewing EG I 1996	-39 for 75/25 dilution	-45 for 75/25 dilution
Clariant Safewing EG I 1996 (88)	-39.5 for 70/30 dilution	-44 for 70/30 dilution
Clariant Safewing MP I 1938 ECO	-25.5 for 65/35 dilution	-32 for 65/35 dilution
Clariant Safewing MP I 1938 ECO (80)	-25 for 71/29 dilution	-32.5 for 71/29 dilution
Clariant Safewing MP I 1938 ECO (80)	Not tested[3]	-18 as supplied
Clariant Safewing MP I 1938 TF	Not available[2]	Not available[2]
Clariant Safewing MP I 1938 TF PreMix 60%	Not available[2]	Not available[2]
Clariant Safewing MP I ECO PLUS (80)	-25 for 71/29 dilution	-33 for 71/29 dilution
Chemical Specialists Prist Wing De-Icer	Not available[2]	Not available[2]
See next page for additional Type I fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.
2 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.
3 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

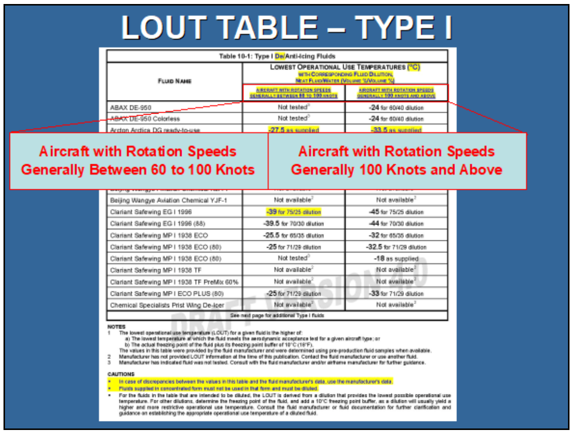
CAUTIONS

- In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid, and add a 10°C freezing point buffer, as a dilution will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.



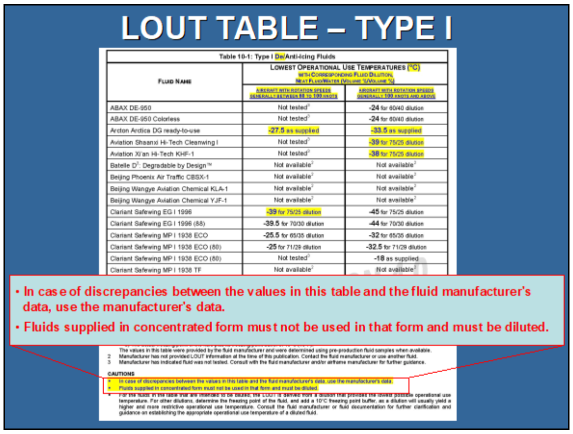
LOUT TABLE – TYPE I

With Corresponding Fluid Dilution
Neat Fluid / Water (Volume %/Volume %)



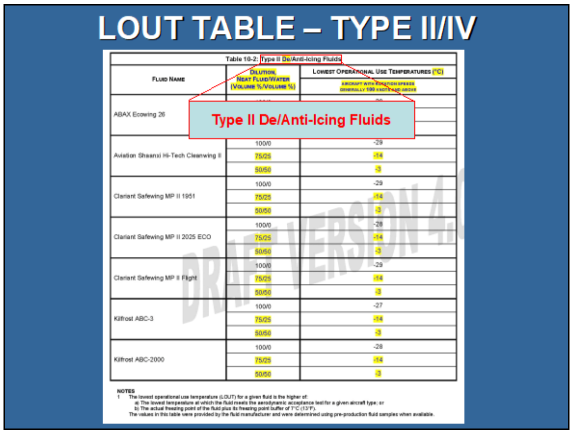
LOUT TABLE – TYPE I

Aircraft with Rotation Speeds Generally Between 60 to 100 Knots	Aircraft with Rotation Speeds Generally 100 Knots and Above



LOUT TABLE – TYPE I

- In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.



LOUT TABLE – TYPE II/IV

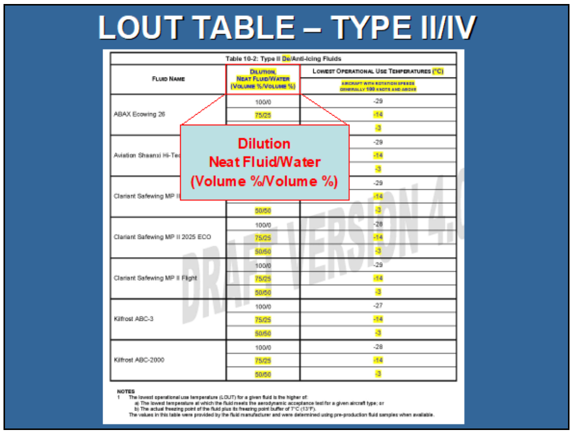
Type II De/Anti-Icing Fluids

Table 10-2: Type II De/Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)
		Aircraft with rotation speeds generally 100 knots and above
ABAX Ecowing 26		
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 1951	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 2025 ECO	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II Flight	100/0	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-28
	75/25	-14
	50/50	-3

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.



LOUT TABLE – TYPE II/IV

Table 10-2: Type II De/Anti-icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)
		Aircraft with rotation speeds generally 100 knots and above
ABAX Ecowing 26	100/0	-29
	75/25	-14
		-3
Aviation Shaanxi Hi-Tec		-29
		-14
		-3
Clariant Safewing MP II		-29
		-14
	50/50	-3
Clariant Safewing MP II 2025 ECO	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II Flight	100/0	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-28
	75/25	-14
	50/50	-3

Dilution
Neat Fluid/Water
(Volume %/Volume %)

NOTES
1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

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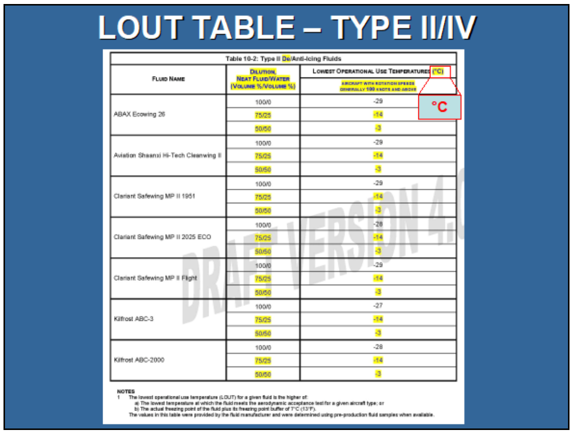


LOUT TABLE – TYPE II/IV

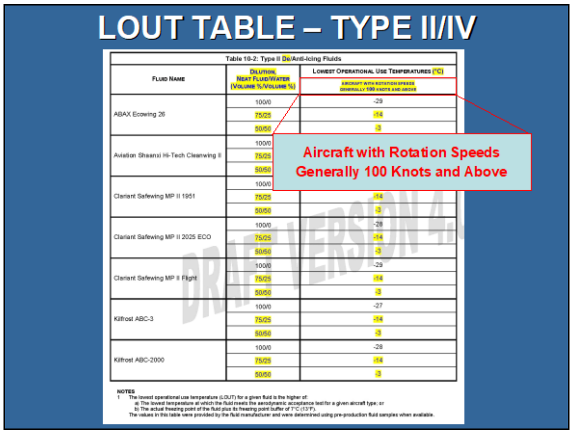
Table 10-2: Type II De/Anti-icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)
		Aircraft with rotation speeds generally 100 knots and above
ABAX Ecowing 26	100/0	-29
	75/25	-14
	50/50	-3
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 1951	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 2025 ECO	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II Flight	100/0	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-28
	75/25	-14
	50/50	-3

°C

NOTES
1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

DRAFT VERSION 4.0



LOUT TABLE – TYPE II/IV

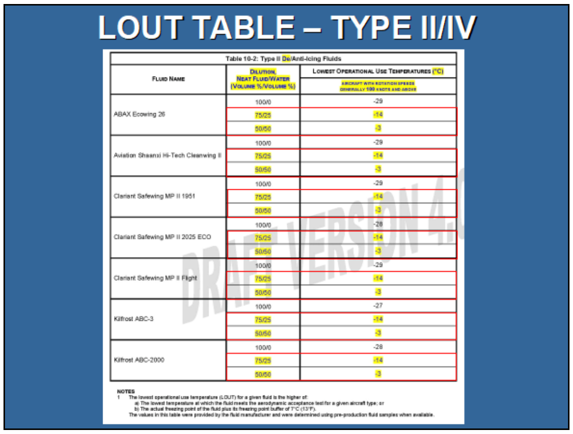
Table 10-2: Type II De/Anti-icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)
		Aircraft with rotation speeds generally 100 knots and above
ABAX Ecowing 26	100/0	-29
	75/25	-14
	50/50	-3
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	
	75/25	
	50/50	
Clariant Safewing MP II 1951	100/0	
	75/25	-14
	50/50	-3
Clariant Safewing MP II 2025 ECO	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II Flight	100/0	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-28
	75/25	-14
	50/50	-3

Aircraft with Rotation Speeds
Generally 100 Knots and Above

NOTES
1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

DRAFT VERSION 4.0



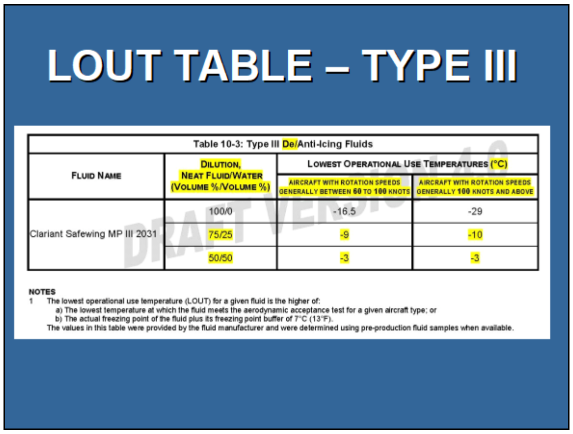
LOUT TABLE – TYPE II/IV

Table 10-2: Type II De/Anti-icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)
		Aircraft with rotation speeds generally 100 knots and above
ABAX Ecowing 26	100/0	-29
	75/25	-14
	50/50	-3
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 1951	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 2025 ECO	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II Flight	100/0	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-28
	75/25	-14
	50/50	-3

NOTES
1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

DRAFT VERSION 4.0



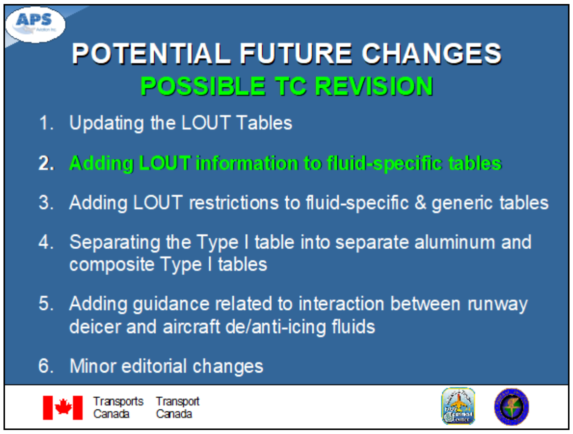
LOUT TABLE – TYPE III

Table 10-3: Type III De/Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures (°C)	
		Aircraft with rotation speeds generally between 60 to 100 knots	Aircraft with rotation speeds generally 100 knots and above
Clariant Safewing MP III 2031	100/0	-16.5	-29
	75/25	-9	-10
	50/50	-3	-3

NOTES
1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).
The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.

DRAFT VERSION 4.0



POTENTIAL FUTURE CHANGES
POSSIBLE TC REVISION

1. Updating the LOUT Tables
2. Adding LOUT information to fluid-specific tables
3. Adding LOUT restrictions to fluid-specific & generic tables
4. Separating the Type I table into separate aluminum and composite Type I tables
5. Adding guidance related to interaction between runway deicer and aircraft de/anti-icing fluids
6. Minor editorial changes

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POTENTIAL TC CHANGES

ADDING LOUT TO FLUID-SPECIFIC TABLES

- The LOUT information contained in the Type II/III/IV LOUT tables would be added to the fluid-specific tables
- This would be done for clarity and ease of use – remove the ambiguity of "Below -14 to -25 or LOUT"

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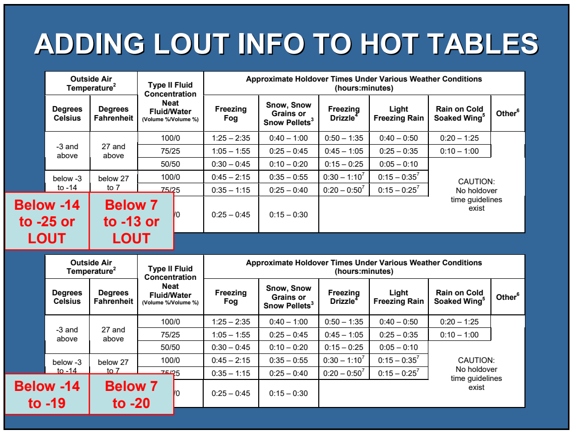
ADDING LOUT INFO TO HOT TABLES



Outside Air Temperature^{2}		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets^{3}	Freezing Drizzle^{4}	Light Freezing Rain	Rain on Cold Soaked Wing^{5}	Other^{6}
-3 and above	27 and above	100/0	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	
		75/25	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10^{7}	0:15 – 0:35^{7}		
		75/25	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50^{7}	0:15 – 0:25^{7}		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	/0	0:25 – 0:45	0:15 – 0:30				

Outside Air Temperature^{2}		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets^{3}	Freezing Drizzle^{4}	Light Freezing Rain	Rain on Cold Soaked Wing^{5}	Other^{6}
-3 and above	27 and above	100/0	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	
		75/25	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10^{7}	0:15 – 0:35^{7}		
		75/25	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50^{7}	0:15 – 0:25^{7}		
Below -14 to -19	Below 7 to -20	/0	0:25 – 0:45	0:15 – 0:30				

POTENTIAL FUTURE CHANGES

POSSIBLE TC REVISION

1. Updating the LOUT Tables
2. Adding LOUT information to fluid-specific tables
3. **Adding LOUT restrictions to fluid-specific & generic tables**
4. Separating the Type I table into separate aluminum and composite Type I tables
5. Adding guidance related to interaction between runway deicer and aircraft de/anti-icing fluids
6. Minor editorial changes

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POTENTIAL FUTURE CHANGES

ADDING LOUT RESTRICTIONS TO HOT TABLES

- In cases where the fluid LOUT is above the lowest temperature in a given temperature band, a note would be added to indicate the restriction on temperature use based on LOUT
- Both fluid-specific and generic HOT tables would be affected
- Again, this is being done for clarity and ease of use

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ADDING LOUT RESTRICTIONS

FLUID-SPECIFIC TABLE

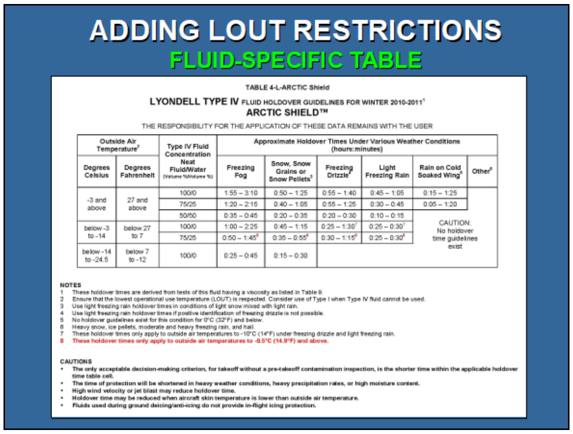


TABLE 4-L-ARCTIC Shield

LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011^{1}
ARCTIC SHIELD™

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

Outside Air Temperature^{2}		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets^{3}	Freezing Drizzle^{4}	Light Freezing Rain	Rain on Cold Soaked Wing^{5}	Other^{6}
-3 and above	27 and above	100/0	1:55 – 3:10	0:50 – 1:25	0:55 – 1:40	0:45 – 1:05	0:15 – 1:25	
		75/25	1:20 – 2:15	0:40 – 1:05	0:55 – 1:25	0:30 – 0:45	0:05 – 1:20	
		50/50	0:35 – 0:45	0:20 – 0:35	0:20 – 0:30	0:10 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00 – 2:25	0:45 – 1:15	0:25 – 1:30^{7}	0:25 – 0:30^{7}		
		75/25	0:50 – 1:45^{8}	0:35 – 0:55^{8}	0:30 – 1:15^{8}	0:25 – 0:30^{8}		
below -14 to -24.5	below 7 to -12	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
8 These holdover times only apply to outside air temperatures to -9.5°C (14.9°F) and above.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

ADDING LOUT RESTRICTIONS

GENERIC TABLE

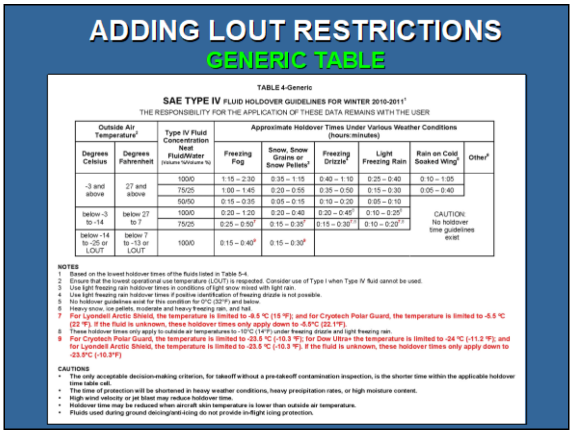


TABLE 4-Generic

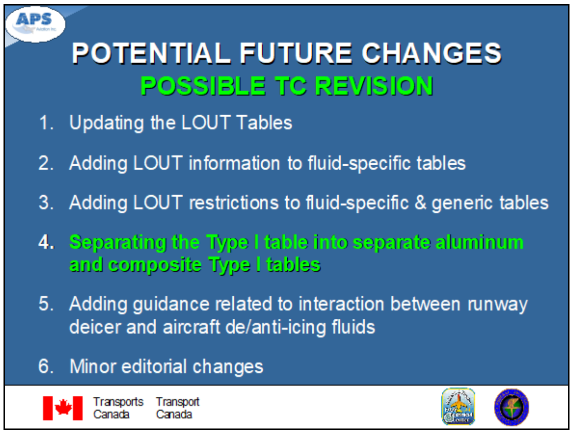
SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011^{1}

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

Outside Air Temperature^{2}		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets^{3}	Freezing Drizzle^{4}	Light Freezing Rain	Rain on Cold Soaked Wing^{5}	Other^{6}
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45^{8}	0:10 – 0:25^{8}		
		75/25	0:25 – 0:50^{7}	0:15 – 0:35^{7}	0:15 – 0:30^{7,8}	0:10 – 0:20^{7,8}		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40^{9}	0:15 – 0:30^{9}				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 For Lyondell Arctic Shield, the temperature is limited to -9.5 °C (15 °F); and for Cryotech Polar Guard, the temperature is limited to -5.5 °C (22 °F). If the fluid is unknown, these holdover times only apply down to -5.5°C (22.1°F).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
9 For Cryotech Polar Guard, the temperature is limited to -23.5 °C (-10.3 °F); for Dow Ultra+ the temperature is limited to -24 °C (-11.2 °F); and for Lyondell Arctic Shield, the temperature is limited to -23.5 °C (-10.3 °F). If the fluid is unknown, these holdover times only apply down to -23.5°C (-10.3°F)

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**



POTENTIAL FUTURE CHANGES
POSSIBLE TC REVISION

1. Updating the LOUT Tables
2. Adding LOUT information to fluid-specific tables
3. Adding LOUT restrictions to fluid-specific & generic tables
4. Separating the Type I table into separate aluminum and composite Type I tables
5. Adding guidance related to interaction between runway deicer and aircraft de/anti-icing fluids
6. Minor editorial changes

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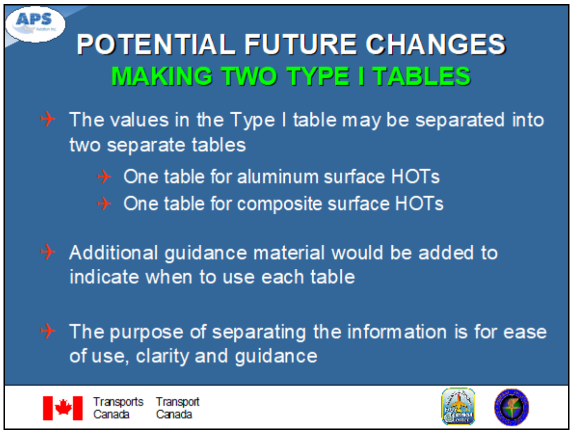

POTENTIAL FUTURE CHANGES
MAKING TWO TYPE I TABLES

- The values in the Type I table may be separated into two separate tables
  - One table for aluminum surface HOTs
  - One table for composite surface HOTs
- Additional guidance material would be added to indicate when to use each table
- The purpose of separating the information is for ease of use, clarity and guidance

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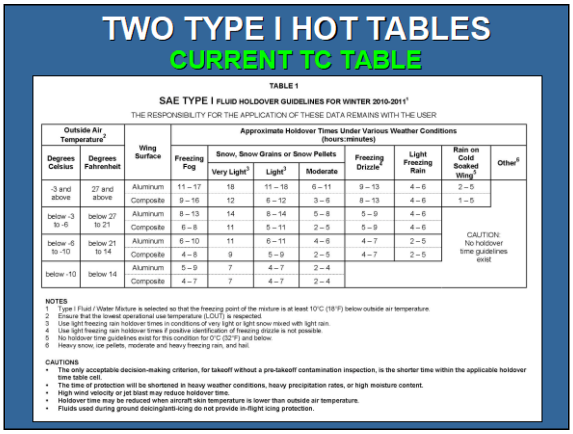


TWO TYPE I HOT TABLES
CURRENT TC TABLE

TABLE 1

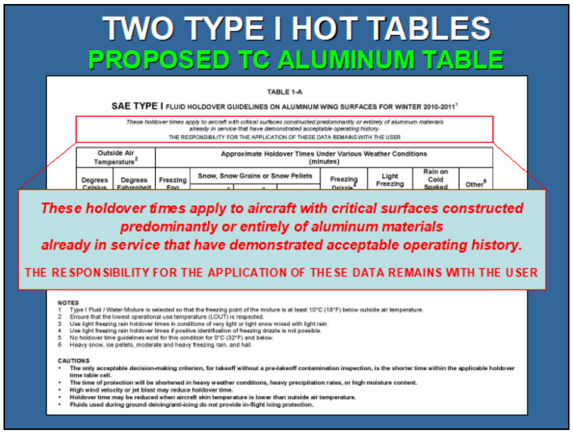
SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**



TWO TYPE I HOT TABLES
PROPOSED TC ALUMINUM TABLE

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES FOR WINTER 2010-2011[1]

These holdover times apply to aircraft with critical surfaces constructed predominantly or entirely of aluminum materials already in service that have demonstrated acceptable operating history.

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

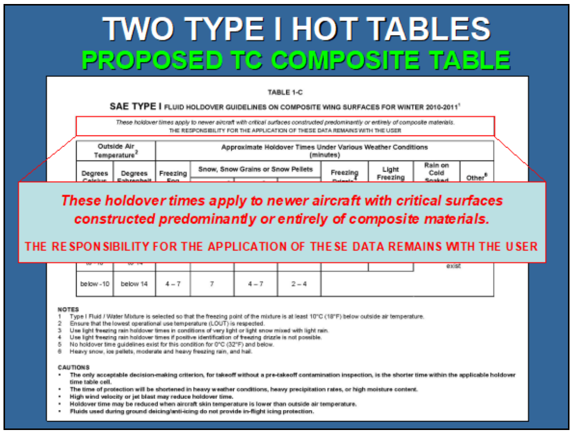
Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing	Rain on Cold Soaked	Other[6]

These holdover times apply to aircraft with critical surfaces constructed predominantly or entirely of aluminum materials already in service that have demonstrated acceptable operating history.

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

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**



TWO TYPE I HOT TABLES
PROPOSED TC COMPOSITE TABLE

TABLE 1-C

SAE TYPE I FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES FOR WINTER 2010-2011[1]

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

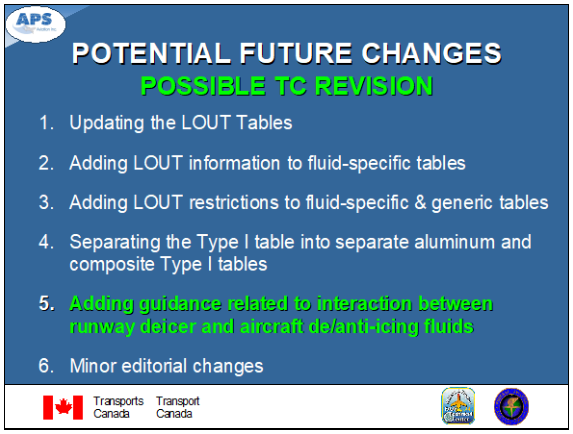
Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing	Rain on Cold Soaked	Other[6]
below -10	below 14	4 – 7	7	4 – 7	2 – 4				

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**



POTENTIAL FUTURE CHANGES
POSSIBLE TC REVISION

1. Updating the LOUT Tables
2. Adding LOUT information to fluid-specific tables
3. Adding LOUT restrictions to fluid-specific & generic tables
4. Separating the Type I table into separate aluminum and composite Type I tables
5. Adding guidance related to interaction between runway deicer and aircraft de/anti-icing fluids
6. Minor editorial changes

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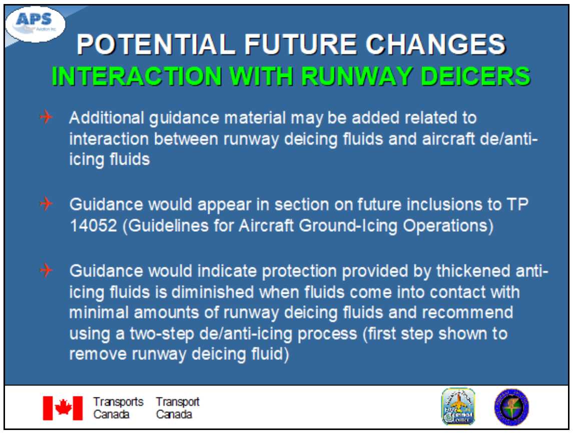
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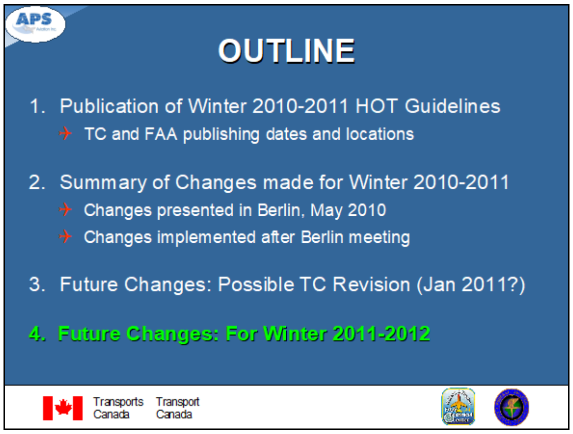
POTENTIAL FUTURE CHANGES
INTERACTION WITH RUNWAY DEICERS

- Additional guidance material may be added related to interaction between runway deicing fluids and aircraft de/anti-icing fluids
- Guidance would appear in section on future inclusions to TP 14052 (Guidelines for Aircraft Ground-Icing Operations)
- Guidance would indicate protection provided by thickened anti-icing fluids is diminished when fluids come into contact with minimal amounts of runway deicing fluids and recommend using a two-step de/anti-icing process (first step shown to remove runway deicing fluid)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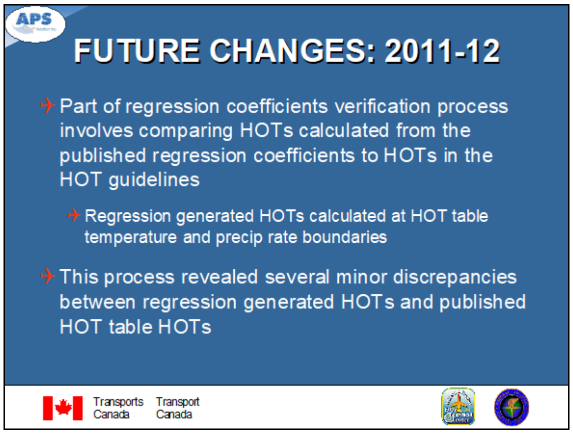
OUTLINE

1. Publication of Winter 2010-2011 HOT Guidelines
    - TC and FAA publishing dates and locations
2. Summary of Changes made for Winter 2010-2011
    - Changes presented in Berlin, May 2010
    - Changes implemented after Berlin meeting
3. Future Changes: Possible TC Revision (Jan 2011?)
4. Future Changes: For Winter 2011-2012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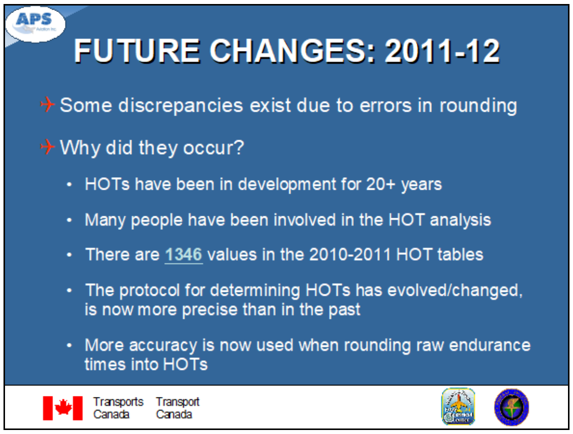
FUTURE CHANGES: 2011-12

- Part of regression coefficients verification process involves comparing HOTs calculated from the published regression coefficients to HOTs in the HOT guidelines
    - Regression generated HOTs calculated at HOT table temperature and precip rate boundaries
- This process revealed several minor discrepancies between regression generated HOTs and published HOT table HOTs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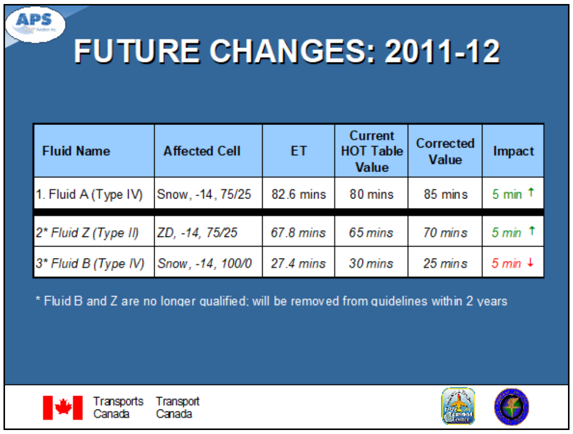
FUTURE CHANGES: 2011-12

- Some discrepancies exist due to errors in rounding
- Why did they occur?
    - HOTs have been in development for 20+ years
    - Many people have been involved in the HOT analysis
    - There are 1346 values in the 2010-2011 HOT tables
    - The protocol for determining HOTs has evolved/changed, is now more precise than in the past
    - More accuracy is now used when rounding raw endurance times into HOTs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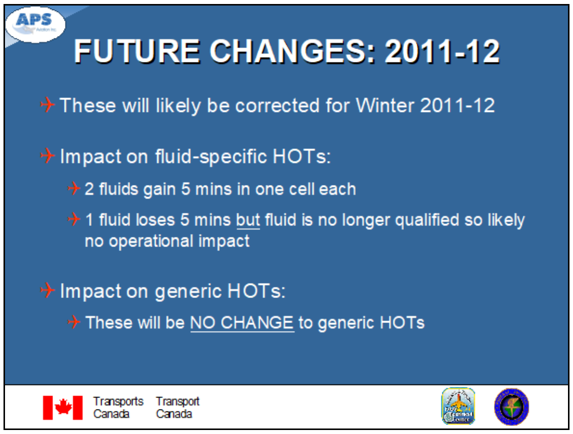
FUTURE CHANGES: 2011-12

Fluid Name	Affected Cell	ET	Current HOT Table Value	Corrected Value	Impact
1. Fluid A (Type IV)	Snow, -14, 75/25	82.6 mins	80 mins	85 mins	5 min ↑
2 Fluid Z (Type II)*	*ZD, -14, 75/25*	*67.8 mins*	*65 mins*	*70 mins*	*5 min ↑*
3 Fluid B (Type IV)*	*Snow, -14, 100/0*	*27.4 mins*	*30 mins*	*25 mins*	*5 min ↓*

* Fluid B and Z are no longer qualified; will be removed from guidelines within 2 years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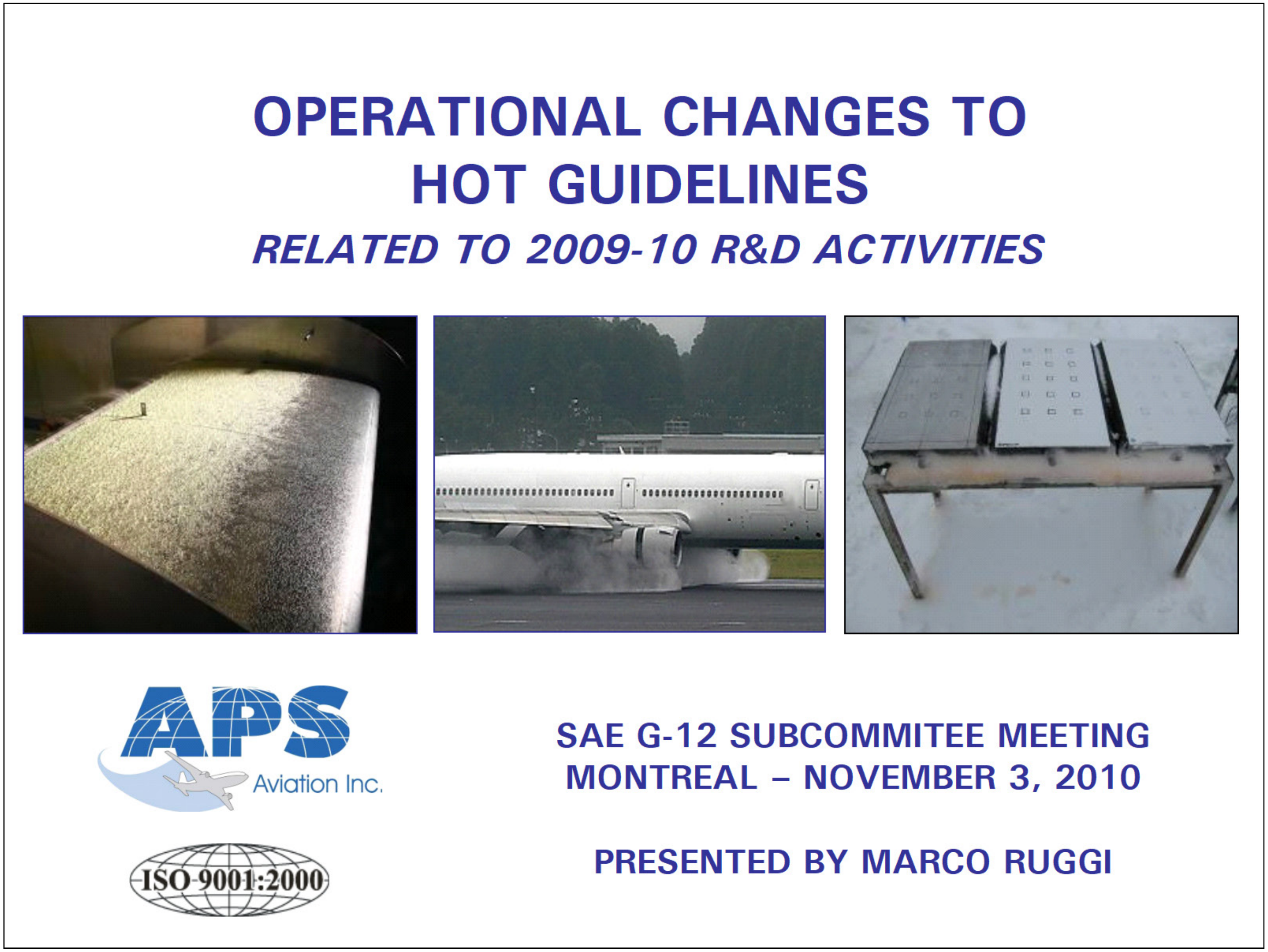
FUTURE CHANGES: 2011-12

- These will likely be corrected for Winter 2011-12
- Impact on fluid-specific HOTs:
    - 2 fluids gain 5 mins in one cell each
    - 1 fluid loses 5 mins but fluid is no longer qualified so likely no operational impact
- Impact on generic HOTs:
    - These will be NO CHANGE to generic HOTs

? QUESTIONS ?

APS
Aviation Inc.

Stephanie Bendickson
email: sbendickson@telus.net



OPERATIONAL CHANGES TO HOT GUIDELINES

RELATED TO 2009-10 R&D ACTIVITIES

APS
Aviation Inc.
ISO 9001:2000

SAE G-12 SUBCOMMITEE MEETING
MONTREAL – NOVEMBER 3, 2010

PRESENTED BY MARCO RUGGI

PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE

OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
- EFFECT OF RDF ON FLUID HOT'S
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN

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PURPOSE

- To provide an update of changes made to the HOT Guidelines as a result of R&D activities
- More detailed presentations were presented in Berlin in May 2010 and are available on the SAE Website
- Detailed reports are in development

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OUTLINE

- **SNOW PELLETS**
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
- EFFECT OF RDF ON FLUID HOT'S
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN

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SNOW PELLETS

APS Aviation Inc.
ISO 9001:2000

BACKGROUND

- Definition of Snow Pellets:
  - 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.
- No HOT Guidelines existed for snow pellets

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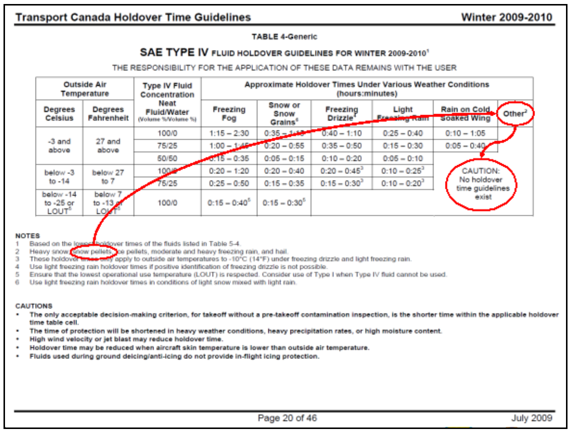

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – [illegible]	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		CAUTION: No holdover time guidelines exist
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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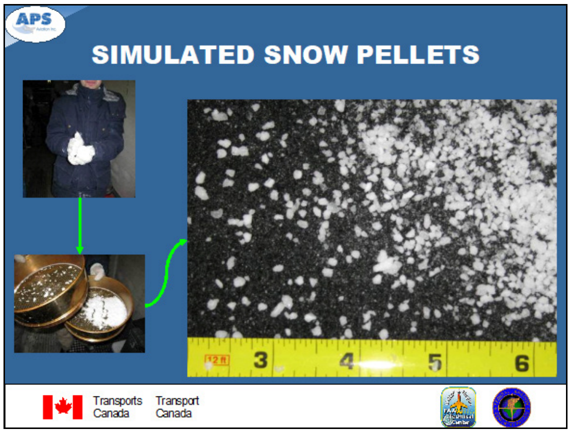
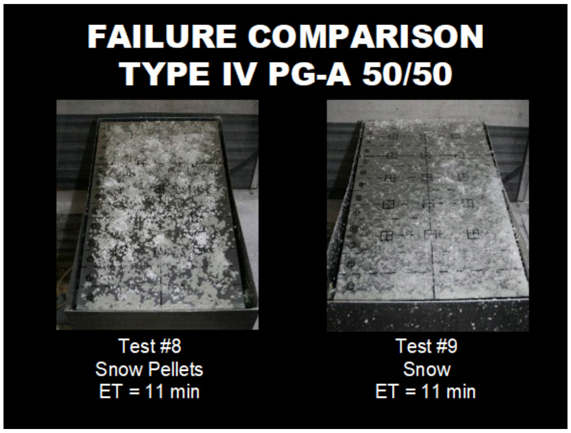


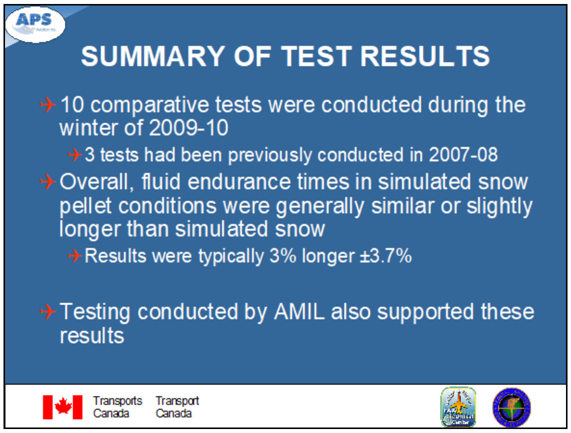
SIMULATED SNOW PELLETS



FAILURE COMPARISON TYPE IV PG-A 50/50

Test #8
Snow Pellets
ET = 11 min

Test #9
Snow
ET = 11 min



SUMMARY OF TEST RESULTS

- 10 comparative tests were conducted during the winter of 2009-10
  - 3 tests had been previously conducted in 2007-08
- Overall, fluid endurance times in simulated snow pellet conditions were generally similar or slightly longer than simulated snow
  - Results were typically 3% longer ±3.7%
- Testing conducted by AMIL also supported these results

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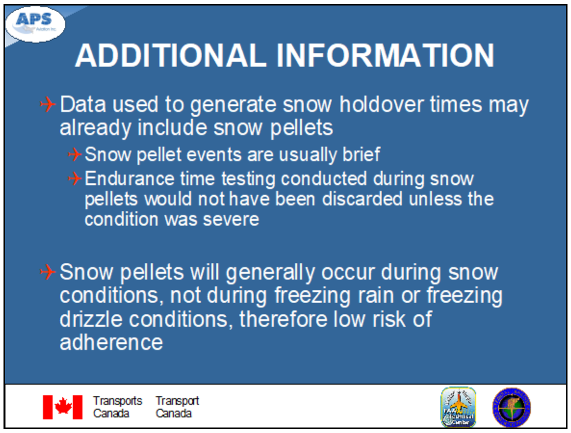

ADDITIONAL INFORMATION

- Data used to generate snow holdover times may already include snow pellets
  - Snow pellet events are usually brief
  - Endurance time testing conducted during snow pellets would not have been discarded unless the condition was severe
- Snow pellets will generally occur during snow conditions, not during freezing rain or freezing drizzle conditions, therefore low risk of adherence

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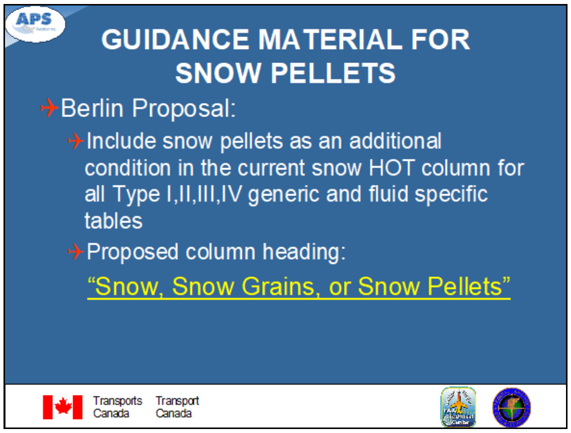

GUIDANCE MATERIAL FOR SNOW PELLETS

- Berlin Proposal:
  - Include snow pellets as an additional condition in the current snow HOT column for all Type I,II,III,IV generic and fluid specific tables
  - Proposed column heading:
    "Snow, Snow Grains, or Snow Pellets"

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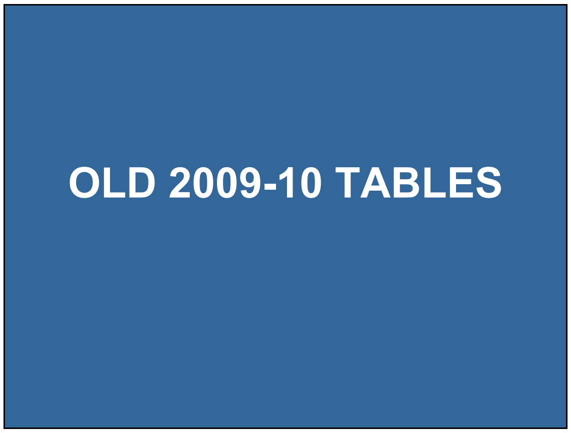
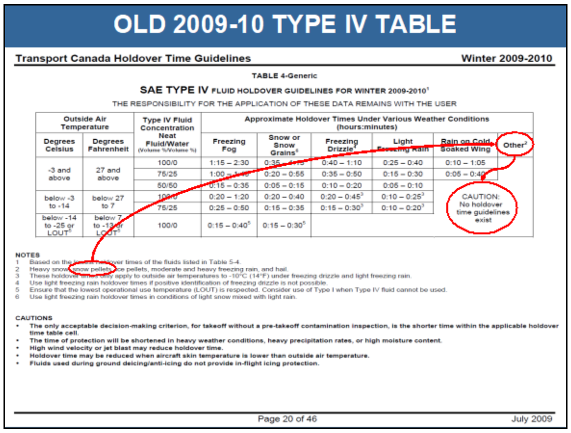


OLD 2009-10 TABLES



OLD 2009-10 TYPE IV TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	CAUTION: No holdover time guidelines exist
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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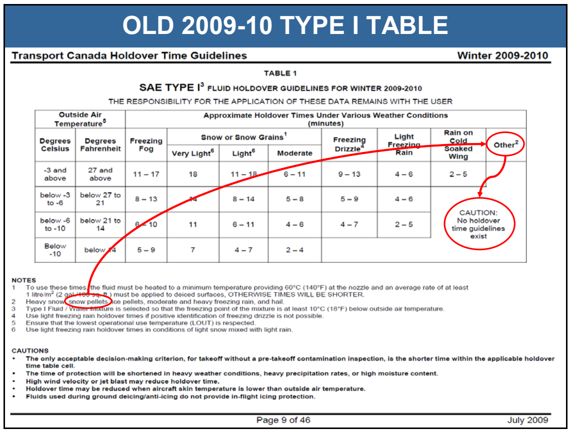

OLD 2009-10 TYPE I TABLE

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
			Very Light[6]	Light[6]	Moderate				
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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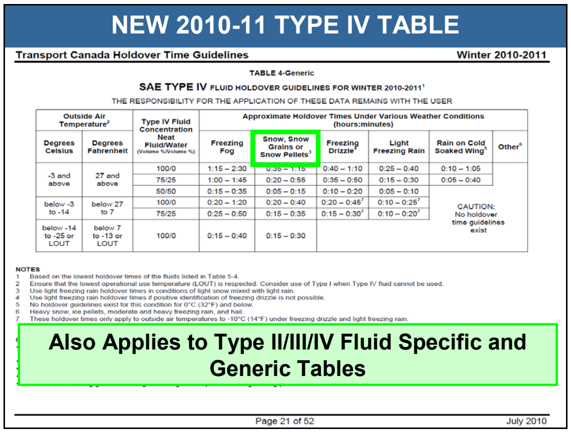
NEW 2010-11 TABLES



NEW 2010-11 TYPE IV TABLE

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 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	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

Also Applies to Type II/III/IV Fluid Specific and Generic Tables

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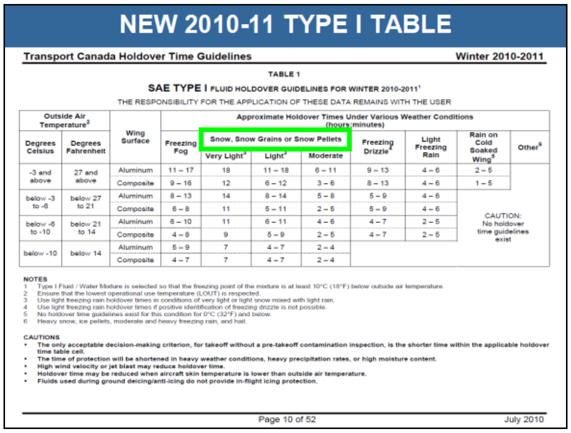

NEW 2010-11 TYPE I TABLE

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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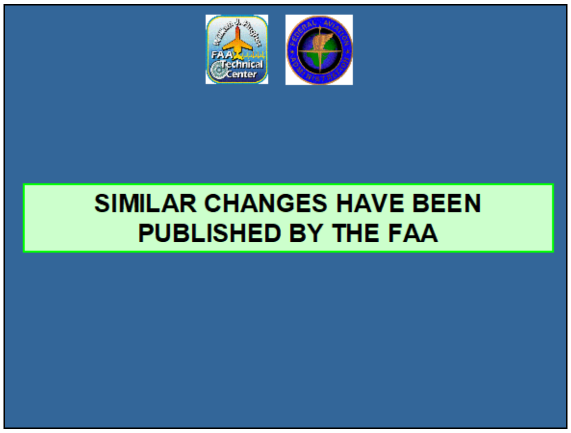
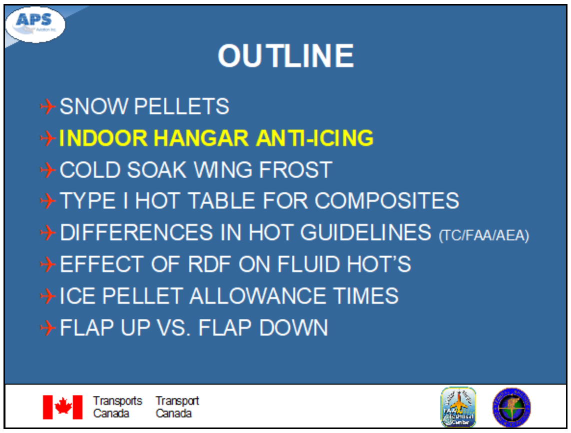


SIMILAR CHANGES HAVE BEEN PUBLISHED BY THE FAA

SNOW PELLETS

ANY ADDITIONAL FEEDBACK???



OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
- EFFECT OF RDF ON FLUID HOT'S
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN

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INDOOR HANGAR ANTI-ICING

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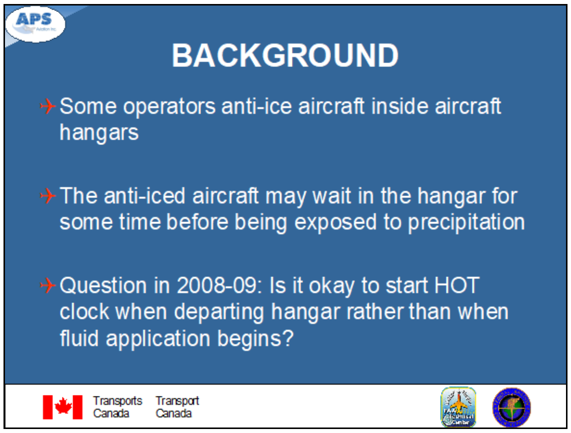

BACKGROUND

- Some operators anti-ice aircraft inside aircraft hangars
- The anti-iced aircraft may wait in the hangar for some time before being exposed to precipitation
- Question in 2008-09: Is it okay to start HOT clock when departing hangar rather than when fluid application begins?

