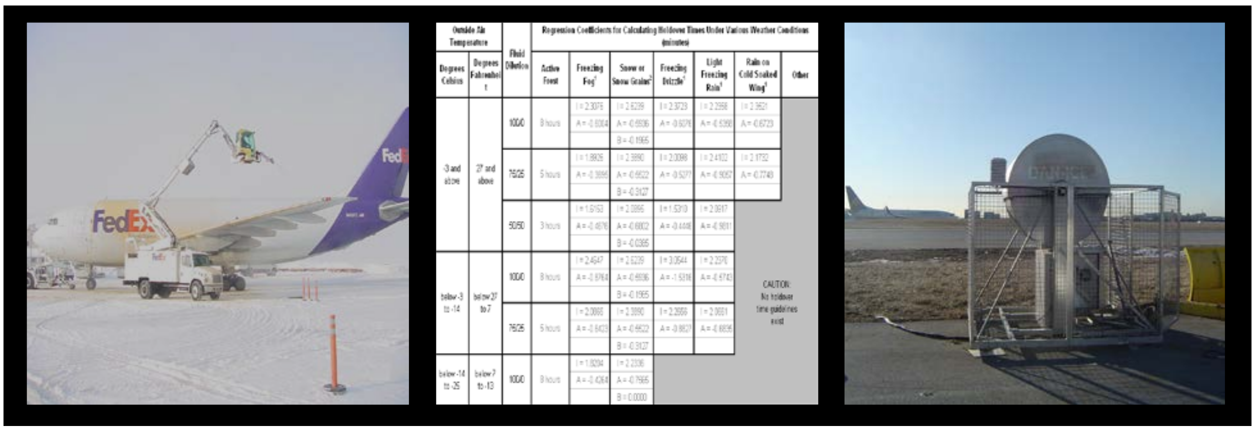
TP 14873E

Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables



Prepared for
Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

And

The Federal Aviation Administration
William J. Hughes Technical Center

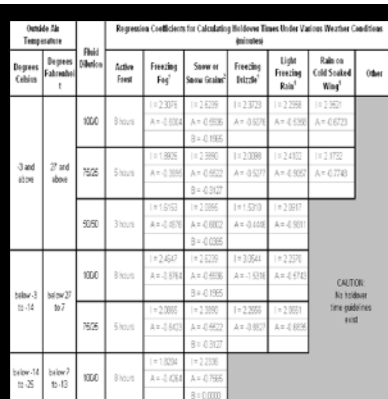
Prepared by

APS Aviation Inc.

December 2008
Final Version 1.0

TP 14873E

Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables



Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Fluid Dilution	Active Frost	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	8 hours	I = 2.3076 A = -0.5004	I = 2.6239 A = -0.5936 B = -0.1965	I = 2.3723 A = -0.6076	I = 2.2958 A = -0.5398	I = 2.3621 A = -0.6723	
		75/25	5 hours	I = 1.8926 A = -0.3896	I = 2.3890 A = -0.4922 B = -0.3127	I = 2.0098 A = -0.5277	I = 2.4102 A = -0.9067	I = 2.1732 A = -0.7749	
		50/50	3 hours	I = 1.6153 A = -0.4676	I = 2.0895 A = -0.6002 B = -0.0385	I = 1.5310 A = -0.4448	I = 2.0917 A = -0.9811		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.4647 A = -0.5764	I = 2.6239 A = -0.5936 B = -0.1965	I = 3.0544 A = -1.5316	I = 2.2370 A = -0.4743	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.0066 A = -0.6423	I = 2.3890 A = -0.4922 B = -0.3127	I = 2.2656 A = -0.8827	I = 2.0681 A = -0.6836		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8204 A = -0.4268	I = 2.2306 A = -0.7565 B = 0.0000				

Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions (minutes)

by

Stephanie Bendickson

Prepared by

APS Aviation Inc.

December 2008
Final Version 1.0

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

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

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:

	_______________________	September 13, 2018
	Stephanie Bendickson Project Analyst	Date

Reviewed by:

	_______________________	September 13, 2018
	John D'Avirro Program Manager	Date

Approved by: **

	_______________________	_______________
	Jack Rigley, P. Eng. 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 December 2008.
It has been published as Final Version 1.0 in September 2018.

