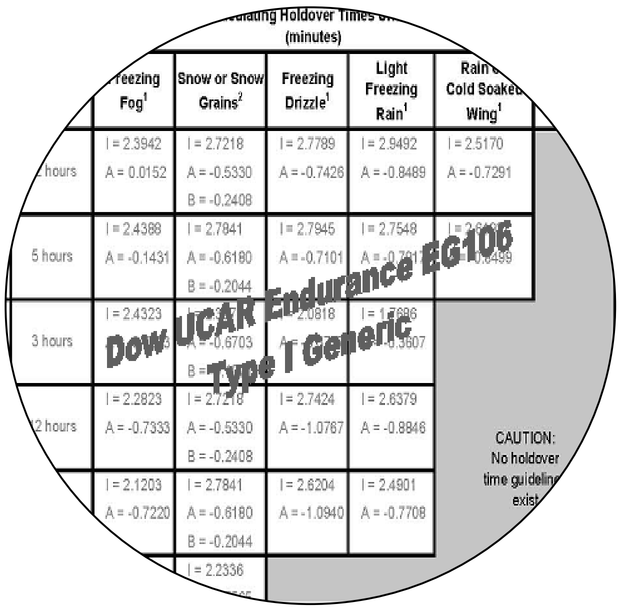
TP 14782E

Regression Coefficients Used to Develop the Winter 2007-08 Type I Generic and Dow UCAR Endurance EG106 Holdover Time Tables



Prepared for
Transportation Development Centre
Transport Canada

In cooperation with

Civil Aviation
Transport Canada

Prepared by

APS Aviation Inc.

January 2008
Final Version 1.0

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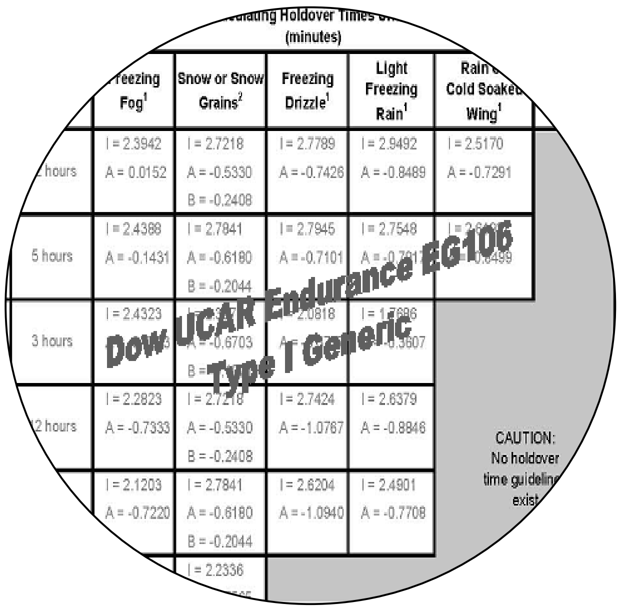

by

Stephanie Bendickson

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January 2008
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DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:		September 13, 2018
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Approved by:	**	
	Jack Rigley Vice President, Communications Engineering ADGA Group	Date

Un sommaire français se trouve avant la table des matières.

This report was first provided to Transport Canada as Final Draft 1.0 in January 2008
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**Final Draft 1.0 of this report was signed and provided to Transport Canada in January 2008. A Transport Canada technical and editorial review was subsequently completed and the report was finalized in September 2018; Jack Rigley was not available to participate in the final review or to sign the current version of the report.*

PREFACE

Under contract to the Transportation Development Centre of Transport Canada, APS Aviation Inc. (APS) has undertaken a research program to advance aircraft ground de/anti-icing technology. The specific objectives of the APS test program are the following:

- To develop holdover time data for all newly-qualified de/anti-icing fluids;
- To evaluate whether holdover times should be developed for ice pellet conditions;
- To examine the effect of heated fluids on Type II, III and IV fluid endurance times;
- To evaluate weather data from previous winters to establish a range of conditions suitable for the evaluation of holdover time limits;
- To assist in the testing of flow of contaminated fluid from aircraft wings during takeoff;
- To assist in the testing of flow of contaminated fluid from simulated aircraft wings during takeoff;
- To validate the laboratory snow test protocol with Type II and IV fluids;
- To develop performance specifications for an integrated weather system that measures holdover time;
- To provide support for the development of a standard that evaluates remote on-ground ice detection systems;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests on non-aluminum plates;
- To conduct endurance time tests in frost on various test surfaces;
- To conduct preliminary wind tunnel endurance time tests in heavy snow;
- To compile historical data for calculation of holdover times based on a small number of inputs;
- To examine the use of non-glycol tempered steam technology to deice aircraft; and
- To assist DND Canada in evaluating the effects of slipstream on anti-icing fluid.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2006-07 are documented in eight reports. The titles of the reports are as follows:

- TP 14452E Feasibility of ROGIDS Test Conditions Stipulated in SAE Draft Standard AS5681;
- TP 14776E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2006-07 Winter;
- TP 14777E Winter Weather Impact on Holdover Time Table Format (1995-2007);
- TP 14778E Flow of Contaminated Fluid from Aircraft Wings: Feasibility Report;
- TP 14779E Development of Allowance Times for Aircraft Deicing Operations During Conditions with Ice Pellets;

- TP 14780E Evaluation of Tempered Steam Technology (TST) for Aircraft Deicing Applications;
- TP 14781E Aircraft Ground Icing General Research Activities During the 2006-07 Winter; and
- TP 14782E Regression Coefficients Used to Develop the Winter 2007-08 Type I Generic and Dow UCAR Endurance EG106 Holdover Time Tables.

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

- *Preliminary Aircraft Deicing Research in Heavy Snow Conditions;*
- *Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2006-07;*
- *Effect of Heat on Fluid Endurance Times Using Composite Surfaces;*
- *Effect of Heat on Endurance Times of Anti-Icing Fluids;*
- *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions; and*
- *Regression Coefficients Used to Develop Aircraft Ground Deicing Holdover Time Tables: Winter 2007-08.*

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

- Support for Testing to Ascertain the Effects of SAE Type IV De/Anti-Icing Fluids on CC-130 Hercules and CP-140 Aurora Aircraft Takeoff Handling.

This report, TP 14782E, has the following objective:

- To document the regression information used to develop the Type I generic and Dow UCAR Endurance EG106 winter 2007-08 aircraft ground deicing holdover time tables.

The objective was met by de-archiving and analysing data from holdover time testing conducted over the winters of 1996-97 to 2006-07.

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 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 would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: George

Balaban, Katrina Bell, Stephanie Bendickson, Ryan Brydges, Michael Chaput, John D'Avirro, Peter Dawson, Dany Posteraro, Marco Ruggi, Joey Tiano, and David Youssef.

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

PROJECT ACKNOWLEDGEMENTS

Special thanks are also extended to Doug Ingold of Transport Canada Civil Aviation - Operational Standards, who was highly involved in this project, and offered valuable guidance in developing the content of this document.

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7. Author(s) Stephanie Bendickson		8. Transport Canada File No. 2450-BP-14
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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 (TDC). Eight reports (including this one) were produced as part of the 2006-2007 research program. The reported project was co-sponsored by the U.S. Federal Aviation Administration.

16. Abstract

The objective of this report is to develop the regression coefficients for generic Type I and Dow UCAR EG106 Type IV Holdover Times for use in generating a Holdover Time Determination Report based on a Holdover Time Determination System and to demonstrate that the values generated are in reasonable accord with that fluid's published Holdover Time table.

This report was written to expedite publication of select data requested by a holdover time determination system manufacturer who requires the regression coefficients and equations for select fluids for operations in 2007-08.

The methodology that is employed to produce holdover times is provided in the report, as are verification tables for the Type I generic and Dow UCAR EG106 data and a description of the limitations of the data. Users of this data are strongly recommended to read the report in its entirety in order to fully understand the data limitations.

The content of this report is to be used in conjunction with a document provided by Transport Canada that exempts a user of a holdover time determination system from the requirement to use the published holdover time tables in their approved ground deicing program.

17. Key Words Holdover times, holdover time determination systems, regression coefficients, deicing, anti-icing	18. Distribution Statement Limited number of copies available from the Transportation Development Centre

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

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15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada. Ils sont disponibles au Centre de développement des transports (CDT). Huit rapports (y compris celui-ci) ont été produits dans le cadre du programme de recherche de 2006-2007. Le projet qui fait l'objet de ce rapport était coparrainé par la Federal Aviation Administration des États-Unis.