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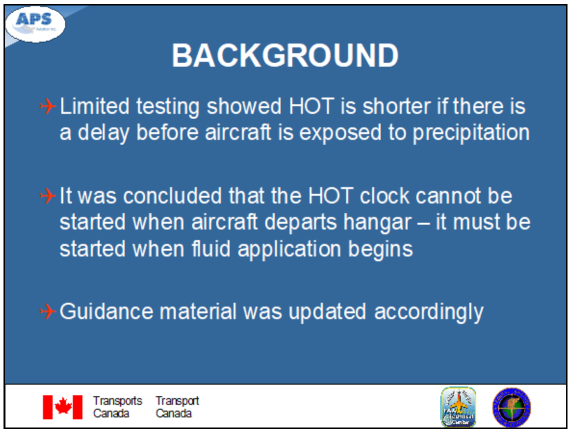

BACKGROUND

- Limited testing showed HOT is shorter if there is a delay before aircraft is exposed to precipitation
- It was concluded that the HOT clock cannot be started when aircraft departs hangar – it must be started when fluid application begins
- Guidance material was updated accordingly

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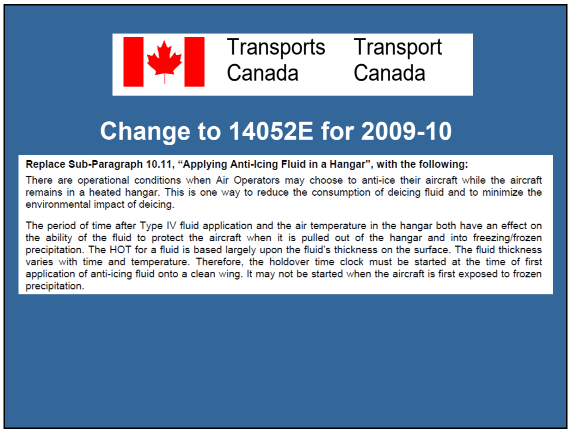

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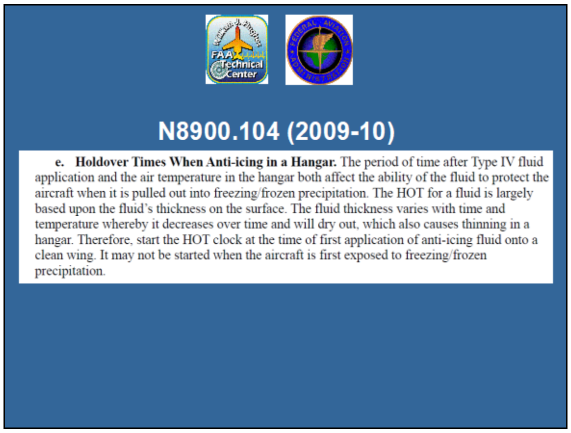
Change to 14052E for 2009-10

Replace Sub-Paragraph 10.11, "Applying Anti-Icing Fluid in a Hangar", with the following:

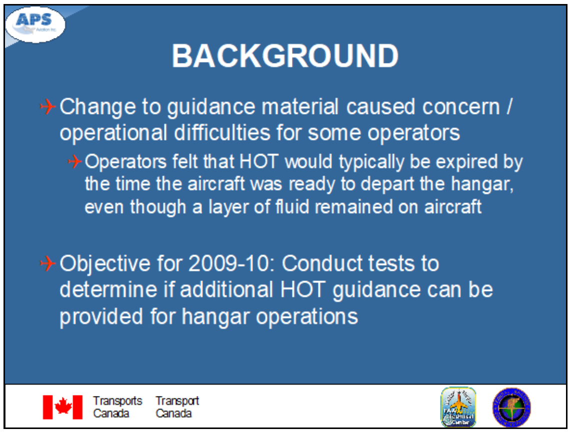
There are operational conditions when Air Operators may choose to anti-ice their aircraft while the aircraft remains in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after Type IV fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Therefore, the holdover time clock must be started at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to frozen precipitation.



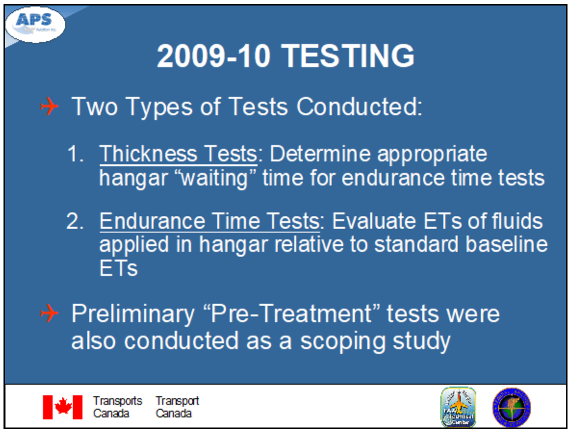
N8900.104 (2009-10)

e. **Holdover Times When Anti-icing in a Hangar.** The period of time after Type IV fluid application and the air temperature in the hangar both affect the ability of the fluid to protect the aircraft when it is pulled out into freezing/frozen precipitation. The HOT for a fluid is largely based upon the fluid's thickness on the surface. The fluid thickness varies with time and temperature whereby it decreases over time and will dry out, which also causes thinning in a hangar. Therefore, start the HOT clock at the time of first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to freezing/frozen precipitation.



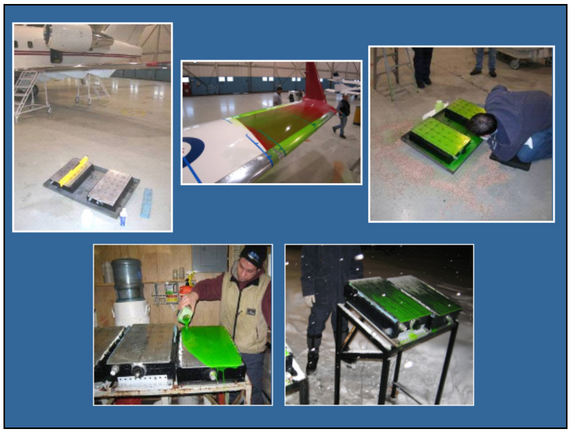
BACKGROUND

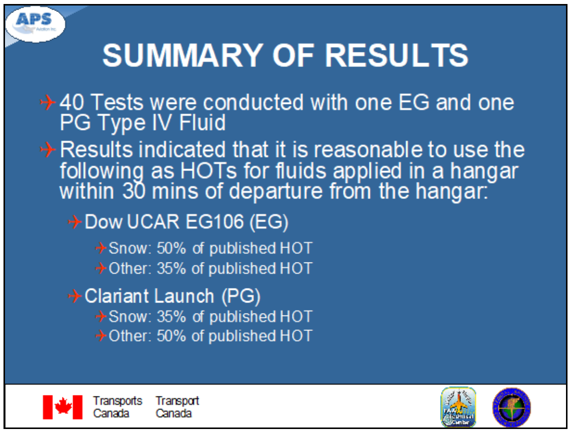
- Change to guidance material caused concern / operational difficulties for some operators
  - Operators felt that HOT would typically be expired by the time the aircraft was ready to depart the hangar, even though a layer of fluid remained on aircraft
- Objective for 2009-10: Conduct tests to determine if additional HOT guidance can be provided for hangar operations



2009-10 TESTING

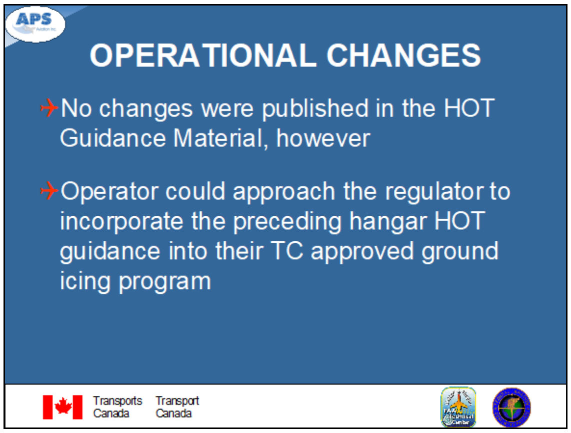
- Two Types of Tests Conducted:
  1. Thickness Tests: Determine appropriate hangar "waiting" time for endurance time tests
  2. Endurance Time Tests: Evaluate ETs of fluids applied in hangar relative to standard baseline ETs
- Preliminary "Pre-Treatment" tests were also conducted as a scoping study





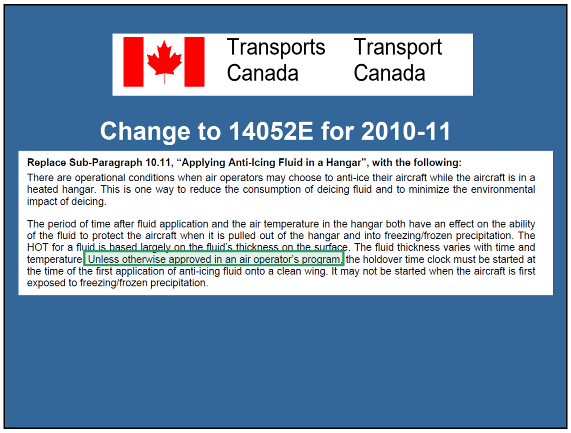
SUMMARY OF RESULTS

- 40 Tests were conducted with one EG and one PG Type IV Fluid
- Results indicated that it is reasonable to use the following as HOTs for fluids applied in a hangar within 30 mins of departure from the hangar:
  - Dow UCAR EG106 (EG)
    - Snow: 50% of published HOT
    - Other: 35% of published HOT
  - Clariant Launch (PG)
    - Snow: 35% of published HOT
    - Other: 50% of published HOT



OPERATIONAL CHANGES

- No changes were published in the HOT Guidance Material, however
- Operator could approach the regulator to incorporate the preceding hangar HOT guidance into their TC approved ground icing program



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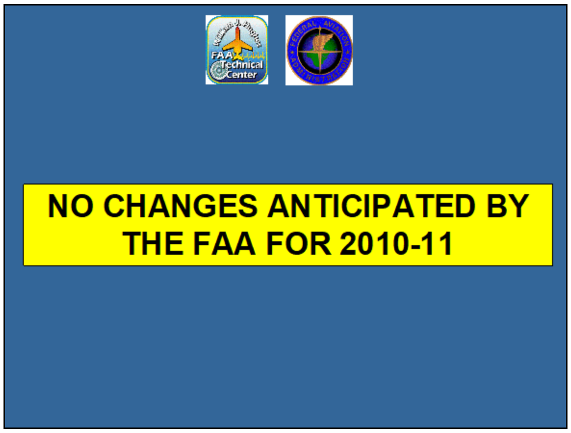
Change to 14052E for 2010-11

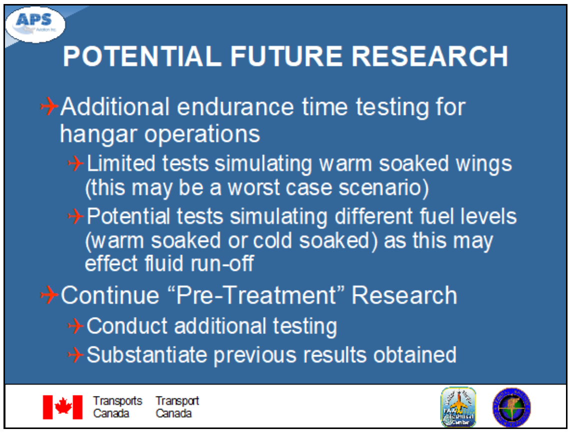
Replace Sub-Paragraph 10.11, "Applying Anti-Icing Fluid in a Hangar", with the following:

There are operational conditions when air operators may choose to anti-ice their aircraft while the aircraft is in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely on the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Unless otherwise approved in an air operator's program, the holdover time clock must be started at the time of the first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to freezing/frozen precipitation.



NO CHANGES ANTICIPATED BY THE FAA FOR 2010-11

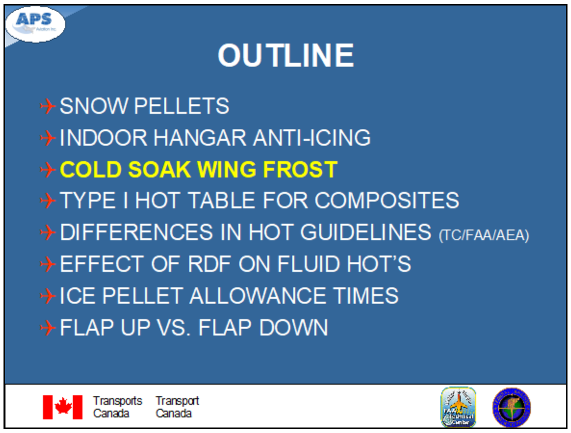


POTENTIAL FUTURE RESEARCH

- Additional endurance time testing for hangar operations
  - Limited tests simulating warm soaked wings (this may be a worst case scenario)
  - Potential tests simulating different fuel levels (warm soaked or cold soaked) as this may effect fluid run-off
- Continue "Pre-Treatment" Research
  - Conduct additional testing
  - Substantiate previous results obtained

ANY ADDITIONAL FEEDBACK???

INDOOR HANGAR ANTI-ICING



OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
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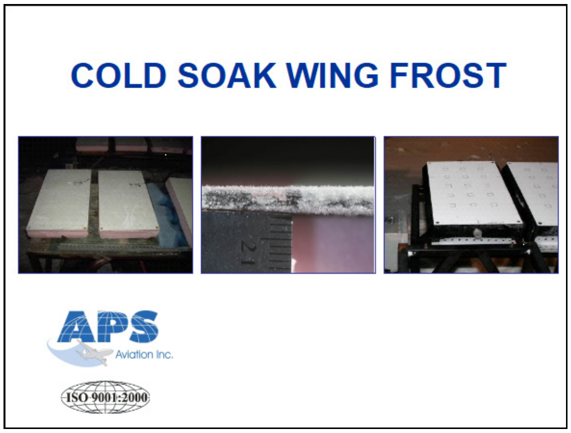
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN



COLD SOAK WING FROST

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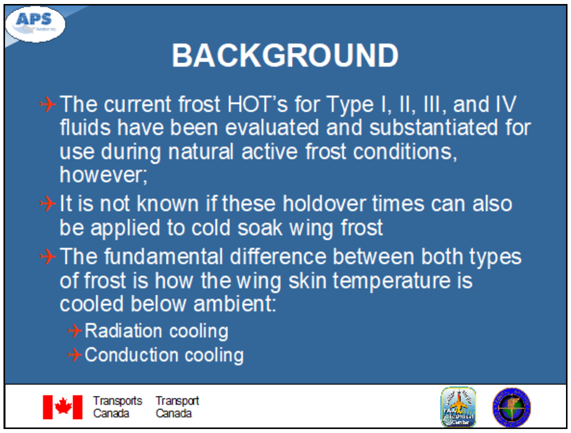

BACKGROUND

- The current frost HOT's for Type I, II, III, and IV fluids have been evaluated and substantiated for use during natural active frost conditions, however;
- It is not known if these holdover times can also be applied to cold soak wing frost
- The fundamental difference between both types of frost is how the wing skin temperature is cooled below ambient:
  - Radiation cooling
  - Conduction cooling

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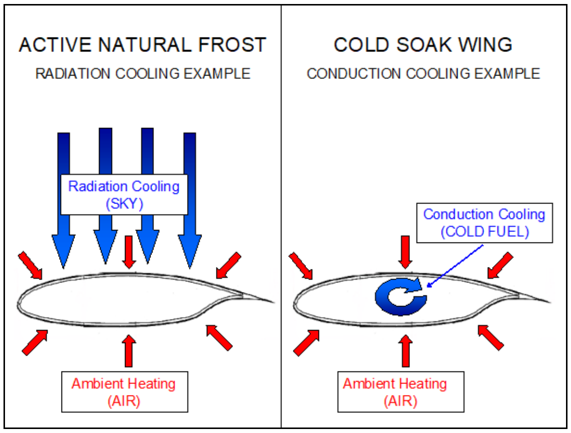


ACTIVE NATURAL FROST

RADIATION COOLING EXAMPLE

Radiation Cooling (SKY)

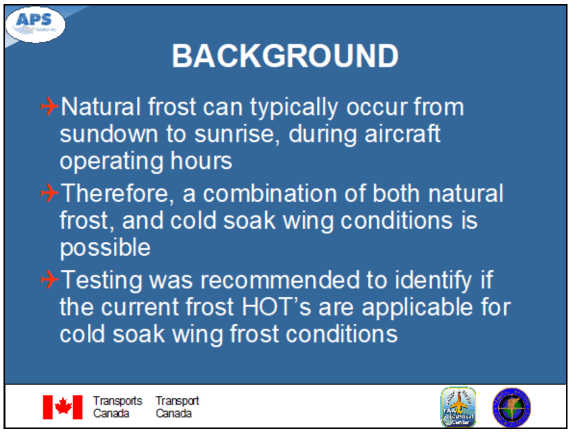
Ambient Heating (AIR)

COLD SOAK WING

CONDUCTION COOLING EXAMPLE

Conduction Cooling (COLD FUEL)

Ambient Heating (AIR)



BACKGROUND

- Natural frost can typically occur from sundown to sunrise, during aircraft operating hours
- Therefore, a combination of both natural frost, and cold soak wing conditions is possible
- Testing was recommended to identify if the current frost HOT's are applicable for cold soak wing frost conditions

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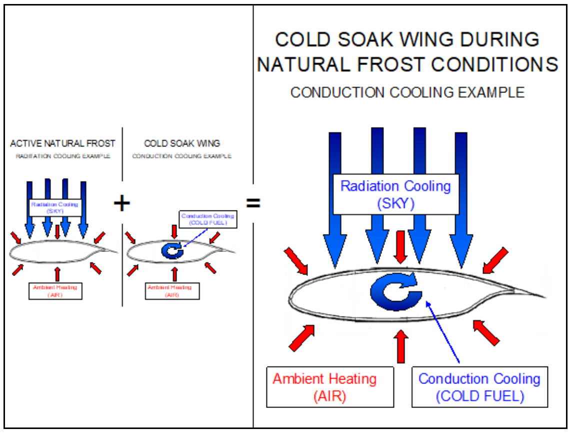


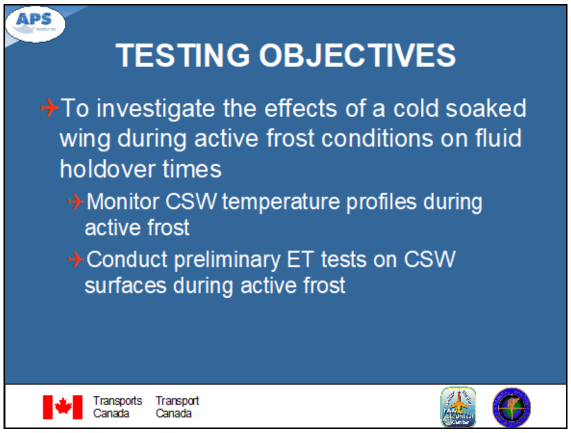
COLD SOAK WING DURING NATURAL FROST CONDITIONS

CONDUCTION COOLING EXAMPLE

Radiation Cooling (SKY)

Ambient Heating (AIR)

Conduction Cooling (COLD FUEL)



TESTING OBJECTIVES

- To investigate the effects of a cold soaked wing during active frost conditions on fluid holdover times
  - Monitor CSW temperature profiles during active frost
  - Conduct preliminary ET tests on CSW surfaces during active frost

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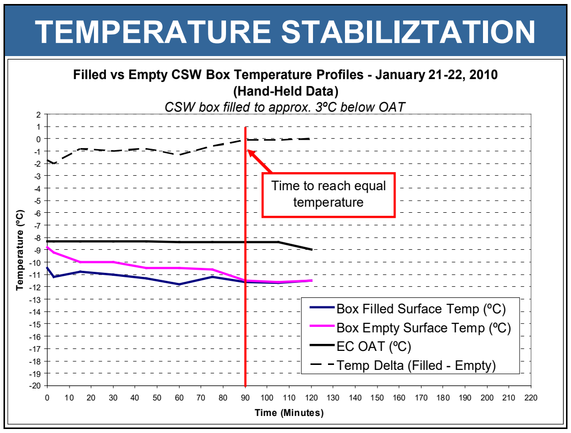
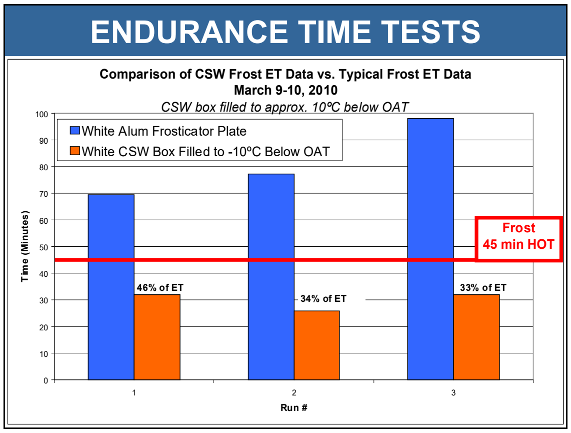


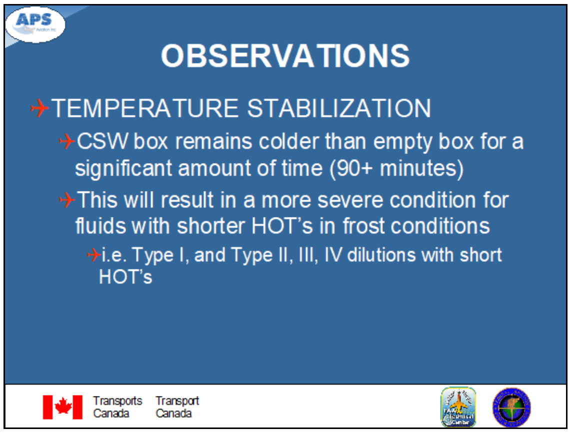
TEMPERATURE STABILIZTATION

Filled vs Empty CSW Box Temperature Profiles - January 21-22, 2010
(Hand-Held Data)
CSW box filled to approx. 3ºC below OAT



ENDURANCE TIME TESTS

Comparison of CSW Frost ET Data vs. Typical Frost ET Data
March 9-10, 2010
CSW box filled to approx. 10ºC below OAT



OBSERVATIONS

- TEMPERATURE STABILIZATION
  - CSW box remains colder than empty box for a significant amount of time (90+ minutes)
  - This will result in a more severe condition for fluids with shorter HOT's in frost conditions
    - i.e. Type I, and Type II, III, IV dilutions with short HOT's

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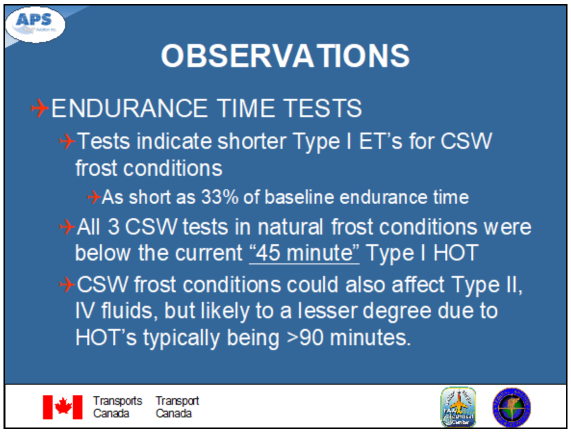

OBSERVATIONS

- ENDURANCE TIME TESTS
  - Tests indicate shorter Type I ET's for CSW frost conditions
    - As short as 33% of baseline endurance time
  - All 3 CSW tests in natural frost conditions were below the current "45 minute" Type I HOT
  - CSW frost conditions could also affect Type II, IV fluids, but likely to a lesser degree due to HOT's typically being >90 minutes.

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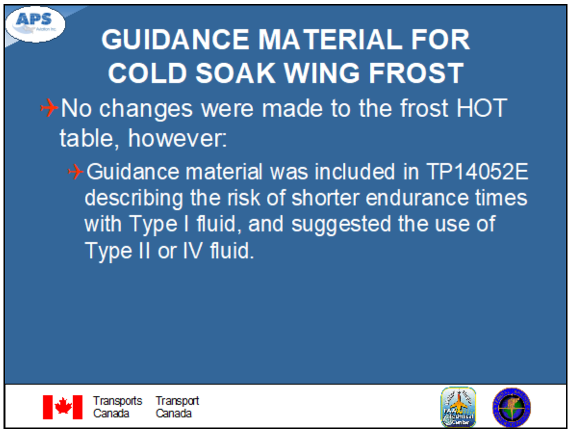

GUIDANCE MATERIAL FOR COLD SOAK WING FROST

- No changes were made to the frost HOT table, however:
  - Guidance material was included in TP14052E describing the risk of shorter endurance times with Type I fluid, and suggested the use of Type II or IV fluid.

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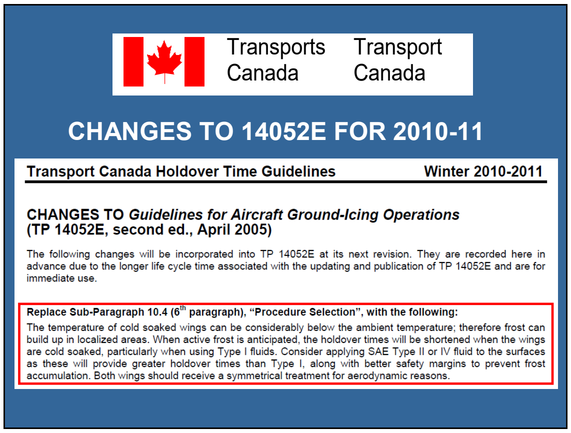

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CHANGES TO 14052E FOR 2010-11

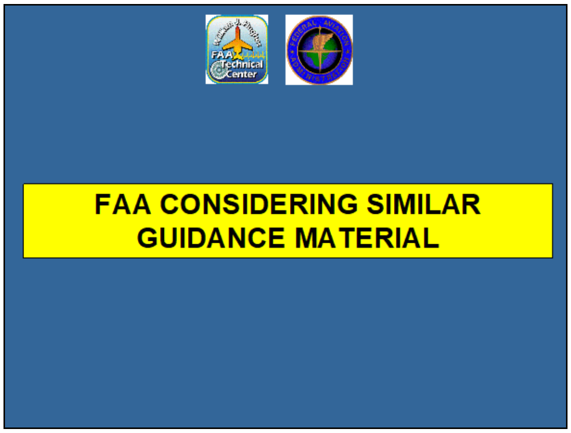
Transport Canada Holdover Time Guidelines **Winter 2010-2011**

CHANGES TO *Guidelines for Aircraft Ground-Icing Operations*
(TP 14052E, second ed., April 2005)

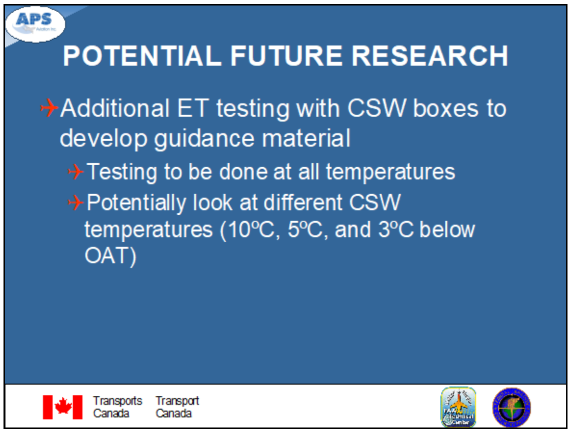
The following changes will be incorporated into TP 14052E at its next revision. They are recorded here in advance due to the longer life cycle time associated with the updating and publication of TP 14052E and are for immediate use.

Replace Sub-Paragraph 10.4 (6th paragraph), "Procedure Selection", with the following:

The temperature of cold soaked wings can be considerably below the ambient temperature; therefore frost can build up in localized areas. When active frost is anticipated, the holdover times will be shortened when the wings are cold soaked, particularly when using Type I fluids. Consider applying SAE Type II or IV fluid to the surfaces as these will provide greater holdover times than Type I, along with better safety margins to prevent frost accumulation. Both wings should receive a symmetrical treatment for aerodynamic reasons.



FAA CONSIDERING SIMILAR GUIDANCE MATERIAL



POTENTIAL FUTURE RESEARCH

- Additional ET testing with CSW boxes to develop guidance material
  - Testing to be done at all temperatures
  - Potentially look at different CSW temperatures (10ºC, 5ºC, and 3ºC below OAT)

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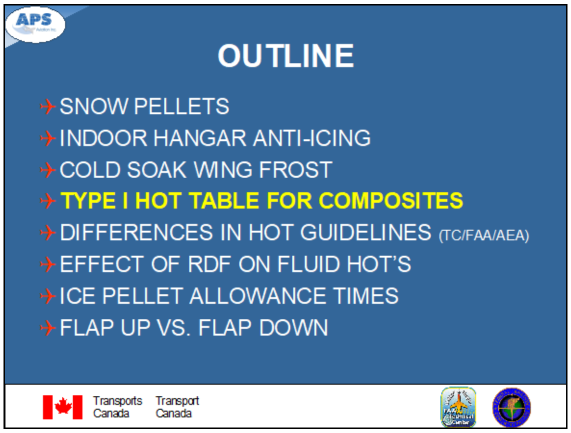
ANY ADDITIONAL FEEDBACK???

COLD SOAK WING FROST



OUTLINE

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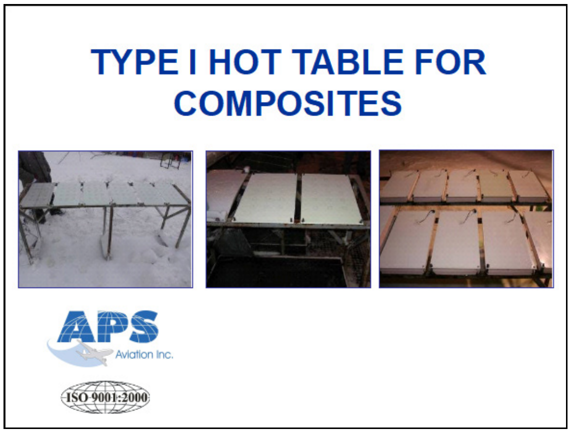

TYPE I HOT TABLE FOR COMPOSITES

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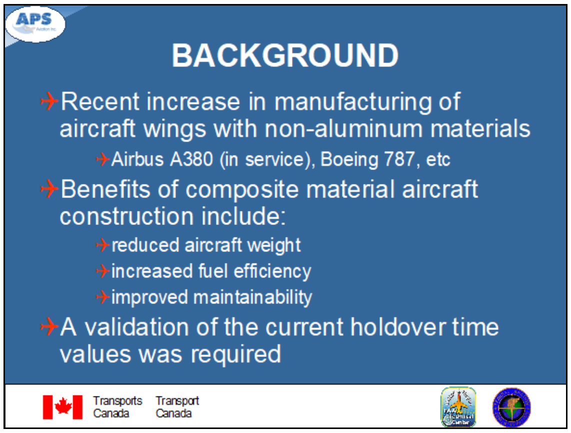

BACKGROUND

- Recent increase in manufacturing of aircraft wings with non-aluminum materials
  - Airbus A380 (in service), Boeing 787, etc
- Benefits of composite material aircraft construction include:
  - reduced aircraft weight
  - increased fuel efficiency
  - improved maintainability
- A validation of the current holdover time values was required

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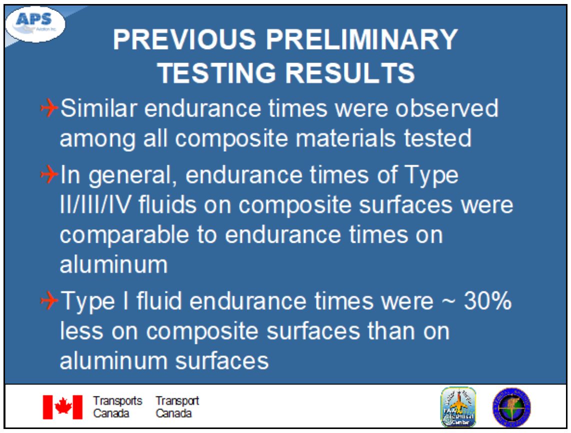

PREVIOUS PRELIMINARY TESTING RESULTS

- Similar endurance times were observed among all composite materials tested
- In general, endurance times of Type II/III/IV fluids on composite surfaces were comparable to endurance times on aluminum
- Type I fluid endurance times were ~ 30% less on composite surfaces than on aluminum surfaces

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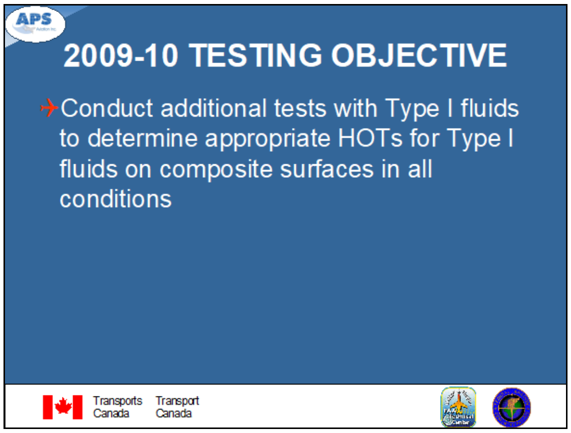

2009-10 TESTING OBJECTIVE

- Conduct additional tests with Type I fluids to determine appropriate HOTs for Type I fluids on composite surfaces in all conditions

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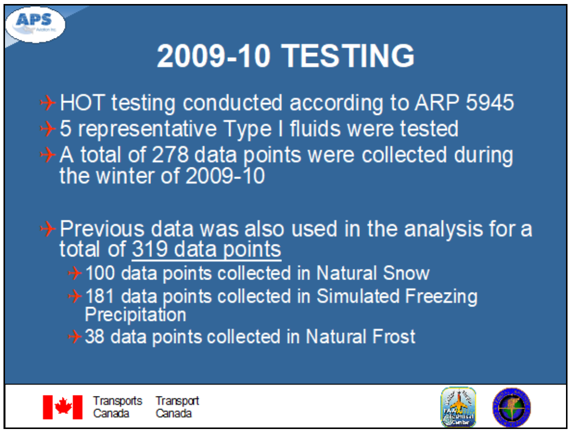

2009-10 TESTING

- HOT testing conducted according to ARP 5945
- 5 representative Type I fluids were tested
- A total of 278 data points were collected during the winter of 2009-10
- Previous data was also used in the analysis for a total of 319 data points
  - 100 data points collected in Natural Snow
  - 181 data points collected in Simulated Freezing Precipitation
  - 38 data points collected in Natural Frost

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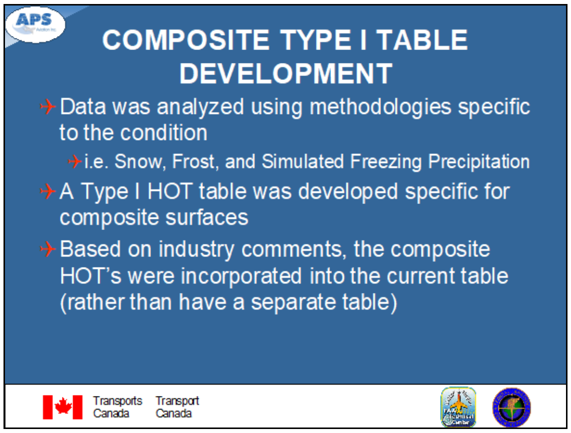

COMPOSITE TYPE I TABLE DEVELOPMENT

- Data was analyzed using methodologies specific to the condition
  - i.e. Snow, Frost, and Simulated Freezing Precipitation
- A Type I HOT table was developed specific for composite surfaces
- Based on industry comments, the composite HOT's were incorporated into the current table (rather than have a separate table)

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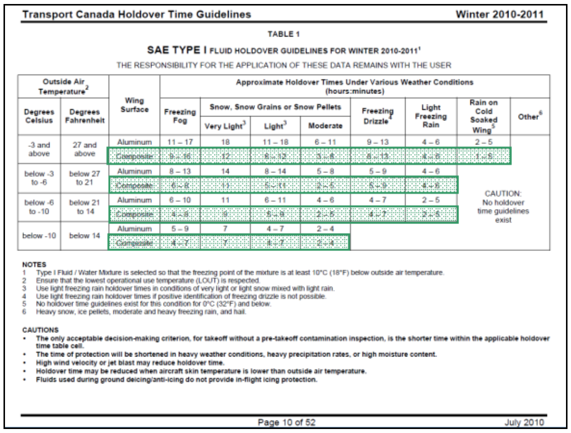

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	8 – 12	3 – 6	6 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 9	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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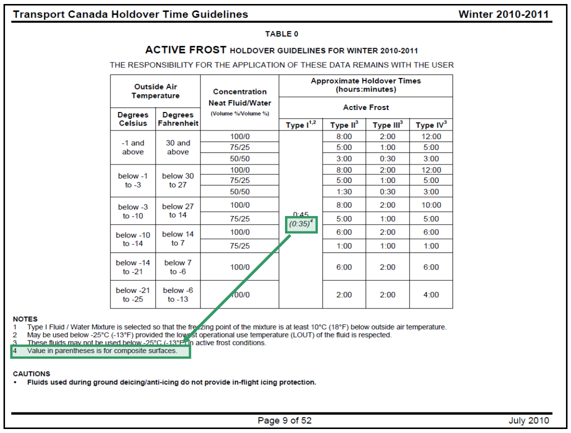


Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2010-2011

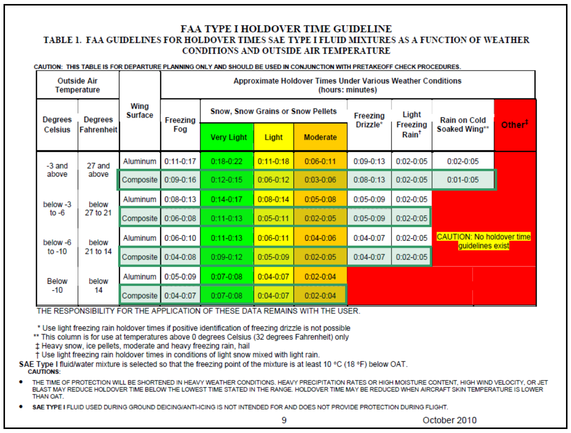
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parentheses is for composite surfaces.

CAUTIONS
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

Page 9 of 52 July 2010



FAA TYPE I HOLDOVER TIME GUIDELINE

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
				Very Light	Light	Moderate				
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-0:06	0:08-0:13	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05		
		Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05	CAUTION: No holdover time guidelines exist	
		Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				
		Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				

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

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

SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE I** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

9 October 2010

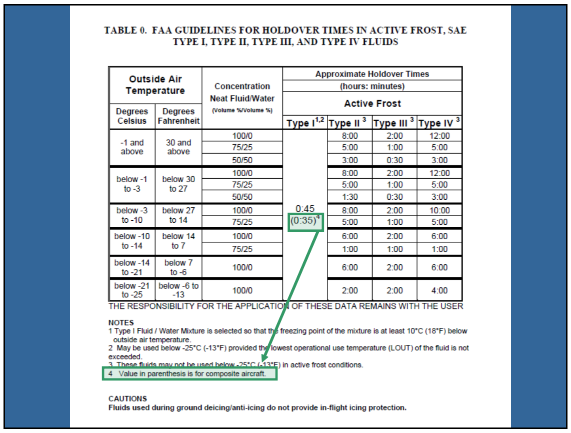


TABLE 0. FAA GUIDELINES FOR HOLDOVER TIMES IN ACTIVE FROST, SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II [3]	Type III [3]	Type IV [3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

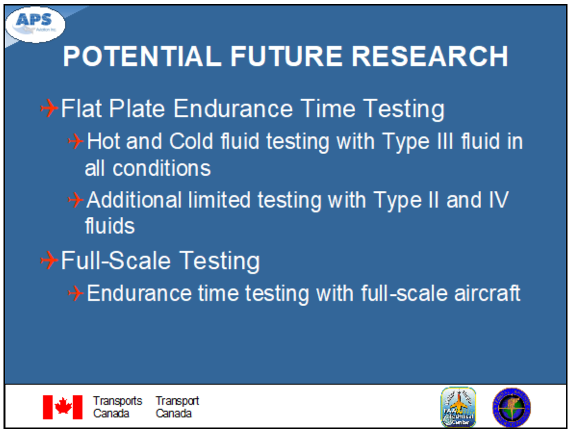
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is not exceeded.
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parenthesis is for composite aircraft.

CAUTIONS

Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.



POTENTIAL FUTURE RESEARCH

- Flat Plate Endurance Time Testing
  - Hot and Cold fluid testing with Type III fluid in all conditions
  - Additional limited testing with Type II and IV fluids
- Full-Scale Testing
  - Endurance time testing with full-scale aircraft

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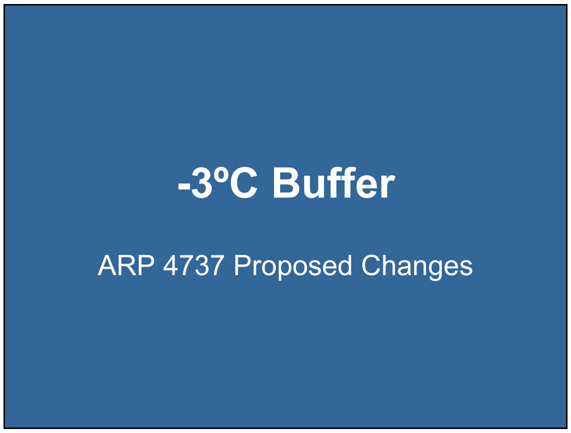
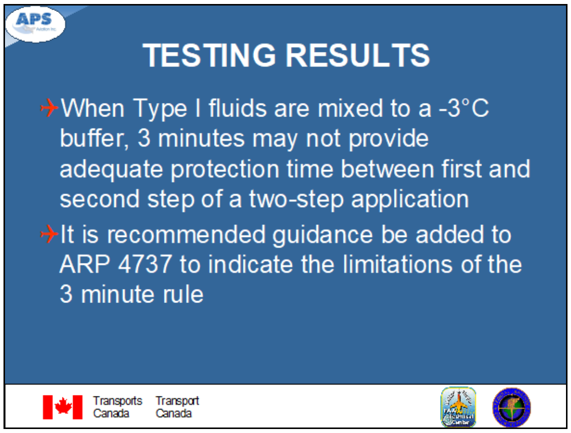


-3ºC Buffer

ARP 4737 Proposed Changes



TESTING RESULTS

- When Type I fluids are mixed to a -3°C buffer, 3 minutes may not provide adequate protection time between first and second step of a two-step application
- It is recommended guidance be added to ARP 4737 to indicate the limitations of the 3 minute rule

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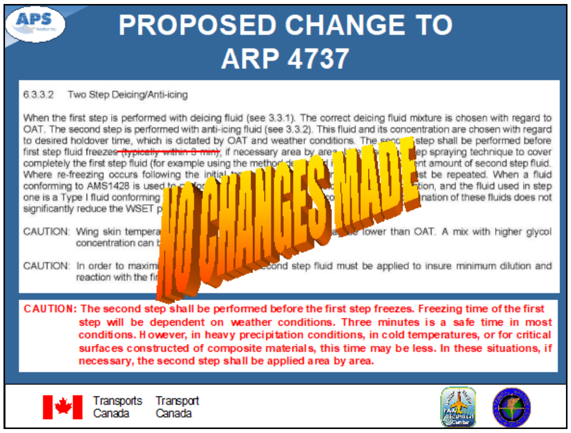

PROPOSED CHANGE TO ARP 4737

6.3.3.2 Two Step Deicing/Anti-icing

When the first step is performed with deicing fluid (see 3.3.1). The correct deicing fluid mixture is chosen with regard to OAT. The second step is performed with anti-icing fluid (see 3.3.2). This fluid and its concentration are chosen with regard to desired holdover time, which is dictated by OAT and weather conditions. The seco[illegible] step shall be performed before first step fluid freezes ~~(typically within 3 min)~~, if necessary area by area [illegible] ep spraying technique to cover completely the first step fluid (for example using the method [illegible] ent amount of second step fluid. Where re-freezing occurs following the initial [illegible] st be repeated. When a fluid conforming to AMS1428 is used [illegible] tion, and the fluid used in step one is a Type I fluid conforming [illegible] nation of these fluids does not significantly reduce the WSET p[illegible]

CAUTION: Wing skin tempera[illegible] lower than OAT. A mix with higher glycol concentration can b[illegible]

CAUTION: In order to maxim[illegible] cond step fluid must be applied to insure minimum dilution and reaction with the fi[illegible]

CAUTION: The second step shall be performed before the first step freezes. Freezing time of the first step will be dependent on weather conditions. Three minutes is a safe time in most conditions. However, in heavy precipitation conditions, in cold temperatures, or for critical surfaces constructed of composite materials, this time may be less. In these situations, if necessary, the second step shall be applied area by area.

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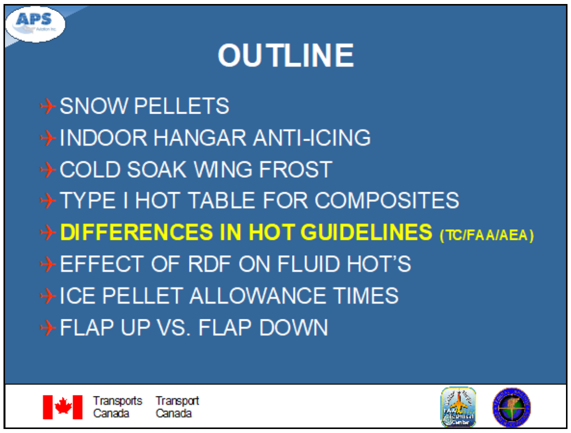
ANY ADDITIONAL FEEDBACK???
TYPE I TABLE FOR COMPOSITES



OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- **DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)**
- EFFECT OF RDF ON FLUID HOT'S
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN

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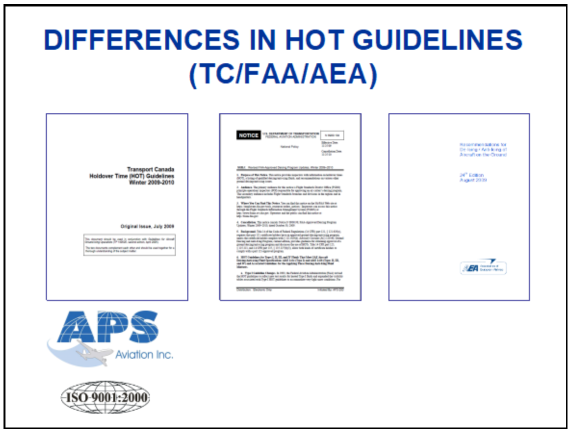


DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2009-2010

Original Issue, July 2009

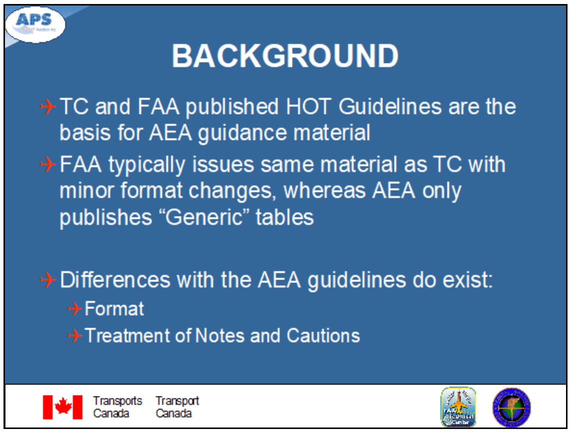
NOTICE

Recommendations for De-Icing / Anti-Icing of Aircraft on the Ground

24th Edition
August 2009

APS Aviation Inc.