***Final Draft 1.0 of this report was signed and provided to Transport Canada in December 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 examine the effect of heated fluids on Type II, III and IV fluid endurance times;
- To evaluate weather data from previous winters that can have an impact on the holdover time table format;
- To assist in the testing of flow of contaminated fluid from aircraft wings during takeoff;
- To validate the laboratory snow test protocol with Type I, II, III and IV fluids;
- To develop performance specifications for an integrated weather system that measures holdover time;
- To conduct general and exploratory de/anti-icing research;
- To conduct endurance time tests on non-aluminum plates;
- To conduct endurance time tests in frost on various test surfaces;
- To compile historical data for calculation of holdover times based on a small number of inputs; and
- To assist DND Canada in evaluating the standards used at various DND sites.

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

- TP 14869E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter;
- TP 14870E Winter Weather Impact on Holdover Time Table Format (1995-2008);
- TP 14871E Aircraft Trials to Examine Anti-Icing Fluid Flow-Off Characteristics: Ice Pellet Allowance Time Expansion Research;
- TP 14872E Aircraft Ground Icing General Research Activities During the 2007-08 Winter;
- TP 14873E Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables; and
- TP 14874E Effect of Heat on Endurance Times of Anti-Icing Fluids – Volumes 1 to 2.

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

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

- *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions.*

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

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

This report, TP 14873E, has the following objective:

- To document the regression information required for the winter 2008-09 aircraft ground deicing holdover time tables and to document how and from where the information was obtained.

This objective was met by analyzing data from holdover time testing conducted from the winters of 1996-97 to 2007-08.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Civil Aviation Group, Transport Canada with support from the Federal Aviation Administration, William J. Hughes Technical Center, Atlantic City, NJ. This program could not have been accomplished without the participation of many organizations. APS 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, Michael Chaput, John D'Avirro, Peter Dawson, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Dany Posteraro, Marco Ruggi, Filippo Suriano, Joey Tiano, David Youssef and Victoria Zoitakis.

Special thanks are extended to Barry Myers, Doug Ingold, 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.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 14873E	2. Project No. B14W	3. Recipient's Catalogue No.
4. Title and Subtitle Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables		5. Publication Date December 2008 6. Performing Organization Document No. CM2103.001
7. Author(s) Stephanie Bendickson		8. Transport Canada File No. 2450-BP-14
9. Performing Organization Name and Address APS Aviation Inc. 6700 Cote-de-Liesse, Suite 102 Montreal, Quebec, H4T 2B5		10. PWGSC File No. TOR-4-37170 11. PWGSC or Transport Canada Contract No. T8156-140243/001/TOR
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) Transport Canada 330 Sparks St., 25th Floor Ottawa, Ontario, K1A 0N5		13. Type of Publication and Period Covered Final 14. Project Officer Antoine Lacroix for Barry Myers

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). Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. This project was co-sponsored by the Federal Aviation Administration.

16. Abstract

The development of holdover time determination systems (HOTDS) has made it necessary that Transport Canada publish regression coefficient and equation information related to fluid holdover times.

This report documents the regression coefficients and equations relevant to the 2008-09 Transport Canada Holdover Time Guidelines. Regression coefficient tables are provided for all fluids for which fluid-specific holdover time tables were published in the 2008-09 Transport Canada Holdover Time Guidelines, for all other data used in the calculation of the values in the generic Type II and Type IV tables, for the only qualified Type III fluid, and for the generic Type I holdover time table.

Due to the dynamic nature of the holdover time tables, the information contained in this report needs to be updated and published on an annual basis.

17. Key Words Anti-icing, deicing, deicing fluid, holdover times, precipitation, endurance times, Type I, Type II, Type III, Type IV, aircraft, ground, test, winter, regression, holdover time determination system	18. Distribution Statement Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified		xiv, 44 apps	—