16. Résumé

Le présent rapport a pour but d'élaborer des coefficients de régression pour les durées d'efficacité des liquides génériques de type I et du liquide de type IV Dow UCAR EG106, pour la production d'un rapport de détermination de durées d'efficacité, fondé sur un système de détermination de durées d'efficacité et pour illustrer que les valeurs générées concordent raisonnablement avec les valeurs publiées des tableaux d'efficacité de ces liquides.

Le présent rapport a été rédigé en vue d'accélérer la publication de certaines données, à la demande d'un fabricant de système de détermination de durées d'efficacité, qui a besoin de coefficients de régression et d'équations pour certains liquides, pour les opérations de 2007-2008.

La méthodologie utilisée pour la production de durées d'efficacité est fournie dans ce rapport, comme le sont les tableaux de vérification des données des liquides génériques de type I et le liquide Dow UCAR EG106 et une description des limites de ces données. La lecture de l'intégrité du présent rapport est fortement recommandée aux utilisateurs de ces données, afin d'en comprendre les limites.

Le contenu du présent rapport doit être utilisé conjointement avec un document fourni par Transports Canada, qui exempte l'utilisateur d'un système de détermination des durées d'efficacité de l'exigence d'utiliser les tableaux de durées d'efficacité de son programme sur les opérations de dégivrage au sol.

17. Mots clés Durées d'efficacité, systèmes de détermination de durées d'efficacité, coefficients de régression, dégivrage, antigivrage	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

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EXECUTIVE SUMMARY

Holdover time determination systems are a recent development in holdover time technology. The systems use real-time meteorological measurements and the curves behind the holdover time tables to generate precise holdover times in real-time. The development of these systems has necessitated that regression coefficient data underlying holdover time tables be published.

The objective of this project was to develop the regression coefficients for generic Type I and Dow UCAR EG106 Type IV holdover times for use with a holdover time determination system and to demonstrate that the resulting values generated by the holdover time determination system are in reasonable accord with the values in those fluids' published holdover time tables.

This report is a component of a more extensive document and has been prepared to expedite publication the regression coefficients and equations required by one air carrier (Type I and Dow UCAR EG106) in the winter of 2007-08.

The required regression coefficients and equations are presented in Tables ES-1 and ES-2 below. In order for a carrier to use these regression coefficients in a holdover time determination system, a regulatory exemption from using the holdover time tables in the carrier's Approved Ground Icing Operations Program needs to be made. This is accomplished through the issue of an exemption document that details the requirements of the regulator for accepting these regression coefficients.

There are some limitations to this data. It is strongly recommended that users of this data read this report in its entirety to understand these limitations.

Table ES-1: Generic Type I Regression Coefficients

<table>
<tr><th colspan="2">Outside Air Temperature</th><th colspan="6">Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions</th></tr>
<tr><th>Degrees Celsius</th><th>Degrees Fahrenheit</th><th>Freezing Fog[1]</th><th>Snow or Snow Grains[2,3]</th><th>Freezing Drizzle[1]</th><th>Light Freezing Rain[1,4]</th><th>Rain on Cold Soaked Wing[1]</th><th>Other</th></tr>
<tr><td>-3 and above</td><td>27 and above</td><td>I = 1.3735
A = -0.4751</td><td rowspan="4">I = 2.0072
A = -0.5752
B = -0.5585</td><td>I = 1.3829
A = -0.3848</td><td>I = 1.4688
A = -0.6200</td><td>I = 0.9355
A = -0.3384</td><td></td></tr>
<tr><td>below -3 to -6</td><td>below 27 to 21</td><td>I = 1.2734
A = -0.5299</td><td>I = 1.3842
A = -0.6152</td><td>I = 1.4688
A = -0.6200</td><td colspan="2" rowspan="3">Caution:
No holdover times exist</td></tr>
<tr><td>below -6 to -10</td><td>below 21 to 14</td><td>I = 1.1678
A = -0.5575</td><td>I = 1.2545
A = -0.5857</td><td>I = 2.2598
A = -1.4012</td></tr>
<tr><td>below -10</td><td>below 14</td><td>I = 1.1473
A = -0.6415</td><td></td><td></td></tr>
</table>

[1] Regression Equation: $t = 10^I R^A$, where R = precipitation rate (g/dm²/h)
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = precipitation rate (g/dm²/h) and T = temperature (in °C)
[3] Snow values in the Type I holdover time table are rounded down to the nearest one minute (i.e. 6.2 mins = 6 mins, 5.9 mins = 5 mins) and therefore may differ slightly from the values calculated using these coefficients.
[4] These coefficients are valid for the Transport Canada table. For the FAA table, the "below -6 to -10" coefficients should also be used for "-3 and above" and "below -3 to -6".

Table ES-2: Dow UCAR Endurance EG106 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	27 and above	100/0	I = 2.4198 A = -0.4664	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.4460 A = -0.5295	I = 2.5011 A = -0.5672	I = 2.5903 A = -0.7102	
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	n/a n/a	
		50/50	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a		
below -3 to -14	below 27 to 7	100/0	I = 2.4942 A = -0.6588	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.5065 A = -0.6779	I = 2.6525 A = -0.7145		CAUTION: No holdover time guidelines exist
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a		
below -14 to -25	below 7 to -13	100/0	I = 2.0589 A = -0.7941	I = 2.2336 A = -0.7565 B = 0.0000				

1 Regression Equation: $t = 10^I R^A$, where R = precipitation rate (g/dm^2/h)

2 Regression Equation: $t = 10^I R^A (2-T)^B$, where R = precipitation rate (g/dm^2/h) and T = temperature (in °C)

SOMMAIRE

Les systèmes de détermination des durées d'efficacité sont un développement récent dans la technologie des durées d'efficacité. Ils utilisent des mesures météorologiques en temps réel et les courbes des tableaux de durées d'efficacité pour la génération de durées d'efficacité précises en temps réel. L'élaboration de ces systèmes a rendue nécessaire la publication des données de coefficient de régression sous-jacentes aux données des tableaux d'efficacité.

Ce projet avait pour but d'élaborer des coefficients de régression pour les durées d'efficacité des liquides génériques de type I et le liquide de type IV Dow UCAR EG106, à utiliser avec un système de détermination de durées d'efficacité et pour illustrer que les valeurs issues du système d'estimation concordent raisonnablement avec les valeurs publiées des tableaux d'efficacité de ces liquides.

Le présent rapport fait partie d'un document plus volumineux et a été rédigé pour accélérer la publication de coefficients de régression et d'équations requis par un transporteur aérien (liquides de type I et Dow UCAR EG106) pour l'hiver 2007-08.

Les coefficients de régression et équations nécessaires sont présentés aux tableaux ES-1 et ES-2 ci-dessous. Pour que le transporteur puisse utiliser ces coefficients de régression avec un système de détermination de durées d'efficacité, une exemption doit être accordée à la réglementation sur l'utilisation des tableaux de durées d'efficacité du programme du transporteur sur les opérations dans des conditions de givrage au sol. Cela se fait par l'émission d'un document d'exemption qui spécifie les exigences de l'organisme de réglementation pour l'acceptation de ces coefficients de régression.

Certaines limites s'appliquent à ces données. La lecture de l'intégrité du présent rapport est fortement recommandée aux utilisateurs de ces données, afin d'en comprendre les limites.