ISO 9001:2000



BACKGROUND

- TC and FAA published HOT Guidelines are the basis for AEA guidance material
- FAA typically issues same material as TC with minor format changes, whereas AEA only publishes "Generic" tables
- Differences with the AEA guidelines do exist:
  - Format
  - Treatment of Notes and Cautions

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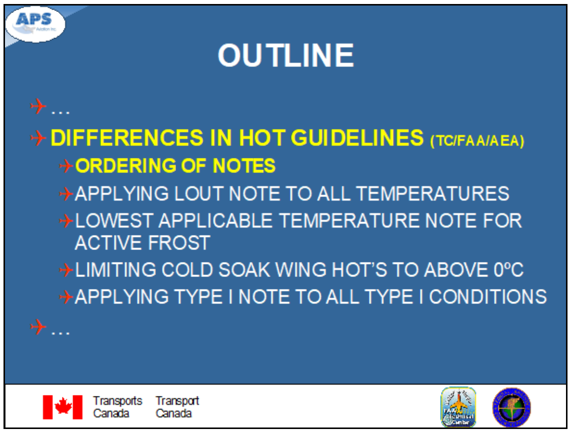

OUTLINE

- …
- **DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)**
  - **ORDERING OF NOTES**
  - APPLYING LOUT NOTE TO ALL TEMPERATURES
  - LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST
  - LIMITING COLD SOAK WING HOT'S TO ABOVE 0°C
  - APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS
- …

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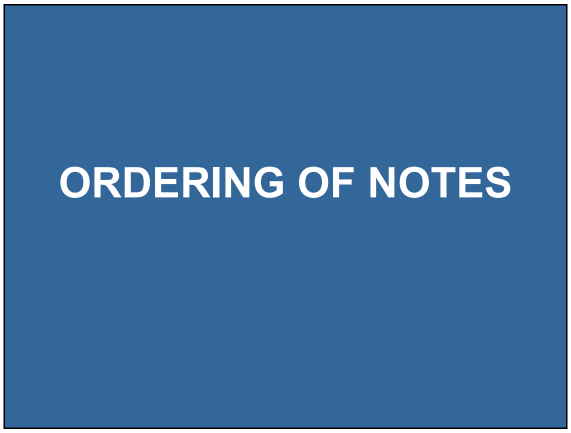


ORDERING OF NOTES

ORDERING OF NOTES

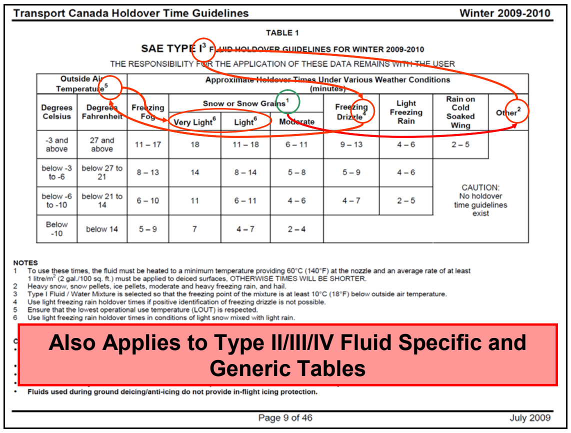
- Over the years, “Notes” to the TC HOT guideline tables have been added and removed
- Notes may have been included at the end of the list of notes to minimize changes required to guidelines
- The result was a listing of notes that was not in order of “how they appear”
  - Should be listed “Left to Right, and Up to Down

ORDERING OF NOTES

- AEA “Notes” were similar to TC “Notes” however, were listed according to the order they appear
- Notes listed in order are easier to reference

*** FAA notes are referenced with symbols, not numbers, therefore does not apply

OLD 2009-10 TABLES



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
			Snow or Snow Grains[1]						
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Very Light[6]	Light[6]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES
1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

Also Applies to Type II/III/IV Fluid Specific and Generic Tables

- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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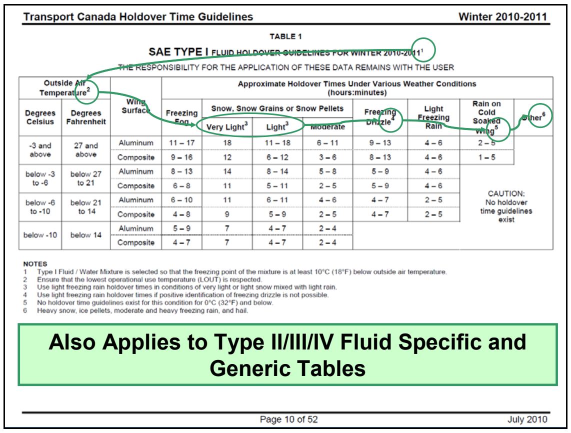
NEW 2010-11 TABLES



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]			Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
				Snow, Snow Grains or Snow Pellets						
Degrees Celsius	Degrees Fahrenheit	Wing Surface	Freezing Fog	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

Also Applies to Type II/III/IV Fluid Specific and Generic Tables

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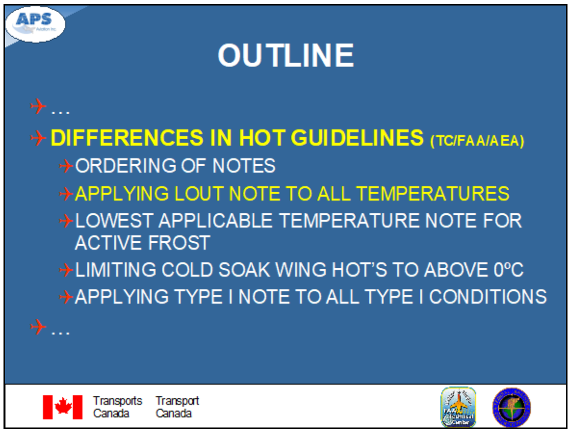

OUTLINE

- …
- **DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)**
  - ORDERING OF NOTES
  - APPLYING LOUT NOTE TO ALL TEMPERATURES
  - LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST
  - LIMITING COLD SOAK WING HOT'S TO ABOVE 0°C
  - APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS
- …

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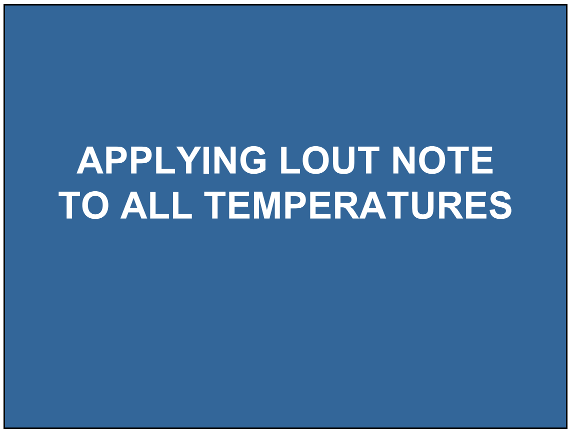
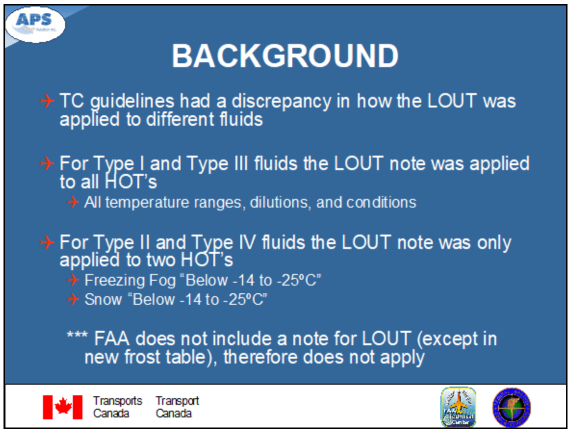


APPLYING LOUT NOTE TO ALL TEMPERATURES



BACKGROUND

- TC guidelines had a discrepancy in how the LOUT was applied to different fluids
- For Type I and Type III fluids the LOUT note was applied to all HOT's
  - All temperature ranges, dilutions, and conditions
- For Type II and Type IV fluids the LOUT note was only applied to two HOT's
  - Freezing Fog "Below -14 to -25°C"
  - Snow "Below -14 to -25°C"

*** FAA does not include a note for LOUT (except in new frost table), therefore does not apply

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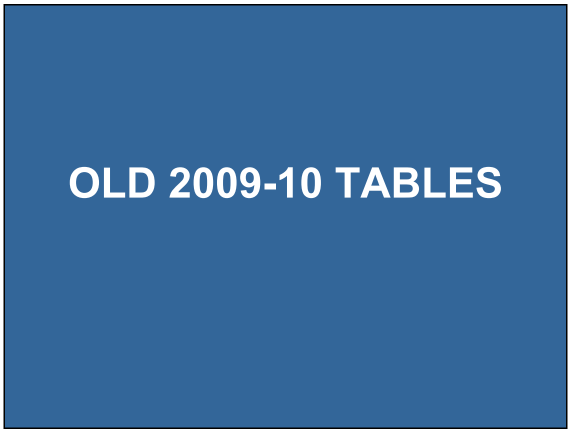
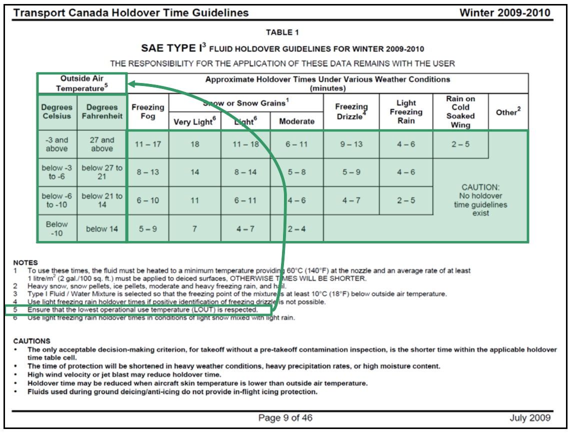


OLD 2009-10 TABLES



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1] Very Light[6]	Snow or Snow Grains[1] Light[6]	Snow or Snow Grains[1] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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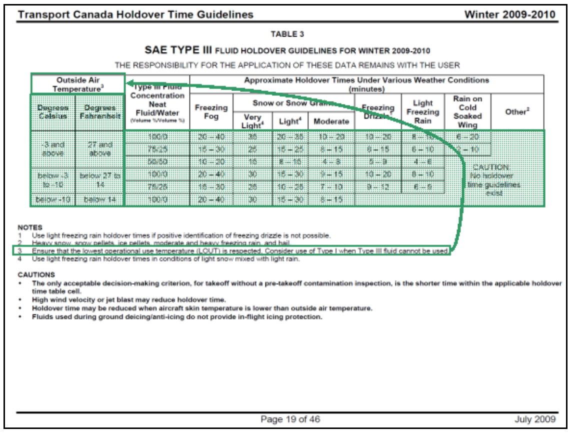

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[3]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains Very Light[4]	Snow or Snow Grains Light[4]	Snow or Snow Grains Moderate	Freezing Drizzle[1]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	6 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
4 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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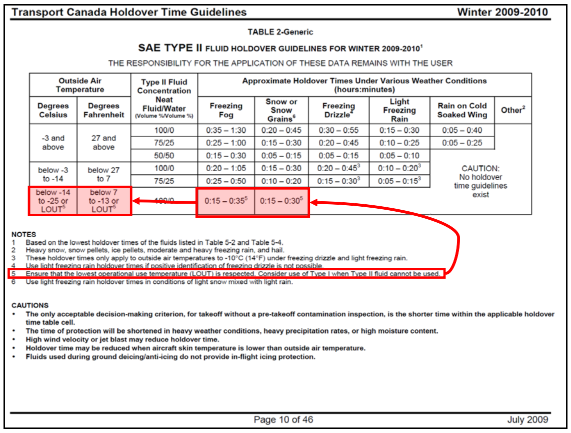

Transport Canada Holdover Time Guidelines Winter 2009-2010

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[3]	0:10 – 0:20[3]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[3]	0:05 – 0:15[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:35[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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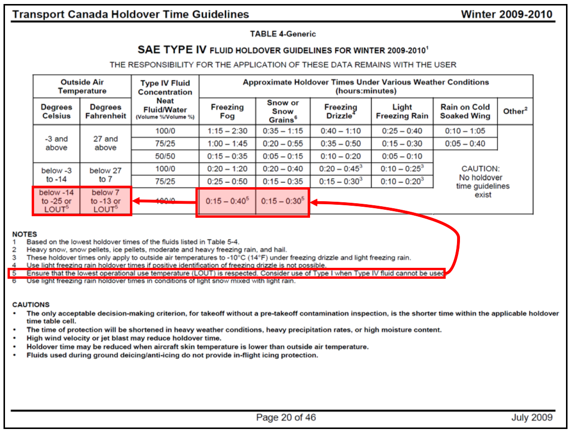

Transport Canada Holdover Time Guidelines Winter 2009-2010

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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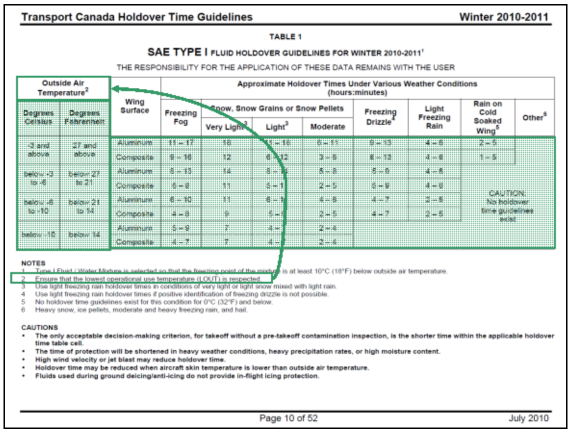
NEW 2010-11 TABLES



Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
				Snow, Snow Grains or Snow Pellets						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
		Composite	9 – 16	12	6 – 12	3 – 6	6 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – [illegible]	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
		Composite	6 – 9	11	5 – [illegible]	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – [illegible]	4 – 8	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – [illegible]	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – [illegible]	2 – 4				
		Composite	4 – 7	7	4 – [illegible]	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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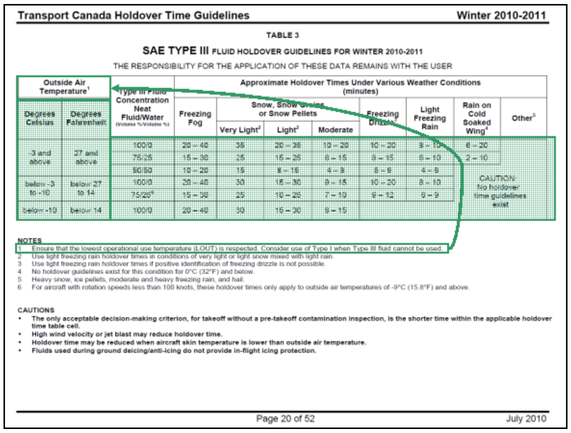

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature[1]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)						
				Snow, Snow Grains or Snow Pellets					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Very Light[2]	Light[2]	Moderate	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25[6]	15 – 30	25	10 – 25	7 – 10	9 – 12	6 – 9		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
2 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4 No holdover guidelines exist for this condition for 0°C (32°F) and below.
5 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
6 For aircraft with rotation speeds less than 100 knots, these holdover times only apply to outside air temperatures of -9°C (15.8°F) and above.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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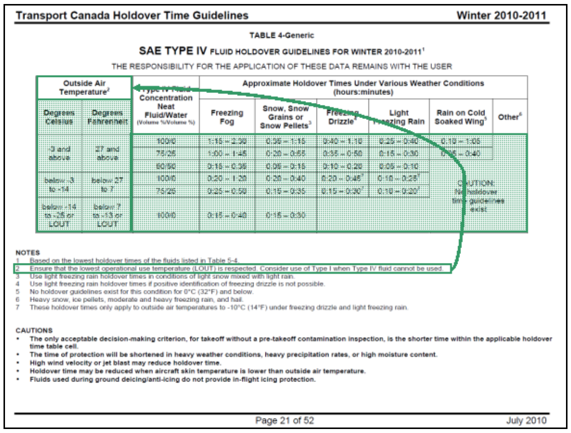

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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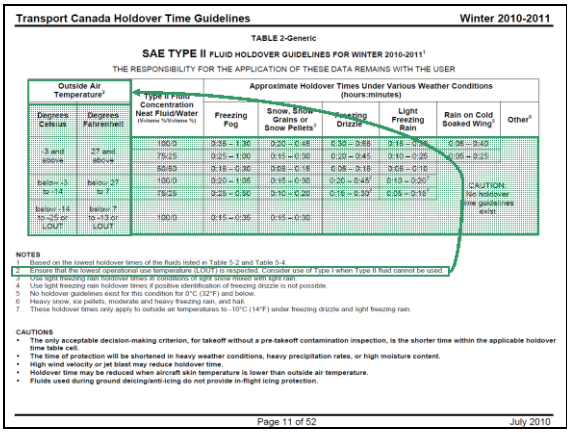

Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[7]	0:10 – 0:20[7]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[7]	0:05 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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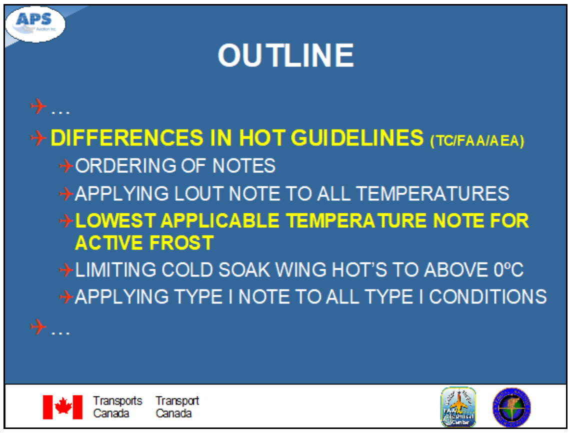

OUTLINE

- …
- **DIFFERENCES IN HOT GUIDELINES** (TC/FAA/AEA)
  - ORDERING OF NOTES
  - APPLYING LOUT NOTE TO ALL TEMPERATURES
  - **LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST**
  - LIMITING COLD SOAK WING HOT'S TO ABOVE 0°C
  - APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS
- …

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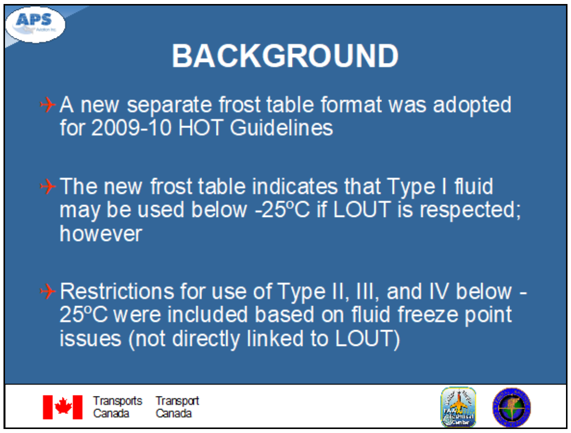
LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST



BACKGROUND

- A new separate frost table format was adopted for 2009-10 HOT Guidelines
- The new frost table indicates that Type I fluid may be used below -25°C if LOUT is respected; however
- Restrictions for use of Type II, III, and IV below -25°C were included based on fluid freeze point issues (not directly linked to LOUT)

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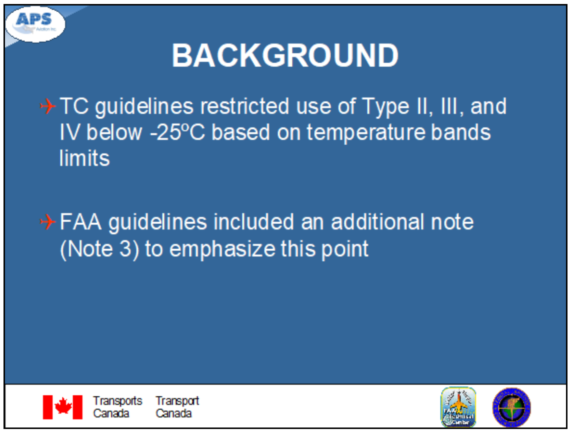

BACKGROUND

- TC guidelines restricted use of Type II, III, and IV below -25°C based on temperature bands limits
- FAA guidelines included an additional note (Note 3) to emphasize this point

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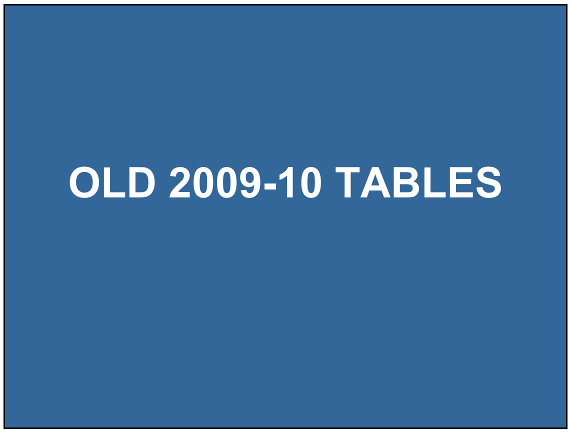
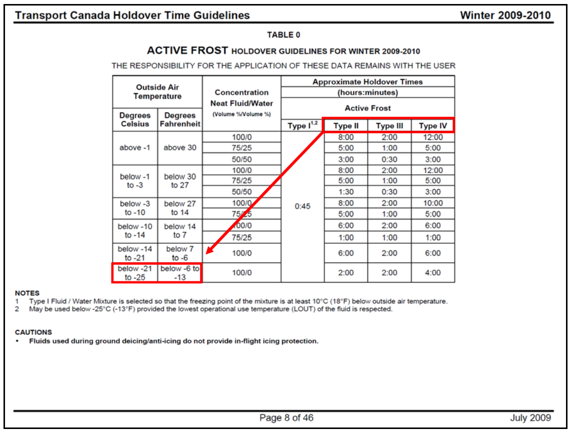


OLD 2009-10 TABLES



Transport Canada Holdover Time Guidelines — Winter 2009-2010

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II	Type III	Type IV
above -1	above 30	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.

2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.

CAUTIONS

- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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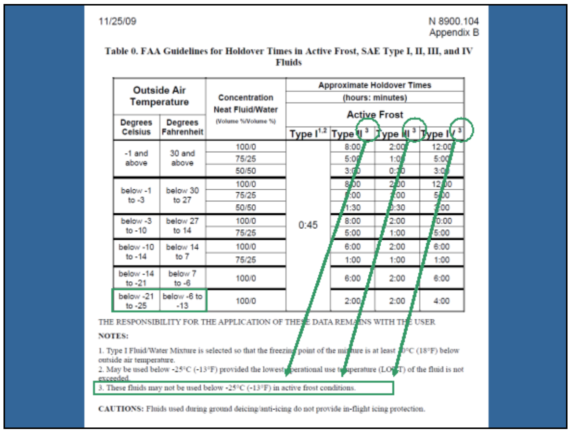

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Appendix B

Table 0. FAA Guidelines for Holdover Times in Active Frost, SAE Type I, II, III, and IV Fluids

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

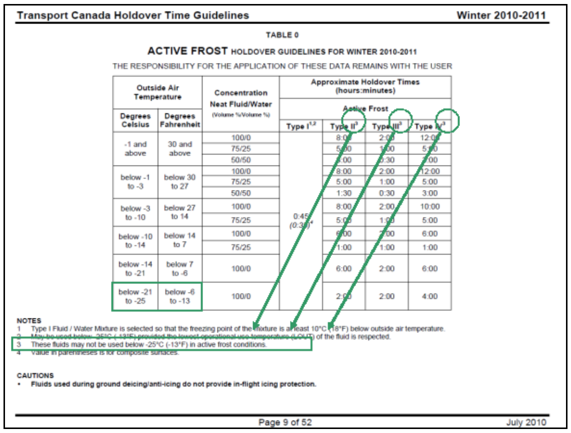
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES:

1. Type I Fluid/Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2. May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is not exceeded.
3. These fluids may not be used below -25°C (-13°F) in active frost conditions.

CAUTIONS: Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

NEW 2010-11 TABLES



Transport Canada Holdover Time Guidelines — Winter 2010-2011

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes)			
			Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.

~~2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT)~~ of the fluid is respected.

3 These fluids may not be used below -25°C (-13°F) in active frost conditions.

~~4 Value in parentheses is for composite surfaces.~~

CAUTIONS

- Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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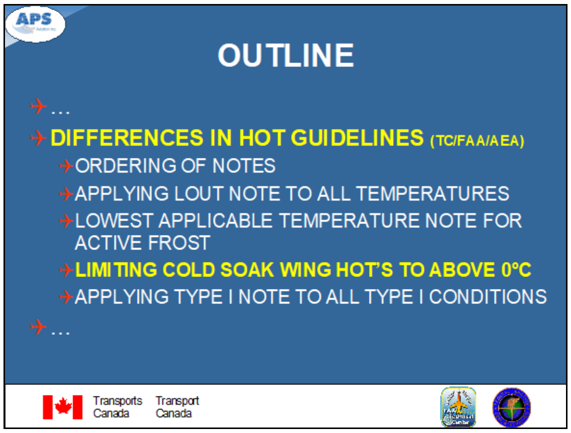

OUTLINE

- …
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
  - ORDERING OF NOTES
  - APPLYING LOUT NOTE TO ALL TEMPERATURES
  - LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST
  - LIMITING COLD SOAK WING HOT'S TO ABOVE 0°C
  - APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS
- …

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LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC

BACKGROUND

- Both FAA and AEA included an additional note in HOT guidance material for Rain on a Cold Soaked Wing "RCSW"
  - Note restricted use of RCSW HOT's to "Above 0°C"
- Discrepancy with TC Guidance material
  - TC RCSW HOT's were applicable to "-3°C and above"
- When developing HOT tables, RCSW is tested at +1°C
  - Methodology uses +1°C to ensure "Rain" and not "Freezing Rain"

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BACKGROUND

- Prior to 2005-06, HOT tables had an "Above 0°C" row
- RCSW HOT's were only applied to "Above 0°C" conditions
- When "Above 0°C" row was removed, RCSW condition was extended to include "Above -3°C"
  - Logic for keeping RCSW for "above -3°C" was:
    - Rain only occurs above 0°C
    - Won't clutter table with another caution note

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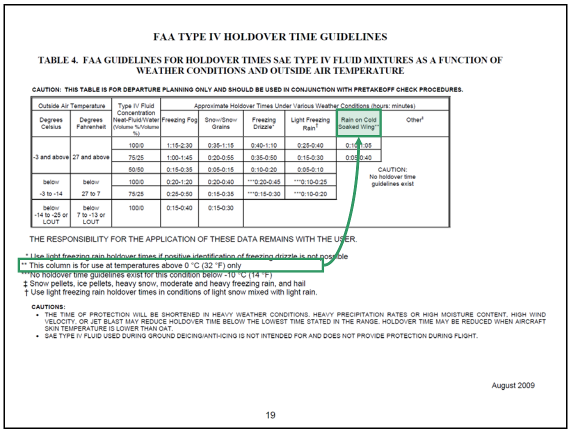
OLD 2009-10 TABLES



FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow/Snow Grains	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	100/0	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:20-0:40	***0:20-0:45	***0:10-0:25		
		75/25	0:25-0:50	0:15-0:35	***0:15-0:30	***0:10-0:20		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15-0:40	0:15-0:30				

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

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

CAUTIONS:
- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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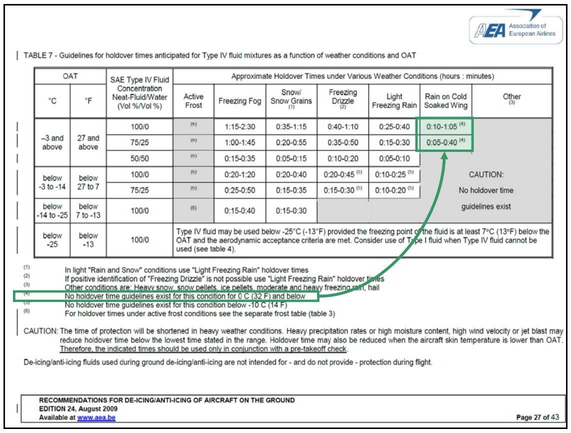

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TABLE 7 - Guidelines for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol %/Vol %)	Approximate Holdover Times under Various Weather Conditions (hours : minutes)						
°C	°F		Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
–3 and above	27 and above	100/0	(6)	1:15-2:30	0:35-1:15	0:40-1:10	0:25-0:40	0:10-1:05 (4)	
		75/25	(6)	1:00-1:45	0:20-0:55	0:35-0:50	0:15-0:30	0:05-0:40 (4)	
		50/50	(6)	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	(6)	0:20-1:20	0:20-0:40	0:20-0:45 (5)	0:10-0:25 (5)	CAUTION: No holdover time guidelines exist	
		75/25	(6)	0:25-0:50	0:15-0:35	0:15-0:30 (5)	0:10-0:20 (5)		
below -14 to -25	below 7 to -13	100/0	(6)	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type IV fluid cannot be used (see table 4).						

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, hail
(4) No holdover time guidelines exist for this condition for 0 C (32 F) and below
(5) No holdover time guidelines exist for this condition below -10 C (14 F)
(6) For holdover times under active frost conditions see the separate frost table (table 3)

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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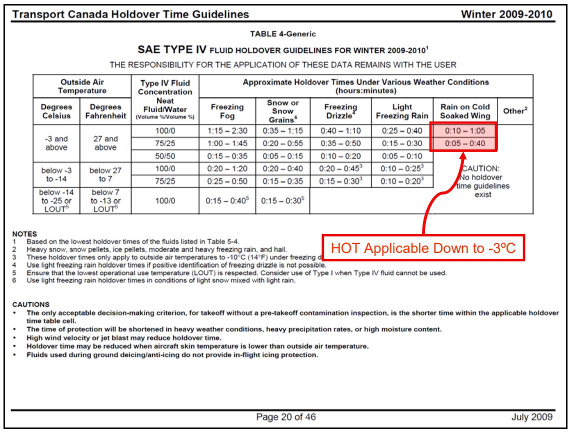

Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010[1]

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

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow or Snow Grains[6]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	100/0	1:15 – 2:30	0:35 – 1:15	0:40 – 1:10	0:25 – 0:40	0:10 – 1:05	
		75/25	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]		
below -14 to -25 or LOUT[5]	below 7 to -13 or LOUT[5]	100/0	0:15 – 0:40[5]	0:15 – 0:30[5]				

HOT Applicable Down to -3ºC

NOTES
1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing d
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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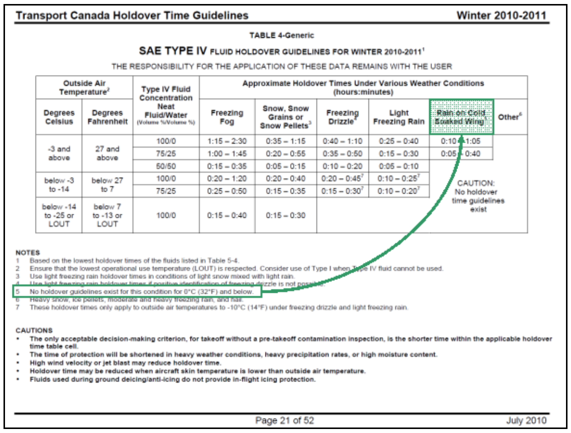
NEW 2010-11 TABLES



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 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	1:00 – 1:45	0:20 – 0:55	0:35 – 0:50	0:15 – 0:30	0:05 – 0:40	
		50/50	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50	0:15 – 0:35	0:15 – 0:30[7]	0:10 – 0:20[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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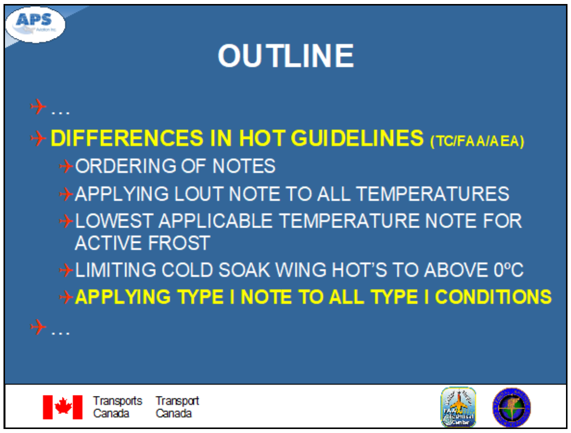

OUTLINE

- …
- **DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)**
  - ORDERING OF NOTES
  - APPLYING LOUT NOTE TO ALL TEMPERATURES
  - LOWEST APPLICABLE TEMPERATURE NOTE FOR ACTIVE FROST
  - LIMITING COLD SOAK WING HOT'S TO ABOVE 0ºC
  - **APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS**
- …

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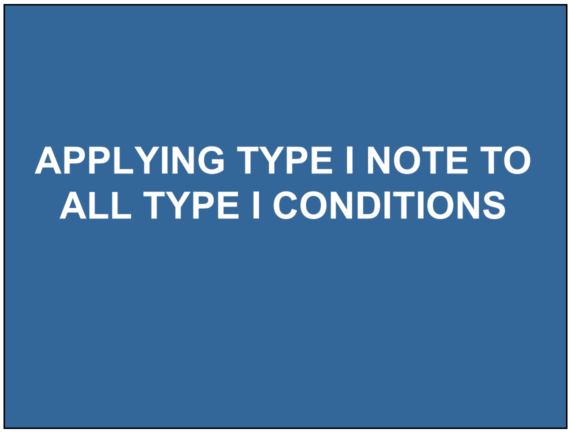
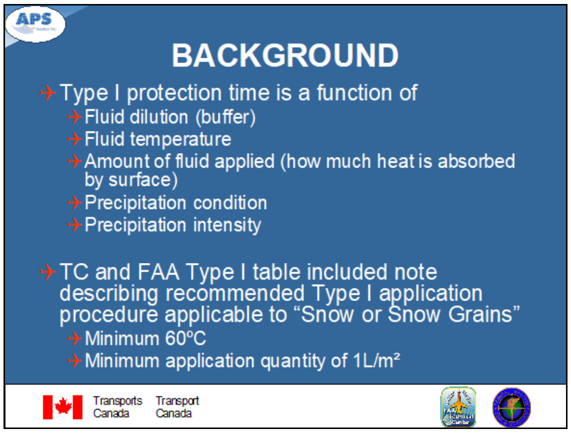


APPLYING TYPE I NOTE TO ALL TYPE I CONDITIONS



BACKGROUND

- Type I protection time is a function of
  - Fluid dilution (buffer)
  - Fluid temperature
  - Amount of fluid applied (how much heat is absorbed by surface)
  - Precipitation condition
  - Precipitation intensity
- TC and FAA Type I table included note describing recommended Type I application procedure applicable to "Snow or Snow Grains"
  - Minimum 60ºC
  - Minimum application quantity of 1L/m²

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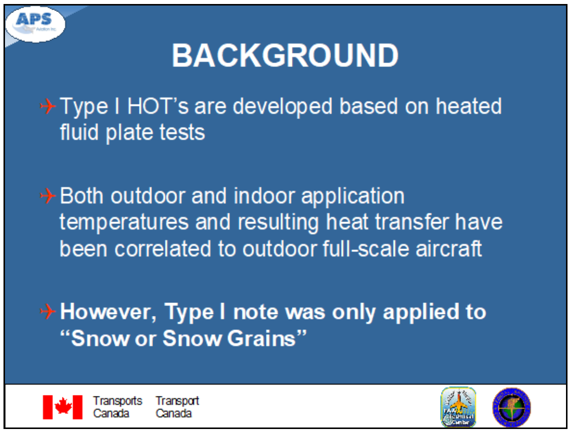

BACKGROUND

- Type I HOT's are developed based on heated fluid plate tests
- Both outdoor and indoor application temperatures and resulting heat transfer have been correlated to outdoor full-scale aircraft
- **However, Type I note was only applied to "Snow or Snow Grains"**

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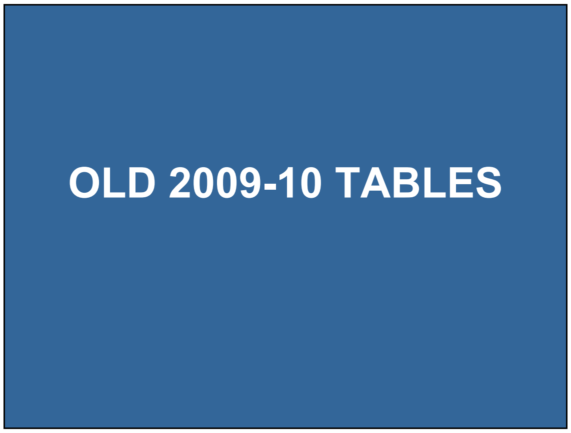
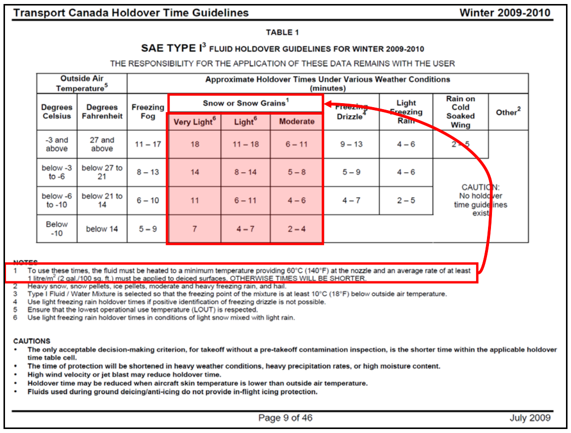


OLD 2009-10 TABLES



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 1

SAE TYPE I[3] FLUID HOLDOVER GUIDELINES FOR WINTER 2009-2010

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

Outside Air Temperature[5]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow or Snow Grains[1] Very Light[6]	Snow or Snow Grains[1] Light[6]	Snow or Snow Grains[1] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[2]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
Below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces. OTHERWISE TIMES WILL BE SHORTER.
2 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
3 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Ensure that the lowest operational use temperature (LOUT) is respected.
6 Use light freezing rain holdover times in conditions of light snow mixed with light rain.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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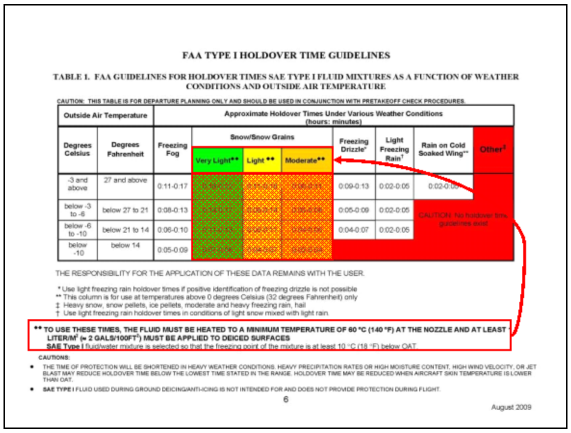

FAA TYPE I HOLDOVER TIME GUIDELINES

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog	Snow/Snow Grains Very Light**	Snow/Snow Grains Light **	Snow/Snow Grains Moderate**	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	0:11-0:17	[illegible]	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	0:08-0:13	[illegible]	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	0:06-0:10	[illegible]	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
below -10	below 14	0:05-0:09	[illegible]	0:04-0:07	0:02-0:04				

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

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

**** TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M^2 (≈ 2 GALS/100FT^2) MUST BE APPLIED TO DEICED SURFACES**
SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE I** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

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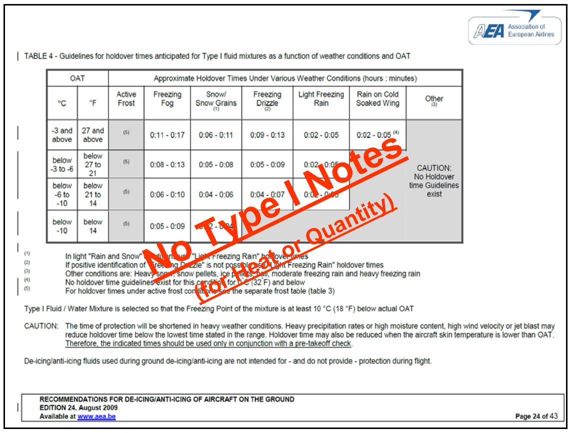

AEA Association of European Airlines

TABLE 4 - Guidelines for holdover times anticipated for Type I fluid mixtures as a function of weather conditions and OAT

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	Snow/ Snow Grains (1)	Freezing Drizzle (2)	Light Freezing Rain	Rain on Cold Soaked Wing	Other (3)
-3 and above	27 and above	(5)	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05 (4)	CAUTION: No Holdover time Guidelines exist
below -3 to -6	below 27 to 21	(5)	0:08 - 0:13	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05		
below -6 to -10	below 21 to 14	(5)	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	[illegible]		
below -10	below 14	(5)	0:05 - 0:09	0:02 - 0:04				

(1) In light "Rain and Snow" conditions use "Light Freezing Rain" holdover times
(2) If positive identification of "Freezing Drizzle" is not possible use "Light Freezing Rain" holdover times
(3) Other conditions are: Heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain
(4) No holdover time guidelines exist for this condition for 0°C (32°F) and below
(5) For holdover times under active frost conditions see the separate frost table (table 3)

Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT

CAUTION: The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

De-icing/anti-icing fluids used during ground de-icing/anti-icing are not intended for - and do not provide - protection during flight.

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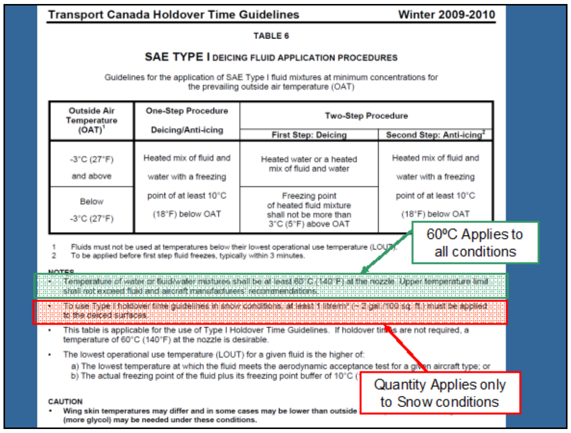
No Type I Notes
(for Heat or Quantity)



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure First Step: Deicing	Two-Step Procedure Second Step: Anti-icing[2]
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
2 To be applied before first step fluid freezes, typically within 3 minutes.

NOTES

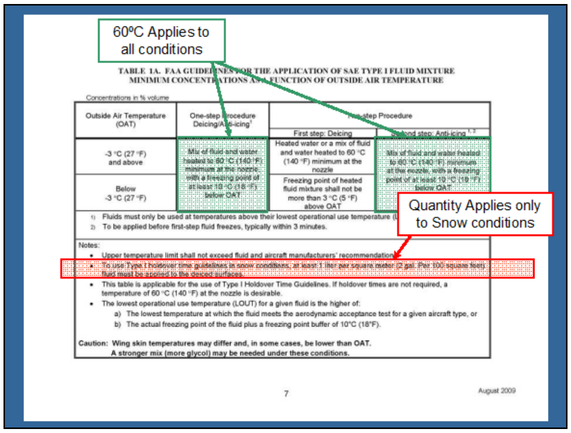
- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in snow conditions, at least 1 litre/m^2 (~ 2 gal./100 sq. ft.) must be applied 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 (

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside** **(more glycol) may be needed under these conditions.**

60ºC Applies to all conditions

Quantity Applies only to Snow conditions



60ºC Applies to all conditions

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

Concentrations in % volume

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure First step: Deicing	Two-step Procedure Second step: Anti-icing [1, 2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

1) Fluids must only be used at temperatures above their lowest operational use temperature (L
2) To be applied before first-step fluid freezes, typically within 3 minutes.

Notes:

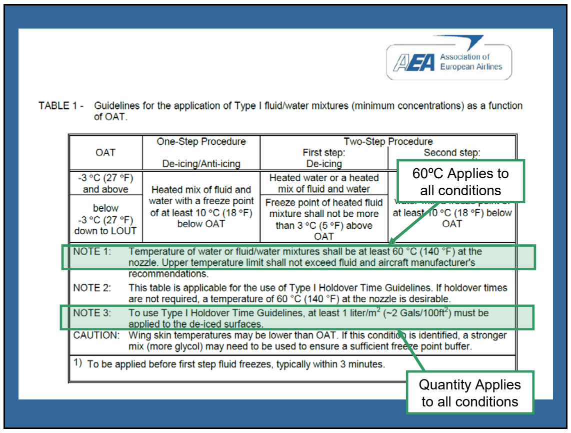
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendation.
- To use Type I holdover time guidelines in snow conditions, at least 1 liter per square meter (2 gal. Per 100 square feet) fluid must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  b) The actual freezing point of the fluid plus a freezing point buffer of 10°C (18°F).

Caution: Wing skin temperatures may differ and, in some cases, be lower than OAT.
A stronger mix (more glycol) may be needed under these conditions.

7

August 2009

Quantity Applies only to Snow conditions



Association of European Airlines

TABLE 1 - Guidelines for the application of Type I fluid/water mixtures (minimum concentrations) as a function of OAT.

OAT	One-Step Procedure De-icing/Anti-icing	Two-Step Procedure First step: De-icing	Second step:
-3 °C (27 °F) and above	Heated mix of fluid and water with a freeze point of at least 10 °C (18 °F) below OAT	Heated water or a heated mix of fluid and water	[illegible] at least 10 °C (18 °F) below OAT
below -3 °C (27 °F) down to LOUT		Freeze point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

NOTE 1: 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 manufacturer's recommendations.

NOTE 2: 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.

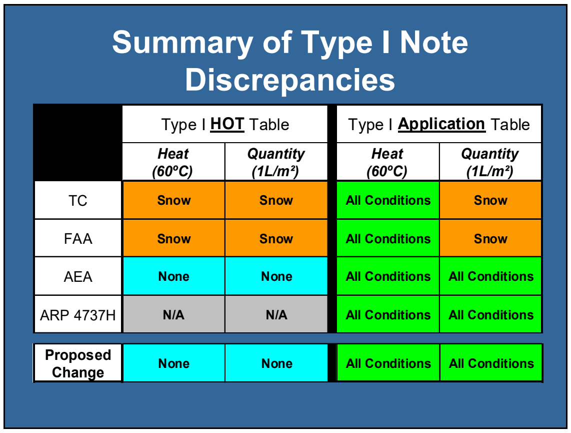
NOTE 3: To use Type I Holdover Time Guidelines, at least 1 liter/m² (~2 Gals/100ft²) must be applied to the de-iced surfaces.

CAUTION: Wing skin temperatures may be lower than OAT. If this condition is identified, a stronger mix (more glycol) may need to be used to ensure a sufficient freeze point buffer.

1) To be applied before first step fluid freezes, typically within 3 minutes.

60ºC Applies to all conditions

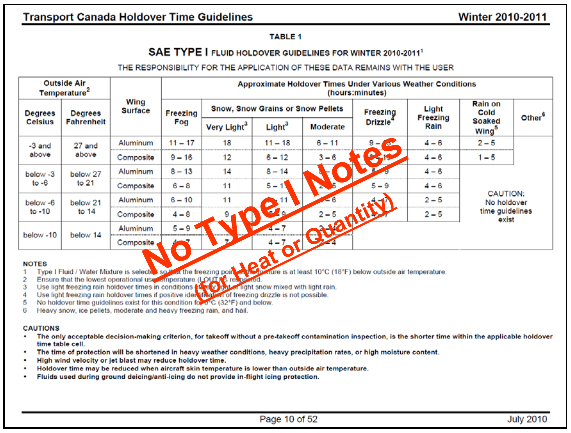
Quantity Applies to all conditions



Summary of Type I Note Discrepancies

	Type I **HOT** Table		Type I **Application** Table	
	Heat (60ºC)	***Quantity (1L/m²)***	***Heat (60ºC)***	***Quantity (1L/m²)***
TC	Snow	Snow	All Conditions	Snow
FAA	Snow	Snow	All Conditions	Snow
AEA	None	None	All Conditions	All Conditions
ARP 4737H	N/A	N/A	All Conditions	All Conditions
Proposed Change	None	None	All Conditions	All Conditions

NEW 2010-11 TABLES



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – [illegible]	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
		Composite	9 – 16	12	6 – 12	3 – 6	[illegible]	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	[illegible]	5 – 9	4 – 6		
		Composite	6 – 8	11	[illegible]	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	[illegible]	[illegible]	4 – 7	2 – 5		
		Composite	4 – 8	9	[illegible]	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	[illegible]	4 – 7	[illegible]				
		Composite	[illegible]	7	4 – 7	[illegible]				

NOTES

1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

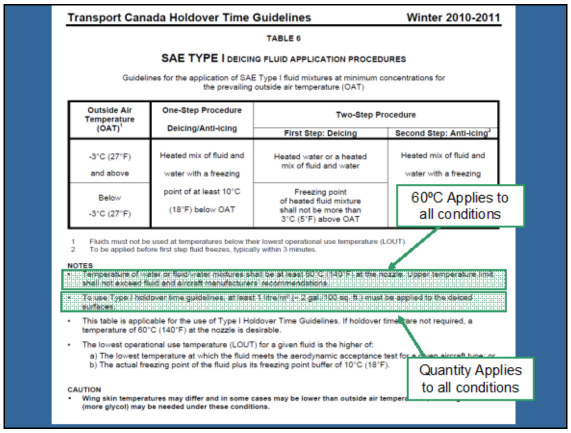
CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

Page 10 of 52 July 2010

No Type I Notes

(for Heat or Quantity)



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 6

SAE TYPE I DEICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure Deicing/Anti-icing	Two-Step Procedure First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing [illegible]
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

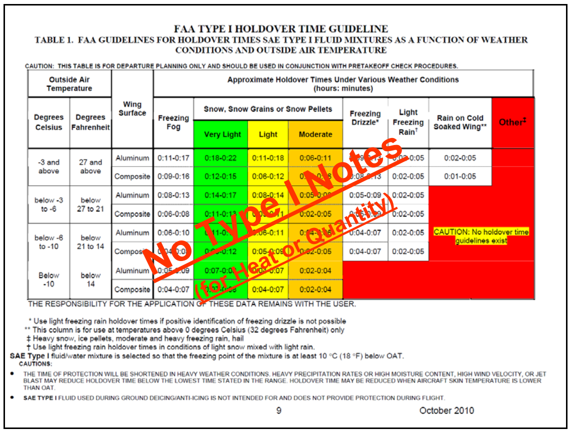
- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside air tempera[illegible] (more glycol) may be needed under these conditions.**

60ºC Applies to all conditions

Quantity Applies to all conditions



FAA TYPE I HOLDOVER TIME GUIDELINE

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets Very Light	Light	Moderate	Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	[illegible]	[illegible]	0:02-0:05	CAUTION: No holdover time guidelines exist
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	[illegible]	[illegible]	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	[illegible]	0:05-0:09	0:02-0:05		
		Composite	0:06-0:08	[illegible]	[illegible]	0:02-0:05	[illegible]	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	[illegible]	[illegible]	[illegible]	0:04-0:07	0:02-0:05		
		Composite	[illegible]	[illegible]	[illegible]	[illegible]	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	[illegible]	[illegible]	[illegible]	0:02-0:04				
		Composite	0:04-0:07	[illegible]	0:04-0:07	0:02-0:04				

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

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

SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE I** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

9 October 2010

No Type I Notes

(for Heat or Quantity)

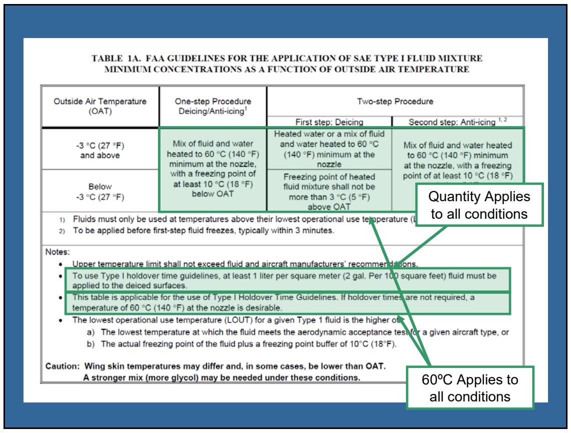


TABLE 1A. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID MIXTURE MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing [1, 2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

1) Fluids must only be used at temperatures above their lowest operational use temperature (LOUT).
2) To be applied before first-step fluid freezes, typically within 3 minutes.

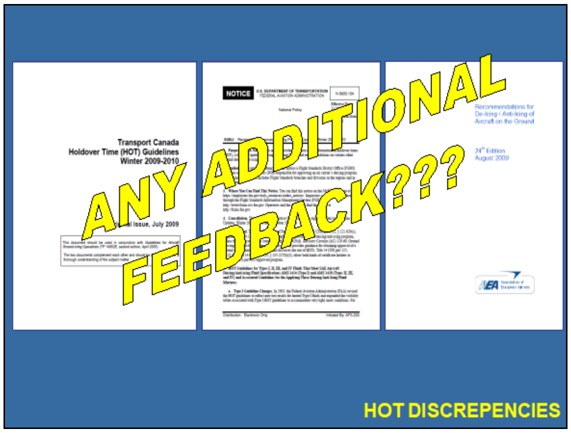
Notes:

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines, at least 1 liter per square meter (2 gal. Per 100 square feet) fluid must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given Type 1 fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  - b) The actual freezing point of the fluid plus a freezing point buffer of 10°C (18°F).

Caution: Wing skin temperatures may differ and, in some cases, be lower than OAT. A stronger mix (more glycol) may be needed under these conditions.

Quantity Applies to all conditions

60ºC Applies to all conditions



Transport Canada
Holdover Time (HOT) Guidelines
Winter 2009-2010

Original Issue, July 2009

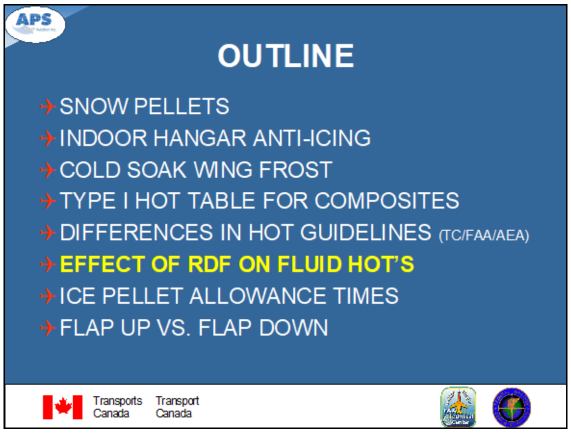
NOTICE U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

Recommendations for De-Icing / Anti-Icing of Aircraft on the Ground

24th Edition
August 2009

ANY ADDITIONAL FEEDBACK???