CDT/TDC 79-005
Rev. 96

Canada

Transports Canada | Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. Nº de la publication de Transports Canada TP 14873E	2. Nº de l'étude B14W	3. Nº de catalogue du destinataire
4. Titre et sous-titre Regression Coefficients and Equations Used to Develop the Winter 2008-09 Aircraft Ground Deicing Holdover Time Tables		5. Date de la publication Décember 2008 6. Nº de document de l'organisme exécutant CM2103.001
7. Auteur(s) Stephanie Bendickson		8. Nº de dossier - Transports Canada 2450-BP-14
9. Nom et adresse de l'organisme exécutant APS Aviation Inc. 6700, Chemin de la Côte-de-Liesse, Bureau 102 Montréal (Québec) H4T 2B5		10. Nº de dossier - TPSGC TOR-4-37170 11. Nº de contrat - TPSGC ou Transports Canada T8156-140243/001/TOR
12. Nom et adresse de l'organisme parrain Centre de développement des transports (CDT) Transport Canada 330 rue Sparks, 25e étage Ottawa (Ontario) K1A 0N5		13. Genre de publication et période visée Final 14. Agent de projet Antoine Lacroix pour Barry Myers

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). Plusieurs rapports ont été produits dans le cadre du programme de recherche de cet hiver. Leur objet apparait à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

L'élaboration de systèmes de détermination de durées d'efficacité (HOTDS) a rendu nécessaire la publication par Transports Canada d'information sur les coefficients de régression et les équations liée aux durées d'efficacité des liquides.

Le présent rapport documente les coefficients de régression et les équations applicables aux lignes directrices de Transports Canada sur les durées d'efficacité pour 2008-2009. Des tableaux de coefficients de régression sont fournis pour tous les liquides pour lesquels des tableaux de durées d'efficacité spécifiques ont été publiés dans les lignes directrices de Transports Canada sur les durées d'efficacité pour 2008-2009, pour toutes les autres données utilisées dans le calcul des valeurs des tableaux de liquides génériques de types II et IV, pour le seul liquide de type III affecté, ainsi que pour le tableau des durées d'efficacité des liquides génériques de type I.

En raison du caractère dynamique des tableaux de durées d'efficacité, l'information contenue dans le présent rapport doit être actualisée et publiée annuellement.

17. Mots clés Antigivrage, dégivrage, liquide de dégivrage, durées d'efficacité, précipitation, temps d'endurance, Type I, Type II, Type III, Type IV, aéronef, sol, essai, hiver, régression, systèmes de détermination de durées d'efficacité	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

19. Classification de sécurité (de cette publication) Non classifiée	20. Classification de sécurité (de cette page) Non classifiée	21. Déclassification (date)	22. Nombre de pages xiv, 44 ann.	23. Prix —

CDT/TDC 79-005
Rev. 96

Canada

EXECUTIVE SUMMARY

Over the past several years, several companies have been developing holdover time determination systems (HOTDS). These systems use real-time meteorological measurements in conjunction with the data underlying the holdover time tables to provide precise holdover times directly to pilots in the cockpit. The development of these systems has made it necessary that Transport Canada publish regression coefficient and equation information related to fluid holdover times.

This report documents the regression coefficients and equations relevant to the 2008-09 Transport Canada Holdover Time Guidelines. Data collection was somewhat complex due to the number of fluids involved, the de-archiving process, the existence of multiple data sets for many fluids, and the fact that in some cases values in the holdover time tables are not derived directly from regression analysis. This majority of this work took place during the winter of 2006-07; further analysis was completed during the winter of 2007-08.

Regression coefficient tables were compiled for all fluids for which fluid-specific holdover time tables were published in the 2008-09 Transport Canada Holdover Time Guidelines, and for all other data used in the calculation of the values in the generic Type II and Type IV tables. Regression coefficient tables were also compiled for the only qualified Type III fluid, and for the generic Type I holdover time table.

Verification tables were developed for each regression coefficient table to ensure the accuracy of the data published in this report. HOTDS manufacturers may find it useful to use these verification tables as an aid in verifying the implementation of their software algorithms. However, HOTDS manufacturers are cautioned that these tables are not all encompassing and that they must develop comprehensive verification and validation methods to ensure the adequacy of their software algorithms.

Due to the critical nature of the data contained in this report, it was first published as an interim report in December 2007. Further analysis completed over the winter of 2007-08 led to this final version of the report. It should be noted that due to the dynamic nature of the holdover time tables, the information contained in this report will need to be updated and published on an annual basis.