Tableau ES-1: Coefficients de régressions – liquides génériques de type I

Température extérieure		Coefficients de régression pour le calcul des durées d'efficacité dans des conditions					
Degrés Celsius	**Degrés Fahrenheit**	**Brouillard verglaçant[1]**	**Neige ou granules de neige[2,3]**	**Bruine verglaçante[1]**	**Pluie verglaçante faible[1,4]**	**Pluie sur aile imprégnée de froid[1]**	**Autre**
-3 et plus	27 et plus	I = 1.3735 A = -0.4751	I = 2.0072 A = -0.5752 B = -0.5585	I = 1.3829 A = -0.3848	I = 1.4688 A = -0.6200	I = 0.9355 A = -0.3384	
au-dessous de -3 à -6	au-dessous de 27 à 21	I = 1.2734 A = -0.5299		I = 1.3842 A = -0.6152	I = 1.4688 A = -0.6200	MISE EN GARDE : Il n'y a pas de lignes directrices pour les durées d'efficacité	
au-dessous de -6 à -10	au-dessous de 21 à 14	I = 1.1678 A = -0.5575		I = 1.2545 A = -0.5857	I = 2.2598 A = -1.4012		
au-dessous de -10	au-dessous de 14	I = 1.1473 A = -0.6415					

[1] Équation de régression : $t = 10^{I} R^{A}$, où R = taux de précipitation (g/dm²/h)

[2] Équation de régression : $t = 10^{I} R^{A} (2-T)^{B}$, où R = taux de précipitation (g/dm²/h) et T = température (en °C)

[3] Pour le liquide de type I et la neige sur une surface d'aluminium, les valeurs sont arrondies vers le bas à la minute la plus près (c.à.d. 6,2 min. = 6 min; 5,9 min. = 5 min.) pour établir les valeurs du tableau des durées d'efficacité.

[4] Ces coefficients sont valides pour le tableau de Transports Canada. Pour le tableau de la FAA, les coefficients « moins de -6 à -10°C » devraient aussi être utilisés pour « -3°C et plus » et « au-dessous de -3 à -6°C ».

Tableau ES-2: Dow UCAR Endurance EG106 coefficients de régressions

Température extérieure		Conc. de liquide	Coefficients de régression pour le calcul des durées d'efficacité dans des conditions					
Degrés Celsius	**Degrés Fahrenheit**		**Brouillard verglaçant[1]**	**Neige ou granules de neige[2]**	**Bruine verglaçante[1]**	**Pluie verglaçante faible[1]**	**Pluie sur aile imprégnée de froid[1]**	**Autre**
-3 et plus	27 et plus	100/0	I = 2.4198 A = -0.4664	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.4460 A = -0.5295	I = 2.5011 A = -0.5672	I = 2.5903 A = -0.7102	
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	n/a n/a	
		50/50	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	MISE EN GARDE : Il n'y a pas de lignes directrices pour les durées d'efficacité	
au-dessous de -3 à -14	au-dessous de 27 à 7	100/0	I = 2.4942 A = -0.6588	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.5065 A = -0.6779	I = 2.6525 A = -0.7145		
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a		
au-dessous de -14 à -25	au-dessous de 7 à -13	100/0	I = 2.0589 A = -0.7941	I = 2.2336 A = -0.7565 B = 0.0000				

[1] Équation de régression : $t = 10^{I} R^{A}$, où R = taux de précipitation (g/dm²/h)

[2] Équation de régression : $t = 10^{I} R^{A} (2-T)^{B}$, où R = taux de précipitation (g/dm²/h) et T = température (en °C)

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
FAA	Federal Aviation Administration
LOUT	Lowest Operational Use Temperature
SAE	SAE International
TC	Transport Canada
TDC	Transportation Development Centre

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1. INTRODUCTION

1.1 Background

Determining holdover times for de/anti-icing fluids and developing guidelines for their use has been a focus of the Transport Canada (TC) ground icing research program since its inception. The Transport Canada Holdover Time Guidelines, which are published annually, provide pilots with tables of the protection times provided by de/anti-icing fluids in winter conditions. The values in the holdover time tables are developed by conducting regression analysis of flat-plate test data collected with de/anti-icing fluids.

Aircraft de/anti-icing fluid holdover time is a function of fluid dilution, precipitation rate, precipitation type and ambient temperature. Although the current methodology for determining holdover times enables values to be calculated at virtually any temperature and precipitation rate, it is neither practical nor feasible to include all of this information in the holdover time guidelines. Instead, holdover times are organized into tables that are divided into cells by precipitation type, temperature range, and fluid dilution. Within each cell, upper and lower values are given based on pre-determined lower and upper precipitation rate limits and the lowest temperature in the temperature range.

In recent years, several companies have been developing systems that measure temperature, precipitation type and precipitation rate in real-time. These systems can use this information together with the holdover time regression analysis information to calculate precise holdover times that can be relayed directly to the cockpit. Known as holdover time determination systems, these systems offer several advantages over the holdover time tables:

- Because values in the holdover time tables are calculated based on the lowest temperature in each temperature range and the highest precipitation rate in each precipitation category, users will be provided with longer holdover times in some conditions;

- Holdover time determination systems are more user-friendly: pilots are simply provided with a number and do not have to consult any tables; and

- The information provided by the systems enables pilots to make better fluid selection decisions. This is expected to increase the use of Type I fluid and decrease the use of Type IV fluid resulting in reduced cost and environmental impact.

1.2 Objectives

The objective of this project was to develop the regression coefficients for generic Type I and DOW UCAR EG106 Type IV holdover times for use with a holdover time determination system and to demonstrate that the resulting values generated by the holdover time determination system are in reasonable accord with the values in those fluids' published holdover time tables.

This report is a component of a more extensive document, *Regression Coefficients used to Develop Aircraft Ground Deicing Holdover Time Tables: Winter 2008-09* (draft title), which documents the regression coefficients and equations used to calculate the values in each holdover time table included in the winter 2008-09 holdover time guidelines. This current report has been prepared to expedite publication of the regression coefficients and equations required by one air carrier (Type I and Dow UCAR EG106) in the winter of 2007-08.

1.3 Requirement of Exemption Document to Use Data Provided in this Report

In order for a carrier to use the regression coefficients provided in this document in a holdover time determination system, a regulatory exemption from using the holdover time tables must be made to the carrier's approved Ground Icing Operations Program. This is accomplished through the issue of an exemption document that details the requirements of the regulator for accepting these regression coefficients. The carrier can then use the information in this report in conjunction with the exemption document.

The purpose of the exemption is to permit the carrier to utilise holdover time determination reports generated by holdover time determination systems in addition to or in lieu of their current holdover time procedures, as part of their approved Ground Icing Operations Program.

The exemption document provided by Transport Canada to one Canadian air carrier is included as Appendix A.

1.4 Report Format

The following list provides short descriptions of subsequent sections of this report:

- Section 2 describes the methodology used to determine holdover times;
- Section 3 presents the required regression coefficient data; and
- Section 4 presents conclusions.

1.4 Note on Frost

At this time, endurance time testing is not conducted in frost conditions. Holdover time tables contain generic values that are based on the high humidity endurance test described in Aerospace Standard (AS) 5901. A frost endurance time test is currently in development and therefore the protocol for determining holdover times in frost may change in the future. However, at this time regression coefficients and equations are not used in the determination of frost holdover times and therefore, no information related to frost is included in Section 2. The generic holdover times are included with the regression coefficient tables in Section 3.

1.5 Validity of Regression Coefficient Data for FAA Guidelines

The data in this report has been prepared for Transport Canada to be used in conjunction with the Transport Canada Holdover Time Guidelines. The Federal Aviation Association (FAA) publishes a separate set of guidelines for operators in the United States. Although for the most part the Transport Canada and FAA guidelines contain the same holdover time values, there are some differences. It is the responsibility of the user to ensure the appropriate application of the data provided in this report.

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2. METHODOLOGY FOR THE DETERMINATION OF HOLDOVER TIMES

The methodology used to determine holdover times for fluid-specific and generic holdover time tables is presented in this section. This information has been included to assist programmers to best apply the regression data provided in Section 3.

2.1 Background

Determining holdover times is one step in the fluid qualification process. The complete process for qualification of Type I, II, III and IV fluids is documented in SAE International (SAE) Aerospace Recommended Practice (ARP) 5718 (1).

There are two processes involved in determining holdover times: measuring endurance times and calculating holdover times.

2.2 Endurance Time Testing

Endurance time tests measure the amount of protection time de/anti-icing fluids offer against ice formation. These tests are carried out on flat plates in natural and simulated precipitation.

Test procedures to measure endurance times have evolved into a refined standard approach that has been followed since 1990. Since that time, endurance time testing for the purpose of developing holdover times has been conducted by APS Aviation Inc. (APS) on behalf of Transport Canada and FAA.

2.2.1 Freezing Precipitation

Freezing fog, freezing rain, light freezing drizzle and cold-soaked wing endurance time tests are conducted in simulated (laboratory) conditions. For each cell in the holdover time table, four tests are conducted at the lowest temperature in the temperature range for that cell: two tests are conducted at the low precipitation rate and two tests at the high precipitation rate for the precipitation type, for a total of four tests per cell.