HOT DISCREPENCIES



OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
- **EFFECT OF RDF ON FLUID HOT'S**
- ICE PELLET ALLOWANCE TIMES
- FLAP UP VS. FLAP DOWN

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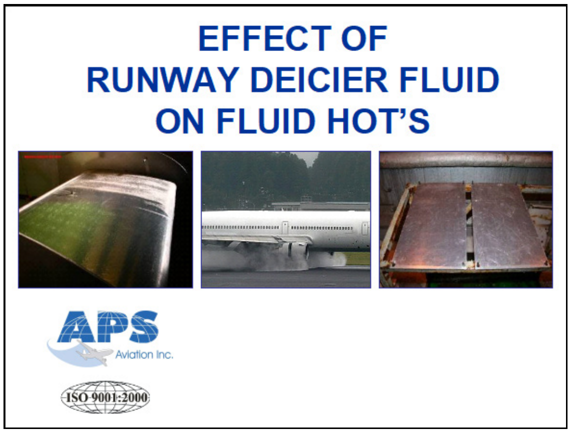
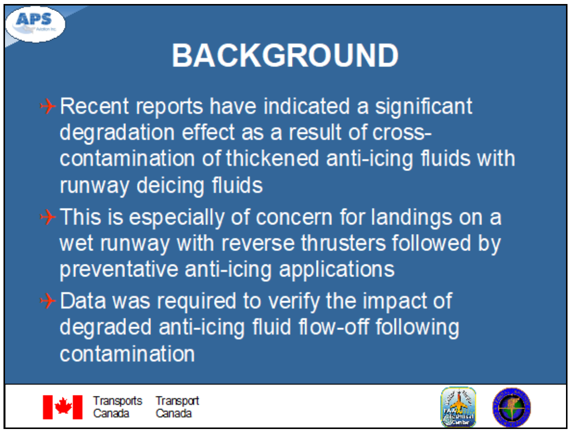


EFFECT OF RUNWAY DEICIER FLUID ON FLUID HOT'S

APS Aviation Inc.

ISO 9001:2000



BACKGROUND

- Recent reports have indicated a significant degradation effect as a result of cross-contamination of thickened anti-icing fluids with runway deicing fluids
- This is especially of concern for landings on a wet runway with reverse thrusters followed by preventative anti-icing applications
- Data was required to verify the impact of degraded anti-icing fluid flow-off following contamination

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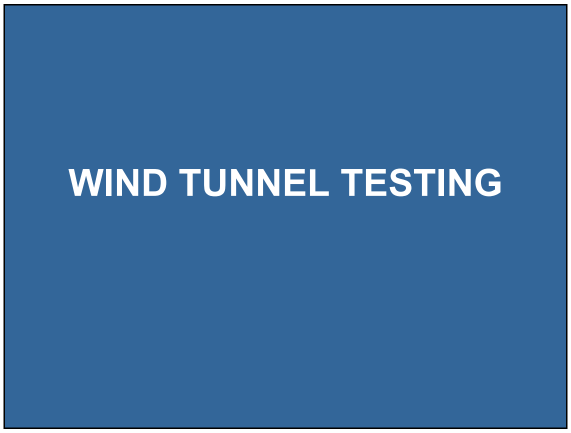


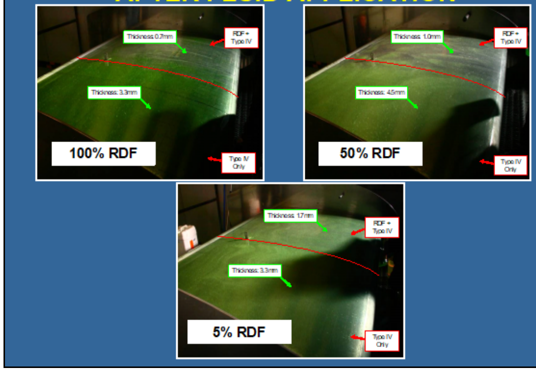
WIND TUNNEL TESTING

WIND TUNNEL TESTING

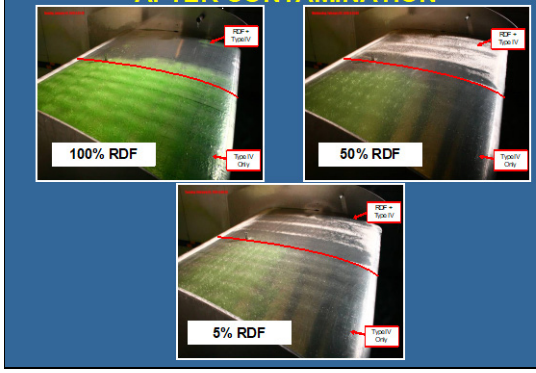
- Three preliminary wind tunnel tests were conducted
- The wing was sectioned in two:
  - STBD: Type IV Fluid (Baseline)
  - PORT: Runway Deicier Fluid + Type IV Fluid
- Wing section was exposed to simulated light freezing rain
  - Contamination was stopped when baseline side showed initial signs of fluid failure
- High speed wind tunnel test was conducted

Transports Canada Transport Canada

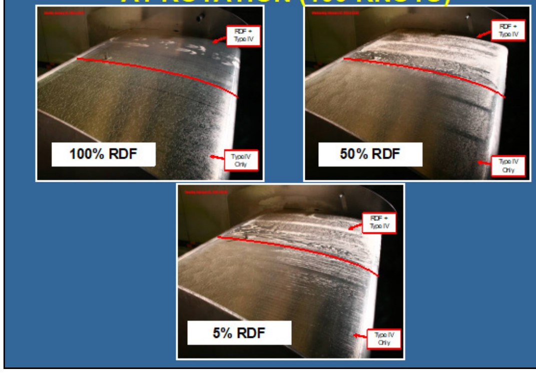
COMPARISON OF VISUAL APPEARANCE AFTER FLUID APPLICATION


Thickness 0.7mm
RDF + Type IV
Thickness: 3.3mm
100% RDF
Type IV Only
Thickness: 1.0mm
RDF + Type IV
Thickness: 4.5mm
50% RDF
Type IV Only
Thickness: 1.7mm
RDF + Type IV
Thickness: 3.3mm
5% RDF
Type IV Only

COMPARISON OF VISUAL APPEARANCE AFTER CONTAMINATION


RDF + Type IV
100% RDF
Type IV Only
RDF + Type IV
50% RDF
Type IV Only
RDF + Type IV
5% RDF
Type IV Only

COMPARISON OF VISUAL APPEARANCE AT ROTATION (100 KNOTS)


RDF + Type IV
100% RDF
Type IV Only
RDF + Type IV
50% RDF
Type IV Only
RDF + Type IV
5% RDF
Type IV Only

WIND TUNNEL TESTING – GENERAL OBSERVATIONS

- Effect of RDF was visually more apparent when when higher concentrations of RDF were used
  - 100% RDF: almost instant degradation
  - 5% RDF: little visual difference initially
- All three tests demonstrated significant differences between the protection of fluid contaminated with RDF and the baseline fluid
  - earlier, more severe adherence
  - adhered contamination was not removed at rotation

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FLAT PLATE TESTING

FLAT PLATE TESTING

- Two comparison tests were conducted using two test plates
  - #1: Type II/IV Fluid (Baseline)
  - #2: Runway Deicier Fluid + Type II/IV Fluid
- Same fluid and dilution applied to both test plates
- Testing conducted in light freezing rain

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FLAT PLATE TESTING OBSERVATIONS

- Results were preliminary but supported the wind tunnel results

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OPERATIONAL INTIATIVE

- Based on the research conducted, the Residues WG issued a letter to IATA, EASA, TC, and FAA to inform the industry of the potential safety issue
- Intent was to distribute the letter to operators, airports and service providers, or incorporate the contents of the letter into appropriate guidance material

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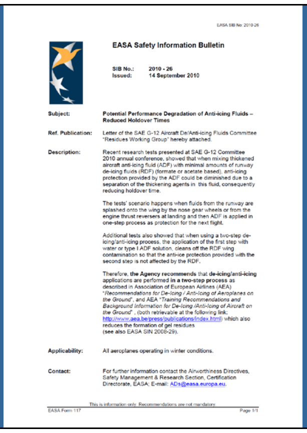


EASA SIB No: 2010-26

EASA Safety Information Bulletin

SIB No.: **2010 - 26**
Issued: **14 September 2010**

Subject: **Potential Performance Degradation of Anti-icing Fluids – Reduced Holdover Times**

Ref. Publication: Letter of the SAE G-12 Aircraft De/Anti-icing Fluids Committee "Residues Working Group" hereby attached.

Description: Recent research tests presented at SAE G-12 Committee 2010 annual conference, showed that when mixing thickened aircraft anti-icing fluid (ADF) with minimal amounts of runway de-icing fluids (RDF) (formate or acetate based), anti-icing protection provided by the ADF could be diminished due to a separation of the thickening agents in this fluid, consequently reducing holdover time.

The tests' scenario happens when fluids from the runway are splashed onto the wing by the nose gear wheels or from the engine thrust reversers at landing and then ADF is applied in one-step process as protection for the next flight.

Additional tests also showed that when using a two-step de-icing/anti-icing process, the application of the first step with water or type I ADF solution, cleans off the RDF wing contamination so that the anti-ice protection provided with the second step is not affected by the RDF.

Therefore, **the Agency recommends** that **de-icing/anti-icing** applications are performed **in a two-step process** as described in Association of European Airlines (AEA) "*Recommendations for De-Icing / Anti-Icing of Aeroplanes on the Ground*", and AEA "*Training Recommendations and Background Information for De-Icing /Anti-Icing of Aircraft on the Ground*" . (both retrievable at the following link: http://www.aea.be/press/publications/index.html) which also reduces the formation of gel residues (see also EASA SIN 2008-29).

Applicability: All aeroplanes operating in winter conditions.

Contact: For further information contact the Airworthiness Directives, Safety Management & Research Section, Certification Directorate, EASA; E-mail: ADs@easa.europa.eu.

This is information only. Recommendations are not mandatory.

EASA Form 117 Page 1/1

Transports Canada Transport Canada

POSSIBLE CHANGE TO TP 14052E FOR 2010-11

Add Sub-Paragraph 10.8.1: "De/Anti-icing Fluid Compatibility with Runway Deicer":

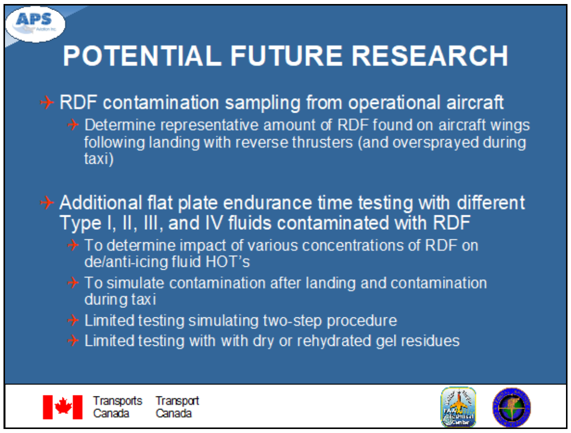
Recent research showed that when thickened aircraft anti-icing fluid came in contact with minimal amounts of runway de-icing fluids (formate or acetate based), anti-icing protection provided by the aircraft anti-icing fluid could be diminished. The separation of the thickening agents in this fluid consequently reduce holdover time.

This can occur when fluids from the runway are splashed onto the wing by the nose gear wheels or from the use of engine thrust reversers at landing prior to when the aircraft is anti-iced using a one-step process as protection for the next flight. Additional tests also showed that when using a two-step deicing/anti-icing process, the application of the first step with water or Type I aircraft anti-icing fluid solution, cleans off the runway de-icing fluids wing contamination so that the anti-ice protection provided with the second step is not affected by the runway de-icing fluids.

Therefore, it is recommended that de-icing/anti-icing applications be performed using a two-step process.

WILL LIKELY BE INCLUDED IN POSSIBLE DEC/JAN REVISION OF TC HOT GUIDELINES

CURRENTLY CONSIDERING PUBLISHING GUIDANCE MATERIAL



POTENTIAL FUTURE RESEARCH

- RDF contamination sampling from operational aircraft
  - Determine representative amount of RDF found on aircraft wings following landing with reverse thrusters (and oversprayed during taxi)
- Additional flat plate endurance time testing with different Type I, II, III, and IV fluids contaminated with RDF
  - To determine impact of various concentrations of RDF on de/anti-icing fluid HOT's
  - To simulate contamination after landing and contamination during taxi
  - Limited testing simulating two-step procedure
  - Limited testing with with dry or rehydrated gel residues

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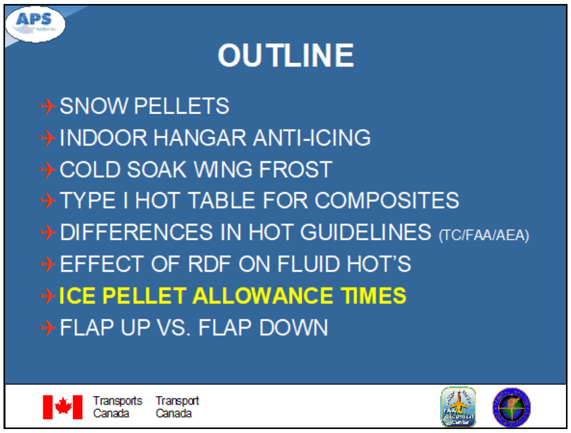

OUTLINE

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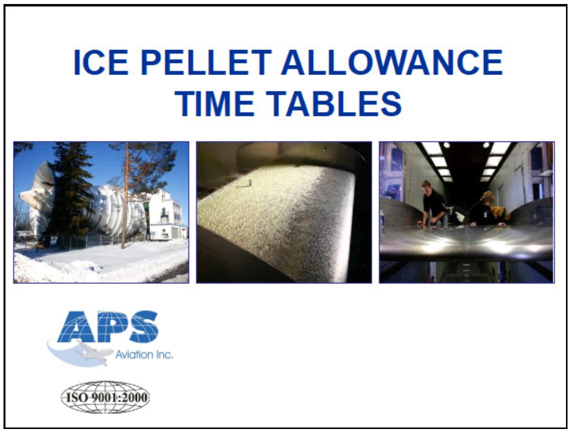
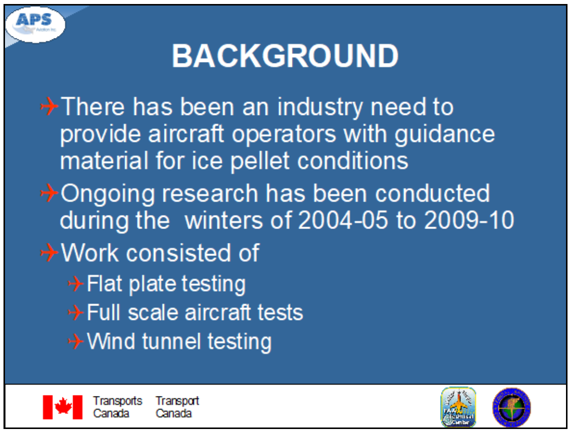


ICE PELLET ALLOWANCE TIME TABLES

APS Aviation Inc.

ISO 9001:2000



BACKGROUND

- There has been an industry need to provide aircraft operators with guidance material for ice pellet conditions
- Ongoing research has been conducted during the winters of 2004-05 to 2009-10
- Work consisted of
  - Flat plate testing
  - Full scale aircraft tests
  - Wind tunnel testing

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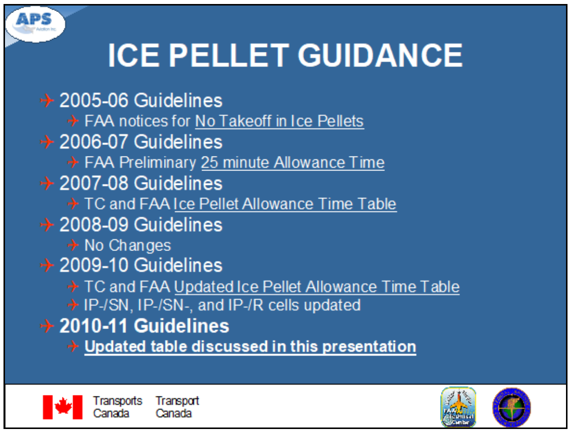

ICE PELLET GUIDANCE

- 2005-06 Guidelines
  - FAA notices for No Takeoff in Ice Pellets
- 2006-07 Guidelines
  - FAA Preliminary 25 minute Allowance Time
- 2007-08 Guidelines
  - TC and FAA Ice Pellet Allowance Time Table
- 2008-09 Guidelines
  - No Changes
- 2009-10 Guidelines
  - TC and FAA Updated Ice Pellet Allowance Time Table
  - IP-/SN, IP-/SN-, and IP-/R cells updated
- **2010-11 Guidelines**
  - **Updated table discussed in this presentation**

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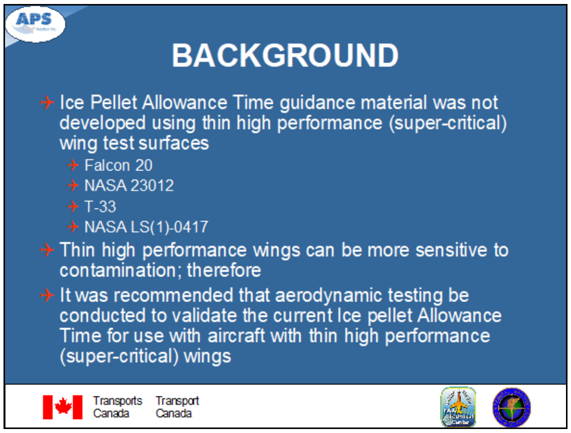

BACKGROUND

- Ice Pellet Allowance Time guidance material was not developed using thin high performance (super-critical) wing test surfaces
  - Falcon 20
  - NASA 23012
  - T-33
  - NASA LS(1)-0417
- Thin high performance wings can be more sensitive to contamination; therefore
- It was recommended that aerodynamic testing be conducted to validate the current Ice pellet Allowance Time for use with aircraft with thin high performance (super-critical) wings

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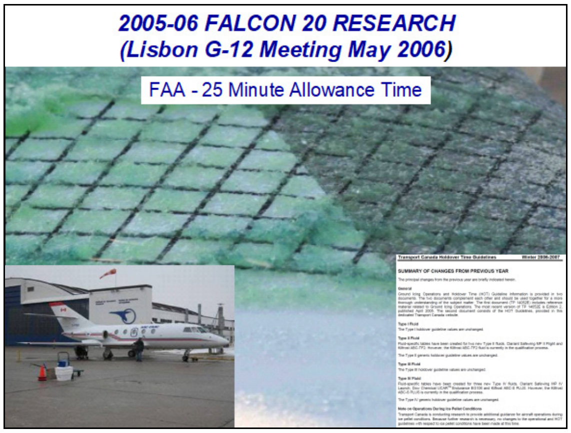


2005-06 FALCON 20 RESEARCH (Lisbon G-12 Meeting May 2006)

FAA - 25 Minute Allowance Time

Transport Canada Holdover Time Guidelines **Winter 2006-2007**

SUMMARY OF CHANGES FROM PREVIOUS YEAR

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

General

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

Type I Fluid

The Type I holdover guideline values are unchanged.

Type II Fluid

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

The Type II generic holdover guideline values are unchanged.

Type III Fluid

The Type III holdover guideline values are unchanged.

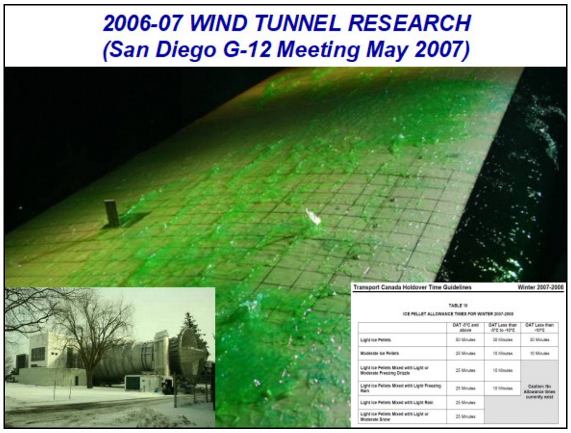
Type IV Fluid

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

The Type IV generic holdover guideline values are unchanged.

Note on Operations During Ice Pellet Conditions

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



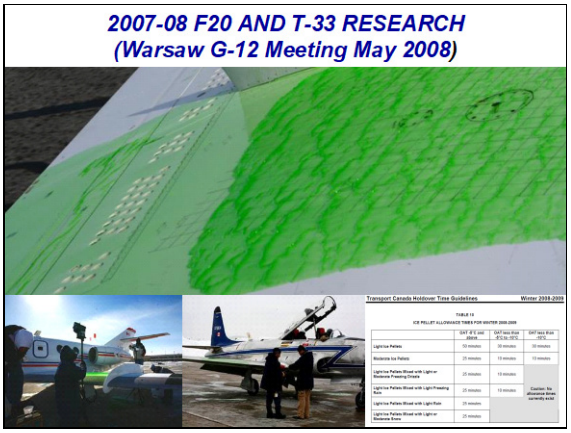
2006-07 WIND TUNNEL RESEARCH (San Diego G-12 Meeting May 2007)

Transport Canada Holdover Time Guidelines **Winter 2007-2008**

TABLE 16

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		



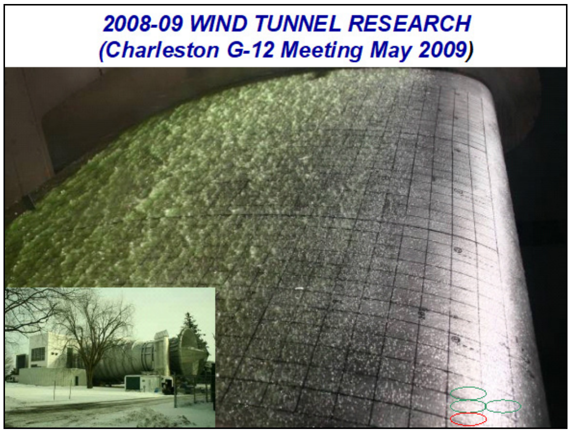
2007-08 F20 AND T-33 RESEARCH (Warsaw G-12 Meeting May 2008)

Transport Canada Holdover Time Guidelines **Winter 2008-2009**

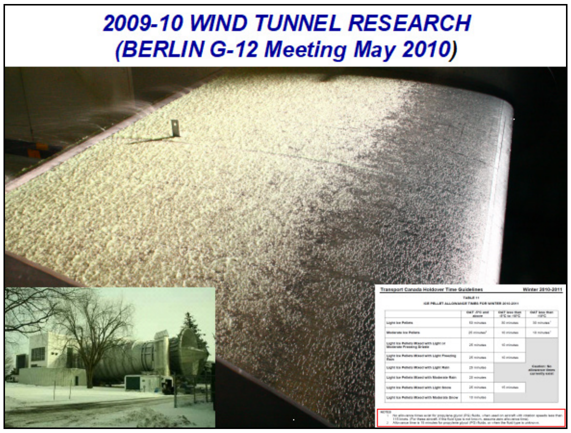
TABLE 18

ICE PELLET ALLOWANCE TIMES FOR WINTER 2008-2009

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Light or Moderate Snow	25 minutes		



2008-09 WIND TUNNEL RESEARCH (Charleston G-12 Meeting May 2009)



2009-10 WIND TUNNEL RESEARCH (BERLIN G-12 Meeting May 2010)

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 11

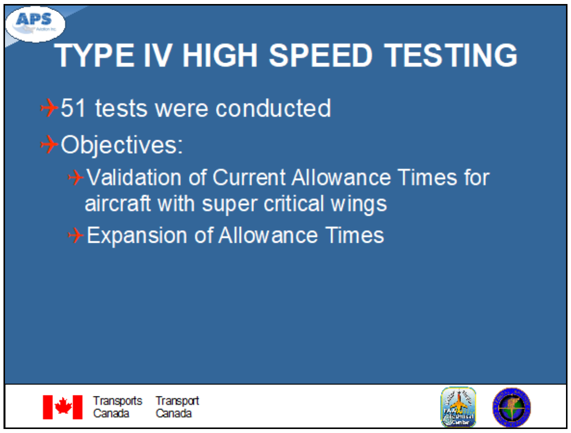
ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	10 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES:

1. No allowance times exist for propylene glycol (PG) fluids, when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).
2. Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

SUMMARY OF 2009-10 TESTING



TYPE IV HIGH SPEED TESTING

- 51 tests were conducted
- Objectives:
  - Validation of Current Allowance Times for aircraft with super critical wings
  - Expansion of Allowance Times

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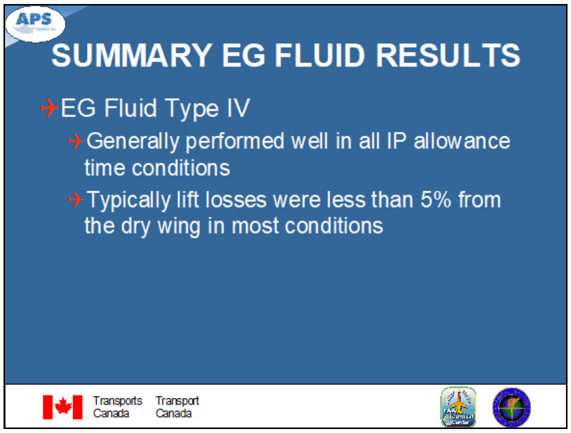

SUMMARY EG FLUID RESULTS

- EG Fluid Type IV
  - Generally performed well in all IP allowance time conditions
  - Typically lift losses were less than 5% from the dry wing in most conditions

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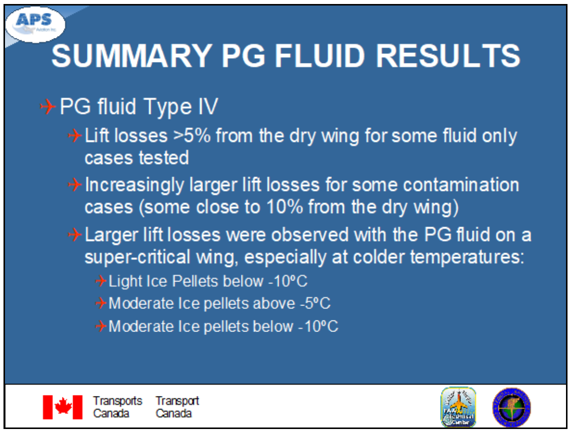

SUMMARY PG FLUID RESULTS

- PG fluid Type IV
  - Lift losses >5% from the dry wing for some fluid only cases tested
  - Increasingly larger lift losses for some contamination cases (some close to 10% from the dry wing)
  - Larger lift losses were observed with the PG fluid on a super-critical wing, especially at colder temperatures:
    - Light Ice Pellets below -10°C
    - Moderate Ice pellets above -5°C
    - Moderate Ice pellets below -10°C

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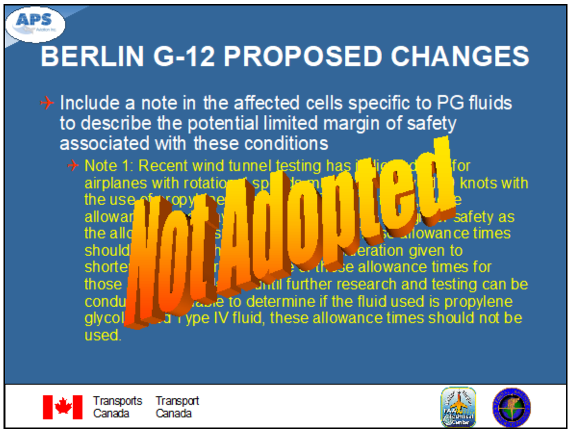

BERLIN G-12 PROPOSED CHANGES

- Include a note in the affected cells specific to PG fluids to describe the potential limited margin of safety associated with these conditions
  - Note 1: Recent wind tunnel testing has [illegible] for airplanes with rotatio[illegible] sp[illegible] knots with the use [illegible] allowar[illegible] safety as the allo[illegible] allowance times should [illegible] eration given to shorte[illegible] se allowance times for those [illegible] until further research and testing can be condu[illegible] to determine if the fluid used is propylene glycol [illegible] ype IV fluid, these allowance times should not be used.

Not Adopted

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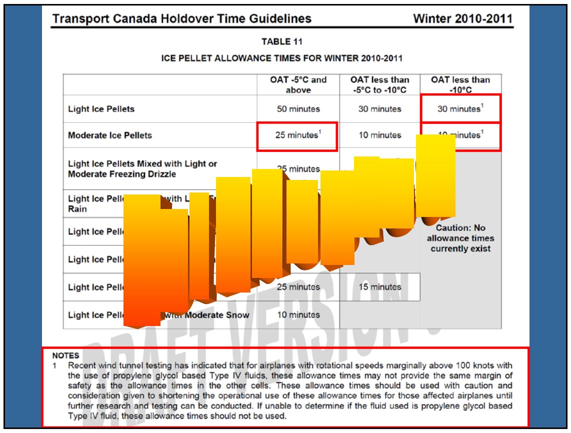


Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 11

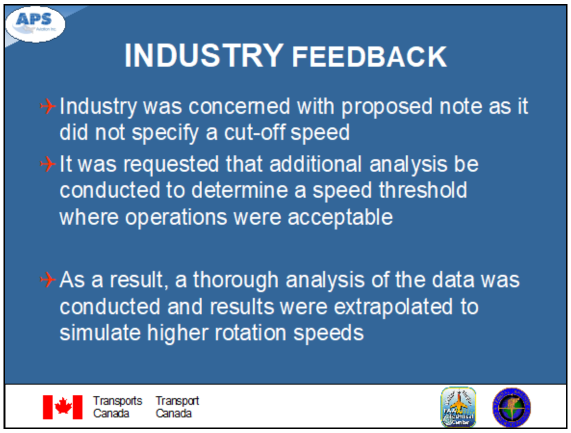
ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[1]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	[illegible]	Caution: No allowance times currently exist
Light Ice Pell[illegible] with L[illegible] Rain	[illegible]	[illegible]	
Light Ice Pell[illegible]	[illegible]	[illegible]	
Light Ice Pell[illegible]	[illegible]	[illegible]	
Light Ice Pell[illegible]	25 minutes	15 minutes	
Light Ice Pell[illegible] with Moderate Snow	10 minutes		

NOTES

1 Recent wind tunnel testing has indicated that for airplanes with rotational speeds marginally above 100 knots with the use of propylene glycol based Type IV fluids, these allowance times may not provide the same margin of safety as the allowance times in the other cells. These allowance times should be used with caution and consideration given to shortening the operational use of these allowance times for those affected airplanes until further research and testing can be conducted. If unable to determine if the fluid used is propylene glycol based Type IV fluid, these allowance times should not be used.

DRAFT VERSION



INDUSTRY FEEDBACK

- Industry was concerned with proposed note as it did not specify a cut-off speed
- It was requested that additional analysis be conducted to determine a speed threshold where operations were acceptable
- As a result, a thorough analysis of the data was conducted and results were extrapolated to simulate higher rotation speeds

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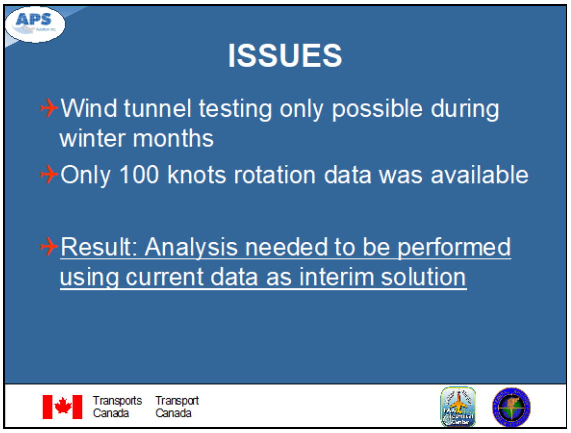
POST BERLIN ANALYSIS



ISSUES

- Wind tunnel testing only possible during winter months
- Only 100 knots rotation data was available
- Result: Analysis needed to be performed using current data as interim solution

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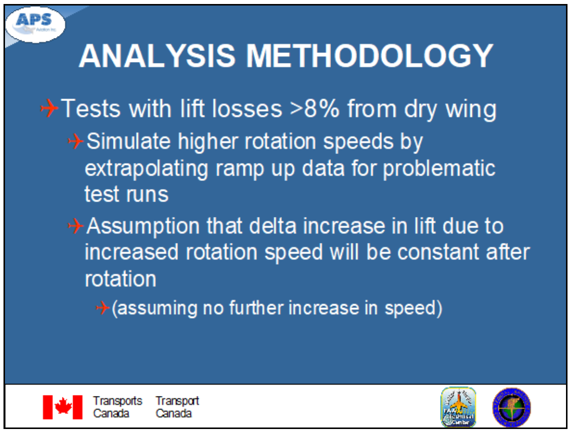

ANALYSIS METHODOLOGY

- Tests with lift losses >8% from dry wing
  - Simulate higher rotation speeds by extrapolating ramp up data for problematic test runs
  - Assumption that delta increase in lift due to increased rotation speed will be constant after rotation
    - (assuming no further increase in speed)

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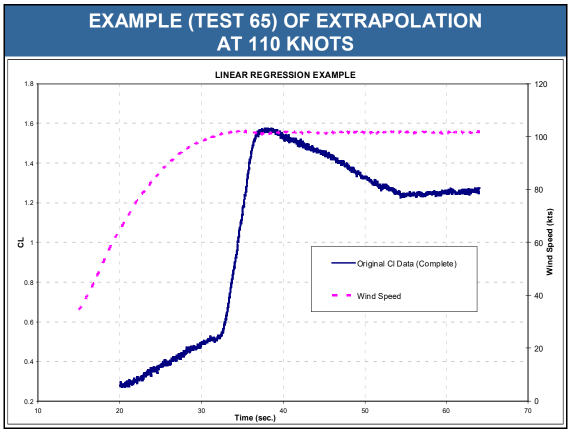
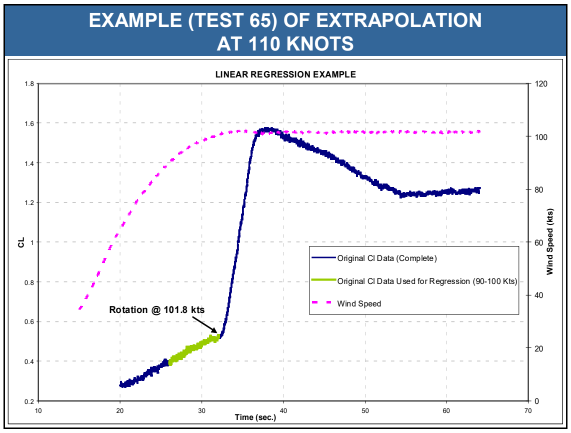
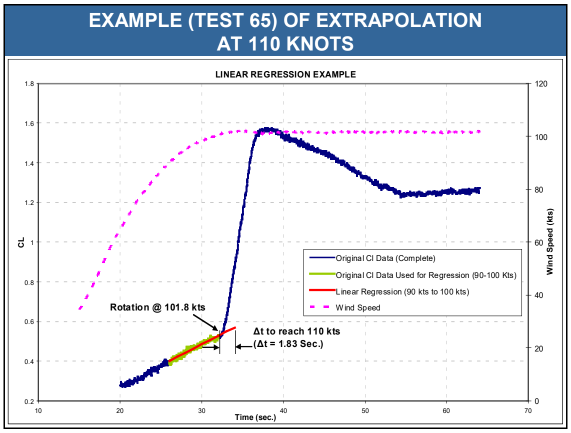


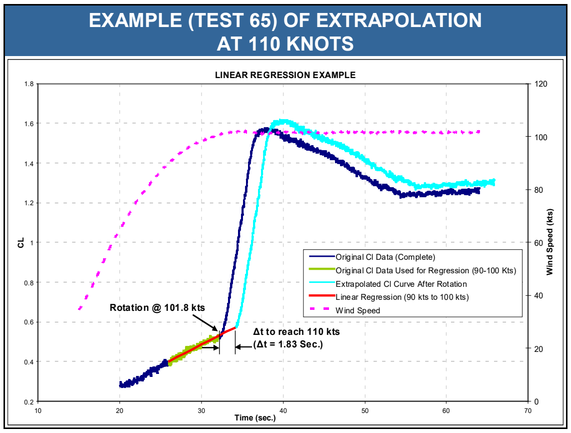
EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



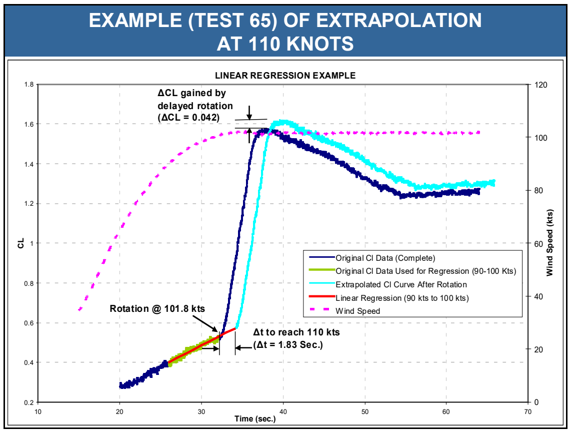
EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



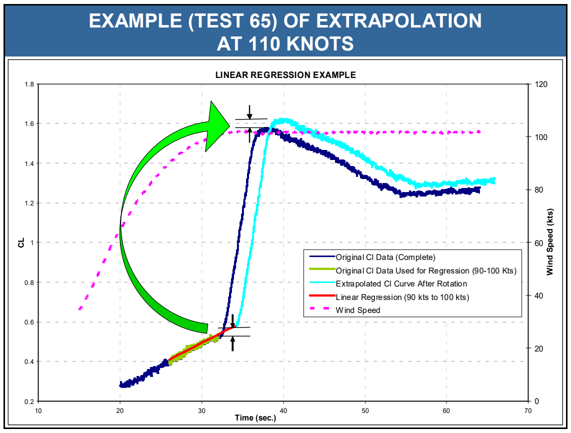
EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



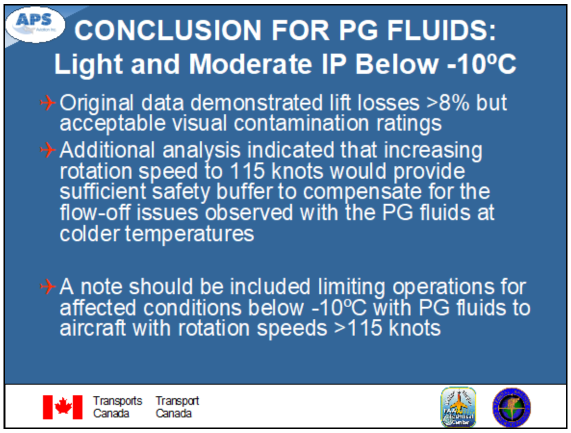
EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



EXAMPLE (TEST 65) OF EXTRAPOLATION AT 110 KNOTS



CONCLUSION FOR PG FLUIDS: Light and Moderate IP Below -10ºC

- Original data demonstrated lift losses >8% but acceptable visual contamination ratings
- Additional analysis indicated that increasing rotation speed to 115 knots would provide sufficient safety buffer to compensate for the flow-off issues observed with the PG fluids at colder temperatures
- A note should be included limiting operations for affected conditions below -10ºC with PG fluids to aircraft with rotation speeds >115 knots

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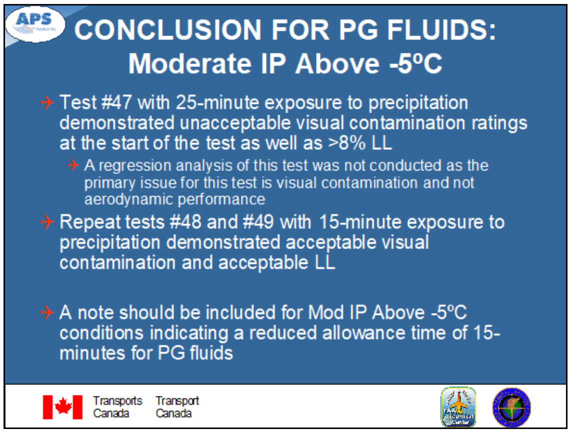

CONCLUSION FOR PG FLUIDS: Moderate IP Above -5ºC

- Test #47 with 25-minute exposure to precipitation demonstrated unacceptable visual contamination ratings at the start of the test as well as >8% LL
  - A regression analysis of this test was not conducted as the primary issue for this test is visual contamination and not aerodynamic performance
- Repeat tests #48 and #49 with 15-minute exposure to precipitation demonstrated acceptable visual contamination and acceptable LL
- A note should be included for Mod IP Above -5ºC conditions indicating a reduced allowance time of 15-minutes for PG fluids

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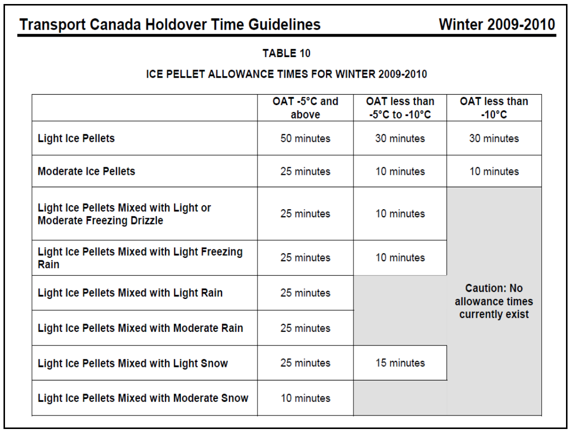
OLD 2009-10 TABLE



Transport Canada Holdover Time Guidelines **Winter 2009-2010**

TABLE 10

ICE PELLET ALLOWANCE TIMES FOR WINTER 2009-2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

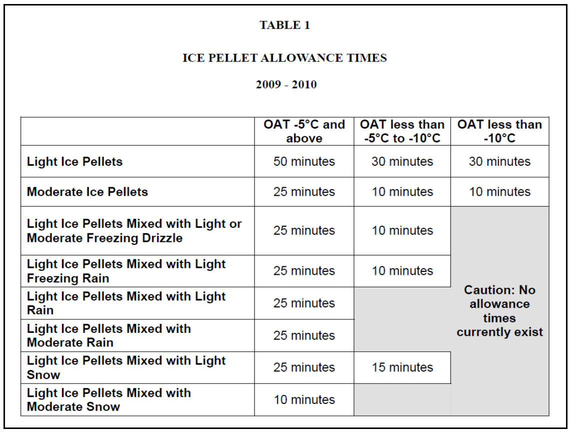


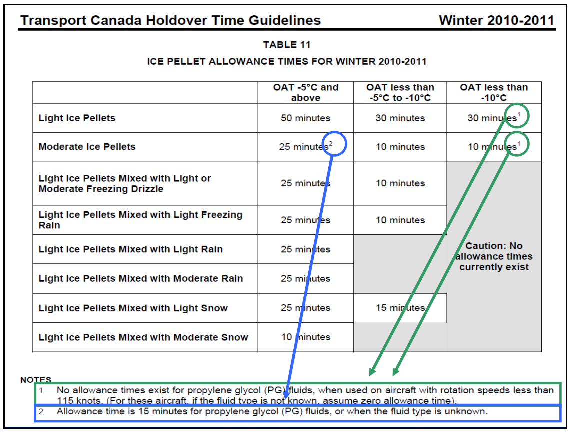
TABLE 1

ICE PELLET ALLOWANCE TIMES

2009 - 2010

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes
Moderate Ice Pellets	25 minutes	10 minutes	10 minutes
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NEW 2010-11 TABLE



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 11

ICE PELLET ALLOWANCE TIMES FOR WINTER 2010-2011

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes		
Light Ice Pellets Mixed with Moderate Rain	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

1 No allowance times exist for propylene glycol (PG) fluids, when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).

2 Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

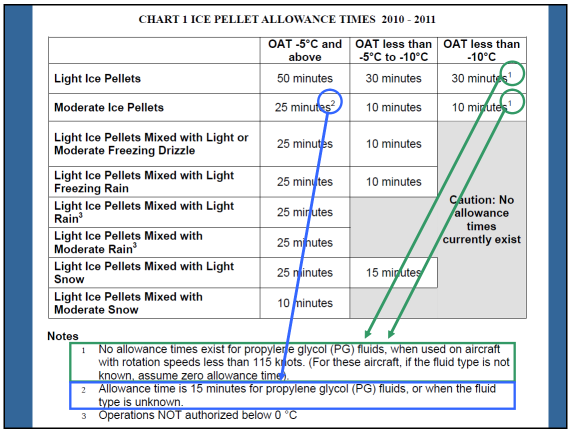


CHART 1 ICE PELLET ALLOWANCE TIMES 2010 - 2011

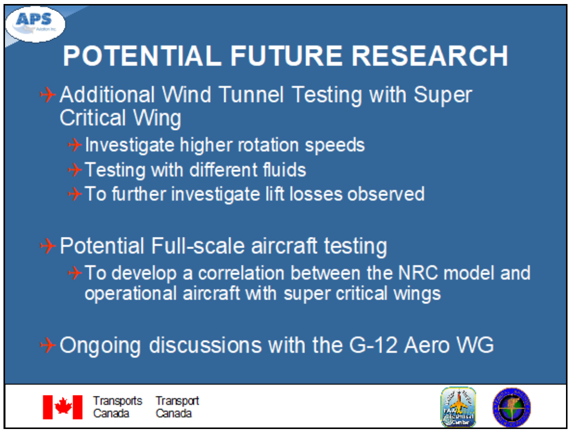
	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain[3]	25 minutes		
Light Ice Pellets Mixed with Moderate Rain[3]	25 minutes		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

Notes

1 No allowance times exist for propylene glycol (PG) fluids, when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).

2 Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

3 Operations NOT authorized below 0 °C



POTENTIAL FUTURE RESEARCH

- Additional Wind Tunnel Testing with Super Critical Wing
  - Investigate higher rotation speeds
  - Testing with different fluids
  - To further investigate lift losses observed
- Potential Full-scale aircraft testing
  - To develop a correlation between the NRC model and operational aircraft with super critical wings
- Ongoing discussions with the G-12 Aero WG

ANY ADDITIONAL FEEDBACK???
ICE PELLET ALLOWANCE TIMES

OUTLINE

- SNOW PELLETS
- INDOOR HANGAR ANTI-ICING
- COLD SOAK WING FROST
- TYPE I HOT TABLE FOR COMPOSITES
- DIFFERENCES IN HOT GUIDELINES (TC/FAA/AEA)
- EFFECT OF RDF ON FLUID HOT'S
- ICE PELLET ALLOWANCE TIMES
- **FLAP UP VS. FLAP DOWN**

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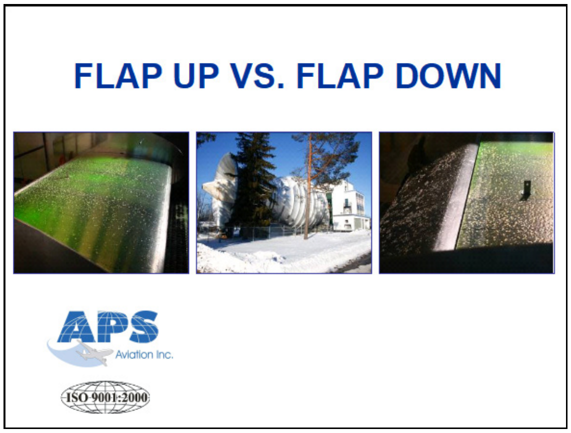
FLAP UP VS. FLAP DOWN



BACKGROUND

- During the winter of 2009-10, wind tunnel testing was conducted with flap set to 20°
- Early results indicated early failure on flap (compared to the rest of the wing) and resulted in a severe condition of the flap at the end of the allowance time
  - When fluid is applied, fluid on flap flows off faster and results in shorter endurance times
- Plans were made during the testing period to have the flap modified to allow the flap to be switched between 0° and 20° during the contamination period
  - 0° or 20° flap setting would be used for fluid application and contamination
  - 20° flap setting would always be used for the take-off run

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SUMMARY OF RESULTS

- Following the modification, some tests which resulted in severe visual ratings on the flap set at 20° were repeated with the flap set at 0° (for the contamination period)
  - This was primarily done for tests which generated good visual flow-off on the main wing, and generated close to 5% lift loss
- The re-run tests with flap 0° generated better visual contamination ratings on the flap, and typically equal or better aerodynamic performance
  - Up to 3% improvement in lift when compared to the dry wing

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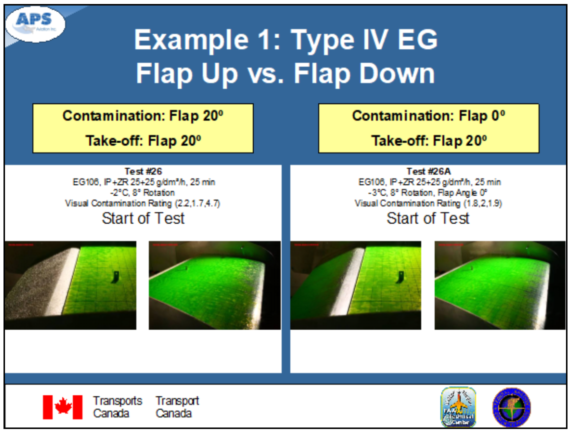
Example 1: Type IV EG Flap Up vs. Flap Down



Contamination: Flap 20°
Take-off: Flap 20°

Test #26
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-2°C, 8° Rotation
Visual Contamination Rating (2.2,1.7,4.7)
Start of Test

Contamination: Flap 0°
Take-off: Flap 20°

Test #26A
EG106, IP+ZR 25+25 $g/dm^2/h$, 25 min
-3°C, 8° Rotation, Flap Angle 0°
Visual Contamination Rating (1.8,2,1.9)
Start of Test

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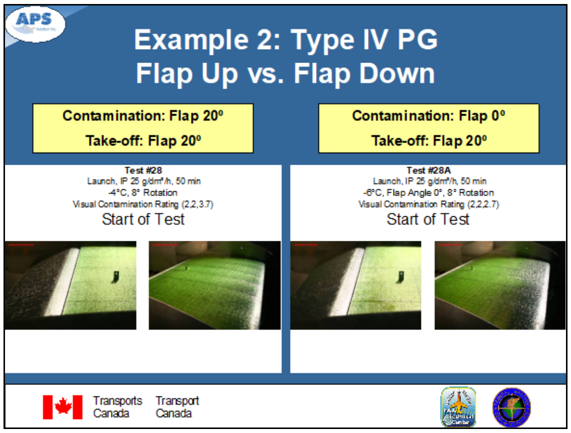

Example 2: Type IV PG Flap Up vs. Flap Down

Contamination: Flap 20° Take-off: Flap 20°	Contamination: Flap 0° Take-off: Flap 20°
Test #28 Launch, IP 25 $g/dm^2/h$, 50 min -4°C, 8° Rotation Visual Contamination Rating (2,2,3.7) Start of Test	**Test #28A** Launch, IP 25 $g/dm^2/h$, 50 min -6°C, Flap Angle 0°, 8° Rotation Visual Contamination Rating (2,2,2.7) Start of Test

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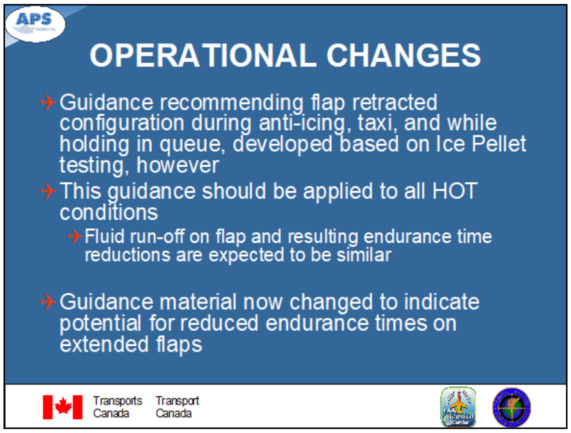

OPERATIONAL CHANGES

- Guidance recommending flap retracted configuration during anti-icing, taxi, and while holding in queue, developed based on Ice Pellet testing, however
- This guidance should be applied to all HOT conditions
  - Fluid run-off on flap and resulting endurance time reductions are expected to be similar
- Guidance material now changed to indicate potential for reduced endurance times on extended flaps

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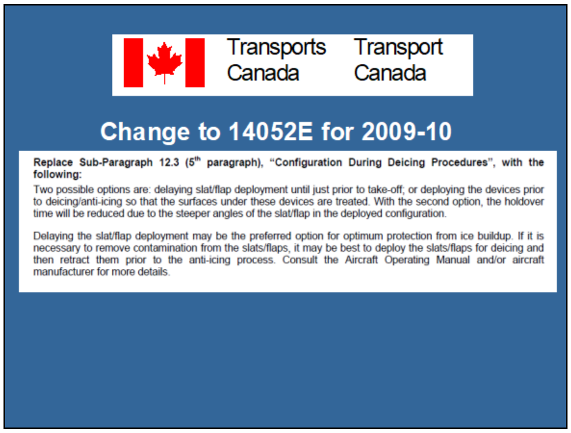


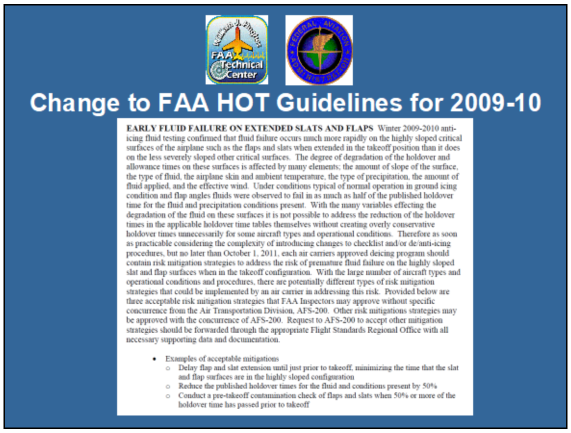
Transports Canada Transport Canada

Change to 14052E for 2009-10

Replace Sub-Paragraph 12.3 (5th paragraph), "Configuration During Deicing Procedures", with the following:

Two possible options are: delaying slat/flap deployment until just prior to take-off; or deploying the devices prior to deicing/anti-icing so that the surfaces under these devices are treated. With the second option, the holdover time will be reduced due to the steeper angles of the slat/flap in the deployed configuration.