The precipitation rate limits for freezing precipitation are as follows:[1]

- Freezing fog: 2 and 5 $g/dm^2/h$;
- Freezing drizzle: 5 and 13 $g/dm^2/h$;
- Light freezing rain: 13 and 25 $g/dm^2/h$; and
- Rain on cold-soaked wing: 5 and 75 $g/dm^2/h$.

2.2.2 Snow

Snow endurance time tests are conducted in natural conditions where temperature and precipitation rate cannot be controlled. Therefore, the protocol for measuring endurance times in snow is slightly different: tests are conducted in natural snow in a range of temperatures and precipitation rates.

The precipitation rate limits used in the holdover time guidelines for snow are as follows:[2]

- Very Light Snow:[3] 4 $g/dm^2/h$;
- Light Snow: 4 and 10 $g/dm^2/h$; and
- Moderate Snow: 10 and 25 $g/dm^2/h$.

2.3 Protocol for Calculating Fluid-Specific Holdover Times

Fluid-specific holdover times are calculated for all Type II, Type III and Type IV fluids submitted for holdover time testing. The Type II and Type IV fluid-specific holdover times are used to develop fluid-specific holdover time tables and to determine the values in the generic Type II and Type IV holdover time tables. The Type III fluid-specific holdover times are calculated to ensure new Type III fluids meet the minimum holdover times set in the generic Type III holdover time table.

The protocol for determining holdover times differs for freezing precipitation and for snow. The freezing precipitation protocol is described in Subsection 2.3.1; the snow protocol is described in Subsection 2.3.2.

[1] Significant research has gone into the selection of these values. See Subsection 2.9.1 of Transport Canada report TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (2).
[2] These definitions are not correlated to meteorological observations.
[3] While the Transport Canada guidelines define very light snow with a single precipitation rate limit (4 $g/dm^2/h$), the FAA guidelines include both a lower limit (3 $g/dm^2/h$) and upper limit (4 $g/dm^2/h$) for very light snow.

2.3.1 Freezing Precipitation Holdover Times

The following steps are used to calculate holdover times in freezing precipitation.

1. For each cell in a holdover table of the given fluid type, a best-fit power law curve is developed from the tests conducted at the low and high precipitation rate condition of that cell using regression analysis. The equation used to treat the data is $\mathbf{t = bR^a}$, where:
   - t = time (minutes);
   - R = rate of precipitation ($g/dm^2/h$); and
   - a, b = coefficients determined from the regression.

2. Holdover times are calculated for the low and high precipitation rate limits for each precipitation type (see Subsection 2.2.1) using the resulting regression equation.

3. For Type II and Type IV fluids, the regression-generated holdover times are subject to rounding rules:
   - Values are rounded to the nearest whole "5" digit. For example, 55.1 to 57.4 minutes is rounded down to 55 minutes; 57.5 to 59.9 minutes is rounded up to 60 minutes;
   - In cases where the regression-generated holdovers are below 10 minutes, the numbers are rounded down as a precautionary measure. For example, 9 minutes is rounded down to 5 minutes; and
   - Values are capped at 2 hours for all precipitation conditions except freezing fog, which are capped at 4 hours.

2.3.2 Snow Holdover Times

The following steps are used to calculate holdover times in snow.

1. The data is grouped by fluid dilution. The data set for each fluid dilution is subjected to a multi-variable regression analysis. The general form of the regression equation is $\mathbf{t = cR^a(2\text{-}T)^b}$, where:[4]
   - t = time (minutes);
   - R = rate of precipitation ($g/dm^2/h$);
   - T = temperature (°C); and
   - a, b, c = coefficients determined from the regression.

[4] This equation was modified by substituting 2-T for the variable T in order to prevent taking the log of a negative number, as natural snow can occur at temperatures approaching +2°C.

2. This results in one regression equation for each fluid dilution in snow. Holdover times are calculated for the precipitation limits of each cell by using the appropriate regression equation and the most restrictive (lowest) temperature for the cell.

3. For Type II and Type IV fluids, the regression-generated holdover times are subject to rounding rules:

   - Values are rounded to the nearest whole "5" digit. For example, 55.1 to 57.4 minutes is rounded down to 55 minutes; 57.5 to 59.9 minutes is rounded up to 60 minutes;
   - In cases where the regression-generated holdovers are below 10 minutes, the numbers are rounded down as a precautionary measure. For example, 9 minutes is rounded down to 5 minutes; and
   - Values are capped at 2 hours.

4. With the exception of Dow UCAR Ultra+, all Type II and Type IV fluids are given generic values in the "below -14 to -25°C snow cell". This decision was made following the winter of 2003-04, due to very limited endurance time data existing for most fluids at these temperatures.

2.4 Protocol for Calculating Generic Holdover Times

The protocol used to determine generic holdover time table values is unique to each fluid type.

2.4.1 Type I Generic Holdover Times

The values in the Type I generic holdover time table are static. This is largely because a significant body of previous research and testing has indicated that all Type I fluids formulated with glycol perform in a similar manner from an endurance time perspective. In fact, regulators no longer require the endurance times of Type I deicing fluids formulated with propylene glycol, ethylene glycol or diethylene glycol to be measured. Endurance times of fluids formulated with other glycol bases or with non-glycol bases are still measured to ensure their performance is similar to the values in the generic Type I table.

The freezing precipitation values in the Type I generic table were established in the early 1990s and substantiated by testing conducted up to and including the winter of 1995-96. One exception is the values in the "below -3 to -6°C" row, which were added to the Type I table in 2003-04. Testing was conducted with five Type I fluids in the winter of 2002-03 to determine appropriate values for the "below -3 to -6°C" row.[5] Type I freezing precipitation values were not established using regression analysis (though they have since been substantiated with regression analysis). Therefore, regression coefficients do not currently exist for the freezing precipitation values in the Type I table.

A new protocol for Type I testing in natural snow was established in the winter of 2001-02. Snow values in the Type I table were determined using the regression coefficients established by 2001-02 testing using the new protocol. These tests are documented in the TC report TP 13994E, *Generation of Holdover Times Using the New Type I Fluid Test Protocol* (3).

It should be noted that the FAA Type I generic holdover time table differs from the Transport Canada table in two places:

1. **Very Light Snow Cells**: The Transport Canada table provides one holdover time in each very light snow cell which is based on a rate of 4 $g/dm^2/h$; the FAA table provides two values in each cell based on rates of 3 and 4 $g/dm^2/h$.

2. **Freezing Rain *"-3°C and above"* and *"below -3 to -6°C"* Cells**: The Transport Canada table gives a holdover time range of 4 to 6 minutes; the FAA table gives a holdover time range of 2 to 5 mins. Both tables give 2 to 5 minutes as the holdover time range in the "below -6 to -10°C" cell.

2.4.2 Type II Generic Holdover Times

The values in the Type II generic holdover time table are generated by taking the shortest holdover times of all fluids on the list of qualified Type II fluids[6] (given as Table 5-2 in the Transport Canada Holdover Time Guidelines), including fluids with expired qualifications, and the values in the 1998-99 Type II generic table. The 1998-99 values are based on a "grandfathered fluid" data set, which consists of data from several fluids tested in several years.

The current protocol for determining Type II generic holdover times also dictates generic Type II values cannot be longer than generic Type IV values. Therefore, the fluids included in the Type IV analysis must also be included in the Type II analysis.

The generic Type II holdover time table is revised each year a new Type II fluid is added to and/or removed from the list of qualified fluids. Minor changes are made regularly.

[5] The selection of freezing precipitation values for the "below -3 to -6°C" row is documented in Transport Canada report TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter*, Subsection 8.4.2 (2).

[6] One fluid, Kilfrost ABC-3, is excluded from the analysis.

2.4.3 Type III Generic Holdover Times

Like the Type I generic holdover time table, the values in the Type III generic holdover time table are static. The values in the table have been fixed since they were established in the winters of 2004-05 (neat fluid) and 2005-06 (75/25 and 50/50 dilution fluids).

The values in the Type III generic guidelines are based on the endurance times of Clariant Safewing MP III 2031 ECO, which is currently the only qualified Type III fluid. The following protocol was used to obtain the generic values:

1. Endurance time tests were conducted with Clariant Safewing 2031;
2. Fluid-specific holdover times were calculated for Clariant Safewing 2031;
3. The fluid-specific values were reduced by 10 percent; and
4. Discretion was used to change the reduced values to relatively round values.

The reason the values were reduced and rounded is that regulators (Transport Canada and the FAA) did not want to produce fluid-specific tables for Type III fluids. By reducing the values, regulators established minimum holdover times applicable to any new Type III fluids submitted for testing.

It should be noted that the FAA Type I generic holdover time table differs from the Transport Canada table in the very light snow cells. The Transport Canada table provides one holdover time in each very light snow cell which is based on a rate of 4 $g/dm^2/h$; the FAA table provides two values in each cell based on rates of 3 and 4 $g/dm^2/h$.

2.4.4 Type IV Generic Holdover Times

The values in the Type IV generic holdover time table are generated by comparing the holdover time values of all fluids on the list of qualified Type IV fluids (given as Table 5-4 in the Transport Canada Holdover Time Guidelines), including fluids with expired qualifications. Unlike Type II fluid, grandfathered fluid data is not included in the analysis, except in the cold-soaked wing cells.

Each number in the generic Type IV holdover time table is evaluated individually. The shortest holdover time from fluids included in the analysis becomes the generic table. In many cases different fluids are responsible for the upper and lower values in a cell.

The generic Type IV holdover time table is revised each year any Type IV fluid is added or removed from the list of qualified fluids. Minor changes are made regularly.

3. DATA

The regression coefficients and equations required for the winter of 2007-08 are provided in this section.

3.1 Regression Coefficients Tables

The coefficients and equations required to calculate holdover times for Type I fluid and Dow UCAR EG106 Type IV fluid are provided in Table 3.1 and Table 3.2. The tables are provided in the same layout as the corresponding holdover time tables.

A footnote is provided at the top of each column in the tables to indicate the form of the regression equation for the cells in that column. The regression coefficients required for the equation are given in the corresponding cells below. The regression equations take one of two forms:

- $t = 10^I R^A$
- $t = 10^I R^A (2\text{-}T)^B$

The three regression coefficients are:

- I = intercept
- A = precipitation rate coefficient
- B = temperature coefficient

In addition, the following inputs are used in the equations:

- T = temperature (in °C)
- R = precipitation rate (in $g/dm^2/h$)

The resulting value of the equation is the holdover time:

- t = holdover time (in minutes)

The coefficients provided in each table cell are valid only for the conditions (temperature, precipitation type, fluid dilution) of that cell. In cells where no temperature coefficient (coefficient "B") is provided, temperature is not an input in the equation. The regression coefficients are derived using the lowest temperature in the temperature range of the cell and must be used for all temperatures in the cell.

As per the protocol described in Subsection 2.3.2, generic regression coefficients have been included in the "below -14 to -25°C" snow cell for Dow UCAR Endurance EG106.

Table 3.1: Generic Type I Regression Coefficients

Outside Air Temperature		Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions					
Degrees Celsius	Degrees Fahrenheit	Freezing Fog[1]	Snow or Snow Grains[2,3]	Freezing Drizzle[1]	Light Freezing Rain[1,4]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	I = 1.3735 A = -0.4751	I = 2.0072 A = -0.5752 B = -0.5585	I = 1.3829 A = -0.3848	I = 1.4688 A = -0.6200	I = 0.9355 A = -0.3384	
below -3 to -6	below 27 to 21	I = 1.2734 A = -0.5299		I = 1.3842 A = -0.6152	I = 1.4688 A = -0.6200	Caution: No holdover times exist	
below -6 to -10	below 21 to 14	I = 1.1678 A = -0.5575		I = 1.2545 A = -0.5857	I = 2.2598 A = -1.4012		
below -10	below 14	I = 1.1473 A = -0.6415					

[1] Regression Equation: $t = 10^I R^A$, where R = precipitation rate (g/dm²/h)
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = precipitation rate (g/dm²/h) and T = temperature (in °C)
[3] Snow values in the Type I holdover time table are rounded down to the nearest one minute (i.e. 6.2 mins = 6 mins, 5.9 mins = 5 mins) and therefore may differ slightly from the values calculated using these coefficients.
[4] These coefficients are valid for the Transport Canada table. For the FAA table, the "below -6 to -10" coefficients should also be used for "-3 and above" and "below -3 to -6".

Table 3.2: Dow UCAR Endurance EG106 Type IV 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	27 and above	100/0	I = 2.4198 A = -0.4664	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.4460 A = -0.5295	I = 2.5011 A = -0.5672	I = 2.5903 A = -0.7102	
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	n/a n/a	
		50/50	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a		
below -3 to -14	below 27 to 7	100/0	I = 2.4942 A = -0.6588	I = 2.8358 A = -0.7951 B = -0.1996	I = 2.5065 A = -0.6779	I = 2.6525 A = -0.7145	CAUTION: No holdover time guidelines exist	
		75/25	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a		
below -14 to -25	below 7 to -13	100/0	I = 2.0589 A = -0.7941	I = 2.2336 A = -0.7565 B = 0.0000				

[1] Regression Equation: $t = 10^I R^A$, where R = precipitation rate (g/dm²/h)
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = precipitation rate (g/dm²/h) and T = temperature (in °C)

3.2 Verification of Regression Coefficients

To verify the accuracy of the regression coefficients, the regression coefficients provided in Table 3.1 and Table 3.2 were used to calculate holdover time values for the boundary conditions for each cell in the associated holdover time table. The resulting values are shown in the verification Table 3.3 and Table 3.4. The values in the verification tables were compared with the corresponding holdover time table values, which are shown in Table 3.5 and Table 3.6. The values were comparable, thereby verifying the accuracy of the regression coefficients.

Table 3.3: Type I Generic Verification Table

Outside Air Temp. (°C)	**Holdover Times Under Various Weather Conditions (minutes)** *As Calculated from Regression Coefficients*										
	Freezing Fog ($g/dm^2/h$)		**Snow** ($g/dm^2/h$)			**Freezing Drizzle** ($g/dm^2/h$)		**Freezing Rain** ($g/dm^2/h$)		**Cold-Soaked Wing** ($g/dm^2/h$)	
	5	**2**	**25**	**10**	**4**	**13**	**5**	**25**	**13**	**75**	**5**
-3°C	11.0	17.0	6.5	11.0	18.6	9.0	13.0	4.0	6.0	2.0	5.0
-6°C	8.0	13.0	5.0	8.5	14.3	5.0	9.0	4.0	6.0		
-10°C	6.0	10.0	4.0	6.7	11.4	4.0	7.0	2.0	5.0		
-25°C	5.0	9.0	2.5	4.3	7.3						

Table 3.4: Dow UCAR Endurance EG106 Verification Table

Outside Air Temp. (°C)	**Fluid Dilution**	**Holdover Times Under Various Weather Conditions (minutes)** *As Calculated from Regression Coefficients*									
		Freezing Fog ($g/dm^2/h$)		**Snow** ($g/dm^2/h$)		**Freezing Drizzle** ($g/dm^2/h$)		**Freezing Rain** ($g/dm^2/h$)		**Cold-Soaked Wing** ($g/dm^2/h$)	
		5	**2**	**25**	**10**	**13**	**5**	**25**	**13**	**75**	**5**
-3°C	100/0	124.1	190.3	38.4	79.6	71.8	119.1	51.1	74.0	18.1	124.1
	75/25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	50/50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
-14°C*	100/0	108.1	197.6	30.5	63.1	56.4*	107.8*	45.0*	71.9*		
	75/25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
-25°C	100/0	31.9	66.0	15.0	30.0						

*Freezing drizzle and freezing rain values in this row calculated at -10°C

Table 3.5: Type I Generic Holdover Time Table

Outside Air Temperature		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
			Very Light	Light	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			

Table 3.6: Dow UCAR Endurance EG106 Holdover Time Table

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	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100/0	2:05 – 3:10	0:40 – 1:20	1:10 – 2:00	0:50 – 1:15	0:20 – 2:00
		75/25					CAUTION: No holdover time guidelines exist
		50/50					
below -3 to -14	below 27 to 7	100/0	1:50 – 3:20	0:30 – 1:05	0:55 – 1:50[3]	0:45 – 1:10[3]	
		75/25					
below -14 to -25	below 7 to -13	100/0	0:30 – 1:05	0:15 – 0:30			

3.3 Holdover Time Determination System Verification

The exemption document provided by Transport Canada to the air carrier which enables the carrier to use the information provided in this report (see Subsection 1.3, sample exemption document provided in Appendix A) stipulates the verification tables (Table 3.1 and Table 3.2) must be used to verify that the regression coefficients and equations have been correctly entered into the holdover time determination system. In addition, the exemption document stipulates the system must be input with variable values outside of the normal range of operations covered by the holdover time tables to ensure it provides proper outputs. For example, testing should be conducted to ensure holdover times are not provided where they do not exist, such as below -10°C in freezing drizzle, or below the lowest operational use temperature (LOUT) of the fluid.