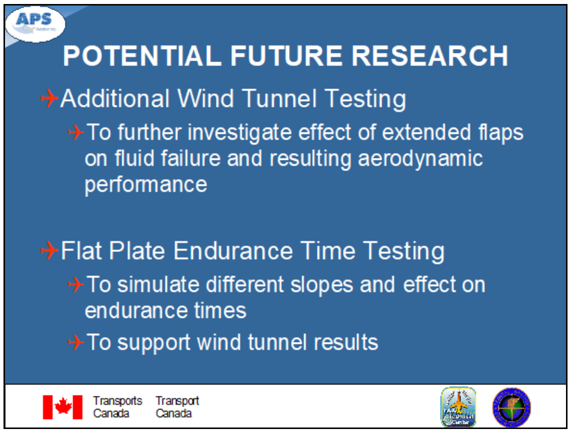
Delaying the slat/flap deployment may be the preferred option for optimum protection from ice buildup. If it is necessary to remove contamination from the slats/flaps, it may be best to deploy the slats/flaps for deicing and then retract them prior to the anti-icing process. Consult the Aircraft Operating Manual and/or aircraft manufacturer for more details.



Change to FAA HOT Guidelines for 2009-10

EARLY FLUID FAILURE ON EXTENDED SLATS AND FLAPS Winter 2009-2010 anti-icing fluid testing confirmed that fluid failure occurs much more rapidly on the highly sloped critical surfaces of the airplane such as the flaps and slats when extended in the takeoff position than it does on the less severely sloped other critical surfaces. The degree of degradation of the holdover and allowance times on these surfaces is affected by many elements; the amount of slope of the surface, the type of fluid, the airplane skin and ambient temperature, the type of precipitation, the amount of fluid applied, and the effective wind. Under conditions typical of normal operation in ground icing condition and flap angles fluids were observed to fail in as much as half of the published holdover time for the fluid and precipitation conditions present. With the many variables effecting the degradation of the fluid on these surfaces it is not possible to address the reduction of the holdover times in the applicable holdover time tables themselves without creating overly conservative holdover times unnecessarily for some aircraft types and operational conditions. Therefore as soon as practicable considering the complexity of introducing changes to checklist and/or de/anti-icing procedures, but no later than October 1, 2011, each air carriers approved deicing program should contain risk mitigation strategies to address the risk of premature fluid failure on the highly sloped slat and flap surfaces when in the takeoff configuration. With the large number of aircraft types and operational conditions and procedures, there are potentially different types of risk mitigation strategies that could be implemented by an air carrier in addressing this risk. Provided below are three acceptable risk mitigation strategies that FAA Inspectors may approve without specific concurrence from the Air Transportation Division, AFS-200. Other risk mitigations strategies may be approved with the concurrence of AFS-200. Request to AFS-200 to accept other mitigation strategies should be forwarded through the appropriate Flight Standards Regional Office with all necessary supporting data and documentation.

- Examples of acceptable mitigations
  - Delay flap and slat extension until just prior to takeoff, minimizing the time that the slat and flap surfaces are in the highly sloped configuration
  - Reduce the published holdover times for the fluid and conditions present by 50%
  - Conduct a pre-takeoff contamination check of flaps and slats when 50% or more of the holdover time has passed prior to takeoff



POTENTIAL FUTURE RESEARCH

- Additional Wind Tunnel Testing
  - To further investigate effect of extended flaps on fluid failure and resulting aerodynamic performance
- Flat Plate Endurance Time Testing
  - To simulate different slopes and effect on endurance times
  - To support wind tunnel results

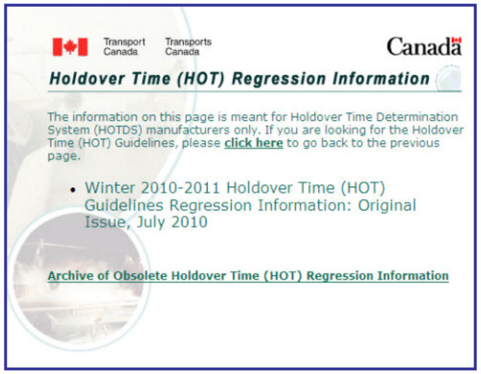
Transports Canada Transport Canada

ANY ADDITIONAL FEEDBACK???
FLAP UP VS. FLAP DOWN

APS Aviation Inc.

Marco Ruggi
mruggi@adga.ca

DISSEMINATION OF HOT GUIDELINES REGRESSION INFORMATION 2010-2011



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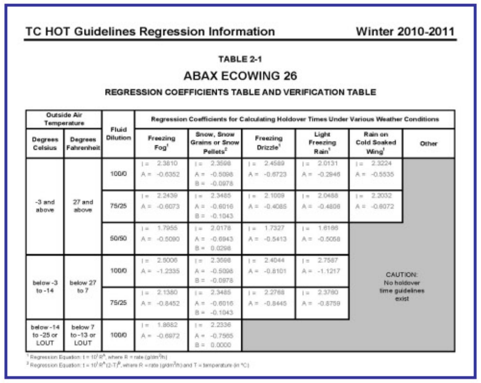
Holdover Time (HOT) Regression Information

The information on this page is meant for Holdover Time Determination System (HOTDS) manufacturers only. If you are looking for the Holdover Time (HOT) Guidelines, please click here to go back to the previous page.

- Winter 2010-2011 Holdover Time (HOT) Guidelines Regression Information: Original Issue, July 2010

Archive of Obsolete Holdover Time (HOT) Regression Information



TC HOT Guidelines Regression Information Winter 2010-2011

TABLE 2-1

ABAX ECOWING 26

REGRESSION COEFFICIENTS TABLE AND VERIFICATION TABLE

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog[1]	Snow, Snow Grains or Snow Pellets[2]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	I = 2.3810 A = -0.6352	I = 2.3598 A = -0.5098 B = -0.0978	I = 2.4589 A = -0.6723	I = 2.0131 A = -0.2946	I = 2.3224 A = -0.5535	
		75/25	I = 2.2439 A = -0.6073	I = 2.3485 A = -0.6016 B = -0.1043	I = 2.1009 A = -0.4085	I = 2.0488 A = -0.4806	I = 2.2032 A = -0.6072	
		50/50	I = 1.7955 A = -0.5090	I = 2.0178 A = -0.6943 B = 0.0298	I = 1.7327 A = -0.5413	I = 1.6166 A = -0.5058		
below -3 to -14	below 27 to 7	100/0	I = 2.9006 A = -1.2335	I = 2.3598 A = -0.5098 B = -0.0978	I = 2.4044 A = -0.8101	I = 2.7587 A = -1.1217	CAUTION: No holdover time guidelines exist	
		75/25	I = 2.1380 A = -0.8452	I = 2.3485 A = -0.6016 B = -0.1043	I = 2.2768 A = -0.8445	I = 2.3780 A = -0.8759		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	I = 1.8882 A = -0.6972	I = 2.2336 A = -0.7565 B = 0.0000				

[1] Regression Equation: $t = 10^I R^A$, where R = rate (g/dm²/h)

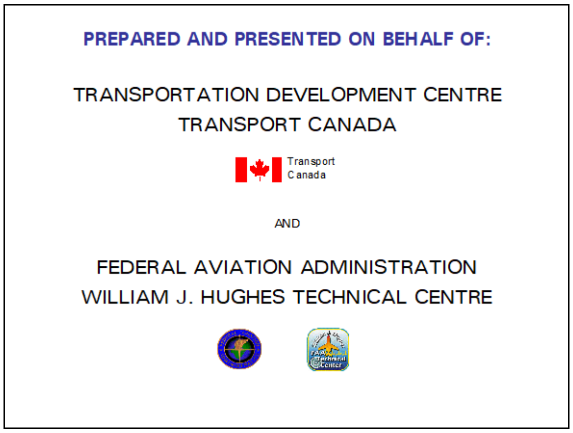
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = rate (g/dm²/h) and T = temperature (in °C)

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT SUBCOMMITTEE MEETING MONTREAL – NOV. 3, 2010

PRESENTED BY STEPHANIE BENDICKSON



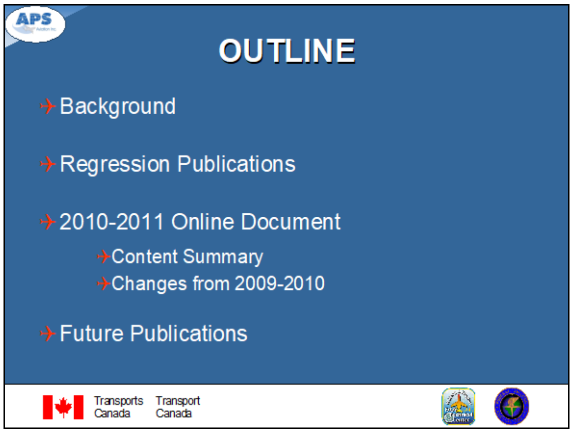
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- Background
- Regression Publications
- 2010-2011 Online Document
  - Content Summary
  - Changes from 2009-2010
- Future Publications

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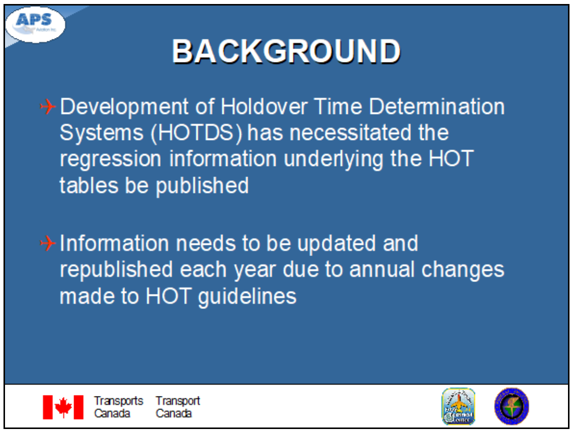

BACKGROUND

- Development of Holdover Time Determination Systems (HOTDS) has necessitated the regression information underlying the HOT tables be published
- Information needs to be updated and republished each year due to annual changes made to HOT guidelines

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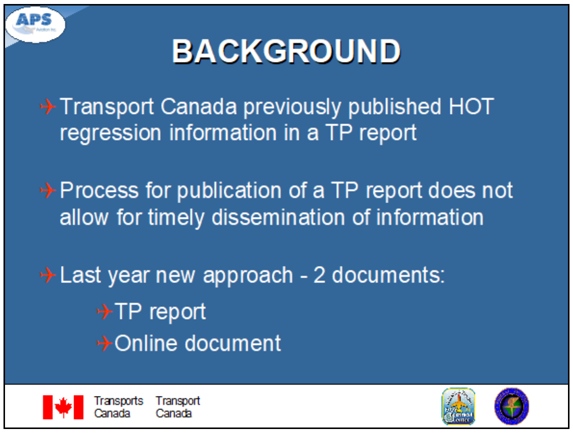

BACKGROUND

- Transport Canada previously published HOT regression information in a TP report
- Process for publication of a TP report does not allow for timely dissemination of information
- Last year new approach - 2 documents:
  - TP report
  - Online document

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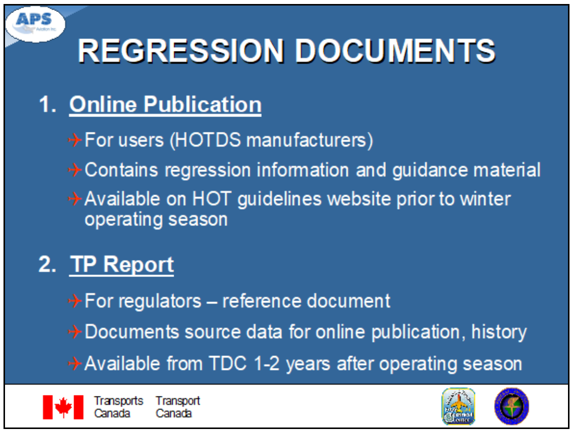

REGRESSION DOCUMENTS

1. **Online Publication**
   - For users (HOTDS manufacturers)
   - Contains regression information and guidance material
   - Available on HOT guidelines website prior to winter operating season
2. **TP Report**
   - For regulators – reference document
   - Documents source data for online publication, history
   - Available from TDC 1-2 years after operating season

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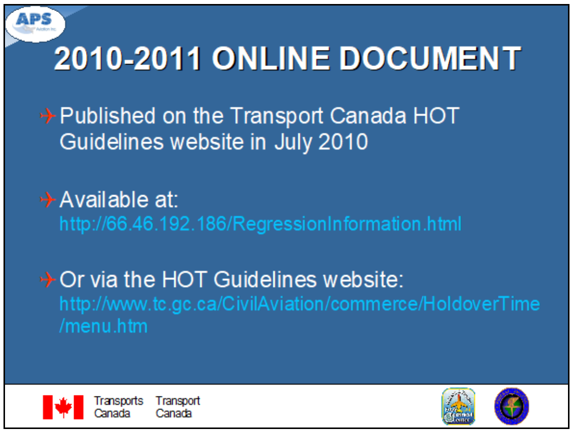

2010-2011 ONLINE DOCUMENT

- Published on the Transport Canada HOT Guidelines website in July 2010
- Available at:
  http://66.46.192.186/RegressionInformation.html
- Or via the HOT Guidelines website:
  http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm

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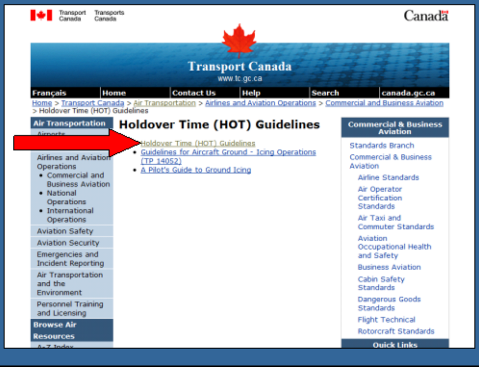
Transport Canada HOT Page



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- Holdover Time (HOT) Guidelines
- Guidelines for Aircraft Ground - Icing Operations (TP 14052)
- A Pilot's Guide to Ground Icing

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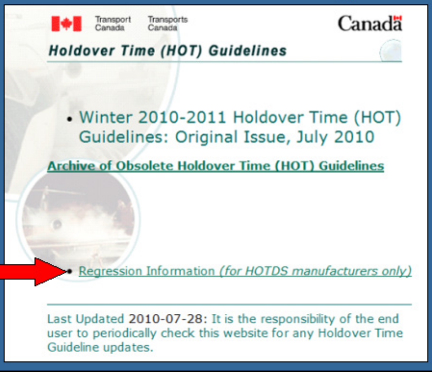

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Holdover Time (HOT) Guidelines

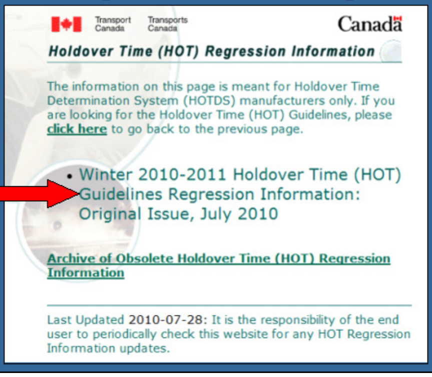
- Winter 2010-2011 Holdover Time (HOT) Guidelines: Original Issue, July 2010

Archive of Obsolete Holdover Time (HOT) Guidelines

- Regression Information *(for HOTDS manufacturers only)*

Last Updated 2010-07-28: It is the responsibility of the end user to periodically check this website for any Holdover Time Guideline updates.

Regression Info Page



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Holdover Time (HOT) Regression Information

The information on this page is meant for Holdover Time Determination System (HOTDS) manufacturers only. If you are looking for the Holdover Time (HOT) Guidelines, please click here to go back to the previous page.

- Winter 2010-2011 Holdover Time (HOT) Guidelines Regression Information: Original Issue, July 2010

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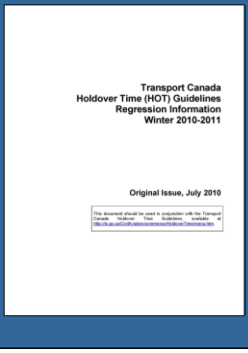
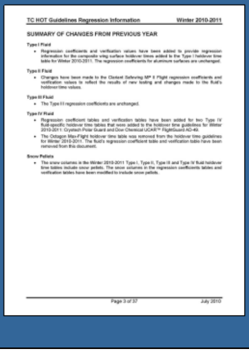
2010-2011 ONLINE DOCUMENT



Transport Canada
Holdover Time (HOT) Guidelines
Regression Information
Winter 2010-2011

Original Issue, July 2010

This document should be used in conjunction with the Transport Canada Holdover Time Guidelines, available at



TC HOT Guidelines Regression Information Winter 2010-2011

SUMMARY OF CHANGES FROM PREVIOUS YEAR

Type I Fluid

- Regression coefficients and verification values have been added to provide regression information for the composite wing surface holdover times added to the Type I holdover time table for Winter 2010-2011. The regression coefficients for aluminum surfaces are unchanged.

Type II Fluid

- Changes have been made to the Clariant Safewing MP II Flight regression coefficients and verification values to reflect the results of new testing and changes made to the fluid's holdover time values.

Type III Fluid

- The Type III regression coefficients are unchanged.

Type IV Fluid

- Regression coefficient tables and verification tables have been added for two Type IV fluid-specific holdover time tables that were added to the holdover time guidelines for Winter 2010-2011: Cryotech Polar Guard and Dow Chemical UCAR™ FlightGuard AD-49.
- The Octagon Max-Flight holdover time table was removed from the holdover time guidelines for Winter 2010-2011. The fluid's regression coefficient table and verification table have been removed from this document.

Snow Pellets

- The snow columns in the Winter 2010-2011 Type I, Type II, Type III and Type IV fluid holdover time tables include snow pellets. The snow columns in the regression coefficients tables and verification tables have been modified to include snow pellets.

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2010-2011 ONLINE DOCUMENT

TC HOT Guidelines Regression Information Winter 2010-2011

GUIDANCE FOR USING REGRESSION INFORMATION

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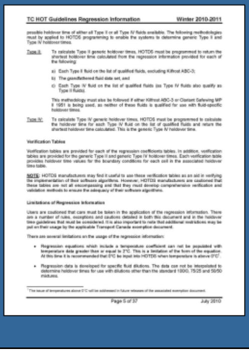

TC HOT Guidelines Regression Information Winter 2010-2011

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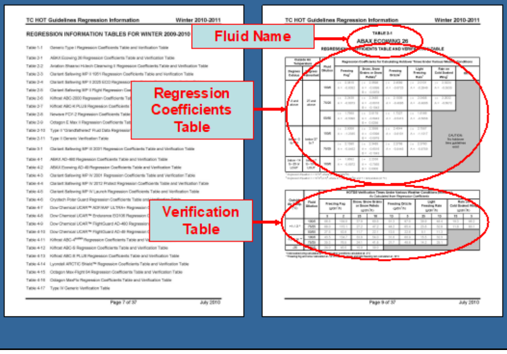
2010-2011 ONLINE DOCUMENT



TC HOT Guidelines Regression Information Winter 2010-2011

Fluid Name

Regression Coefficients Table

Verification Table

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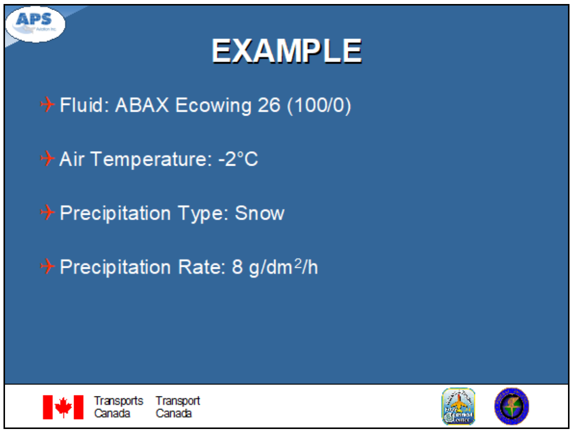

EXAMPLE

- Fluid: ABAX Ecowing 26 (100/0)
- Air Temperature: -2°C
- Precipitation Type: Snow
- Precipitation Rate: 8 g/dm²/h

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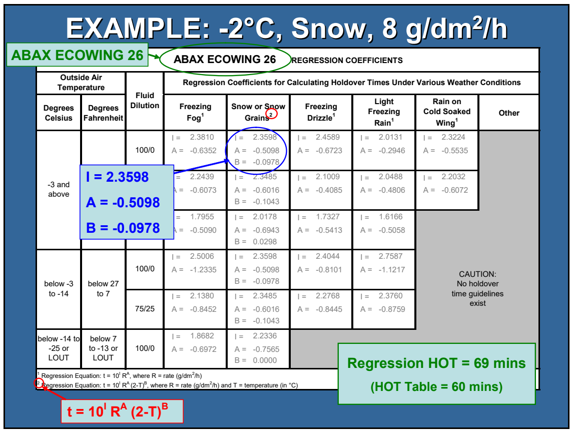


EXAMPLE: -2°C, Snow, 8 g/dm²/h

ABAX ECOWING 26

ABAX ECOWING 26 REGRESSION COEFFICIENTS

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above		100/0	I = 2.3810 A = -0.6352	I = 2.3598 A = -0.5098 B = -0.0978	I = 2.4589 A = -0.6723	I = 2.0131 A = -0.2946	I = 2.3224 A = -0.5535	CAUTION: No holdover time guidelines exist
			I = 2.2439 A = -0.6073	I = 2.3485 A = -0.6016 B = -0.1043	I = 2.1009 A = -0.4085	I = 2.0488 A = -0.4806	I = 2.2032 A = -0.6072	
			I = 1.7955 A = -0.5090	I = 2.0178 A = -0.6943 B = 0.0298	I = 1.7327 A = -0.5413	I = 1.6166 A = -0.5058		
below -3 to -14	below 27 to 7	100/0	I = 2.5006 A = -1.2335	I = 2.3598 A = -0.5098 B = -0.0978	I = 2.4044 A = -0.8101	I = 2.7587 A = -1.1217		
		75/25	I = 2.1380 A = -0.8452	I = 2.3485 A = -0.6016 B = -0.1043	I = 2.2768 A = -0.8445	I = 2.3760 A = -0.8759		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	I = 1.8682 A = -0.6972	I = 2.2336 A = -0.7565 B = 0.0000				

[1] Regression Equation: $t = 10^I R^A$, where R = rate (g/dm²/h)

[2] Regression Equation: $t = 10^I R^A (2\text{-}T)^B$, where R = rate (g/dm²/h) and T = temperature (in °C)

I = 2.3598

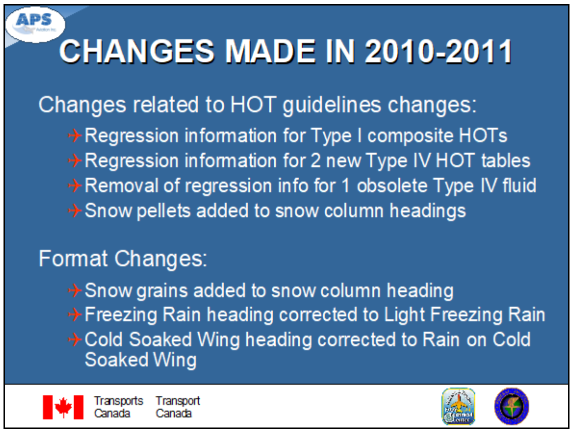
A = -0.5098

B = -0.0978

$t = 10^I R^A (2\text{-}T)^B$

Regression HOT = 69 mins

(HOT Table = 60 mins)



CHANGES MADE IN 2010-2011

Changes related to HOT guidelines changes:

- Regression information for Type I composite HOTs
- Regression information for 2 new Type IV HOT tables
- Removal of regression info for 1 obsolete Type IV fluid
- Snow pellets added to snow column headings

Format Changes:

- Snow grains added to snow column heading
- Freezing Rain heading corrected to Light Freezing Rain
- Cold Soaked Wing heading corrected to Rain on Cold Soaked Wing

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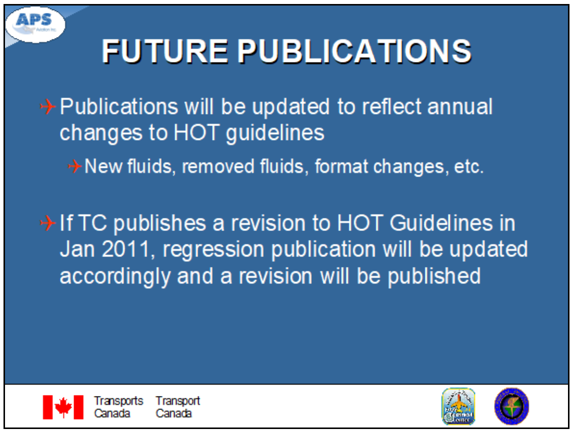


FUTURE PUBLICATIONS

- Publications will be updated to reflect annual changes to HOT guidelines
  - New fluids, removed fluids, format changes, etc.
- If TC publishes a revision to HOT Guidelines in Jan 2011, regression publication will be updated accordingly and a revision will be published

Transports Canada Transport Canada

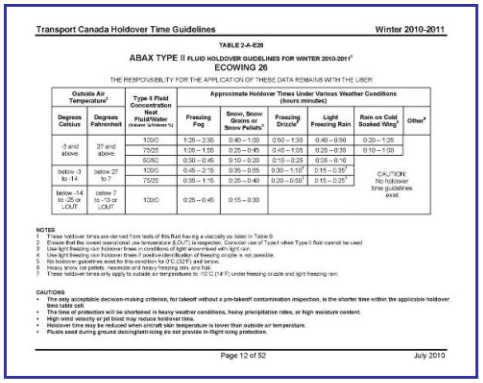
? QUESTIONS ?

APS Aviation Inc.

Stephanie Bendickson

email: sbendickson@telus.net

RECOMMENDED CHANGES TO ARP 5718: CALCULATING MORE PRECISE HOTS



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 2-A-E26

ABAX TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]
ECOWING 26

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:10 – 0:20	0:15 – 0:25	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	0:35 – 0:55	0:30 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:15	0:25 – 0:40	0:20 – 0:50[7]	0:15 – 0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 Use light freezing rain holdover times in conditions of light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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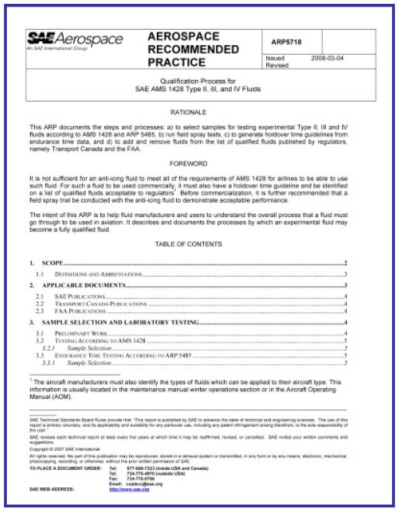

SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

ARP5718

Issued 2008-03-04
Revised

Qualification Process for
SAE AMS 1428 Type II, III, and IV Fluids

RATIONALE

This ARP documents the steps and processes: a) to select samples for testing experimental Type II, III and IV fluids according to AMS 1428 and ARP 5485, b) run field spray tests, c) to generate holdover time guidelines from endurance time data, and d) to add and remove fluids from the list of qualified fluids published by regulators, namely Transport Canada and the FAA.

FOREWORD

It is not sufficient for an anti-icing fluid to meet all of the requirements of AMS 1428 for airlines to be able to use such fluid. For such a fluid to be used commercially, it must also have a holdover time guideline and be identified on a list of qualified fluids acceptable to regulators[1]. Before commercialization, it is further recommended that a field spray trial be conducted with the anti-icing fluid to demonstrate acceptable performance.

The intent of this ARP is to help fluid manufacturers and users to understand the overall process that a fluid must go through to be used in aviation. It describes and documents the processes by which an experimental fluid may become a fully qualified fluid.

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3.3.1 Sample Selection 5

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[1] The aircraft manufacturers must also identify the types of fluids which can be applied to their aircraft type. This information is usually located in the maintenance manual winter operations section or in the Aircraft Operating Manual (AOM).

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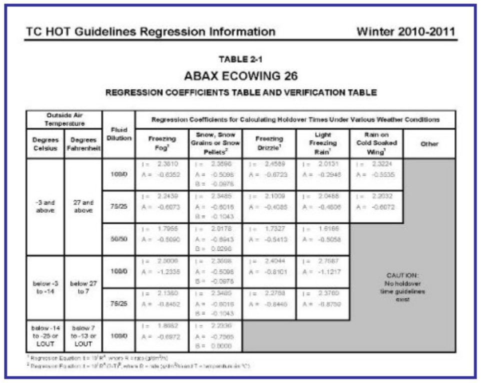


TC HOT Guidelines Regression Information **Winter 2010-2011**

TABLE 2-1

ABAX ECOWING 26

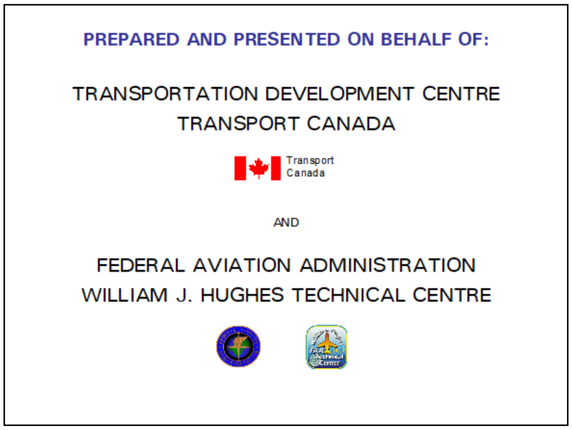
REGRESSION COEFFICIENTS TABLE AND VERIFICATION TABLE

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog[1]	Snow, Snow Grains or Snow Pellets[2]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	I = 2.3810 A = -0.6352	I = 2.3698 A = -0.5098 B = -0.0978	I = 2.4589 A = -0.6723	I = 2.0131 A = -0.2946	I = 2.3224 A = -0.5535	
		75/25	I = 2.2439 A = -0.6073	I = 2.3485 A = -0.8016 B = -0.1043	I = 2.1009 A = -0.4086	I = 2.0488 A = -0.4606	I = 2.2032 A = -0.6072	
		50/50	I = 1.7956 A = -0.5090	I = 2.0178 A = -0.8943 B = 0.0298	I = 1.7327 A = -0.5413	I = 1.6166 A = -0.5058		
below -3 to -14	below 27 to 7	100/0	I = 2.5008 A = -1.2336	I = 2.3698 A = -0.5098 B = -0.0978	I = 2.4044 A = -0.8101	I = 2.7587 A = -1.1217	CAUTION: No holdover time guidelines exist	
		75/25	I = 2.1360 A = -0.8452	I = 2.3485 A = -0.8016 B = -0.1043	I = 2.2788 A = -0.8440	I = 2.3780 A = -0.8750		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	I = 1.8882 A = -0.6972	I = 2.2336 A = -0.7565 B = 0.0000				

[1] Regression Equation: $t = 10^I R^A$, where R = rate (g/dm²/h)
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = rate (g/dm²/h) and T = temperature (in °C)

SAE G-12 HOT SUBCOMMITTEE MEETING
MONTREAL – NOV. 3, 2010

PRESENTED BY STEPHANIE BENDICKSON



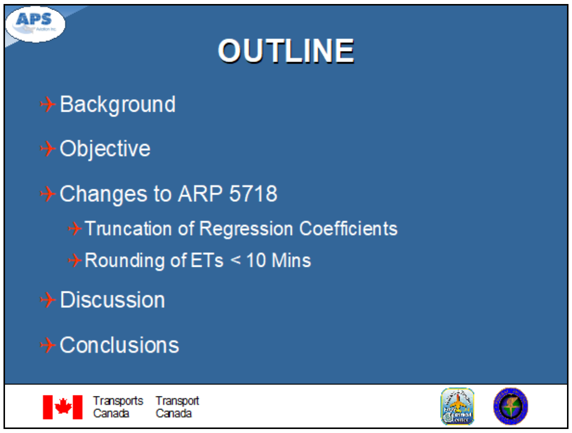
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTRE



OUTLINE

- Background
- Objective
- Changes to ARP 5718
  - Truncation of Regression Coefficients
  - Rounding of ETs < 10 Mins
- Discussion
- Conclusions

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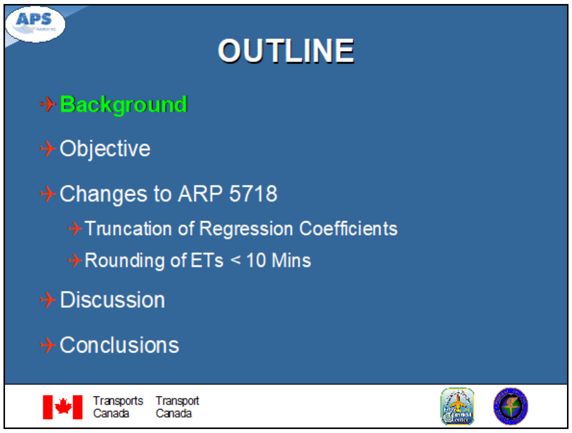

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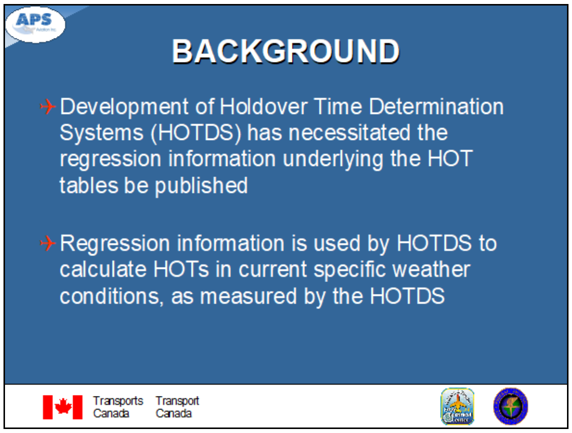

BACKGROUND

- Development of Holdover Time Determination Systems (HOTDS) has necessitated the regression information underlying the HOT tables be published
- Regression information is used by HOTDS to calculate HOTs in current specific weather conditions, as measured by the HOTDS

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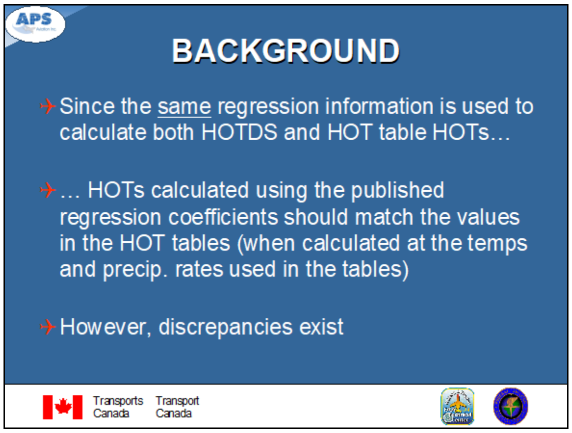

BACKGROUND

- Since the same regression information is used to calculate both HOTDS and HOT table HOTs…
- … HOTs calculated using the published regression coefficients should match the values in the HOT tables (when calculated at the temps and precip. rates used in the tables)
- However, discrepancies exist

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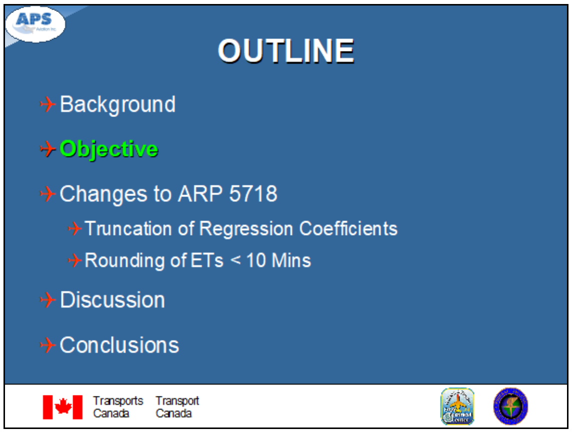

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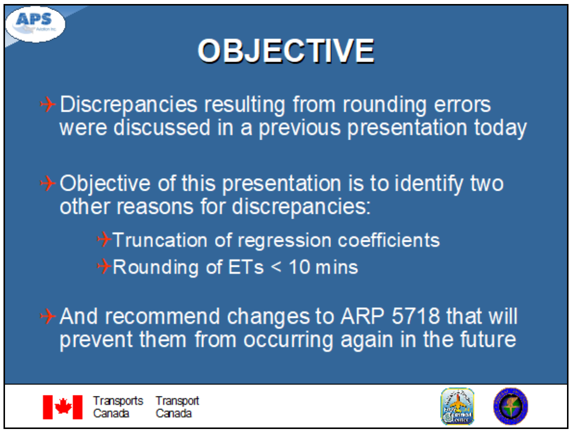

OBJECTIVE

- Discrepancies resulting from rounding errors were discussed in a previous presentation today
- Objective of this presentation is to identify two other reasons for discrepancies:
  - Truncation of regression coefficients
  - Rounding of ETs < 10 mins
- And recommend changes to ARP 5718 that will prevent them from occurring again in the future

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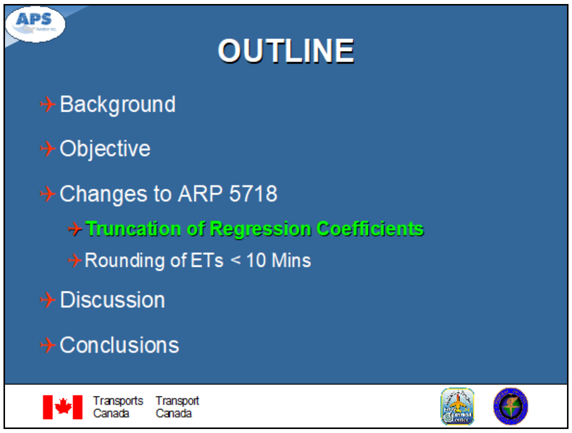

OUTLINE

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- Changes to ARP 5718
  - **Truncation of Regression Coefficients**
  - Rounding of ETs < 10 Mins
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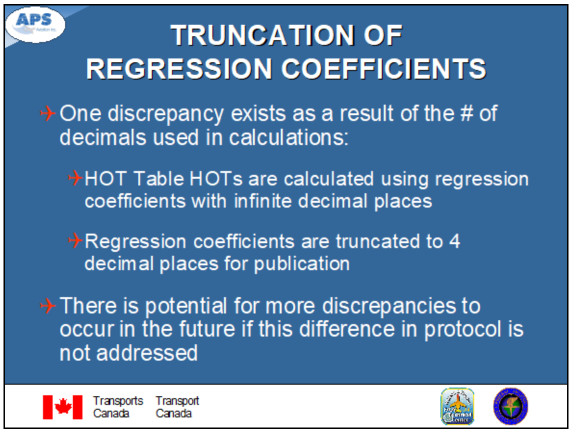

TRUNCATION OF REGRESSION COEFFICIENTS

- One discrepancy exists as a result of the # of decimals used in calculations:
  - HOT Table HOTs are calculated using regression coefficients with infinite decimal places
  - Regression coefficients are truncated to 4 decimal places for publication
- There is potential for more discrepancies to occur in the future if this difference in protocol is not addressed

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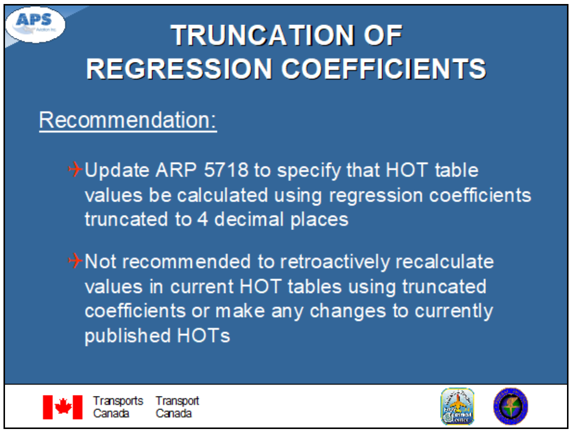

TRUNCATION OF REGRESSION COEFFICIENTS

Recommendation:

- Update ARP 5718 to specify that HOT table values be calculated using regression coefficients truncated to 4 decimal places
- Not recommended to retroactively recalculate values in current HOT tables using truncated coefficients or make any changes to currently published HOTs

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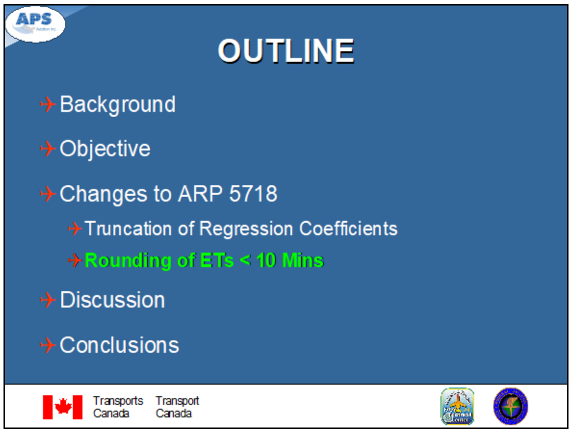

OUTLINE

- Background
- Objective
- Changes to ARP 5718
  - Truncation of Regression Coefficients
  - **Rounding of ETs < 10 Mins**
- Discussion
- Conclusions

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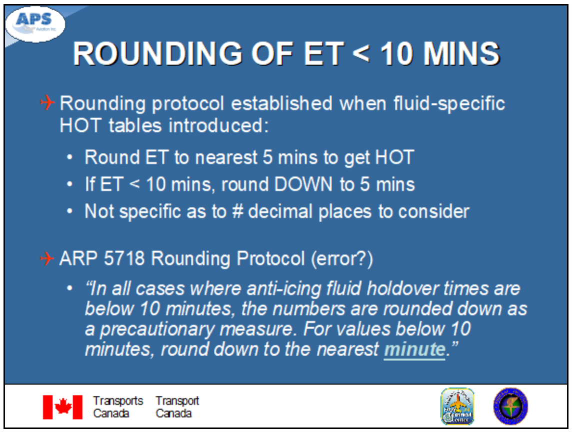

ROUNDING OF ET < 10 MINS

- Rounding protocol established when fluid-specific HOT tables introduced:
  - Round ET to nearest 5 mins to get HOT
  - If ET < 10 mins, round DOWN to 5 mins
  - Not specific as to # decimal places to consider
- ARP 5718 Rounding Protocol (error?)
  - *"In all cases where anti-icing fluid holdover times are below 10 minutes, the numbers are rounded down as a precautionary measure. For values below 10 minutes, round down to the nearest minute."*

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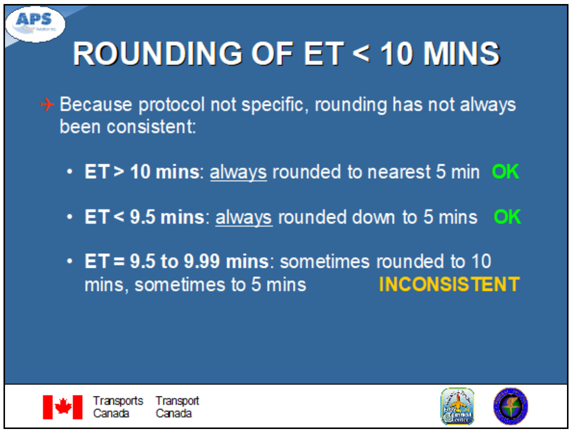

ROUNDING OF ET < 10 MINS

- Because protocol not specific, rounding has not always been consistent:
  - **ET > 10 mins**: always rounded to nearest 5 min **OK**
  - **ET < 9.5 mins**: always rounded down to 5 mins **OK**
  - **ET = 9.5 to 9.99 mins**: sometimes rounded to 10 mins, sometimes to 5 mins **INCONSISTENT**

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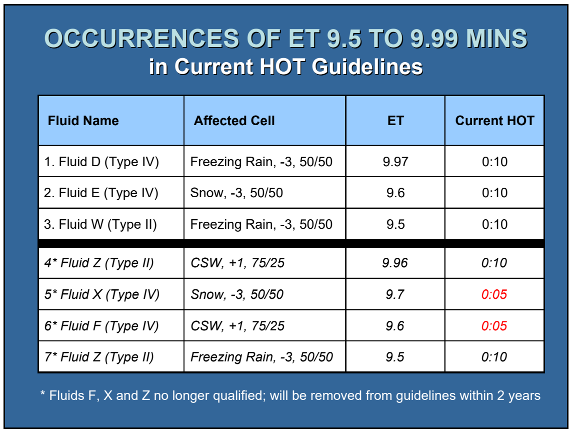
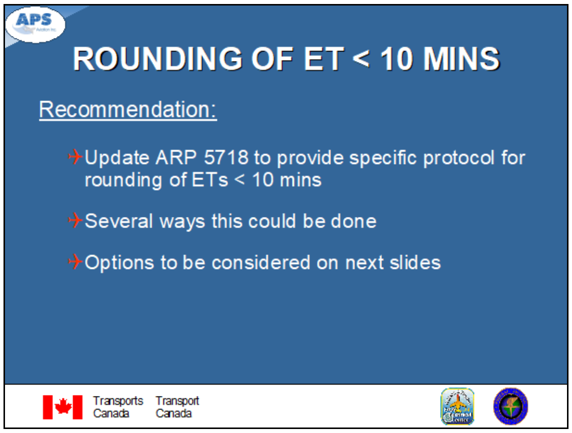


OCCURRENCES OF ET 9.5 TO 9.99 MINS
in Current HOT Guidelines

Fluid Name	Affected Cell	ET	Current HOT
1. Fluid D (Type IV)	Freezing Rain, -3, 50/50	9.97	0:10
2. Fluid E (Type IV)	Snow, -3, 50/50	9.6	0:10
3. Fluid W (Type II)	Freezing Rain, -3, 50/50	9.5	0:10
4 Fluid Z (Type II)*	*CSW, +1, 75/25*	*9.96*	*0:10*
5 Fluid X (Type IV)*	*Snow, -3, 50/50*	*9.7*	*0:05*
6 Fluid F (Type IV)*	*CSW, +1, 75/25*	*9.6*	*0:05*
7 Fluid Z (Type II)*	*Freezing Rain, -3, 50/50*	*9.5*	*0:10*

* Fluids F, X and Z no longer qualified; will be removed from guidelines within 2 years



ROUNDING OF ET < 10 MINS

Recommendation:

- Update ARP 5718 to provide specific protocol for rounding of ETs < 10 mins
- Several ways this could be done
- Options to be considered on next slides

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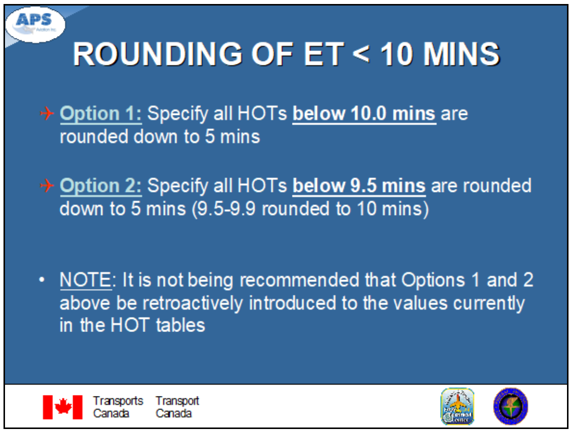

ROUNDING OF ET < 10 MINS

- Option 1: Specify all HOTs **below 10.0 mins** are rounded down to 5 mins
- Option 2: Specify all HOTs **below 9.5 mins** are rounded down to 5 mins (9.5-9.9 rounded to 10 mins)
- NOTE: It is not being recommended that Options 1 and 2 above be retroactively introduced to the values currently in the HOT tables

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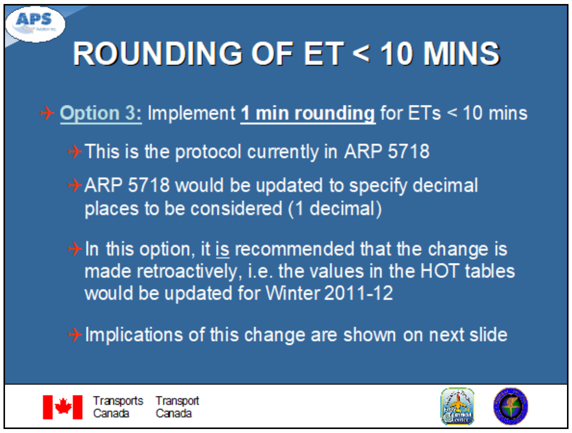

ROUNDING OF ET < 10 MINS

- Option 3: Implement **1 min rounding** for ETs < 10 mins
  - This is the protocol currently in ARP 5718
  - ARP 5718 would be updated to specify decimal places to be considered (1 decimal)
  - In this option, it is recommended that the change is made retroactively, i.e. the values in the HOT tables would be updated for Winter 2011-12
  - Implications of this change are shown on next slide

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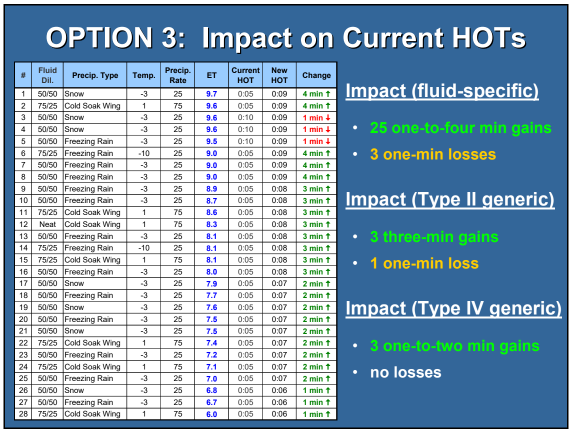


OPTION 3: Impact on Current HOTs

#	Fluid Dil.	Precip. Type	Temp.	Precip. Rate	ET	Current HOT	New HOT	Change
1	50/50	Snow	-3	25	9.7	0:05	0:09	4 min ↑
2	75/25	Cold Soak Wing	1	75	9.6	0:05	0:09	4 min ↑
3	50/50	Snow	-3	25	9.6	0:10	0:09	1 min ↓
4	50/50	Snow	-3	25	9.6	0:10	0:09	1 min ↓
5	50/50	Freezing Rain	-3	25	9.5	0:10	0:09	1 min ↓
6	75/25	Freezing Rain	-10	25	9.0	0:05	0:09	4 min ↑
7	50/50	Freezing Rain	-3	25	9.0	0:05	0:09	4 min ↑
8	50/50	Freezing Rain	-3	25	9.0	0:05	0:09	4 min ↑
9	50/50	Freezing Rain	-3	25	8.9	0:05	0:08	3 min ↑
10	50/50	Freezing Rain	-3	25	8.7	0:05	0:08	3 min ↑
11	75/25	Cold Soak Wing	1	75	8.6	0:05	0:08	3 min ↑
12	Neat	Cold Soak Wing	1	75	8.3	0:05	0:08	3 min ↑
13	50/50	Freezing Rain	-3	25	8.1	0:05	0:08	3 min ↑
14	75/25	Freezing Rain	-10	25	8.1	0:05	0:08	3 min ↑
15	75/25	Cold Soak Wing	1	75	8.1	0:05	0:08	3 min ↑
16	50/50	Freezing Rain	-3	25	8.0	0:05	0:08	3 min ↑
17	50/50	Snow	-3	25	7.9	0:05	0:07	2 min ↑
18	50/50	Freezing Rain	-3	25	7.7	0:05	0:07	2 min ↑
19	50/50	Snow	-3	25	7.6	0:05	0:07	2 min ↑
20	50/50	Freezing Rain	-3	25	7.5	0:05	0:07	2 min ↑
21	50/50	Snow	-3	25	7.5	0:05	0:07	2 min ↑
22	75/25	Cold Soak Wing	1	75	7.4	0:05	0:07	2 min ↑
23	50/50	Freezing Rain	-3	25	7.2	0:05	0:07	2 min ↑
24	75/25	Cold Soak Wing	1	75	7.1	0:05	0:07	2 min ↑
25	50/50	Freezing Rain	-3	25	7.0	0:05	0:07	2 min ↑
26	50/50	Snow	-3	25	6.8	0:05	0:06	1 min ↑
27	50/50	Freezing Rain	-3	25	6.7	0:05	0:06	1 min ↑
28	75/25	Cold Soak Wing	1	75	6.0	0:05	0:06	1 min ↑

Impact (fluid-specific)

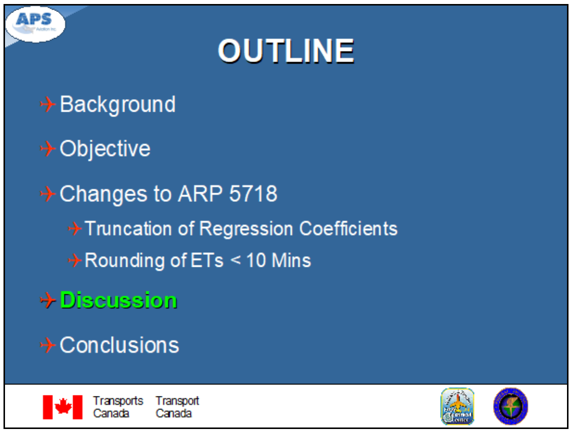
- **25 one-to-four min gains**
- **3 one-min losses**

Impact (Type II generic)

- **3 three-min gains**
- **1 one-min loss**

Impact (Type IV generic)

- **3 one-to-two min gains**
- **no losses**



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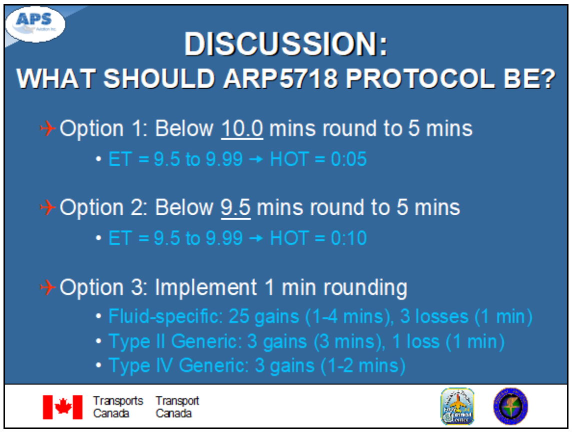

DISCUSSION:
WHAT SHOULD ARP5718 PROTOCOL BE?