3.4 Period of Data Validity

The regression coefficients contained in this report are valid for the winter 2007-08 operating season. As the holdover time tables are published on an annual basis and are subject to change each year, users of this data must obtain the regression coefficients from Transport Canada on an annual basis or verify that they have not changed from the previous winter operating season.

3.5 Data Limitations

One limitation of this data is that the regression equations for snow, which include a temperature coefficient, can not be populated with temperature data greater than or equal to 2°C. This is a limitation of the form of the equation.

A second limitation involves calculating holdover times outside of the precipitation rate limits used in the development of holdover time tables (see Subsection 2.2). These values are not necessarily accurate. The regression coefficients are based on best-fit power-law curves and the shape of these curves can result in extreme values outside the precipitation rate limits at which endurance time tests were conducted. This is illustrated in Figure 3.1.

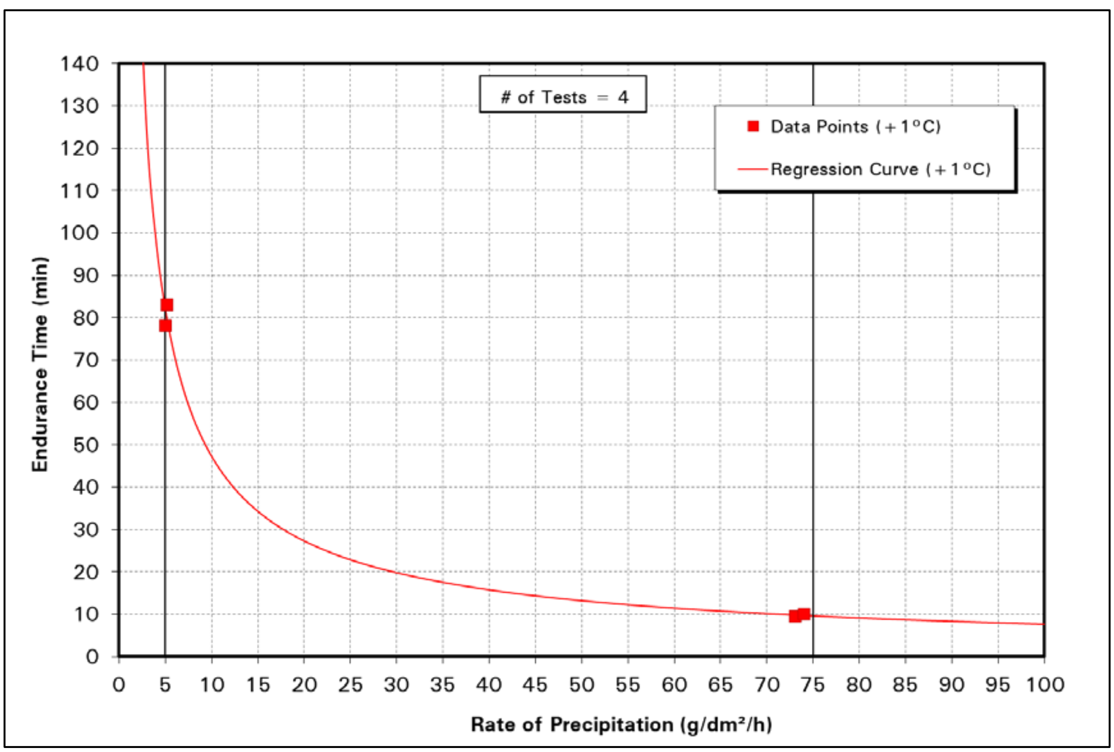

Figure 3.1: Sample Regression Curve – Cold-Soaked Wing

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4. CONCLUSIONS

The regression coefficients for Type I and Dow UCAR EG106 fluids are provided in this report and have been found to provide holdover time values equivalent to those in the holdover time tables. A carrier can use these regression coefficients in a holdover time determination system, provided it has received an exemption from using the holdover time tables from Transport Canada.

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REFERENCES

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

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

3. Alwaid, A., Dawson, P., Moc, N., *Generation of Holdover Times Using the New Type I Fluid Test Protocol,* APS Aviation Inc., Transportation Development Centre, Montreal, December 2002, TP 13994E, 106.

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APPENDIX A

WESTJET EXEMPTION FROM SUBSECTION 602.11(4) OF THE CANADIAN AVIATION REGULATIONS AND SECTIONS 1.0, 3.0, 6.0, 6.2, 6.3 AND 7.1.1.1 OF STANDARD 622.11
GROUND ICING OPERATIONS

Exemption from Subsection 602.11(4) of the *Canadian Aviation Regulations* and Sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11 *Ground Icing Operations*

WHEN A HOLDOVER TIME DETERMINATION REPORT (HOTDR), GENERATED BY A HOLDOVER TIME DETERMINATION SYSTEM (HOTDS) is being utilized as part of an approved Ground Icing Operations Program, pursuant to subsection 5.9(2) of the *Aeronautics Act*, and after taking into account that the exemption is in the public interest and is not likely to affect aviation safety, I hereby exempt **WestJet, 5055 11 Street NE, Calgary, Alberta, T2E 8N4, Canada,** from the requirements related explicitly to the element of Holdover Timetables (HOT) forming part of the Ground Icing Operations Program as stipulated in sections 1.0, 3.0, 6.0, 6.2, 6.3 and 7.1.1.1 of Standard 622.11, *Ground Icing Operations,* made pursuant to subsection 602.11(4) of the *Canadian Aviation Regulations* (CARs). The above provisions are attached at Appendix A to this exemption.

PURPOSE

The purpose of this exemption is to permit **WestJet**, to utilize HOTDR generated by a HOTDS, in addition to or in lieu of their current HOT procedures, as part of their approved Ground Icing Operations Program.

APPLICATION

This exemption applies to **WestJet** when using a HOTDR generated from a HOTDS as part of their approved Ground Icing Operations Program, at Canadian airports identified in the Program.

CONDITIONS

This exemption is subject to the following conditions:

1. When not utilizing the HOTDS, all requirements/elements of Standard 622.11 *Ground Icing Operations*, shall continue to apply as part of the approved Ground Icing Operations Program;

2. When utilizing the HOTDS, every requirement/element of Standard 622.11 *Ground Icing Operations*, not explicitly exempted from in, or not related to, this Ministerial exemption, including those stipulated in sections 1.0, 3.0, 6.0,

6.2, 6.3, 7.1.1.1, shall continue to apply as part of the approved Ground Icing Operations Program;

3. Prior to using the HOTDS, WestJet shall ensure that the HOTDS has been declared by the service provider and/or the manufacturer as applicable, to have met the applicable minimum performance specification attached at Appendix C to this exemption;

4. WestJet shall revise the Company Operations Manual (COM) to include operational procedures associated with the use of the HOTDS. The revised COM shall be approved by Transport Canada Civil Aviation prior to the utilization of the HOTDR;

5. WestJet shall have a contingency plan in the COM to address the possible outage of the HOTDS;

6. WestJet shall develop and provide a training program for their flight crew and operations personnel as approved by Transport Canada Civil Aviation on the use of the applicable HOTDS and associated reports;

7. When using a HOTDS (during active Freezing Fog, Rain on Cold Soaked Wing, Freezing Drizzle or Freezing Rain precipitation conditions) that outputs a single value Hold Over Time, the single value Hold Over Time shall be considered limiting. Under these conditions, take-off after the single value Hold Over Time is exceeded shall be prohibited unless an external tactile inspection is conducted and the aircraft is deemed acceptable for flight or the aircraft is re-deiced/anti-iced as required;

8. When using a HOTDS (during active snow precipitation conditions) that outputs a single value Hold Over Time, the single value Hold Over Time shall be considered limiting unless WestJet has identified acceptable procedures and inspections to ensure that contamination is not adhering to the critical surfaces;

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

10. WestJet shall identify in the COM, the airports where it intends on using a HOTDS for HOT decision-making information.