- Option 1: Below 10.0 mins round to 5 mins
  - ET = 9.5 to 9.99 → HOT = 0:05
- Option 2: Below 9.5 mins round to 5 mins
  - ET = 9.5 to 9.99 → HOT = 0:10
- Option 3: Implement 1 min rounding
  - Fluid-specific: 25 gains (1-4 mins), 3 losses (1 min)
  - Type II Generic: 3 gains (3 mins), 1 loss (1 min)
  - Type IV Generic: 3 gains (1-2 mins)

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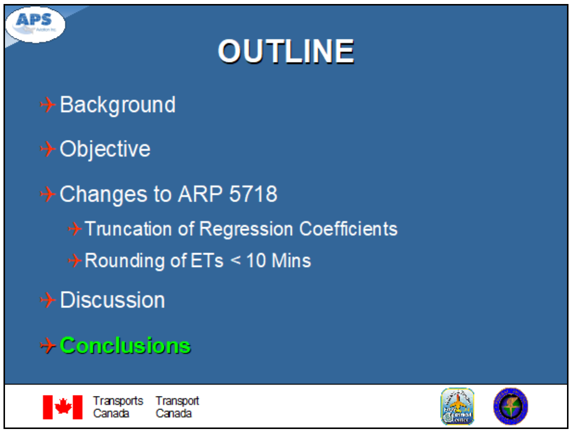

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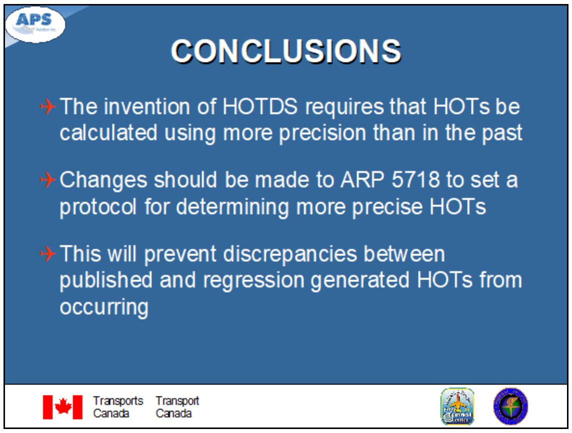

CONCLUSIONS

- The invention of HOTDS requires that HOTs be calculated using more precision than in the past
- Changes should be made to ARP 5718 to set a protocol for determining more precise HOTs
- This will prevent discrepancies between published and regression generated HOTs from occurring

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? QUESTIONS ?

APS Aviation Inc.

Stephanie Bendickson

email: sbendickson@telus.net

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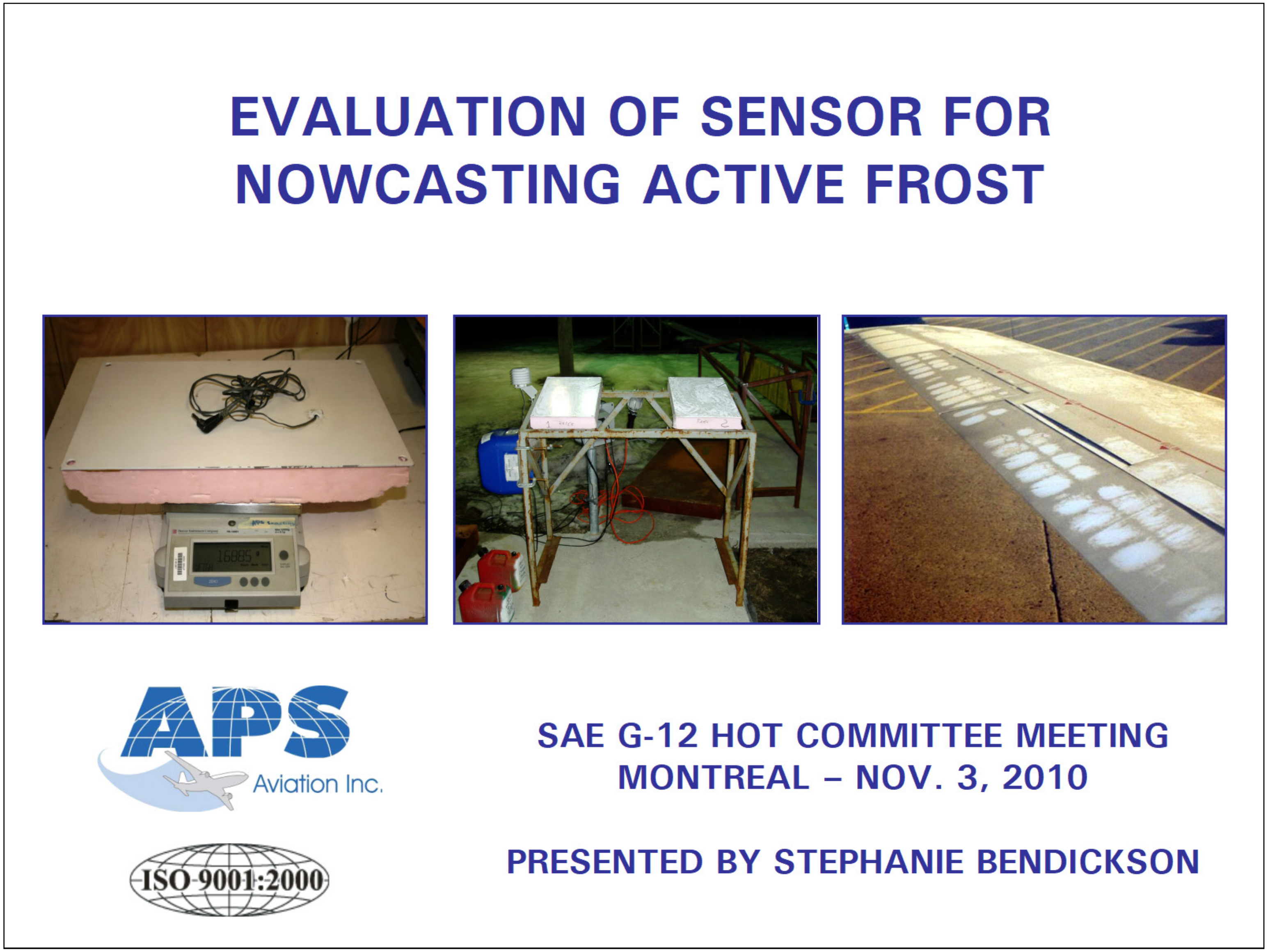

EVALUATION OF SENSOR FOR NOWCASTING ACTIVE FROST

APS Aviation Inc.

ISO 9001:2000

SAE G-12 HOT COMMITTEE MEETING
MONTREAL – NOV. 3, 2010

PRESENTED BY STEPHANIE BENDICKSON

PREPARED AND PRESENTED ON BEHALF OF:

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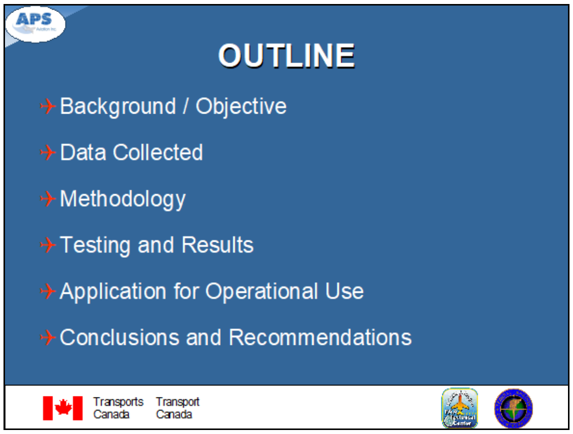
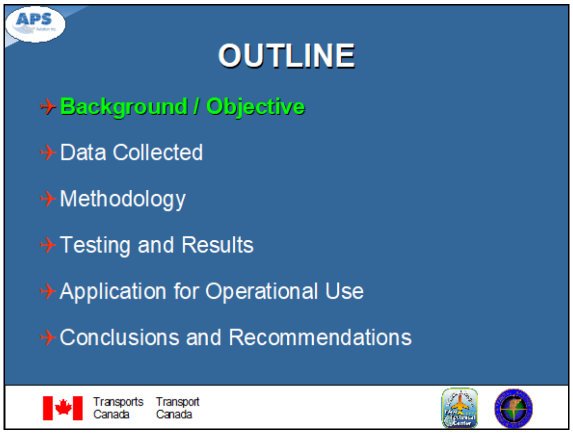


OUTLINE

- Background / Objective
- Data Collected
- Methodology
- Testing and Results
- Application for Operational Use
- Conclusions and Recommendations



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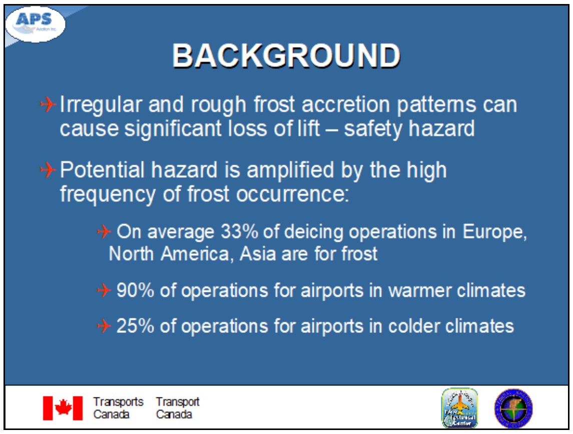
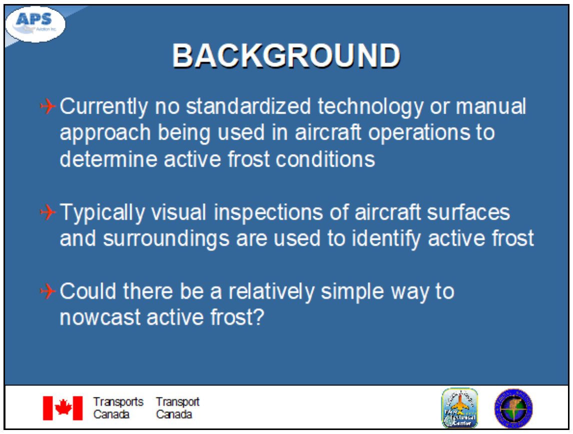


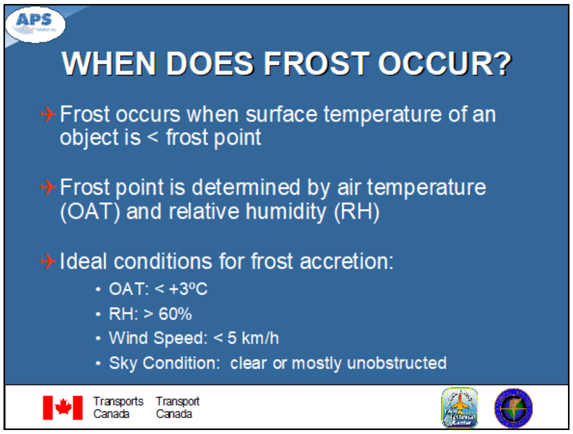
BACKGROUND

- Irregular and rough frost accretion patterns can cause significant loss of lift – safety hazard
- Potential hazard is amplified by the high frequency of frost occurrence:
  - On average 33% of deicing operations in Europe, North America, Asia are for frost
  - 90% of operations for airports in warmer climates
  - 25% of operations for airports in colder climates



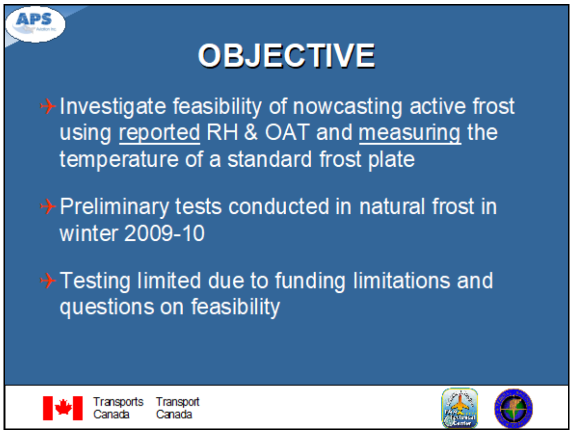
BACKGROUND

- Currently no standardized technology or manual approach being used in aircraft operations to determine active frost conditions
- Typically visual inspections of aircraft surfaces and surroundings are used to identify active frost
- Could there be a relatively simple way to nowcast active frost?



WHEN DOES FROST OCCUR?

- Frost occurs when surface temperature of an object is < frost point
- Frost point is determined by air temperature (OAT) and relative humidity (RH)
- Ideal conditions for frost accretion:
  - OAT: < +3°C
  - RH: > 60%
  - Wind Speed: < 5 km/h
  - Sky Condition: clear or mostly unobstructed



OBJECTIVE

- Investigate feasibility of nowcasting active frost using reported RH & OAT and measuring the temperature of a standard frost plate
- Preliminary tests conducted in natural frost in winter 2009-10
- Testing limited due to funding limitations and questions on feasibility

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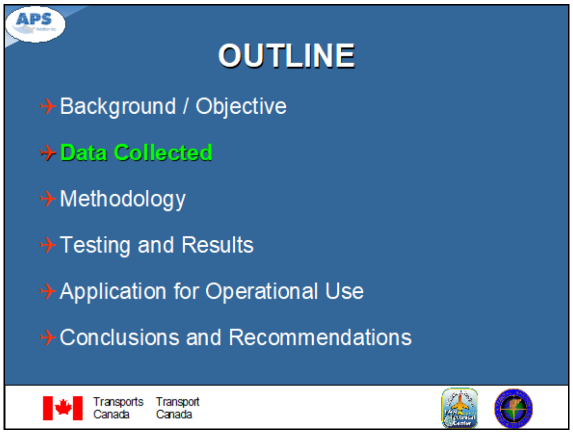

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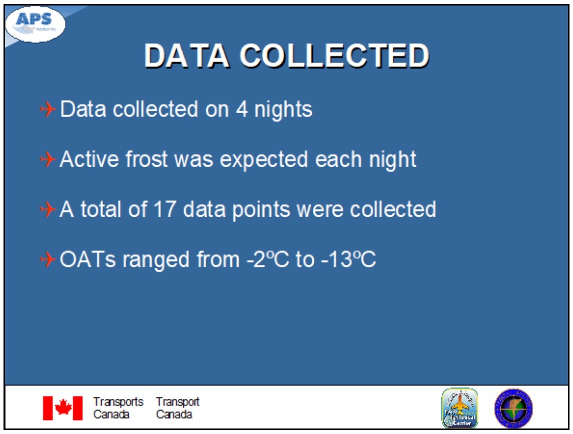

DATA COLLECTED

- Data collected on 4 nights
- Active frost was expected each night
- A total of 17 data points were collected
- OATs ranged from -2ºC to -13ºC

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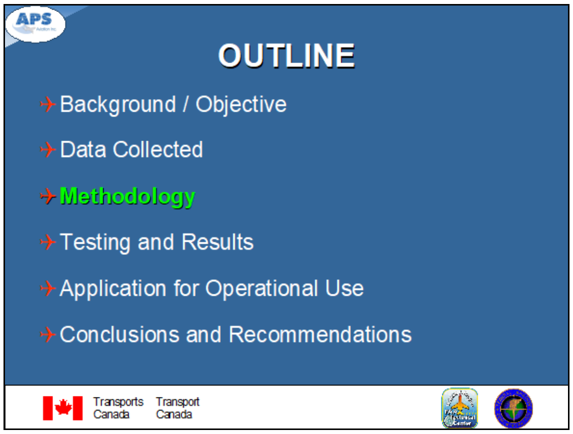

OUTLINE

- Background / Objective
- Data Collected
- **Methodology**
- Testing and Results
- Application for Operational Use
- Conclusions and Recommendations

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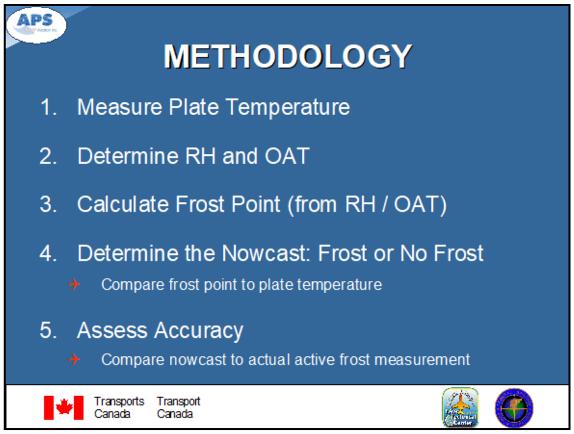

METHODOLOGY

1. Measure Plate Temperature
2. Determine RH and OAT
3. Calculate Frost Point (from RH / OAT)
4. Determine the Nowcast: Frost or No Frost
   - Compare frost point to plate temperature
5. Assess Accuracy
   - Compare nowcast to actual active frost measurement

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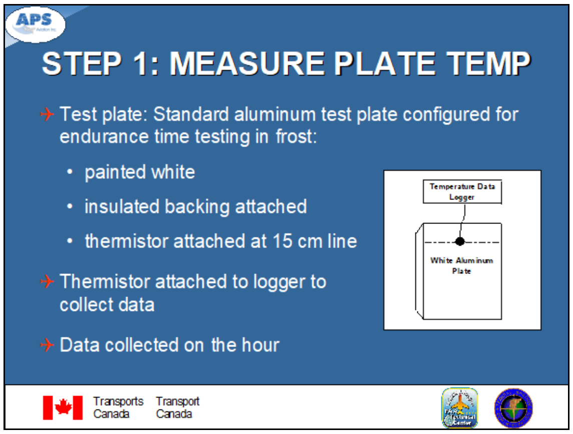

STEP 1: MEASURE PLATE TEMP

- Test plate: Standard aluminum test plate configured for endurance time testing in frost:
  - painted white
  - insulated backing attached
  - thermistor attached at 15 cm line
- Thermistor attached to logger to collect data
- Data collected on the hour

Temperature Data Logger
White Aluminum Plate

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STEP 2: DETERMINE OAT & RH

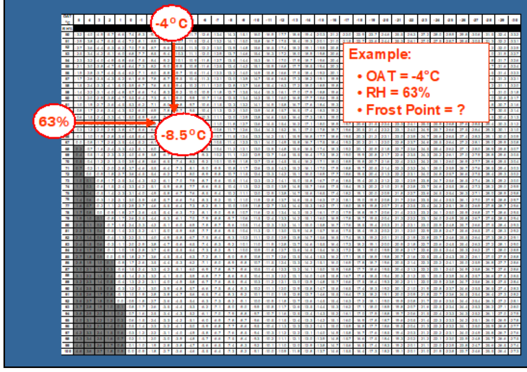
- Obtained from Environment Canada (weather station adjacent to APS test site)
- Collected each hour, on the hour

MONTREAL/PIERRE ELLIOTT TRUDEAU INTL
QUEBEC

Hourly Data Report for November 17th 2009

Time	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00	-0.9	-5.0	74	29	9	25.0	101.89		-4	Clear
01:00	0.1	-4.5	71	29	7	25.0	101.95			Clear
02:00	1.3	-3.6	70	4	4	25.0	102.01			Clear
03:00	-0.1	-4.1	74	1	6	25.0	102.09		-2	Clear
04:00	-1.2	-4.3	79	34	9	25.0	102.15		-4	Clear
05:00	-2.0	-5.0	80	35	7	25.0	102.24		-5	Clear
06:00	-1.8	-5.2	78	36	7	25.0	102.28		-4	Clear
07:00	-0.6	-4.7	74	2	7	48.3	102.33		-3	Clear
08:00	0.1	-4.2	73	3	6	48.3	102.41			Clear
09:00	1.7	-3.7	67	2	15	24.1	102.49			Clear
10:00	2.8	-4.4	59	4	15	24.1	102.55			Clear

STEP 3: CALCULATE FROST POINT



Example:
- OAT = -4°C
- RH = 63%
- Frost Point = ?

STEP 4: DETERMINE NOWCAST

- Active Frost Nowcast is determined by the relationship between the frost point and the plate temperature:
  - Plate Temp < Frost Point, nowcast = "active frost"
  - Plate Temp > Frost Point, nowcast = "no active frost"

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STEP 5: ASSESS ACCURACY

- How to determine if predictions are accurate?
- Standard frost ET test plate (same one used to collect surface temp) used to determine if active frost really is occurring
  - Plate weighed 15 mins before the hour (i.e. 22:45)
  - Plate exposed to ambient conditions
  - Plate weighed 15 mins after the hour (i.e. 23:15)
  - If weight increases, active frost is present

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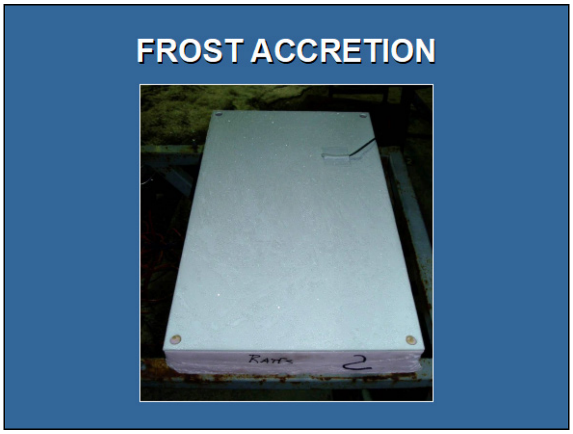
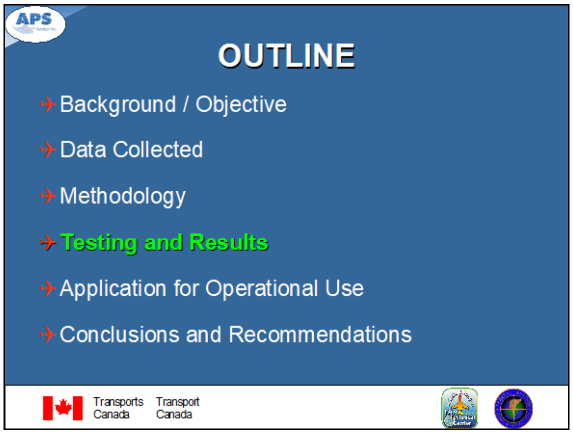
WEIGHING TEST PLATE

EXPOSURE TO FROST



FROST ACCRETION



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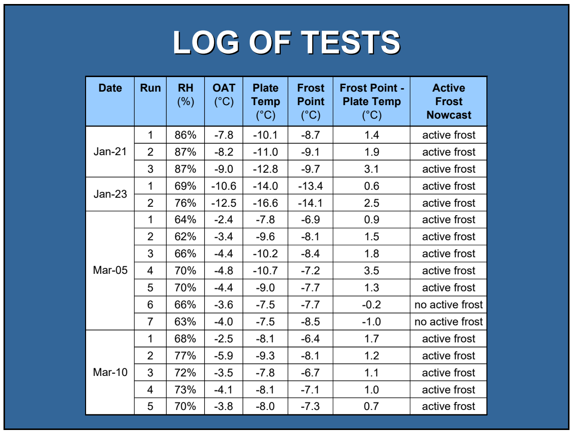
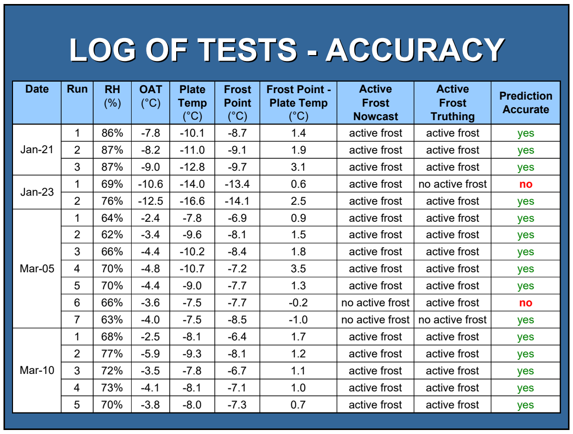


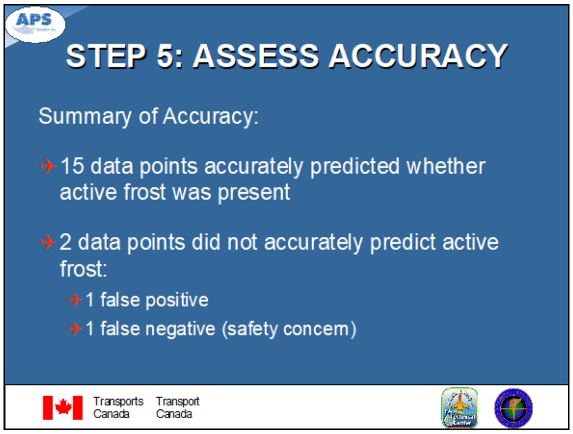
LOG OF TESTS

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Frost Point - Plate Temp (°C)	Active Frost Nowcast
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost
	2	87%	-8.2	-11.0	-9.1	1.9	active frost
	3	87%	-9.0	-12.8	-9.7	3.1	active frost
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	active frost
	2	76%	-12.5	-16.6	-14.1	2.5	active frost
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost
	2	62%	-3.4	-9.6	-8.1	1.5	active frost
	3	66%	-4.4	-10.2	-8.4	1.8	active frost
	4	70%	-4.8	-10.7	-7.2	3.5	active frost
	5	70%	-4.4	-9.0	-7.7	1.3	active frost
	6	66%	-3.6	-7.5	-7.7	-0.2	no active frost
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost
	2	77%	-5.9	-9.3	-8.1	1.2	active frost
	3	72%	-3.5	-7.8	-6.7	1.1	active frost
	4	73%	-4.1	-8.1	-7.1	1.0	active frost
	5	70%	-3.8	-8.0	-7.3	0.7	active frost



LOG OF TESTS - ACCURACY

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Frost Point - Plate Temp (°C)	Active Frost Nowcast	Active Frost Truthing	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	active frost	no active frost	**no**
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost	yes
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	no active frost	active frost	**no**
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	no active frost	yes
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost	yes
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost	yes



STEP 5: ASSESS ACCURACY

Summary of Accuracy:

- 15 data points accurately predicted whether active frost was present
- 2 data points did not accurately predict active frost:
  - 1 false positive
  - 1 false negative (safety concern)

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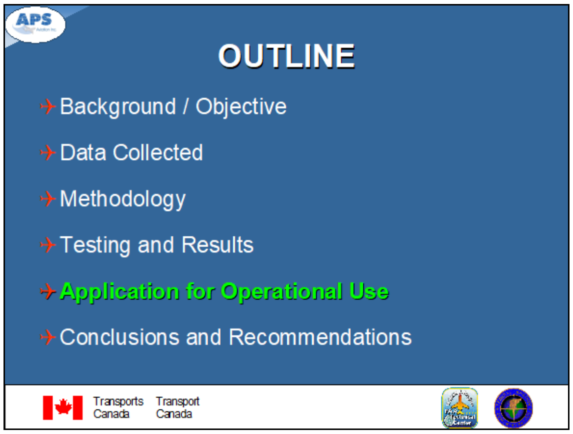

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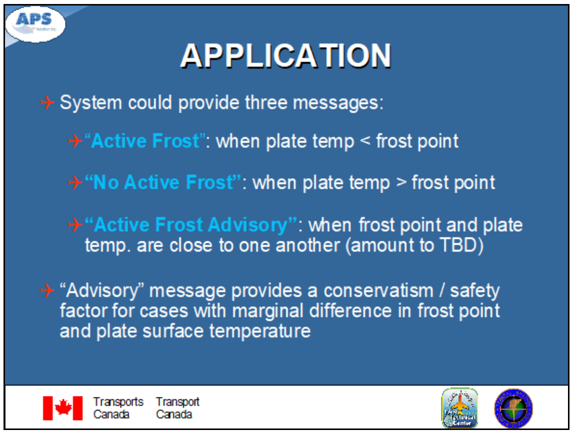

APPLICATION

- System could provide three messages:
  - "Active Frost": when plate temp < frost point
  - "No Active Frost": when plate temp > frost point
  - "Active Frost Advisory": when frost point and plate temp. are close to one another (amount to TBD)
- "Advisory" message provides a conservatism / safety factor for cases with marginal difference in frost point and plate surface temperature

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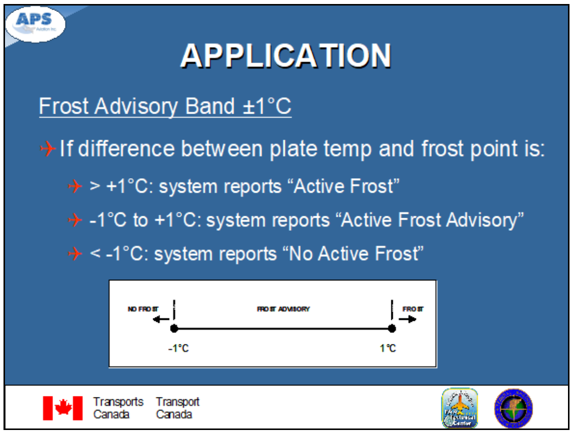

APPLICATION

Frost Advisory Band ±1°C

- If difference between plate temp and frost point is:
  - > +1°C: system reports "Active Frost"
  - -1°C to +1°C: system reports "Active Frost Advisory"
  - < -1°C: system reports "No Active Frost"

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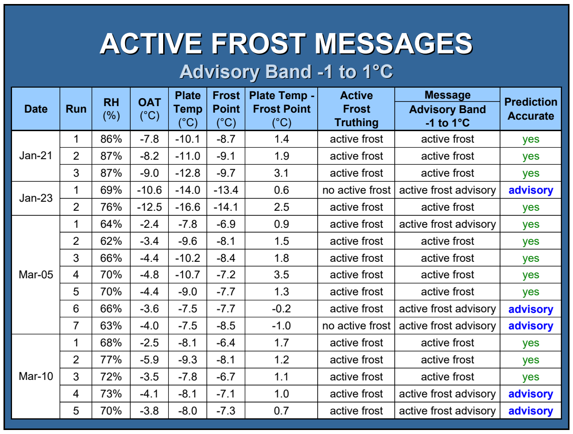
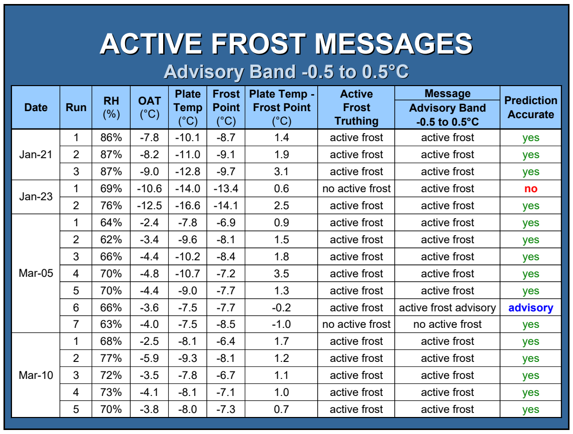


ACTIVE FROST MESSAGES

Advisory Band -1 to 1°C

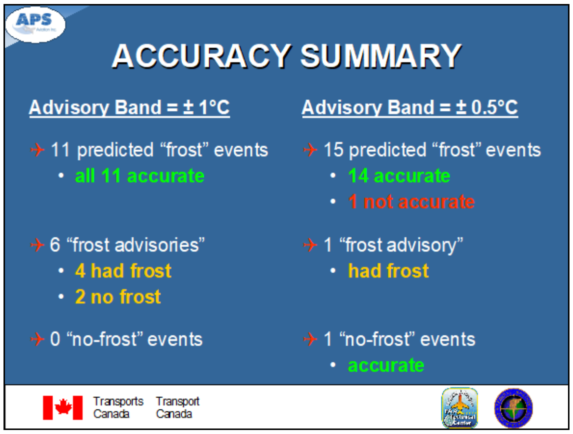
Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Plate Temp - Frost Point (°C)	Active Frost Truthing	Message Advisory Band -1 to 1°C	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	no active frost	active frost advisory	advisory
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost advisory	yes
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	active frost	active frost advisory	advisory
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	active frost advisory	advisory
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost advisory	advisory
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost advisory	advisory



ACTIVE FROST MESSAGES

Advisory Band -0.5 to 0.5°C

Date	Run	RH (%)	OAT (°C)	Plate Temp (°C)	Frost Point (°C)	Plate Temp - Frost Point (°C)	Active Frost Truthing	Message Advisory Band -0.5 to 0.5°C	Prediction Accurate
Jan-21	1	86%	-7.8	-10.1	-8.7	1.4	active frost	active frost	yes
	2	87%	-8.2	-11.0	-9.1	1.9	active frost	active frost	yes
	3	87%	-9.0	-12.8	-9.7	3.1	active frost	active frost	yes
Jan-23	1	69%	-10.6	-14.0	-13.4	0.6	no active frost	active frost	no
	2	76%	-12.5	-16.6	-14.1	2.5	active frost	active frost	yes
Mar-05	1	64%	-2.4	-7.8	-6.9	0.9	active frost	active frost	yes
	2	62%	-3.4	-9.6	-8.1	1.5	active frost	active frost	yes
	3	66%	-4.4	-10.2	-8.4	1.8	active frost	active frost	yes
	4	70%	-4.8	-10.7	-7.2	3.5	active frost	active frost	yes
	5	70%	-4.4	-9.0	-7.7	1.3	active frost	active frost	yes
	6	66%	-3.6	-7.5	-7.7	-0.2	active frost	active frost advisory	advisory
	7	63%	-4.0	-7.5	-8.5	-1.0	no active frost	no active frost	yes
Mar-10	1	68%	-2.5	-8.1	-6.4	1.7	active frost	active frost	yes
	2	77%	-5.9	-9.3	-8.1	1.2	active frost	active frost	yes
	3	72%	-3.5	-7.8	-6.7	1.1	active frost	active frost	yes
	4	73%	-4.1	-8.1	-7.1	1.0	active frost	active frost	yes
	5	70%	-3.8	-8.0	-7.3	0.7	active frost	active frost	yes



ACCURACY SUMMARY

Advisory Band = ± 1°C

- 11 predicted "frost" events
  - all 11 accurate
- 6 "frost advisories"
  - 4 had frost
  - 2 no frost
- 0 "no-frost" events

Advisory Band = ± 0.5°C

- 15 predicted "frost" events
  - 14 accurate
  - 1 not accurate
- 1 "frost advisory"
  - had frost
- 1 "no-frost" events
  - accurate

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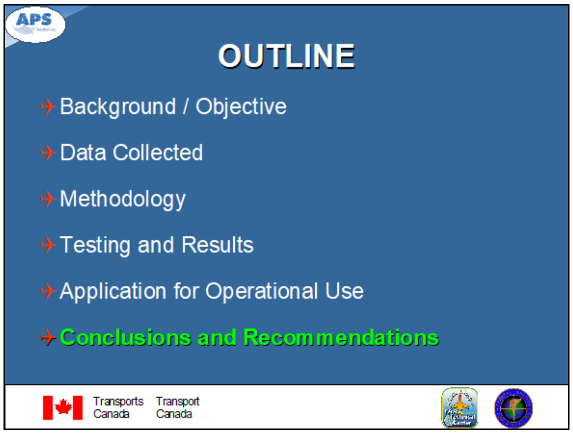

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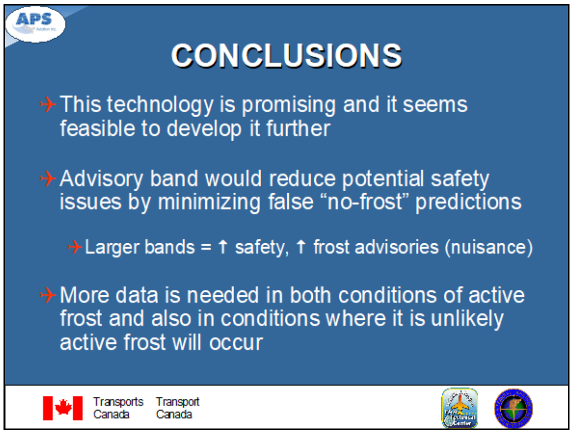

CONCLUSIONS

- This technology is promising and it seems feasible to develop it further
- Advisory band would reduce potential safety issues by minimizing false "no-frost" predictions
  - Larger bands = ↑ safety, ↑ frost advisories (nuisance)
- More data is needed in both conditions of active frost and also in conditions where it is unlikely active frost will occur

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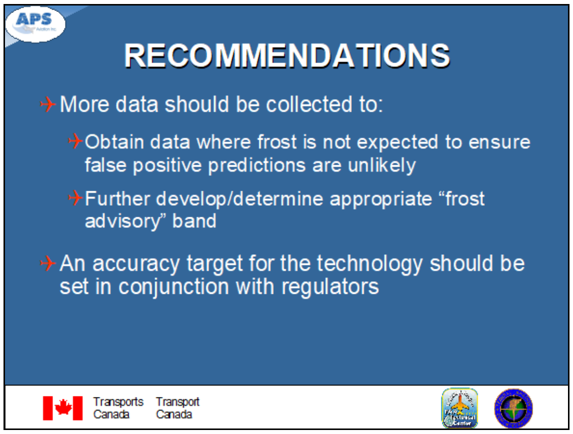

RECOMMENDATIONS

- More data should be collected to:
  - Obtain data where frost is not expected to ensure false positive predictions are unlikely
  - Further develop/determine appropriate "frost advisory" band
- An accuracy target for the technology should be set in conjunction with regulators

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? QUESTIONS ?

APS Aviation Inc.

Stephanie Bendickson

email: sbendickson@telus.net

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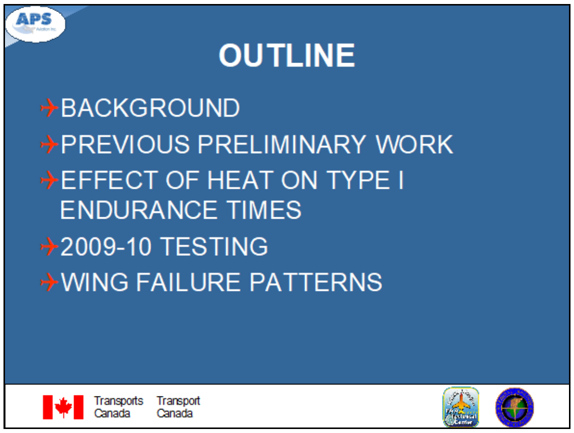
COMPOSITE MATERIALS HOT TESTING REVIEW

APS Aviation Inc.

ISO 9001:2000

SAE G-12 SUBCOMMITEE MEETING
MONTREAL – NOVEMBER 3, 2010

PRESENTED BY MARCO RUGGI



OUTLINE

- BACKGROUND
- PREVIOUS PRELIMINARY WORK
- EFFECT OF HEAT ON TYPE I ENDURANCE TIMES
- 2009-10 TESTING
- WING FAILURE PATTERNS

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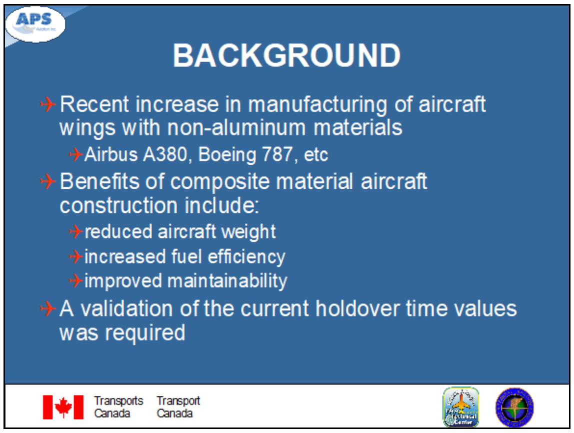

BACKGROUND

- Recent increase in manufacturing of aircraft wings with non-aluminum materials
  - Airbus A380, Boeing 787, etc
- Benefits of composite material aircraft construction include:
  - reduced aircraft weight
  - increased fuel efficiency
  - improved maintainability
- A validation of the current holdover time values was required

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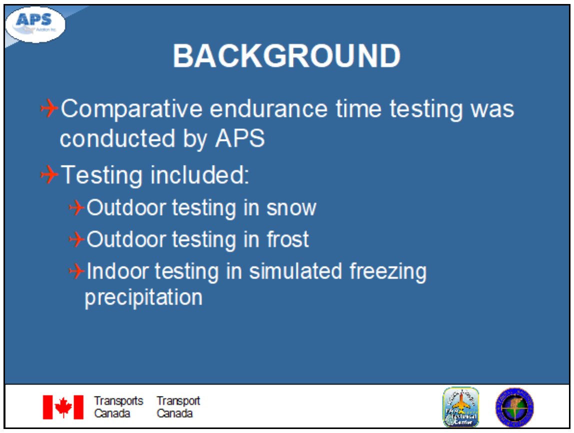

BACKGROUND

- Comparative endurance time testing was conducted by APS
- Testing included:
  - Outdoor testing in snow
  - Outdoor testing in frost
  - Indoor testing in simulated freezing precipitation

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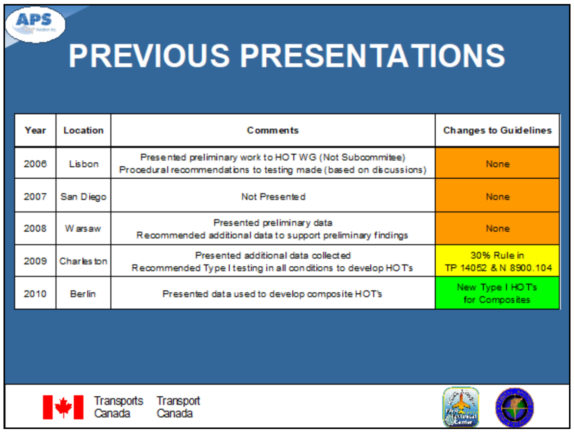

PREVIOUS PRESENTATIONS

Year	Location	Comments	Changes to Guidelines
2006	Lisbon	Presented preliminary work to HOT WG (Not Subcommitee) Procedural recommendations to testing made (based on discussions)	None
2007	San Diego	Not Presented	None
2008	Warsaw	Presented preliminary data Recommended additional data to support preliminary findings	None
2009	Charleston	Presented additional data collected Recommended Type I testing in all conditions to develop HOT's	30% Rule in TP 14052 & N 8900.104
2010	Berlin	Presented data used to develop composite HOT's	New Type I HOT's for Composites

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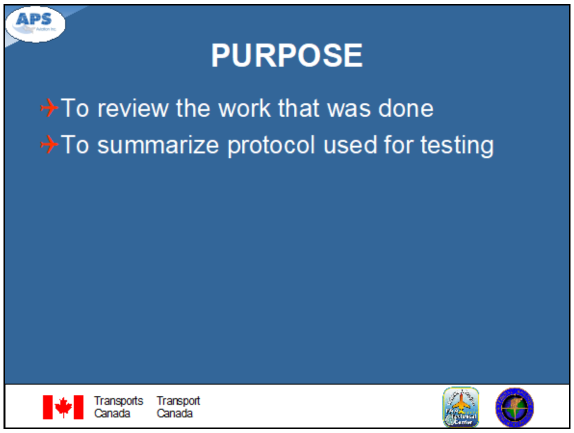

PURPOSE

- To review the work that was done
- To summarize protocol used for testing

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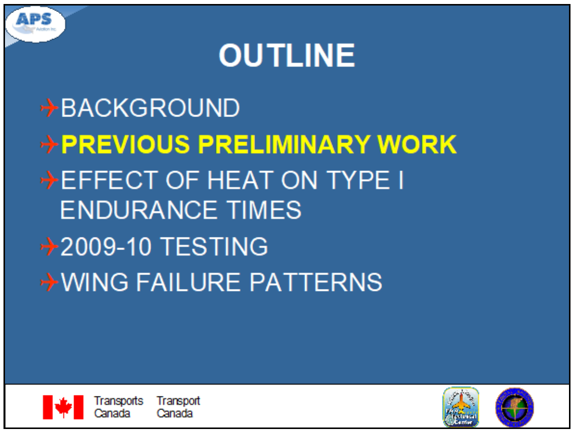

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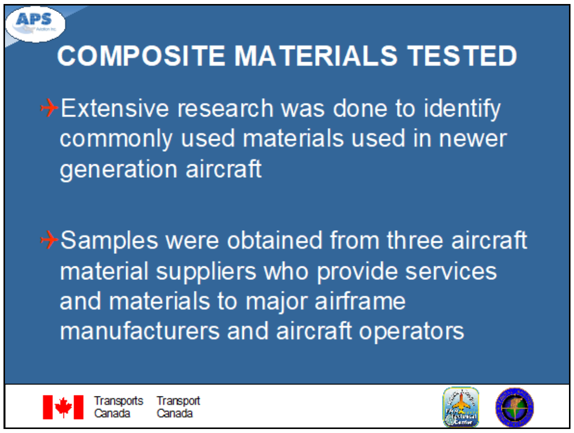

COMPOSITE MATERIALS TESTED

- Extensive research was done to identify commonly used materials used in newer generation aircraft
- Samples were obtained from three aircraft material suppliers who provide services and materials to major airframe manufacturers and aircraft operators

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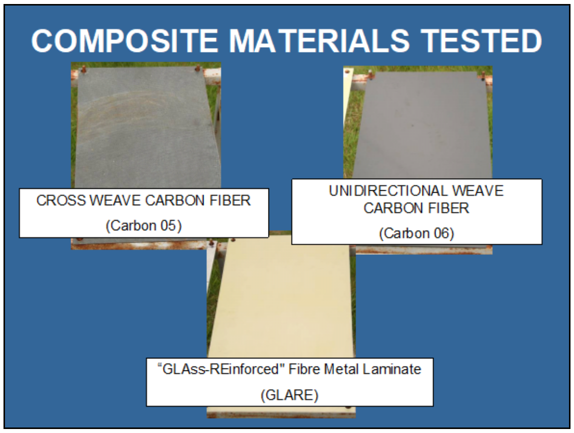
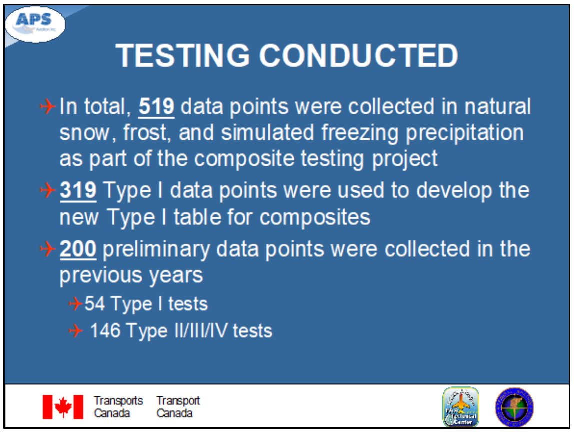