VALIDITY

This Exemption is valid until the earliest of the following:

(a) June 30, 2009, at 23:59 EDT;

(b) the date on which any of the conditions of this exemption is breached; or

(c) the date on which this exemption is cancelled, in writing, by the Minister of Transport, Infrastructure and Communities, where he is of the opinion that it is no longer in the public interest or that it is likely to affect aviation safety.

CANCELLATION

The exemption from subsection 602.11(4) and sections 1.0, 3.0, 6.0, 6.2 and 7.1.1.1 of Standard 622.11 of the *Canadian Aviation Regulations* issued to WestJet on March 30, 2007, at Ottawa, Ontario, Canada, by the Director Standards on behalf of the Minister of Transport, Infrastructure and Communities is hereby canceled because it is the opinion of the Minister that it is no longer in the public interest or is likely to affect aviation safety.

Dated at Ottawa, Ontario, Canada this 21st day of DEC 2007, on behalf of the **Minister of Transport, Infrastructure and Communities**.

Don Sherritt
Director Standards

APPENDIX A

Canadian Aviation Regulations

602.11(4)

(4) Where conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft, no person shall conduct or attempt to conduct a take-off in an aircraft unless

(a) for aircraft that are not operated under Subpart 5 of Part VII,

(i) the aircraft has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces, or

(ii) the operator has established an aircraft inspection program in accordance with the *Operating and Flight Rules Standards*, and the dispatch and take-off of the aircraft are in accordance with that program; and

(b) for aircraft that are operated under Subpart 5 of Part VII, the operator has established an aircraft inspection program in accordance with the *Operating and Flight Rules Standards*, and the dispatch and take-off of the aircraft are in accordance with that program.

622.11 Ground Icing Operations

1.0 Introduction

In order to operate an aircraft under icing conditions in accordance with the requirements of CAR Section 602.11, an operator must have a program as specified in these standards and the dispatch and take-off of the aircraft shall comply with that program. These Ground Icing Operations Standards specify the program elements, for both operations and training, that shall be addressed in an operator's Ground Icing Operations Program and described in the appropriate operator's manuals. As applied to Canadian operators, these Standards outline a Program's minimum requirements, which may be adapted according to the needs of the individual operator. Foreign operators should use this Standard as a guideline for the development of their Ground Icing Operations Program in Canada.

3.0 Program Elements

The following elements, which are described in the sections below, will be included in an operator's Ground Icing Operations Program and described in the appropriate manual(s):

- The Operator's Management Plan;
- Aircraft De-icing/Anti-icing Procedures;
- Holdover Timetables;
- Aircraft Inspection and Reporting Procedures; and
- Training and Testing.

6.0 Holdover Timetables

The use of holdover timetables is not mandatory. Holdover timetables, as approved by the Director, Air Carrier, may be used either as guidelines or decision-making criteria in assessing whether it is safe to take off. When holdover timetables are used as decision-making criteria, only high confidence level times shall be used and the procedures to be followed after holdover time has expired must be clearly documented. Where applicable in a Program, an operator's manual will cover the following areas with regard to holdover timetables:

6.2 Use of Holdover Timetables

Holdover timetables provide an estimate of the length of time de-icing/anti-icing fluids are effective. Because holdover time is influenced by a number of factors, established times may be adjusted by the pilot-in-command according to the weather or other conditions. Operators' manuals must describe the procedures to be followed for using holdover timetables. When the tables are used as decision-making criteria, the procedures to be followed by the pilot-in-command (PIC) for varying the established values must also be specified.

6.3 Take-off after Holdover Times Have Been Exceeded

When holdover timetables are used as decision-making criteria, take-off after holdover times have been exceeded can occur only if a pre-take-off contamination inspection is conducted or the aircraft is de-iced/anti-iced again. The operator's Program must specify the procedures to be followed when holdover time is exceeded, and these procedures must appear in the appropriate manuals.

Holdover timetables, approved according to the conditions outlined in section 6 of these Standards, may be used to determine, without a tactile or visual Pre-take-off Contamination Inspection, that critical surfaces are not contaminated.

APPENDIX B

DEFINITIONS

- **Anti-Icing Fluid** means a fluid applied to an aircraft as a precautionary procedure that provides protection against the formation of frost or ice and the accumulation of snow on treated surfaces of an aircraft for a period of time;
- **Deicing Fluid** means a fluid applied to an aircraft to remove contamination in the form of frost, ice or snow;
- **Glycol Pan Measurements** means a process to determine precipitation rate by using a glycol-wetted pan that is weighed precisely before and after a timed exposure to precipitation. This methodology has been included in SAE Aerospace Recommended Practice (ARP) 5485 and 5945, and has been historically employed by Transport Canada in the development of fluid holdover time tables for de/anti-icing fluids;
- **Holdover Time** means the determined time that an application of de/anti-icing fluid applied to an aircraft is nominally effective in preventing frost, ice or snow from adhering to the treated surfaces based on using Holdover timetables published by Transport Canada or based on a Holdover Time Determination System Report;
- **Holdover Time Determination System Report (HOTDR)** means a Holdover Time generated by a Holdover Time Determination System;
- **Holdover Time Determination System (HOTDS)** means a near real-time system that samples a number of atmospheric inputs and uses these in conjunction with HOT regression curves and associated coefficients for specific de/anti-icing fluids to produce a holdover time determination report;
- **Holdover Timetables** means tables of holdover times for de/anti-icing fluids published as Holdover Time (HOT) Guidelines, by Transport Canada;
- **LOUT** means Lowest Operational Use Temperature;
- **Manufacturer** means the producer of a Holdover Time Determination System;
- **Regression Analysis** means a data analysis protocol used by Transport Canada to analyze fluid endurance time data for the generation of holdover times for de/anti-icing fluids; and
- **Service Provider**, in this context, means a person or organization that:
    1. provides holdover time reports using a Holdover Time Determination System that meets the application of this exemption; or

2. provides precipitation rate, type and temperature information for use by a Holdover Time Determination System in computing Holdover Time Determination System reports that meet the application of this exemption.

APPENDIX C

MINIMUM ASSURANCE REQUIREMENTS AND PERFORMANCE SPECIFICATIONS FOR HOLDOVER TIME DETERMINATION SYSTEMS

Sections 1, 2 and 3 of this appendix specify the minimum assurance requirements and sections 4 and 5 the minimum performance specifications for the Holdover Time Determination Systems.

In this document, the "Air Operator" means **WestJet.**

1. QUALITY MANAGEMENT SYSTEM

1.1 The Air Operator shall ensure that the service provider or manufacturer, establish, document, implement and maintain a quality management system that comprises procedures, processes and resources necessary to provide for the quality management of the Holdover Time Determination System and reports to be supplied.

1.2 The quality management system required by Subsection 1.1 shall at a minimum:

a) Establish and maintain operational manuals and documentation;

b) Establish and maintain system commissioning protocols;

c) Establish and maintain system inspection requirements and methods;

d) Establish quality control and quality monitoring to include software integrity and data dissemination;

e) Specify qualifications and training requirements for personnel who commission, inspect or maintain the system; and

f) If non-conformance is identified, ensure that action is initiated to determine and correct the cause.

1.3 The documentation in Subsection 1.2 shall be made available to the Minister, upon reasonable notice by the Minister.

2. TRAINING AND QUALIFICATIONS

2.1 The Air Operator shall ensure and document that the manufacturer or service provider maintains records to demonstrate that all persons providing installation, commissioning, inspection and maintenance services of a Holdover Time Determination System are qualified persons who have received appropriate training and have demonstrated sufficient knowledge, skills and competence to perform their assigned duties.

Note: The Air Operator shall ensure and document that the manufacturer or service provider has specified the minimum training requirements applicable to persons engaged in these duties.

2.2 The Air Operator shall make a copy of the documentation referenced in 2.1 available to the Minister, upon reasonable notice by the Minister.