COMPOSITE MATERIALS TESTED

CROSS WEAVE CARBON FIBER
(Carbon 05)
UNIDIRECTIONAL WEAVE CARBON FIBER
(Carbon 06)
"GLAss-REinforced" Fibre Metal Laminate
(GLARE)



TESTING CONDUCTED

- In total, **519** data points were collected in natural snow, frost, and simulated freezing precipitation as part of the composite testing project
- **319** Type I data points were used to develop the new Type I table for composites
- **200** preliminary data points were collected in the previous years
  - 54 Type I tests
  - 146 Type II/III/IV tests

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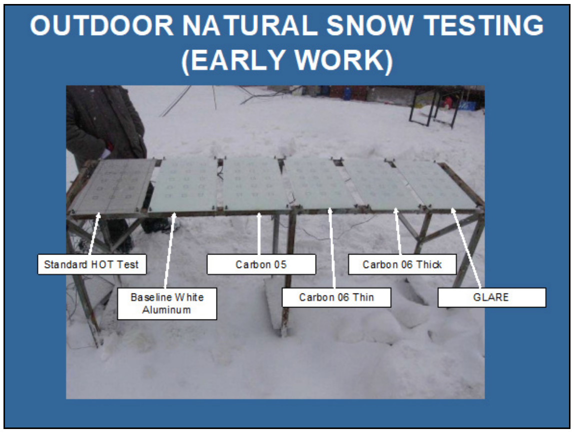
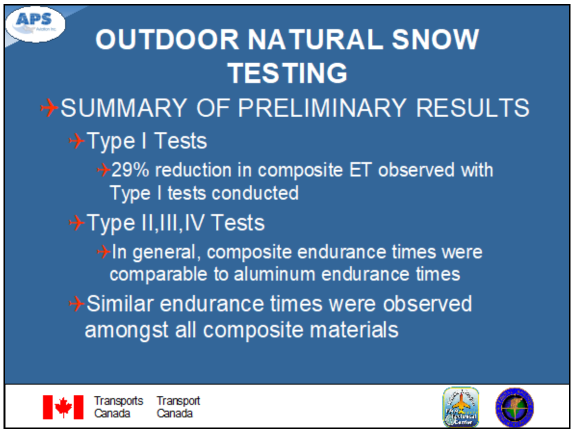


OUTDOOR NATURAL SNOW TESTING (EARLY WORK)

Standard HOT Test
Baseline White Aluminum
Carbon 05
Carbon 06 Thin
Carbon 06 Thick
GLARE



OUTDOOR NATURAL SNOW TESTING

- SUMMARY OF PRELIMINARY RESULTS
  - Type I Tests
    - 29% reduction in composite ET observed with Type I tests conducted
  - Type II,III,IV Tests
    - In general, composite endurance times were comparable to aluminum endurance times
  - Similar endurance times were observed amongst all composite materials

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OUTDOOR NATURAL FROST TESTING (EARLY WORK)

OUTDOOR NATURAL FROST TESTING

- SUMMARY OF PRELIMINARY RESULTS
  - Type I Tests
    - 23% reduction in composite ET observed with Type I tests conducted
  - Similar endurance times were observed amongst all composite materials
  - Type II,III,IV Tests were not conducted

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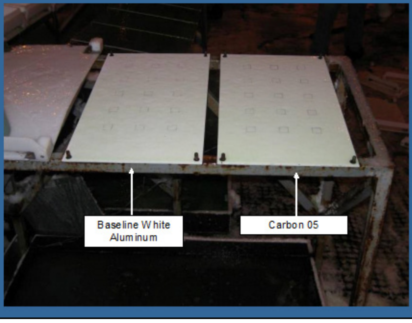
INDOOR SIMULATED FREEZING PRECIPITATION TESTING (EARLY WORK)



INDOOR SIMULATED FREEZING PRECIPITATION TESTING

- SUMMARY OF PRELIMINARY RESULTS
  - Similar trend to snow data
  - Type I Tests
    - 26% reduction in composite ET observed with Type I tests conducted
  - Type II,III,IV Tests
    - In general, composite endurance times were comparable to aluminum endurance times

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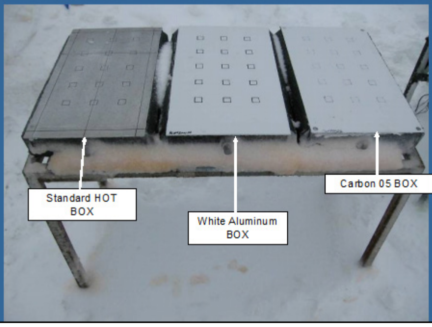
OUTDOOR LEADING EDGE THERMAL EQUIVALENT BOX TESTS (EARLY WORK)



OUTDOOR LEADING EDGE THERMAL EQUIVALENT BOX TESTS

- SUMMARY OF PRELIMINARY 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

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OUTLINE

- BACKGROUND
- PREVIOUS PRELIMINARY WORK
- **EFFECT OF HEAT ON TYPE I ENDURANCE TIMES**
- 2009-10 TESTING
- WING FAILURE PATTERNS

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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

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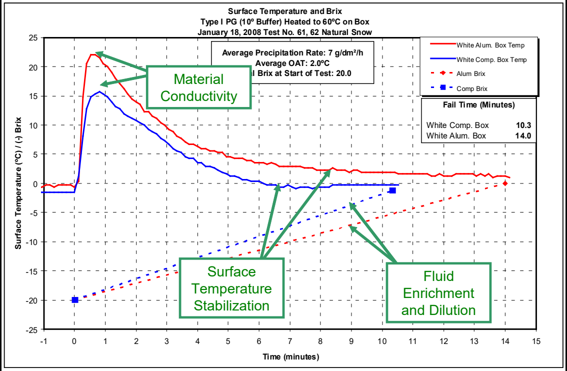
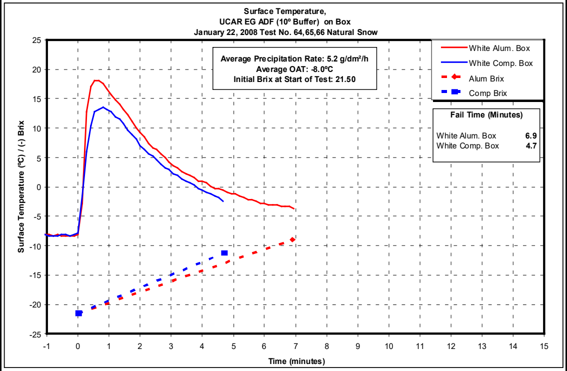
EFFECT OF HEAT ON TYPE I ENDURANCE TIMES

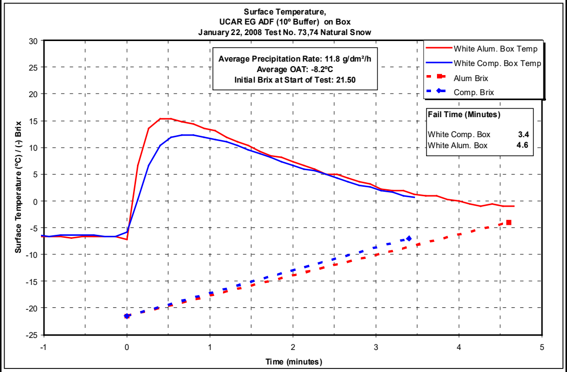
EXAMPLE 1: NATURAL SNOW



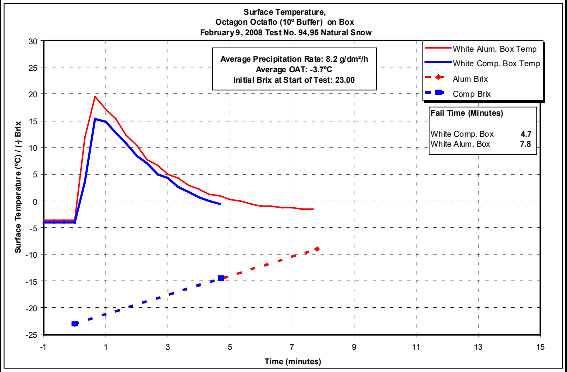
EXAMPLE 2: NATURAL SNOW

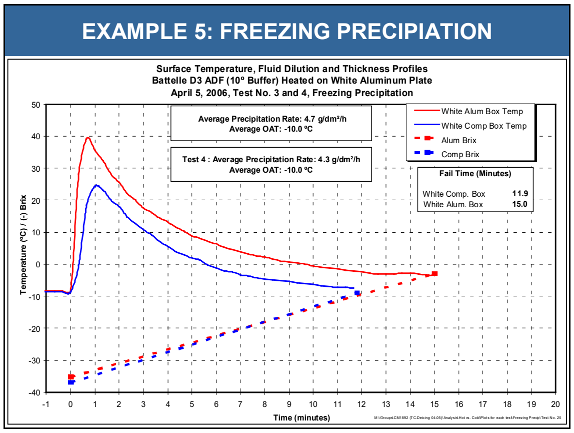


EXAMPLE 3: NATURAL SNOW

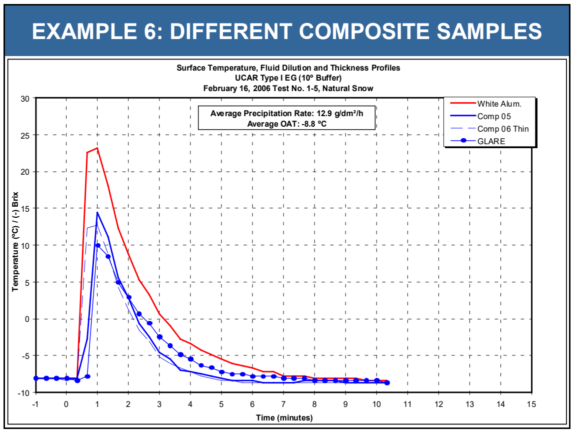


EXAMPLE 4: NATURAL SNOW

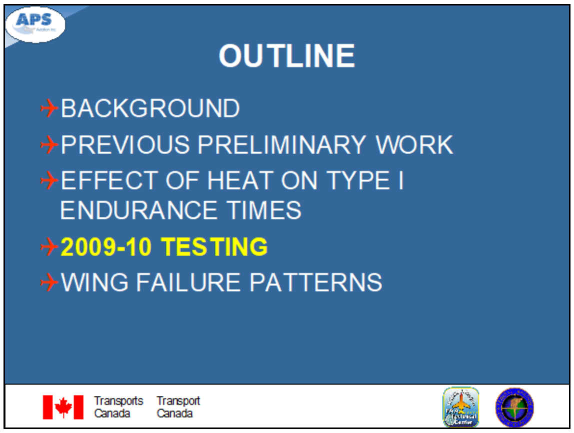




EXAMPLE 5: FREEZING PRECIPIATION



EXAMPLE 6: DIFFERENT COMPOSITE SAMPLES



OUTLINE

- BACKGROUND
- PREVIOUS PRELIMINARY WORK
- EFFECT OF HEAT ON TYPE I ENDURANCE TIMES
- **2009-10 TESTING**
- WING FAILURE PATTERNS

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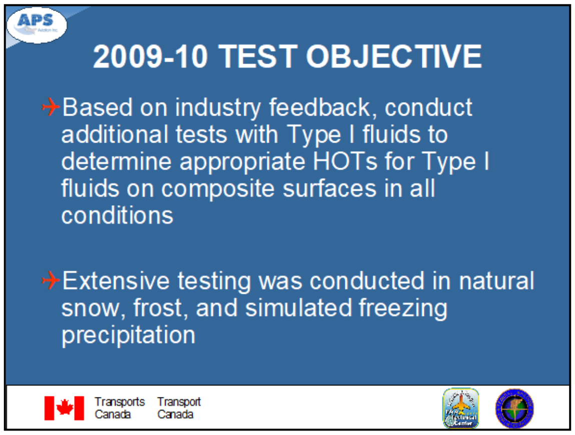

2009-10 TEST OBJECTIVE

- Based on industry feedback, conduct additional tests with Type I fluids to determine appropriate HOTs for Type I fluids on composite surfaces in all conditions

- Extensive testing was conducted in natural snow, frost, and simulated freezing precipitation

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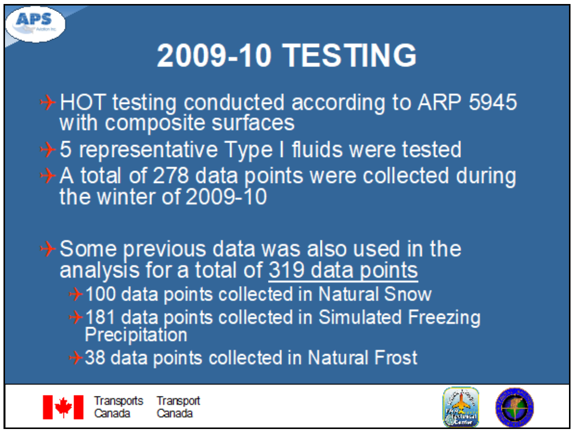

2009-10 TESTING

- HOT testing conducted according to ARP 5945 with composite surfaces
- 5 representative Type I fluids were tested
- A total of 278 data points were collected during the winter of 2009-10

- Some previous data was also used in the analysis for a total of 319 data points
  - 100 data points collected in Natural Snow
  - 181 data points collected in Simulated Freezing Precipitation
  - 38 data points collected in Natural Frost

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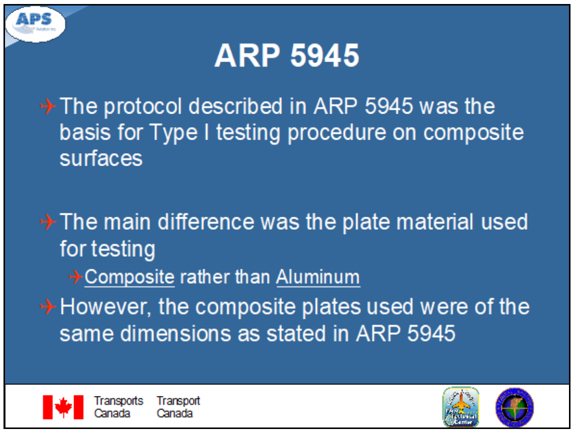

ARP 5945

- The protocol described in ARP 5945 was the basis for Type I testing procedure on composite surfaces

- The main difference was the plate material used for testing
  - Composite rather than Aluminum
- However, the composite plates used were of the same dimensions as stated in ARP 5945

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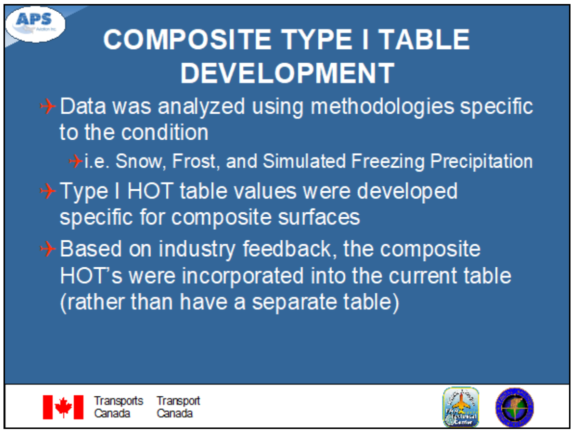

COMPOSITE TYPE I TABLE DEVELOPMENT

- Data was analyzed using methodologies specific to the condition
  - i.e. Snow, Frost, and Simulated Freezing Precipitation
- Type I HOT table values were developed specific for composite surfaces
- Based on industry feedback, the composite HOT's were incorporated into the current table (rather than have a separate table)

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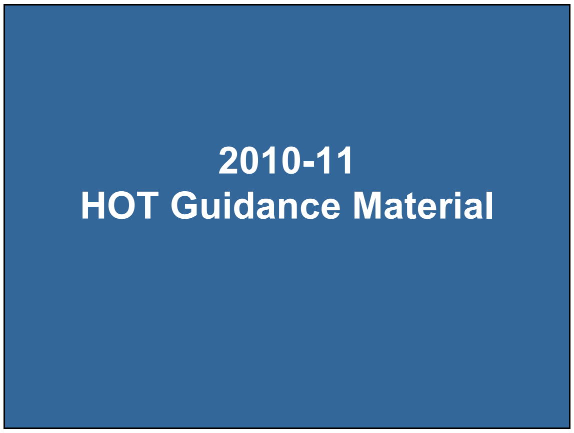
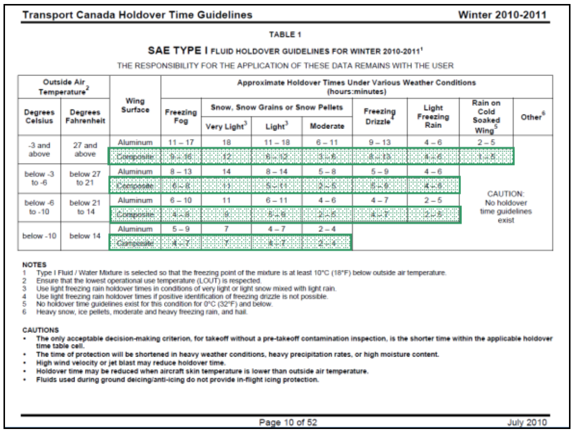


2010-11 HOT Guidance Material



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1

SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2010-2011[1]

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

Outside Air Temperature[2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	Aluminum	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
		Composite	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	Aluminum	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
		Composite	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	Aluminum	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
		Composite	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	Aluminum	5 – 9	7	4 – 7	2 – 4				
		Composite	4 – 7	7	4 – 7	2 – 4				

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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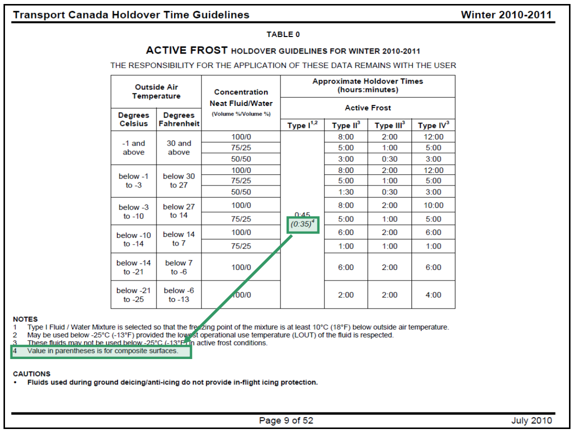

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2010-2011

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

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours:minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is respected.
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parentheses is for composite surfaces.

CAUTIONS
- **Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.**

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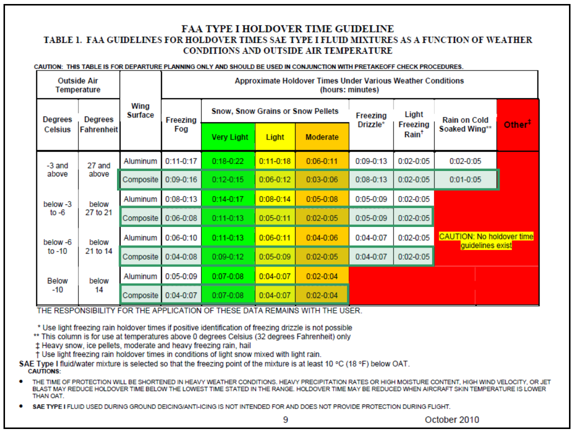


FAA TYPE I HOLDOVER TIME GUIDELINE

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle*	Light Freezing Rain†	Rain on Cold Soaked Wing**	Other‡
				Very Light	Light	Moderate				
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
		Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-0:06	0:08-0:13	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
		Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
		Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				
		Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.
SAE Type I fluid/water mixture is selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.
CAUTIONS:
- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- **SAE TYPE I** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

9 October 2010

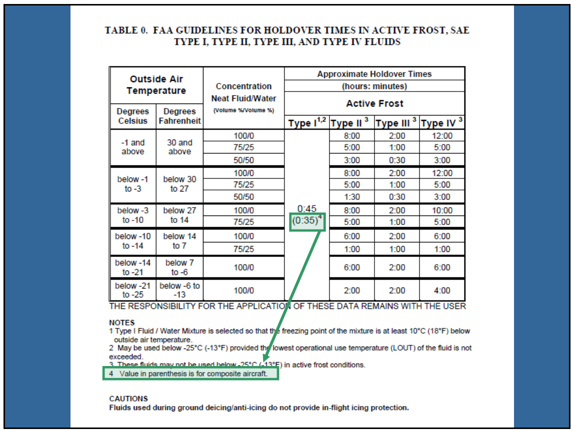


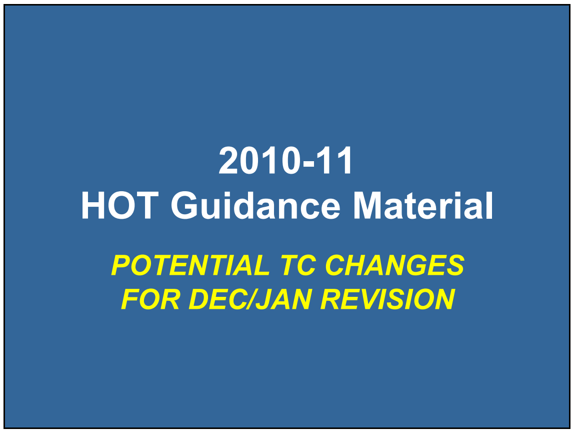
TABLE 0. FAA GUIDELINES FOR HOLDOVER TIMES IN ACTIVE FROST, SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS

Outside Air Temperature		Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times (hours: minutes) Active Frost			
Degrees Celsius	Degrees Fahrenheit		Type I[1,2]	Type II[3]	Type III[3]	Type IV[3]
-1 and above	30 and above	100/0	0:45 (0:35)[4]	8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0		8:00	2:00	12:00
		75/25		5:00	1:00	5:00
		50/50		1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0		8:00	2:00	10:00
		75/25		5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0		6:00	2:00	6:00
		75/25		1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0		6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0		2:00	2:00	4:00

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

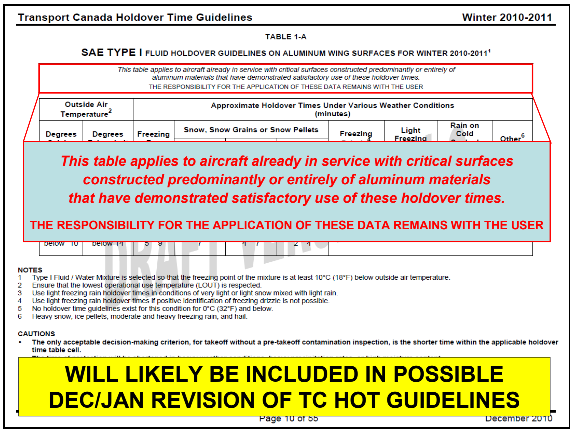
NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 May be used below -25°C (-13°F) provided the lowest operational use temperature (LOUT) of the fluid is not exceeded.
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parenthesis is for composite aircraft.

CAUTIONS
Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.



2010-11
HOT Guidance Material

POTENTIAL TC CHANGES FOR DEC/JAN REVISION



Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES FOR WINTER 2010-2011[1]

This table applies to aircraft already in service with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

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

This table applies to aircraft already in service with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

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

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.

WILL LIKELY BE INCLUDED IN POSSIBLE DEC/JAN REVISION OF TC HOT GUIDELINES

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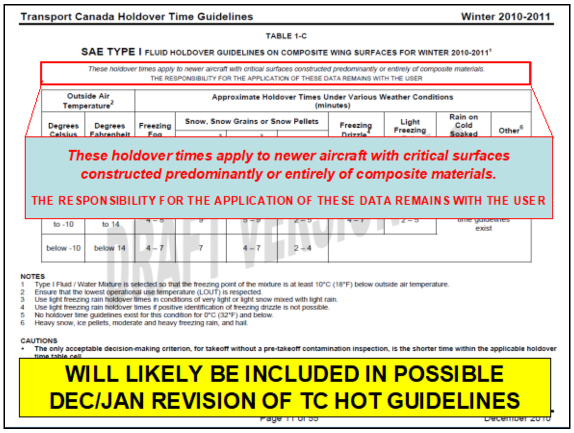

Transport Canada Holdover Time Guidelines **Winter 2010-2011**

TABLE 1-C

SAE TYPE I FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES FOR WINTER 2010-2011[1]

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

NOTES
1 Type I Fluid / Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.

CAUTIONS
- The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.

WILL LIKELY BE INCLUDED IN POSSIBLE DEC/JAN REVISION OF TC HOT GUIDELINES

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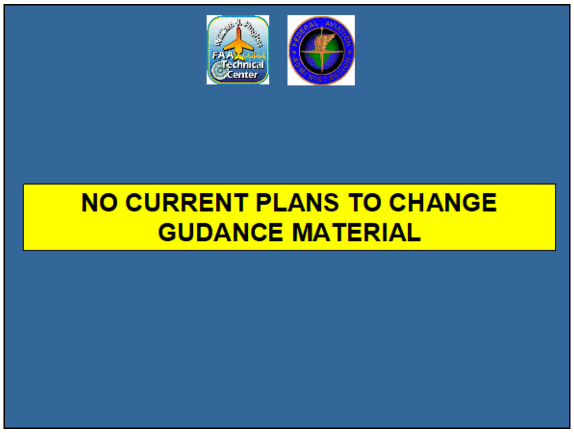
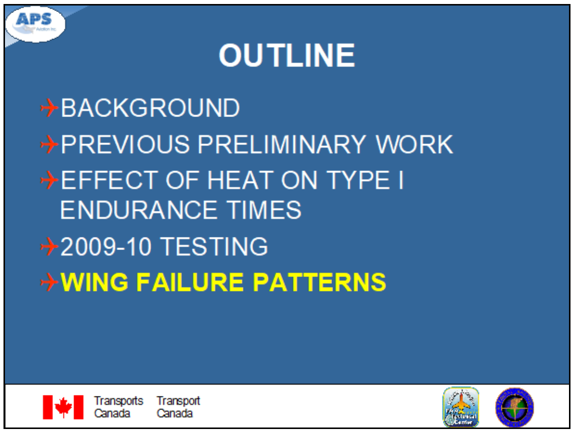


NO CURRENT PLANS TO CHANGE GUDANCE MATERIAL



OUTLINE

- BACKGROUND
- PREVIOUS PRELIMINARY WORK
- EFFECT OF HEAT ON TYPE I ENDURANCE TIMES
- 2009-10 TESTING
- **WING FAILURE PATTERNS**

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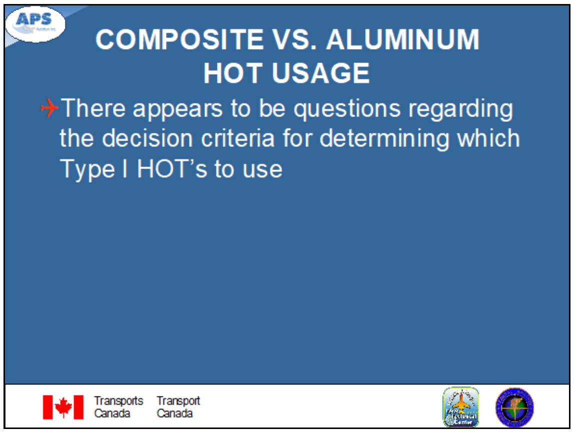

COMPOSITE VS. ALUMINUM HOT USAGE

- There appears to be questions regarding the decision criteria for determining which Type I HOT's to use

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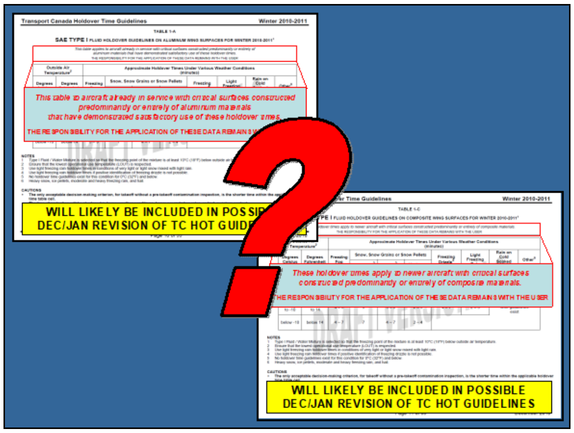


Transport Canada Holdover Time Guidelines Winter 2010-2011

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES FOR WINTER 2010-2011

This table to aircraft already in service with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS W

WILL LIKELY BE INCLUDED IN POSSIB
DEC/JAN REVISION OF TC HOT GUIDE

Winter 2010-2011

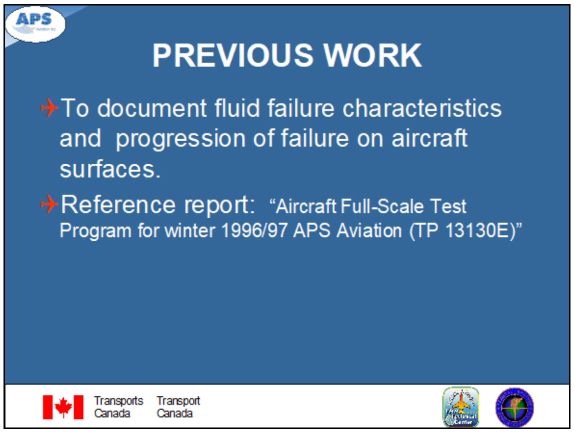
TABLE 1-C

FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES FOR WINTER 2010-2011

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

WILL LIKELY BE INCLUDED IN POSSIBLE
DEC/JAN REVISION OF TC HOT GUIDELINES



PREVIOUS WORK

- To document fluid failure characteristics and progression of failure on aircraft surfaces.
- Reference report: "Aircraft Full-Scale Test Program for winter 1996/97 APS Aviation (TP 13130E)"

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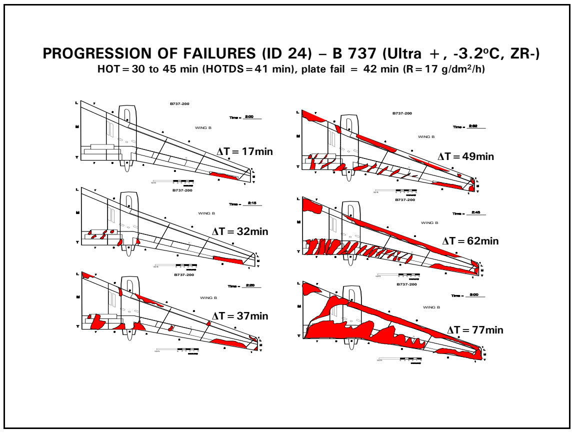
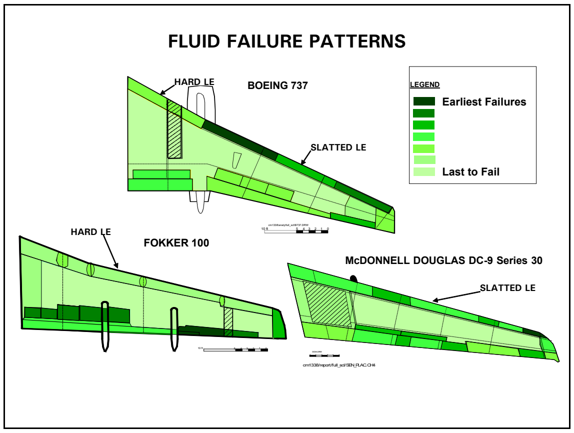
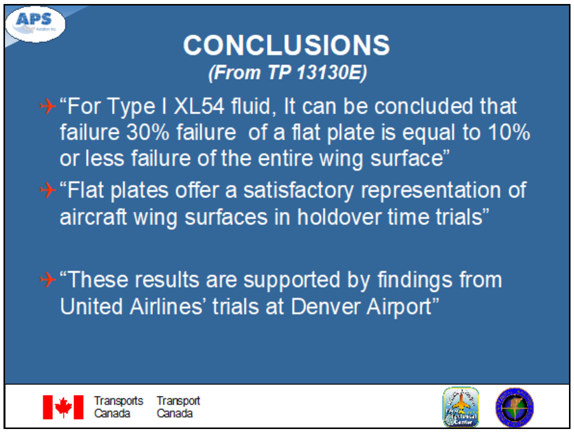


PROGRESSION OF FAILURES (ID 24) – B 737 (Ultra +, -3.2ºC, ZR-)

HOT = 30 to 45 min (HOTDS = 41 min), plate fail = 42 min (R = 17 g/dm²/h)



FLUID FAILURE PATTERNS



CONCLUSIONS
(From TP 13130E)

- "For Type I XL54 fluid, It can be concluded that failure 30% failure of a flat plate is equal to 10% or less failure of the entire wing surface"
- "Flat plates offer a satisfactory representation of aircraft wing surfaces in holdover time trials"
- "These results are supported by findings from United Airlines' trials at Denver Airport"

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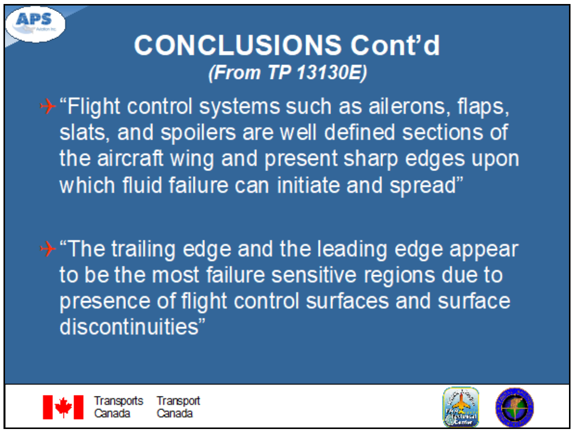

CONCLUSIONS Cont'd
(From TP 13130E)

- "Flight control systems such as ailerons, flaps, slats, and spoilers are well defined sections of the aircraft wing and present sharp edges upon which fluid failure can initiate and spread"
- "The trailing edge and the leading edge appear to be the most failure sensitive regions due to presence of flight control surfaces and surface discontinuities"

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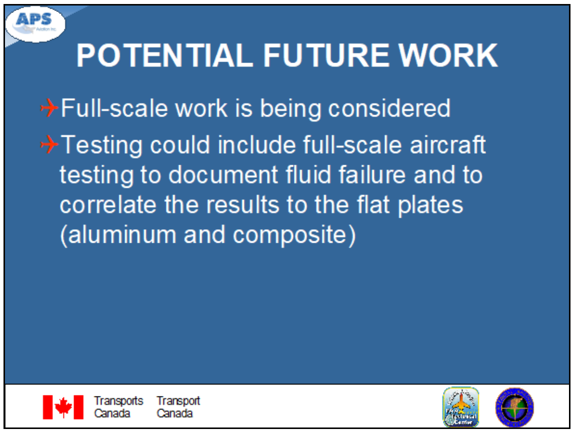


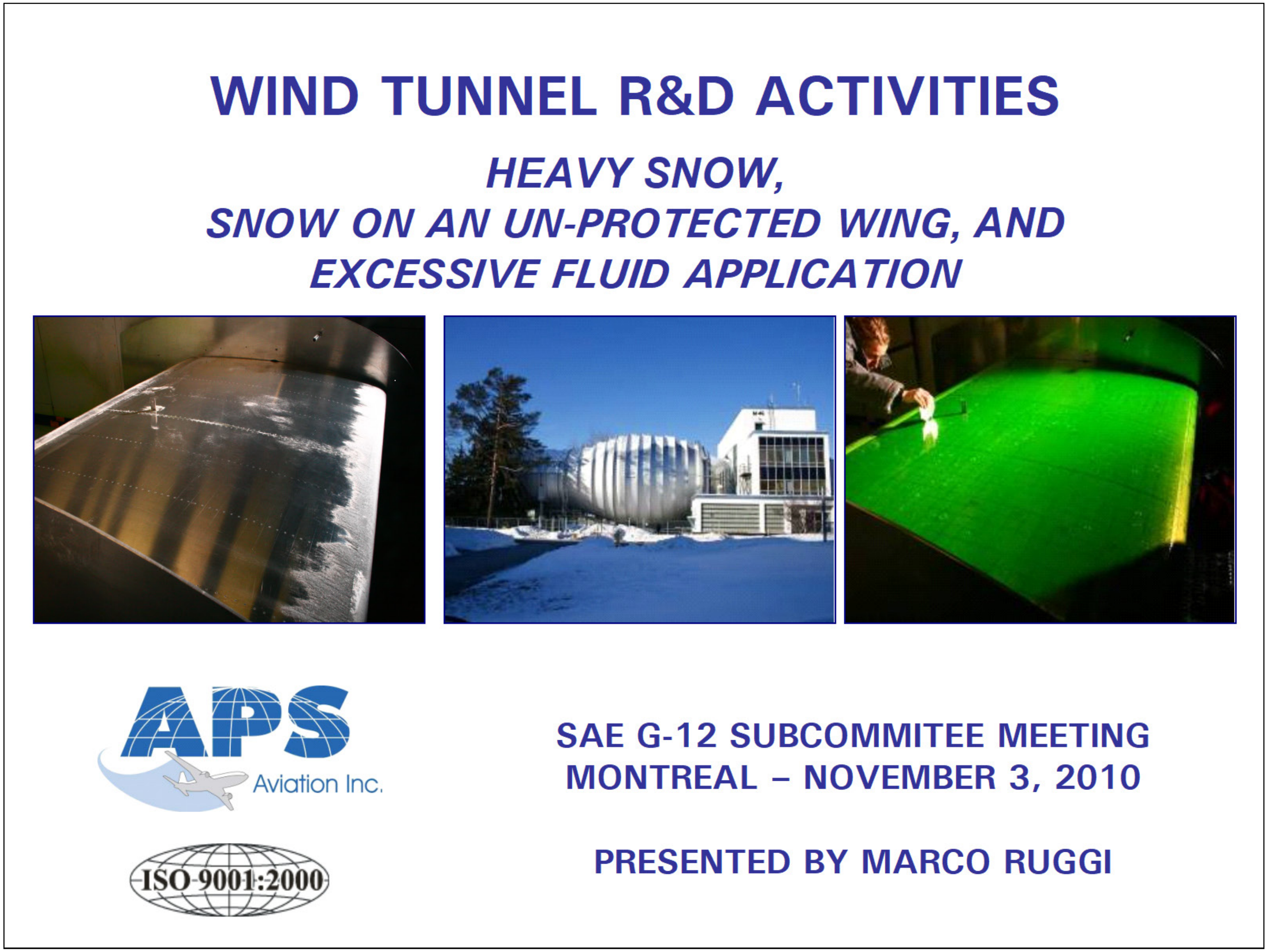
POTENTIAL FUTURE WORK

- Full-scale work is being considered
- Testing could include full-scale aircraft testing to document fluid failure and to correlate the results to the flat plates (aluminum and composite)

APS
Transports Canada Transport Canada

APS Aviation Inc.

Marco Ruggi
mruggi@adga.ca

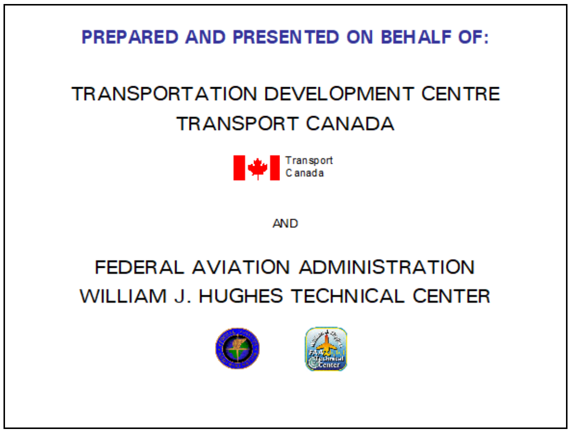


WIND TUNNEL R&D ACTIVITIES

HEAVY SNOW,
SNOW ON AN UN-PROTECTED WING, AND EXCESSIVE FLUID APPLICATION

SAE G-12 SUBCOMMITEE MEETING
MONTREAL – NOVEMBER 3, 2010

PRESENTED BY MARCO RUGGI



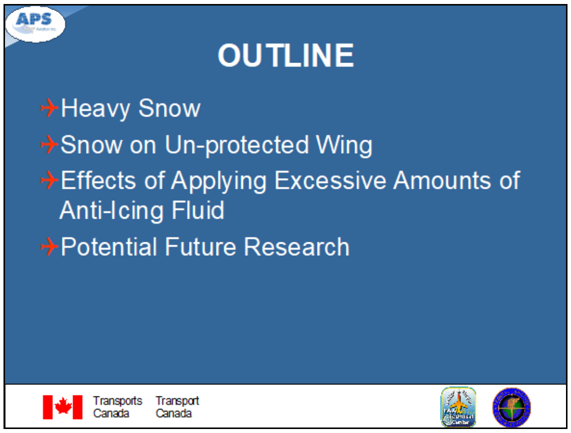
PREPARED AND PRESENTED ON BEHALF OF:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

Transport
Canada

AND

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER



OUTLINE

- Heavy Snow
- Snow on Un-protected Wing
- Effects of Applying Excessive Amounts of Anti-Icing Fluid
- Potential Future Research

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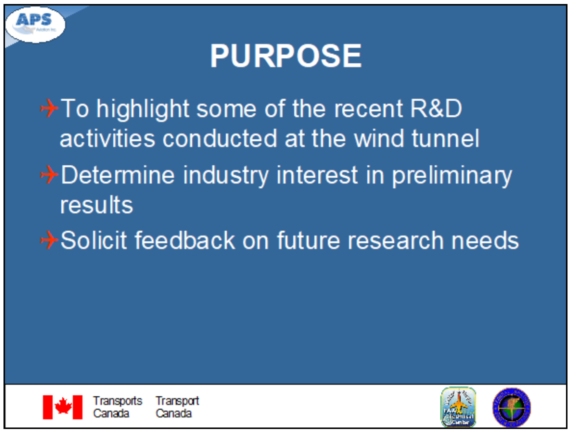

PURPOSE

- To highlight some of the recent R&D activities conducted at the wind tunnel
- Determine industry interest in preliminary results
- Solicit feedback on future research needs

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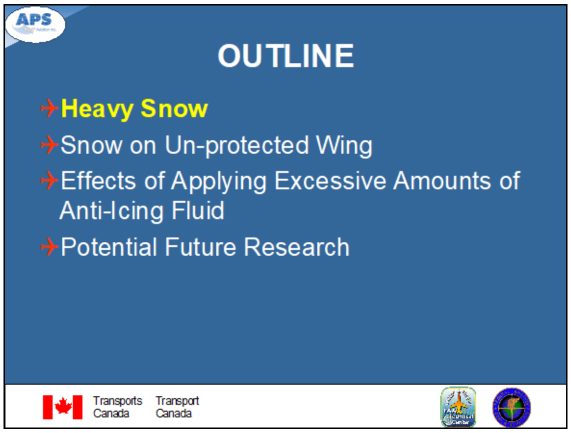

OUTLINE

- **Heavy Snow**
- Snow on Un-protected Wing
- Effects of Applying Excessive Amounts of Anti-Icing Fluid
- Potential Future Research

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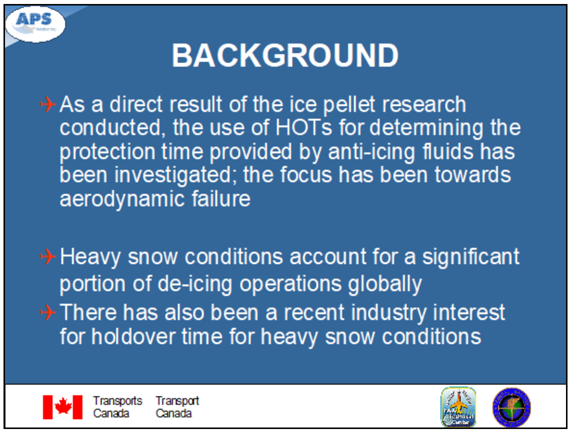
HEAVY SNOW



BACKGROUND

- As a direct result of the ice pellet research conducted, the use of HOTs for determining the protection time provided by anti-icing fluids has been investigated; the focus has been towards aerodynamic failure
- Heavy snow conditions account for a significant portion of de-icing operations globally
- There has also been a recent industry interest for holdover time for heavy snow conditions

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BACKGROUND

- Previous preliminary work has been conducted in the wind tunnel in conjunction with the ice pellet allowance time testing
- In addition, flat plate testing in S++ is also ongoing with the “snowmaker” machine

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OBJECTIVE

- To investigate the fluid aerodynamic flow-off characteristics of anti-icing fluid contaminated with simulated heavy snow versus moderate snow.

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METHODOLOGY

- Comparative tests were conducted simulating moderate and heavy snow conditions
  - Moderate Snow – 25 g/dm²/hr
  - Heavy Snow – 50 g/dm²/hr
- The intensity and exposure time of the snow precipitation was based on the current HOTs for snow conditions

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2009-10 S++ TESTING

- 13 tests were conducted
  - 4 comparative data sets
  - Type IV EG, PG, and Type III PG

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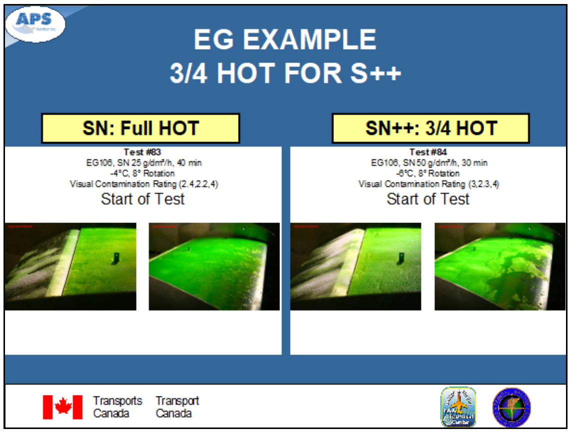
EG EXAMPLE 3/4 HOT FOR S++

S++: 30 min Vs. SN: 40min.

OAT: -4 to -6ºC



EG EXAMPLE 3/4 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm²/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (2.4,2.2,4)
Start of Test

SN++: 3/4 HOT

Test #84
EG106, SN 50 g/dm²/h, 30 min
-6°C, 8° Rotation
Visual Contamination Rating (3,2.3,4)
Start of Test

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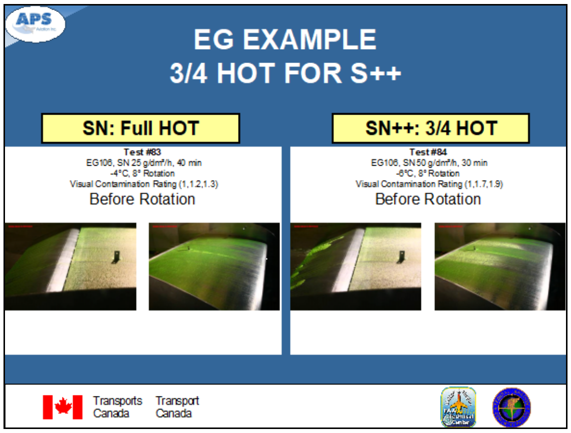

EG EXAMPLE
3/4 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm²/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.2,1.3)
Before Rotation

SN++: 3/4 HOT

Test #84
EG106, SN 50 g/dm²/h, 30 min
-6°C, 8° Rotation
Visual Contamination Rating (1,1.7,1.9)
Before Rotation

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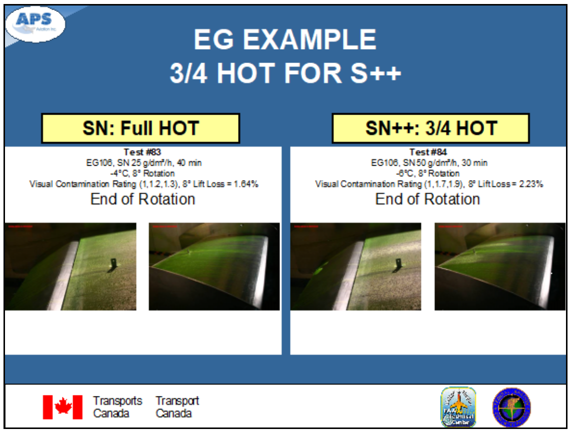

EG EXAMPLE
3/4 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm²/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.2,1.3), 8° Lift Loss = 1.64%
End of Rotation

SN++: 3/4 HOT

Test #84
EG106, SN 50 g/dm²/h, 30 min
-6°C, 8° Rotation
Visual Contamination Rating (1,1.7,1.9), 8° Lift Loss = 2.23%
End of Rotation

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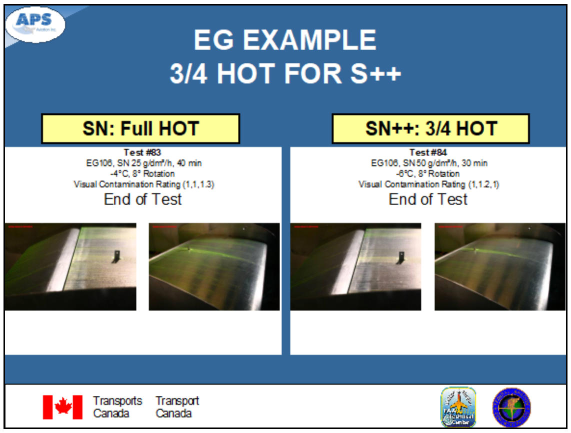

EG EXAMPLE
3/4 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm²/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1,1.3)
End of Test

SN++: 3/4 HOT

Test #84
EG106, SN 50 g/dm²/h, 30 min
-6°C, 8° Rotation
Visual Contamination Rating (1,1.2,1)
End of Test

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TEST - SUMMARY

- Heavy Snow Test (3/4 HOT)
  - Acceptable visual contamination, but slightly more severe as compared to baseline
  - Lift losses slightly worse as compared to baseline SN test (2.2% vs. 1.6% LL)

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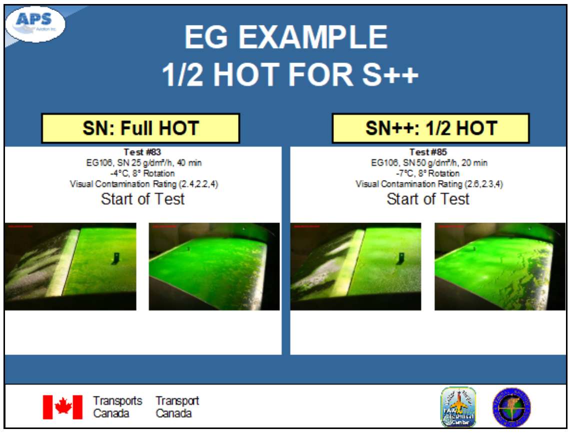
EG EXAMPLE
1/2 HOT FOR S++

S++: 20 min Vs. SN: 40min.

OAT: -4 to -7ºC



EG EXAMPLE
1/2 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm²/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (2.4,2.2,4)
Start of Test

SN++: 1/2 HOT

Test #85
EG106, SN 50 g/dm²/h, 20 min
-7°C, 8° Rotation
Visual Contamination Rating (2.6,2.3,4)
Start of Test

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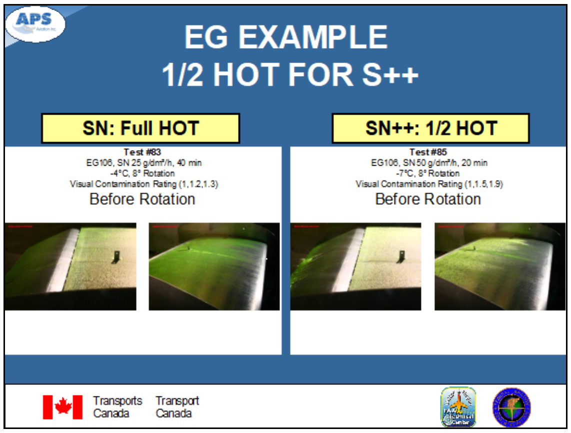

EG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm^2/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.2,1.3)
Before Rotation

SN++: 1/2 HOT

Test #85
EG106, SN 50 g/dm^2/h, 20 min
-7°C, 8° Rotation
Visual Contamination Rating (1,1.5,1.9)
Before Rotation

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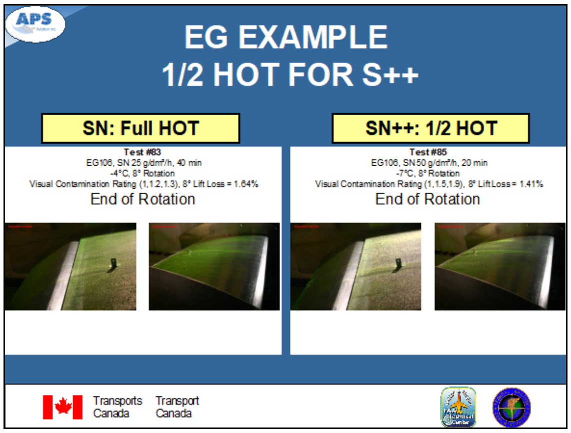

EG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #83
EG106, SN 25 g/dm^2/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.2,1.3), 8° Lift Loss = 1.64%
End of Rotation

SN++: 1/2 HOT

Test #85
EG106, SN 50 g/dm^2/h, 20 min
-7°C, 8° Rotation
Visual Contamination Rating (1,1.5,1.9), 8° Lift Loss = 1.41%
End of Rotation

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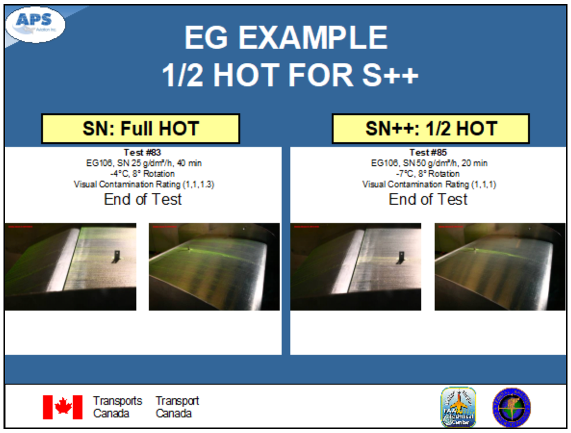


EG EXAMPLE 1/2 HOT FOR S++

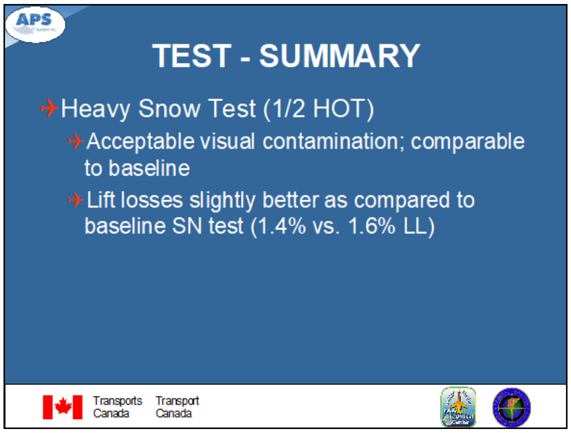
SN: Full HOT

Test #83
EG106, SN 25 g/dm^2/h, 40 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1,1.3)
End of Test

SN++: 1/2 HOT

Test #85
EG106, SN 50 g/dm^2/h, 20 min
-7°C, 8° Rotation
Visual Contamination Rating (1,1,1)
End of Test

Transports Canada Transport Canada



TEST - SUMMARY

- Heavy Snow Test (1/2 HOT)
  - Acceptable visual contamination; comparable to baseline
  - Lift losses slightly better as compared to baseline SN test (1.4% vs. 1.6% LL)

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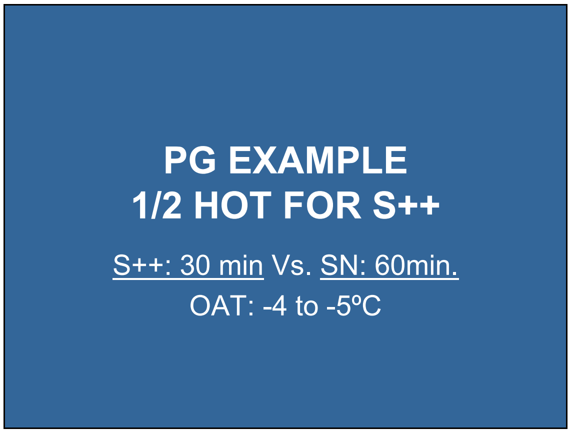
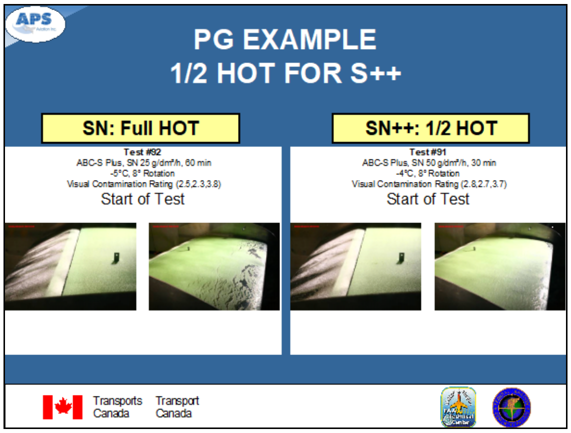


PG EXAMPLE 1/2 HOT FOR S++

S++: 30 min Vs. SN: 60min.

OAT: -4 to -5ºC



PG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 g/dm^2/h, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (2.5,2.3,3.8)
Start of Test

SN++: 1/2 HOT

Test #91
ABC-S Plus, SN 50 g/dm^2/h, 30 min
-4°C, 8° Rotation
Visual Contamination Rating (2.8,2.7,3.7)
Start of Test

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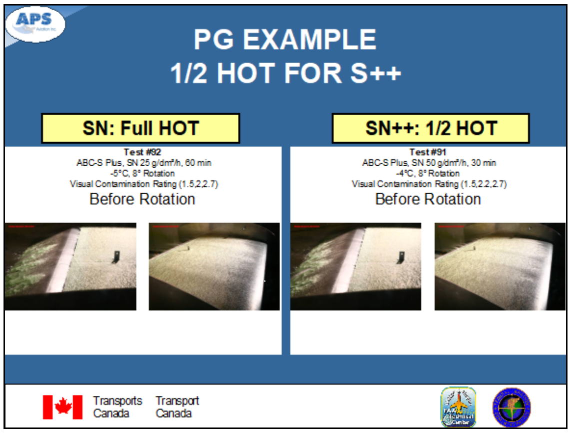


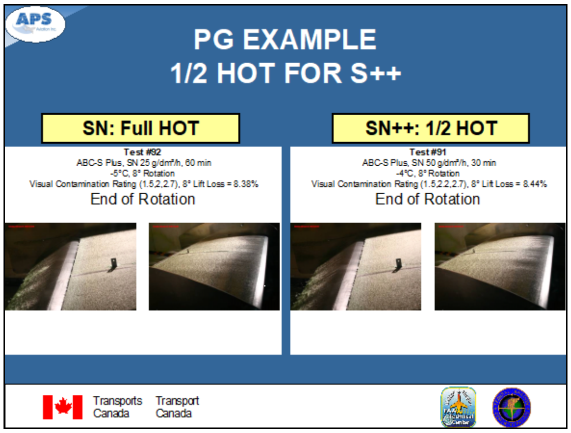
PG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1.5,2,2.7)
Before Rotation

SN++: 1/2 HOT

Test #91
ABC-S Plus, SN 50 $g/dm^2/h$, 30 min
-4°C, 8° Rotation
Visual Contamination Rating (1.5,2.2,2.7)
Before Rotation



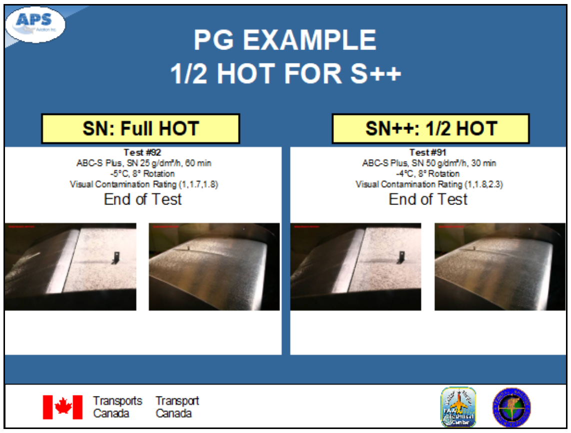
PG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1.5,2,2.7), 8° Lift Loss = 8.38%
End of Rotation

SN++: 1/2 HOT

Test #91
ABC-S Plus, SN 50 $g/dm^2/h$, 30 min
-4°C, 8° Rotation
Visual Contamination Rating (1.5,2.2,2.7), 8° Lift Loss = 8.44%
End of Rotation



PG EXAMPLE 1/2 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1,1.7,1.8)
End of Test

SN++: 1/2 HOT

Test #91
ABC-S Plus, SN 50 $g/dm^2/h$, 30 min
-4°C, 8° Rotation
Visual Contamination Rating (1,1.8,2.3)
End of Test

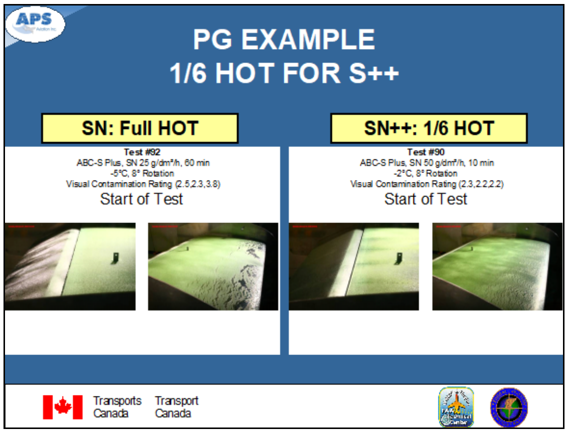
TEST - SUMMARY

- Heavy Snow Test (1/2 HOT)
  - Residual contamination present on the leading edge at the time of rotation
    - Visual contamination levels comparable to baseline
  - Large lift losses observed (8.4%), however, lift losses equal to baseline SN test

PG EXAMPLE 1/6 HOT FOR S++

S++: 10 min Vs. SN: 60min.

OAT: -2 to -5ºC



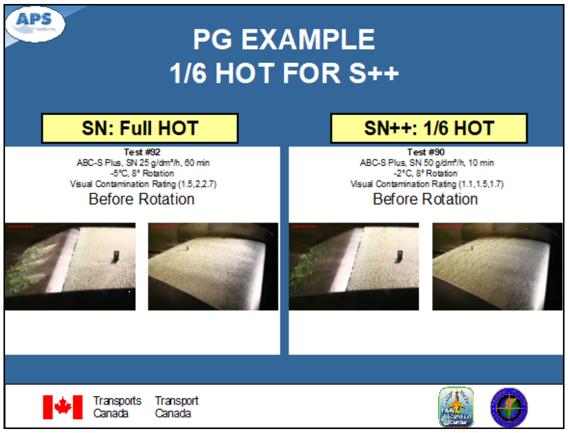
PG EXAMPLE 1/6 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (2.5,2.3,3.8)
Start of Test

SN++: 1/6 HOT

Test #90
ABC-S Plus, SN 50 $g/dm^2/h$, 10 min
-2°C, 8° Rotation
Visual Contamination Rating (2.3,2.2,2.2)
Start of Test



PG EXAMPLE
1/6 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1.5,2,2.7)
Before Rotation

SN++: 1/6 HOT

Test #90
ABC-S Plus, SN 50 $g/dm^2/h$, 10 min
-2°C, 8° Rotation
Visual Contamination Rating (1.1,1.5,1.7)
Before Rotation

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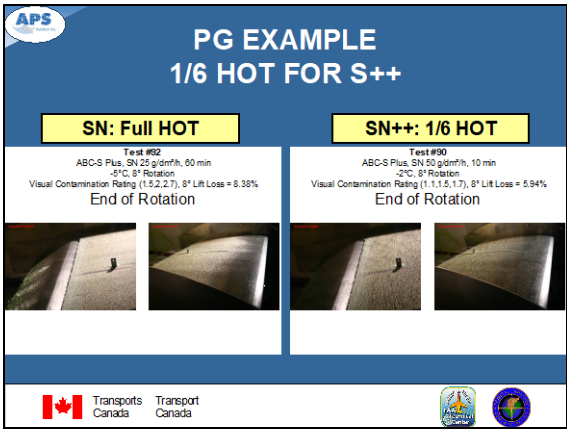

PG EXAMPLE
1/6 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1.5,2,2.7), 8° Lift Loss = 8.38%
End of Rotation

SN++: 1/6 HOT

Test #90
ABC-S Plus, SN 50 $g/dm^2/h$, 10 min
-2°C, 8° Rotation
Visual Contamination Rating (1.1,1.5,1.7), 8° Lift Loss = 5.94%
End of Rotation

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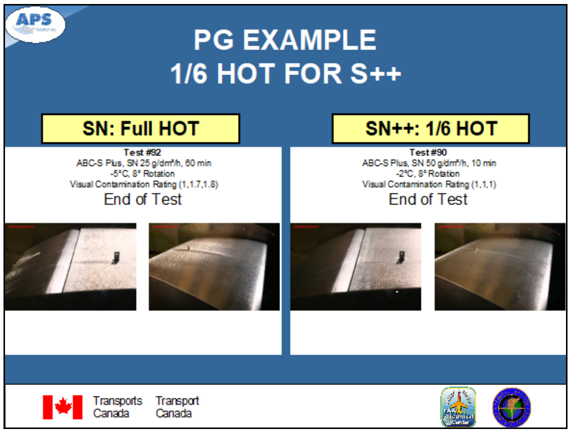

PG EXAMPLE
1/6 HOT FOR S++

SN: Full HOT

Test #92
ABC-S Plus, SN 25 $g/dm^2/h$, 60 min
-5°C, 8° Rotation
Visual Contamination Rating (1,1.7,1.8)
End of Test

SN++: 1/6 HOT

Test #90
ABC-S Plus, SN 50 $g/dm^2/h$, 10 min
-2°C, 8° Rotation
Visual Contamination Rating (1,1,1)
End of Test

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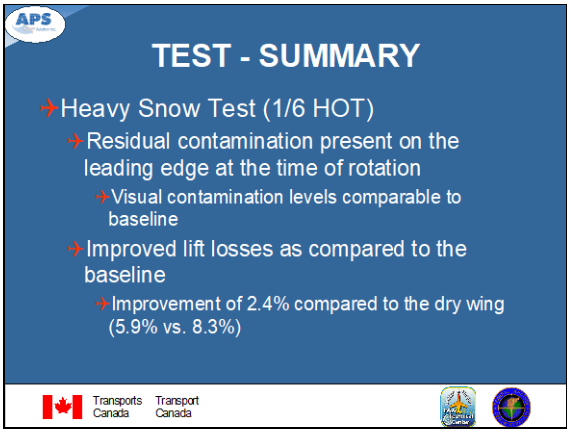

TEST - SUMMARY

- Heavy Snow Test (1/6 HOT)
  - Residual contamination present on the leading edge at the time of rotation
    - Visual contamination levels comparable to baseline
  - Improved lift losses as compared to the baseline
    - Improvement of 2.4% compared to the dry wing (5.9% vs. 8.3%)

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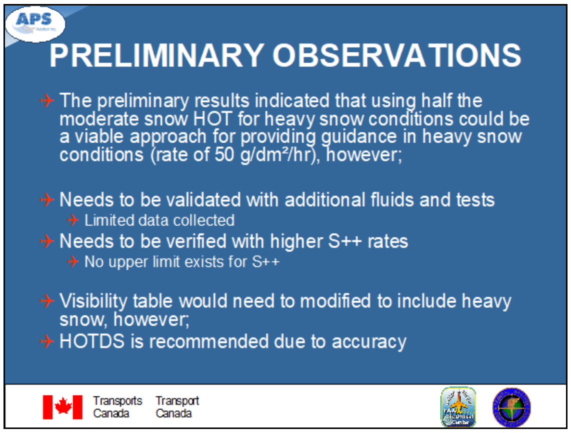

PRELIMINARY OBSERVATIONS

- The preliminary results indicated that using half the moderate snow HOT for heavy snow conditions could be a viable approach for providing guidance in heavy snow conditions (rate of 50 $g/dm^2/hr$), however;

- Needs to be validated with additional fluids and tests
  - Limited data collected
- Needs to be verified with higher S++ rates
  - No upper limit exists for S++

- Visibility table would need to modified to include heavy snow, however;
- HOTDS is recommended due to accuracy

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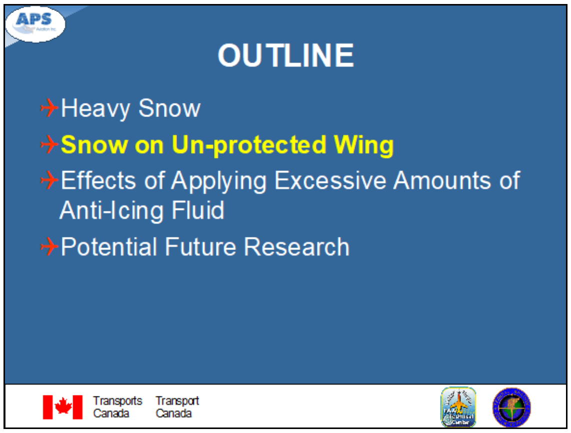
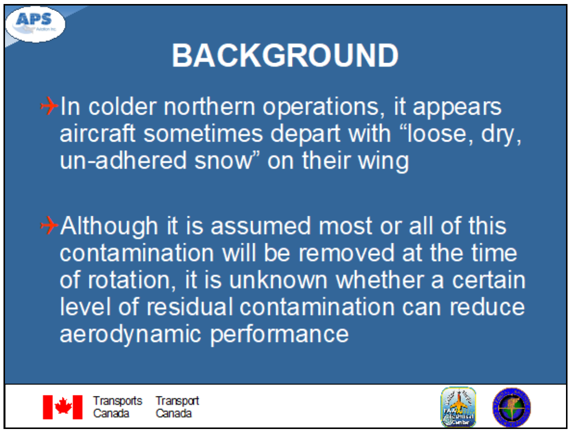


OUTLINE

- Heavy Snow
- **Snow on Un-protected Wing**
- Effects of Applying Excessive Amounts of Anti-Icing Fluid
- Potential Future Research

Transports Canada Transport Canada

SNOW ON UN-PROTECTED WING



BACKGROUND

- In colder northern operations, it appears aircraft sometimes depart with “loose, dry, un-adhered snow” on their wing
- Although it is assumed most or all of this contamination will be removed at the time of rotation, it is unknown whether a certain level of residual contamination can reduce aerodynamic performance

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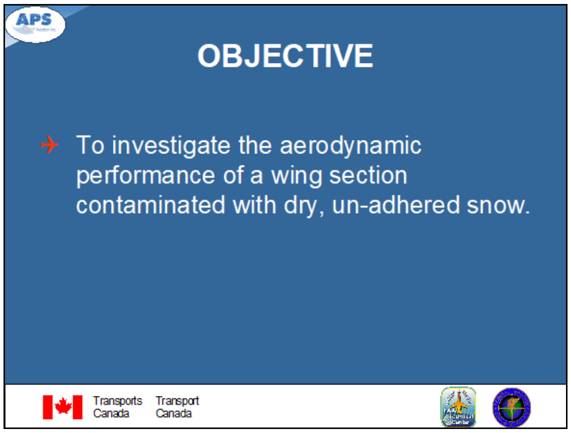

OBJECTIVE

- To investigate the aerodynamic performance of a wing section contaminated with dry, un-adhered snow.

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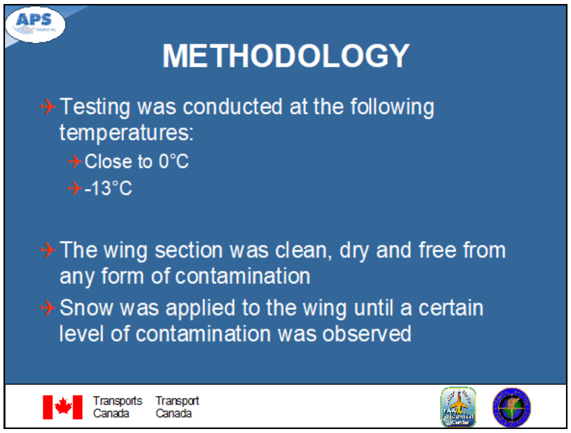

METHODOLOGY

- Testing was conducted at the following temperatures:
  - Close to 0°C
  - -13°C
- The wing section was clean, dry and free from any form of contamination
- Snow was applied to the wing until a certain level of contamination was observed

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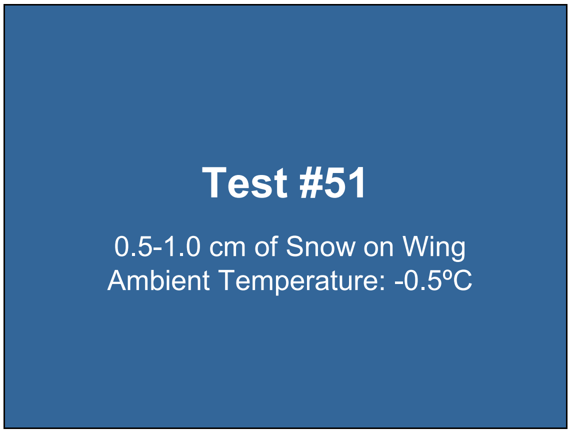
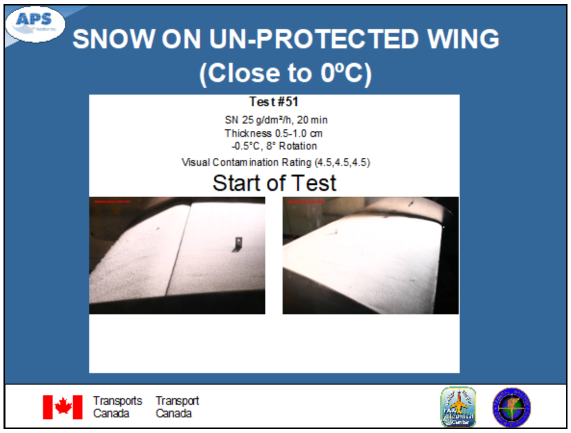


Test #51

0.5-1.0 cm of Snow on Wing
Ambient Temperature: -0.5°C



SNOW ON UN-PROTECTED WING (Close to 0ºC)

Test #51

SN 25 g/dm²/h, 20 min
Thickness 0.5-1.0 cm
-0.5°C, 8° Rotation
Visual Contamination Rating (4.5,4.5,4.5)

Start of Test

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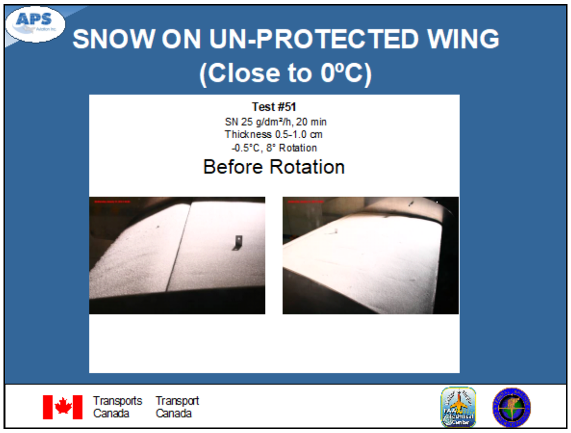
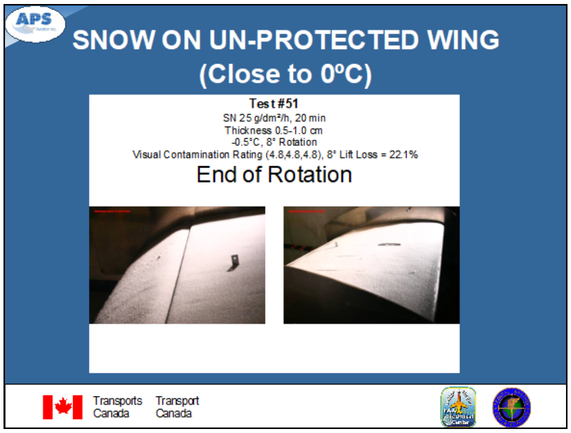


SNOW ON UN-PROTECTED WING (Close to 0ºC)

Test #51
SN 25 g/dm²/h, 20 min
Thickness 0.5-1.0 cm
-0.5°C, 8° Rotation

Before Rotation

Transports Canada Transport Canada



SNOW ON UN-PROTECTED WING (Close to 0ºC)

Test #51
SN 25 g/dm²/h, 20 min
Thickness 0.5-1.0 cm
-0.5°C, 8° Rotation
Visual Contamination Rating (4.8,4.8,4.8), 8° Lift Loss = 22.1%

End of Rotation

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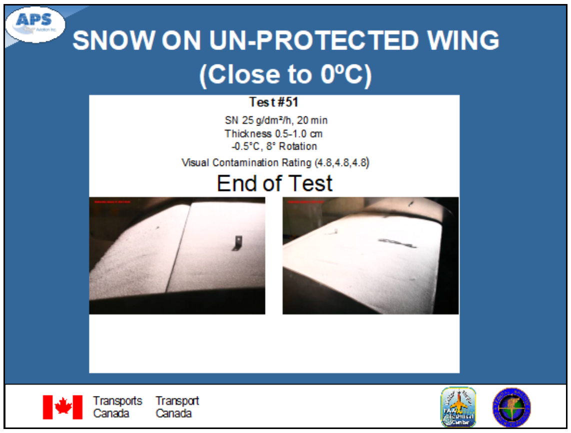
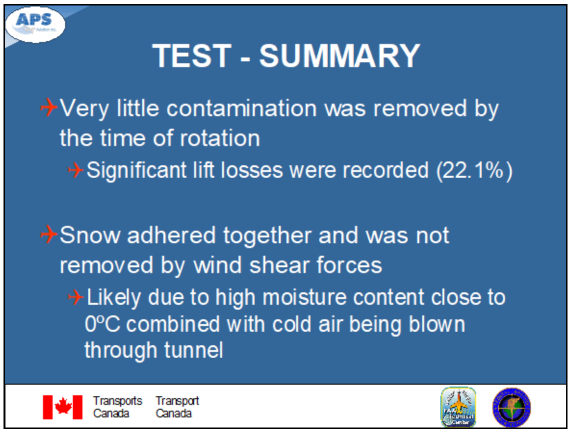


SNOW ON UN-PROTECTED WING (Close to 0ºC)

Test #51
SN 25 g/dm²/h, 20 min
Thickness 0.5-1.0 cm
-0.5°C, 8° Rotation
Visual Contamination Rating (4.8,4.8,4.8)

End of Test

Transports Canada Transport Canada



TEST - SUMMARY

- Very little contamination was removed by the time of rotation
  - Significant lift losses were recorded (22.1%)
- Snow adhered together and was not removed by wind shear forces
  - Likely due to high moisture content close to 0ºC combined with cold air being blown through tunnel

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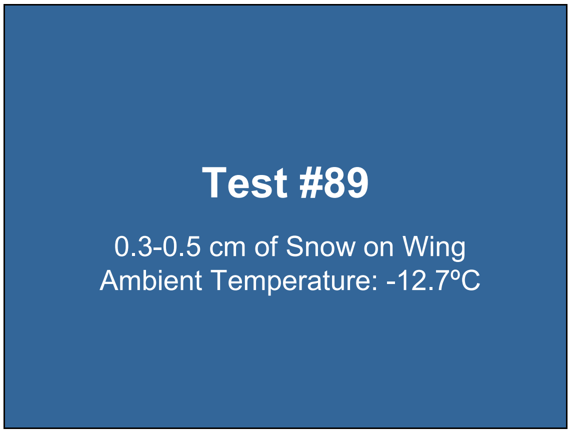
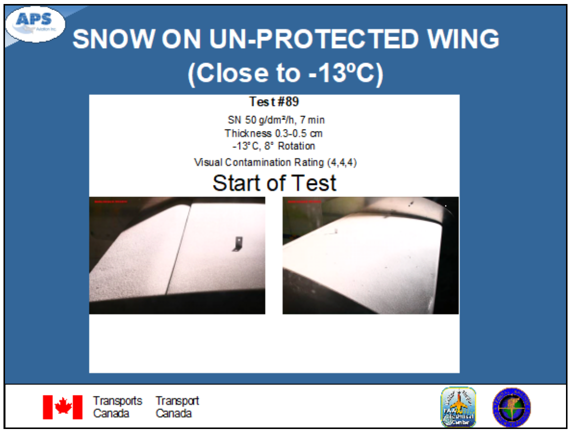


Test #89

0.3-0.5 cm of Snow on Wing
Ambient Temperature: -12.7ºC



SNOW ON UN-PROTECTED WING (Close to -13ºC)

Test #89
SN 50 g/dm²/h, 7 min
Thickness 0.3-0.5 cm
-13°C, 8° Rotation
Visual Contamination Rating (4,4,4)

Start of Test

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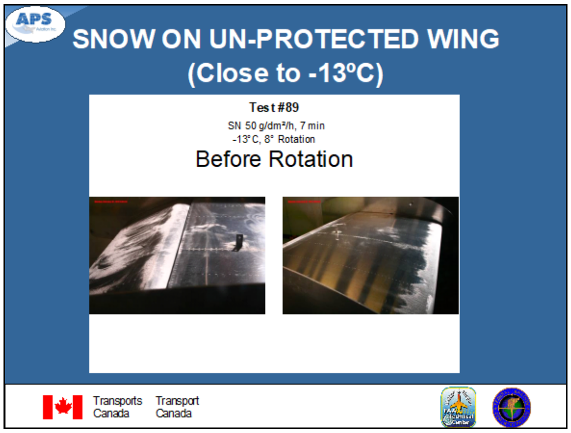


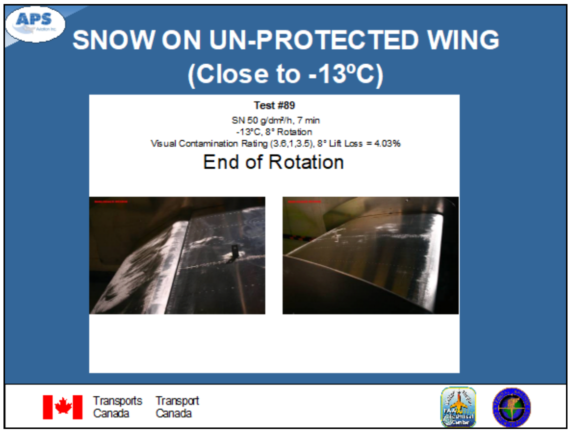
SNOW ON UN-PROTECTED WING (Close to -13ºC)

Test #89

SN 50 $g/dm^2/h$, 7 min
-13°C, 8° Rotation

Before Rotation

Transports Canada Transport Canada



SNOW ON UN-PROTECTED WING (Close to -13ºC)

Test #89

SN 50 $g/dm^2/h$, 7 min
-13°C, 8° Rotation
Visual Contamination Rating (3.6,1,3.5), 8° Lift Loss = 4.03%

End of Rotation

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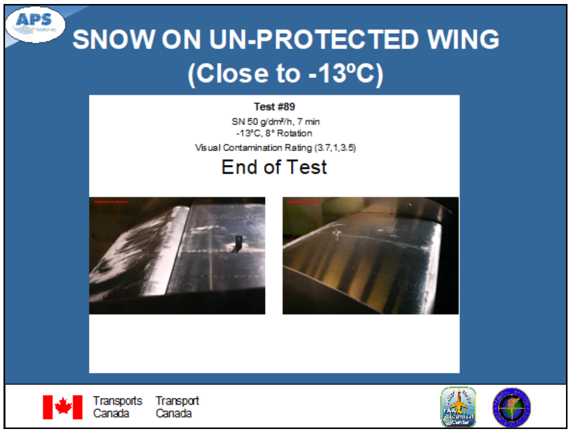


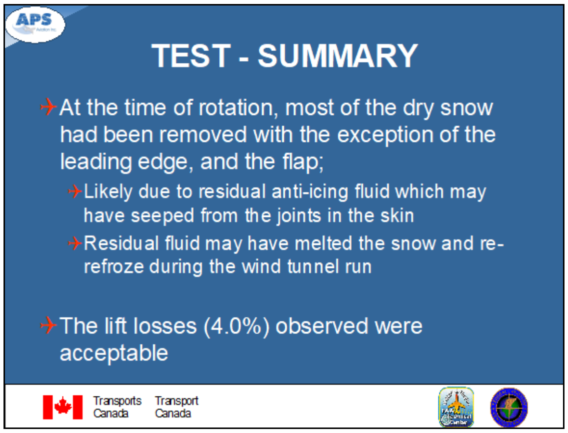
SNOW ON UN-PROTECTED WING (Close to -13ºC)

Test #89

SN 50 $g/dm^2/h$, 7 min
-13°C, 8° Rotation
Visual Contamination Rating (3.7,1,3.5)

End of Test

Transports Canada Transport Canada



TEST - SUMMARY

- At the time of rotation, most of the dry snow had been removed with the exception of the leading edge, and the flap;
  - Likely due to residual anti-icing fluid which may have seeped from the joints in the skin
  - Residual fluid may have melted the snow and re-refroze during the wind tunnel run
- The lift losses (4.0%) observed were acceptable

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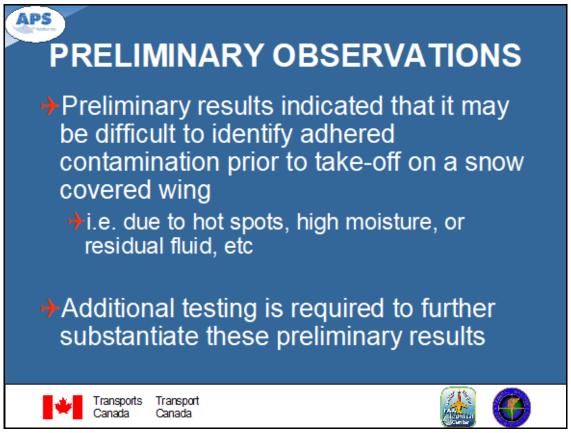

PRELIMINARY OBSERVATIONS

- Preliminary results indicated that it may be difficult to identify adhered contamination prior to take-off on a snow covered wing
  - i.e. due to hot spots, high moisture, or residual fluid, etc
- Additional testing is required to further substantiate these preliminary results

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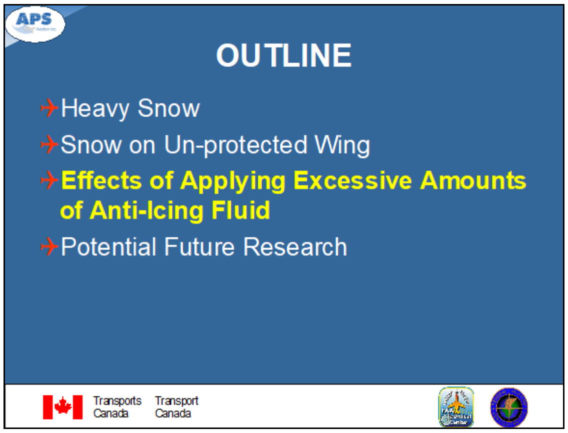

OUTLINE

- Heavy Snow
- Snow on Un-protected Wing
- **Effects of Applying Excessive Amounts of Anti-Icing Fluid**
- Potential Future Research

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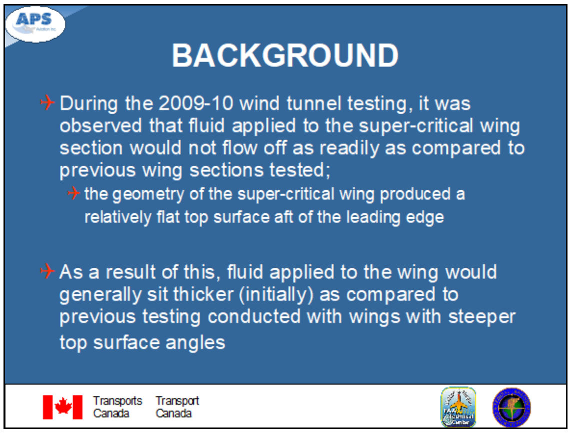
EFFECTS OF APPLYING EXCESIVE AMOUNTS OF ANTI-ICING FLUID



BACKGROUND

- During the 2009-10 wind tunnel testing, it was observed that fluid applied to the super-critical wing section would not flow off as readily as compared to previous wing sections tested;
  - the geometry of the super-critical wing produced a relatively flat top surface aft of the leading edge
- As a result of this, fluid applied to the wing would generally sit thicker (initially) as compared to previous testing conducted with wings with steeper top surface angles

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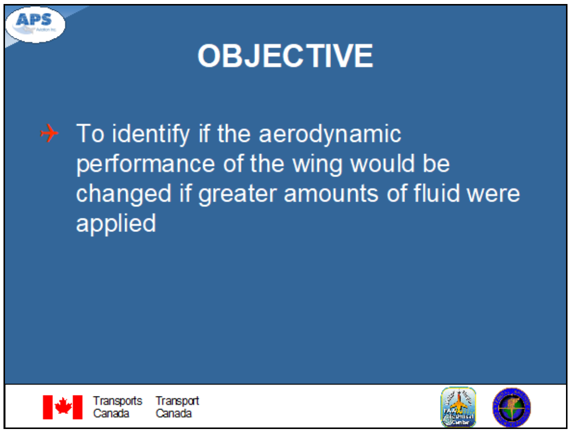

OBJECTIVE

- To identify if the aerodynamic performance of the wing would be changed if greater amounts of fluid were applied

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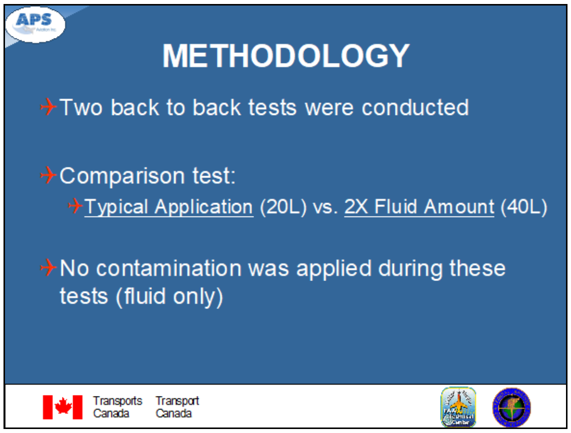

METHODOLOGY

- Two back to back tests were conducted
- Comparison test:
  - Typical Application (20L) vs. 2X Fluid Amount (40L)
- No contamination was applied during these tests (fluid only)

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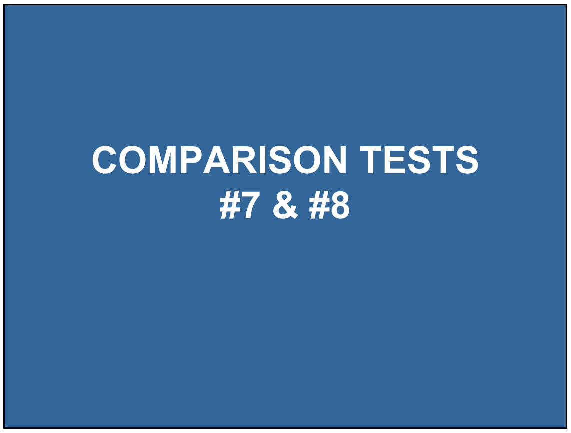
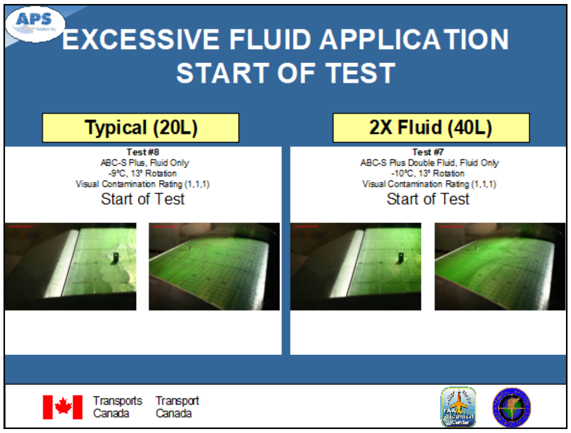


COMPARISON TESTS #7 & #8



EXCESSIVE FLUID APPLICATION START OF TEST

Typical (20L)

Test #8
ABC-S Plus, Fluid Only
-9°C, 13° Rotation
Visual Contamination Rating (1,1,1)
Start of Test

2X Fluid (40L)

Test #7
ABC-S Plus Double Fluid, Fluid Only
-10°C, 13° Rotation
Visual Contamination Rating (1,1,1)
Start of Test

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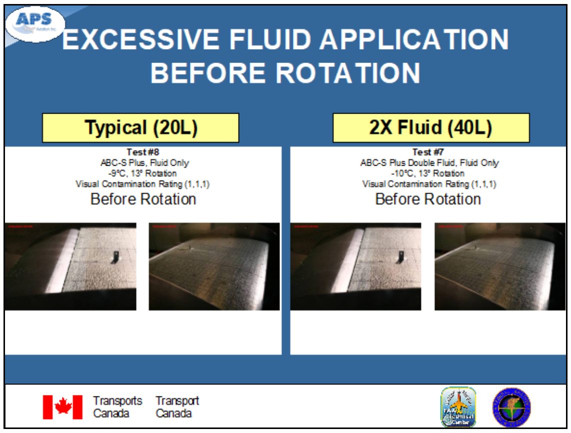

EXCESSIVE FLUID APPLICATION BEFORE ROTATION

Typical (20L)

Test #8
ABC-S Plus, Fluid Only
-9°C, 13° Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

2X Fluid (40L)

Test #7
ABC-S Plus Double Fluid, Fluid Only
-10°C, 13° Rotation
Visual Contamination Rating (1,1,1)
Before Rotation

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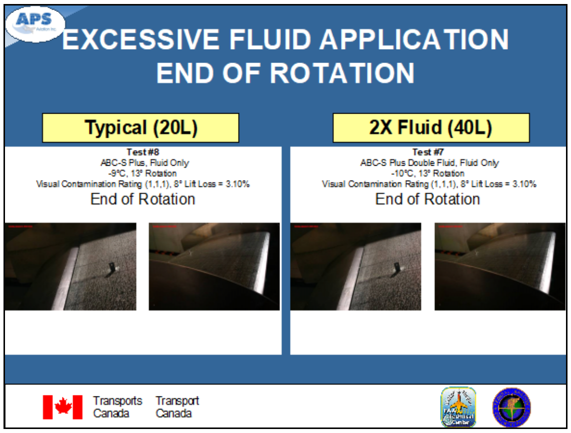

EXCESSIVE FLUID APPLICATION END OF ROTATION

Typical (20L)

Test #8
ABC-S Plus, Fluid Only
-9°C, 13° Rotation
Visual Contamination Rating (1,1,1), 8° Lift Loss = 3.10%
End of Rotation

2X Fluid (40L)

Test #7
ABC-S Plus Double Fluid, Fluid Only
-10°C, 13° Rotation
Visual Contamination Rating (1,1,1), 8° Lift Loss = 3.10%
End of Rotation

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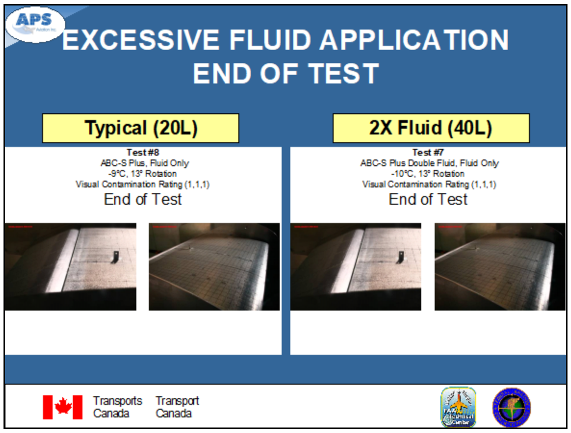

EXCESSIVE FLUID APPLICATION END OF TEST

Typical (20L)

Test #8
ABC-S Plus, Fluid Only
-9°C, 13° Rotation
Visual Contamination Rating (1,1,1)
End of Test

2X Fluid (40L)

Test #7
ABC-S Plus Double Fluid, Fluid Only
-10°C, 13° Rotation
Visual Contamination Rating (1,1,1)
End of Test

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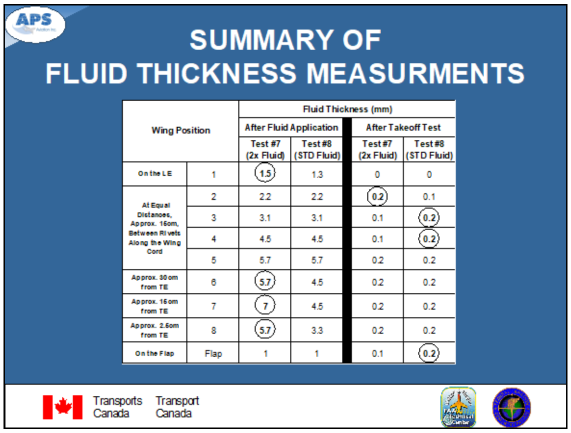

SUMMARY OF FLUID THICKNESS MEASURMENTS

Wing Position		Fluid Thickness (mm)			
		After Fluid Application		After Takeoff Test	
		Test #7 (2x Fluid)	Test #8 (STD Fluid)	Test #7 (2x Fluid)	Test #8 (STD Fluid)
On the LE	1	1.5	1.3	0	0
At Equal Distances, Approx. 15cm, Between Rivets Along the Wing Cord	2	2.2	2.2	0.2	0.1
	3	3.1	3.1	0.1	0.2
	4	4.5	4.5	0.1	0.2
	5	5.7	5.7	0.2	0.2
Approx. 30cm from TE	6	5.7	4.5	0.2	0.2
Approx. 15cm from TE	7	7	4.5	0.2	0.2
Approx. 2.5cm from TE	8	5.7	3.3	0.2	0.2
On the Flap	Flap	1	1	0.1	0.2

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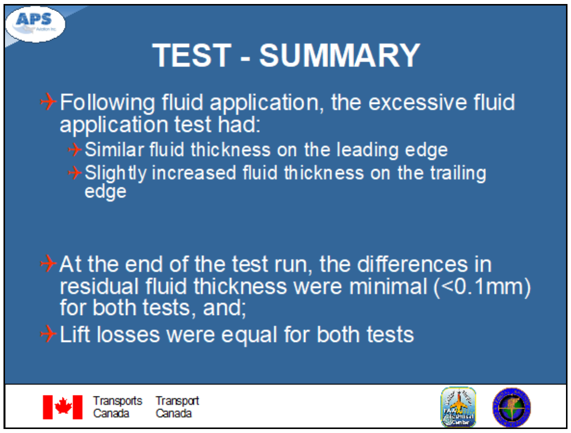

TEST - SUMMARY

- Following fluid application, the excessive fluid application test had:
  - Similar fluid thickness on the leading edge
  - Slightly increased fluid thickness on the trailing edge
- At the end of the test run, the differences in residual fluid thickness were minimal (<0.1mm) for both tests, and;
- Lift losses were equal for both tests

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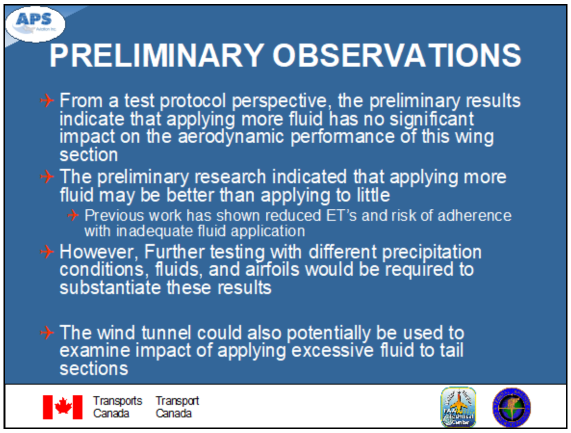

PRELIMINARY OBSERVATIONS

- From a test protocol perspective, the preliminary results indicate that applying more fluid has no significant impact on the aerodynamic performance of this wing section
- The preliminary research indicated that applying more fluid may be better than applying to little
  - Previous work has shown reduced ET's and risk of adherence with inadequate fluid application
- However, Further testing with different precipitation conditions, fluids, and airfoils would be required to substantiate these results
- The wind tunnel could also potentially be used to examine impact of applying excessive fluid to tail sections

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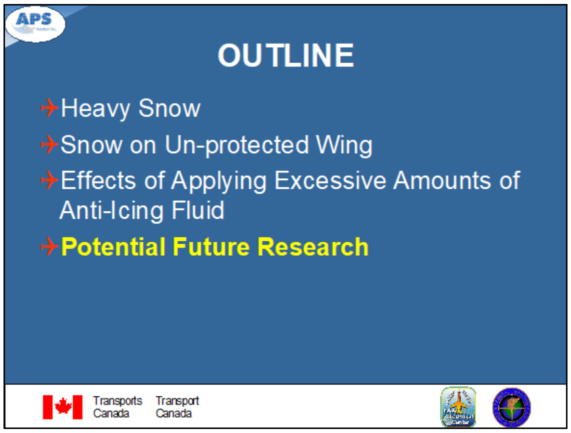

OUTLINE

- Heavy Snow
- Snow on Un-protected Wing
- Effects of Applying Excessive Amounts of Anti-Icing Fluid
- **Potential Future Research**

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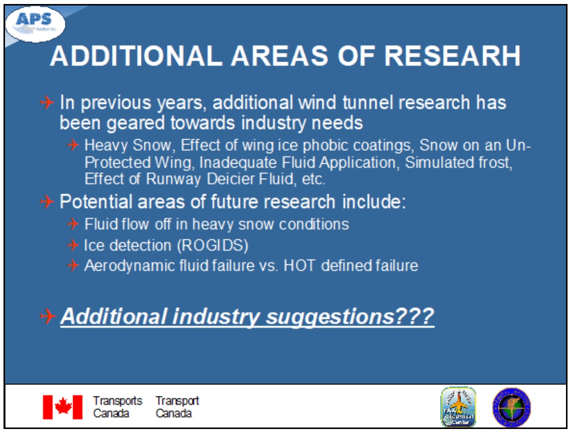

ADDITIONAL AREAS OF RESEARH

- In previous years, additional wind tunnel research has been geared towards industry needs
  - Heavy Snow, Effect of wing ice phobic coatings, Snow on an Un-Protected Wing, Inadequate Fluid Application, Simulated frost, Effect of Runway Deicier Fluid, etc.
- Potential areas of future research include:
  - Fluid flow off in heavy snow conditions
  - Ice detection (ROGIDS)
  - Aerodynamic fluid failure vs. HOT defined failure
- ***Additional industry suggestions???***

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