3. INSTALLATION, SITING, OPERATION AND MAINTENANCE OF DEICING AND ANTI-ICING FLUID HOLDOVER TIME DETERMINATION SYSTEMS

3.1 The Air Operator shall ensure that the service provider or manufacturer as applicable, has established and followed practices, procedures and specifications for the siting, installation, commissioning, operation and maintenance of the Holdover Time Determination Systems, including the co-ordination of activities with the aerodrome operator.

Note: Specifications concerning the siting and installation of equipment on aerodromes are contained in TP312, Aerodrome Standards and Recommended Practices.

3.2 The input instruments shall be sited in sufficient proximity of each other to provide coherent sampling of meteorological inputs for holdover time determination in transitional weather conditions.

3.3 The Air Operator shall document the requirements of Subsection 3.1 and make a copy available to the Minister, upon reasonable notice by the Minister.

4. ACCURACY OF HOLDOVER TIME INPUT INSTRUMENTS AND DETERMINATION SYSTEMS

4.1 The Air Operator shall verify that the manufacturer obtains test data and establish practices and procedures that demonstrate that the data inputs and

Holdover Time Determinations meet the accuracy requirements established for each element.

4.2 The Air Operator shall make the documentation required by Subsection 4.1 available to the Minister, upon reasonable notice by the Minister.

4.3 The Air Operator shall verify that the manufacturer has test data that demonstrates compliance of the data inputs and Holdover Time Determinations with Subsection 4.1 in accordance with the following requirements:

a) The test data shall be sufficiently complete to assure that the results are representative of the design and performance specifications of the system and include the following:

i. For those instruments for which it is practical, the relationship between the value indicated by an instrument and the corresponding known value of a measure and;
ii. The testing of instruments over a range that is representative of the expected environmental conditions (regardless of whether in a controlled environment or in the field); and
iii. Testing of instruments in comparison with other instruments or human observations, in the outdoor operational environment, where practical.

b) The test data shall consist of the following:

i. Raw data collected during testing, and
ii. The results of the reduction and analysis of the data.

c) The Air Operator shall verify that the person verifying the test data in accordance with paragraph (d) confirms that the results of the reduction and analysis of the test data demonstrate that the data inputs and Holdover Time Determinations meet the accuracy requirements set out in this Appendix under operational conditions encountered by the Holdover Time Determination System.

d) The Air Operator shall confirm that the manufacturer's test data have been verified as meeting the accuracy requirements of this Appendix by a person who is:

i. Independent from the manufacturer of the Holdover Time Determination System and from the service provider and has a degree in the natural or applied sciences of mathematics from a recognized university and experience in: instrumental references, standards and traceability, methods of statistical analysis and an understanding of the operating principles and use of the instruments involved; or

ii. A licensed professional engineer (P.Eng) in Canada.

e) The Air Operator shall verify that the manufacturer obtains a written confirmation of the verification of the test data from the person who verified the test data pursuant to paragraph (d) and shall, upon reasonable notice by the Minister, provide a copy to the Minister.

f) The Air Operator shall ensure that the manufacturer demonstrates and confirms that the HOTDS has built-in fault detection checks that, in the event of system input/output failure (such as loss of an input instrument or corruption of data in a HOTDR) or other critical system hardware or software failure, prevent a misleading report from being issued. Demonstration shall be carried out on an end-to-end basis from input instruments in the field to delivery of Holdover Time Determination System Reports to the Air Operator.

g) The Air Operator shall ensure that the manufacturer demonstrates initial and ensures ongoing quality assurance of the computational software, hardware and end to end data integrity as follows:

   i. The software must be designed, developed, produced and maintained in accordance with appropriate software assurance standards.

   ii. The hardware must be designed, developed, produced and maintained in accordance with appropriate hardware assurance standards.

   iii. End-to-end data integrity shall include means of minimizing misleading data caused by all sources (ex: corrupted fluid coefficients, corrupted data transmissions, etc.) through the use of CRC checks or similar safeguards.

h) The Air Operator shall ensure that the manufacturer confirms that the accuracy of the timing methods or device used to establish the time of the report is sufficient for the intended purpose.

i) The Air Operator shall ensure that the manufacturer documents the processes and procedures used to comply with the requirements of paragraphs (a) and (h) and shall make them available to the Minister, upon reasonable notice by the Minister.

5. TECHNICAL REQUIREMENTS FOR DATA INPUTS AND HOLDOVER TIME DETERMINATIONS

5.1 The Air Operator shall ensure that the manufacturer establishes and document practices and procedures for compliance with the provisions of Subsections 5.1.1 thru 5.1.23, which are applicable to the manufacturer's Holdover Time Determination System, and make a copy available to the Minister, upon reasonable notice by the Minister.

Wind

5.1.1 If required by the HOTDS, surface wind data inputs shall meet the following requirements:

a) Wind instruments shall be ice resistant by design;

b) The instruments shall be sited so as to provide representative input to any compensation factors that are generated to correct precipitation accumulation rates during high wind conditions; and

c) The instruments shall function for winds of at least 100 knots.

5.1.2 The accuracy of wind sensors and outputs shall be such that;

a) The direction, if utilized, is correctly measured within ± 10 degrees; and

b) The mean speed is correctly measured within ± 2 knots up to 20 knots and with 10% above 20 knots.

5.1.3 The accuracy of the wind instruments shall be established in accordance with Subsection 5.1.2, paragraphs (a) and (b), to at least a 95% confidence in wind tunnel testing.

Precipitation

5.1.4 Systems used for the determination of precipitation shall:

a) Meet or exceed accuracy requirements as follows with reference to human observations:

   i. Correctly detect the presence of precipitation of a water equivalent rate of at least 2.0 $g/dm^2/h$, other than drizzle, at least 90% of the time;
   ii. Correctly detect the presence of and distinguish between liquid or frozen precipitation, of a water equivalent rate of at least 2.0 $g/dm^2/h$, at least 80% of the time; and
   iii. Correctly detect the presence of ice accretion or freezing precipitation, of at least 2.0 $g/dm^2/h$, with at least a 90% probability.

b) Except as addressed in accordance with (c), differentiate between and, where applicable determine the intensity of rain, freezing rain freezing drizzle and snow;

c) Accurately detect the presence of fog or freezing fog conditions;

d) Indicate that type of precipitation is "unknown", if the type cannot be determined; and

e) In the event of unknown precipitation, the equipment shall report that a holdover time is unavailable.

Temperature

5.1.5 Temperature measurements shall be accurate to within 1°C.

5.1.6 The accuracy requirements of Subsection 5.1.5 shall be demonstrated with at least a 95% confidence level during laboratory testing that is traceable to a reference standard.

Precipitation Rate

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

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

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

5.1.9 The accuracy requirements of Subsection 5.1.8 shall be demonstrated with at least a 95% confidence level during comparative tests with the HOTDS and glycol pans.

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

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

5.1.11 Notwithstanding section 5.1.10, the precipitation rate input for the purpose of computing fluid holdover time (Subsections 5.1.12 to 5.1.18) shall not be less than 2.0 $g/dm^2/h$.

Holdover Time Determinations

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

5.1.12.1 those obtained from or published by TC; or
5.1.12.2 those where traceability and validity has be demonstrated to be equivalent to those in 5.1.12.1.

5.1.13 Holdover Time Determinations from the system for all de/anti-icing fluids shall be computed using the regression curves and associated coefficients referenced in 5.1.12.

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

As a minimum this verification will include:

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

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

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

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

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

5.1.19 In accordance with the currently accepted practice for HOT table development, Holdover Time Determinations from the system for Type II and IV de/anti-icing fluids shall be capped as follows:

Freezing Fog	4 hrs;
Snow	2 hrs;
Freezing Drizzle	2 hrs;
Light Freezing Rain	2 hrs;
Rain on Cold Soaked Wing	2 hrs.

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

Holdover Time Determination Reports

5.1.21 A Holdover Time Determination Report shall contain as a minimum de/anti-icing Holdover Time(s) and fluid type. The report may contain additional items such as:

a) Precipitation type;

b) Precipitation intensity;

c) Precipitation trend; and

d) Fluid brand.

These additional items shall be as agreed to with the service provider and/or the aircraft operator.

5.1.22 The service provider shall retain a copy of each Holdover Time Determination Report for at least 24 months.

5.1.23 The service provider shall provide a copy of the Holdover Time Determination Reports required by 5.1.21 to the Minister, upon ***reasonable notice by the Minister.***