SOMMAIRE

Depuis de nombreuses années, plusieurs entreprises élaborent des systèmes de détermination des durées d'efficacité (HOTDS). Ces systèmes utilisent des mesures météorologiques en temps réel conjointement avec les données des tableaux de durées d'efficacité, pour donner aux pilotes des durées d'efficacité précises directement au poste de pilotage. L'élaboration de ces systèmes a rendu nécessaire la publication par Transports Canada d'information sur les coefficients de régression et l'équation en lien avec les durées d'efficacité des liquides.

Le présent rapport documente les coefficients de régression et les équations applicables aux lignes directrices de Transports Canada sur les durées d'efficacité pour 2008-2009. La collecte de données s'est avérée plutôt complexe en raison de la quantité de liquides affectés, du processus de classement, de l'existence de nombreux ensembles de données pour plusieurs liquides et du fait que, dans certains cas, les valeurs des tableaux de durées d'efficacité ne découlent pas directement de l'analyse de régression. La majorité des travaux a été tenue au cours de l'hiver 2006-2007 et une analyse plus approfondie a été tenue au cours de l'hiver 2007-08.

Des tableaux de coefficient de régression ont été dressés pour tous les liquides pour lesquels des tableaux de durées d'efficacité spécifiques aux liquides ont été publiés dans les lignes directrices de Transports Canada pour 2008-2009, ainsi que pour toutes les autres données utilisées pour le calcul des valeurs des tableaux de liquides génériques de types II et IV. Des tableaux de coefficients de régression ont également été dressés pour le seul liquide de type III affecté, ainsi que pour le tableau de durées d'efficacité pour les liquides génériques de type I.

Des tableaux de vérification ont été élaborés pour chaque tableau de coefficient de régression, afin d'assurer l'exactitude des données publiées dans ce rapport. Les fabricants de HOTDS pourraient apprécier l'utilisation de ces tableaux de vérification, en guise d'outil pour vérifier la mise en œuvre de leurs algorithmes logiciels. Cependant, les fabricants de HOTDS sont avisés que ces tableaux ne sont pas exhaustifs et qu'ils doivent mettre en place des méthodes complètes de vérification et de validation pour assurer la justesse de leurs algorithmes logiciels.

En raison du caractère critique des données de ce rapport, il a d'abord été publié en décembre 2007 comme rapport intérimaire. L'analyse plus approfondie effectuée au cours de l'hiver 2007-2008 a mené à la version finale du présent rapport. Il faut souligner qu'en raison de la nature dynamique des tableaux de durées d'efficacité, l'information contenue dans le présent rapport devra être actualisée et publiée annuellement.

CONTENTS Page

LIST OF APPENDICES

LIST OF TABLES **Page**

LIST OF FIGURES **Page**

This page intentionally left blank.

GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CAR	Canadian Aviation Regulation
FAA	Federal Aviation Administration
HOTDS	Holdover Time Determination Systems
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
SAE	SAE International
TC	Transport Canada
TDC	Transportation Development Centre

This page intentionally left blank.

1. INTRODUCTION

For more than a decade, the Transportation Development Centre (TDC), Transport Canada (TC) has managed and conducted research related to aircraft ground operations under winter precipitation conditions. The objective of the research program is to reduce the risks inherent in taking off in hazardous winter weather, particularly in snow, freezing precipitation, and following overnight frost conditions. As part of this program, TDC has undertaken research at various sites in Canada and has coordinated worldwide testing. Research has been conducted 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 de/anti-icing fluid manufacturers.

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 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 of these cells, upper and lower values are given based on predetermined 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, called holdover time determination systems (HOTDS), use the information they measure together with holdover time regression information to calculate more specific holdover times which can be relayed directly to the cockpit. There are several advantages gained by using HOTDS in place of the traditional holdover time tables:

1. **Extended Holdover Times**: Because holdover time table values are calculated based on the lowest temperature in each temperature range and the highest

precipitation rate in each precipitation category, and HOTDS can calculate values at any temperature or precipitation rate, users may be provided with longer holdover times in some conditions;

2. **Ease of Use:** HOTDS are more user-friendly than holdover time tables as pilots can be provided simply with a holdover time; pilots do not have to determine the holdover time themselves by looking up specific weather conditions in the appropriate holdover time table; and

3. **Environmental and Cost Savings:** The information provided by HOTDS enables pilots to make better fluid selection decisions. This is forecast to increase the use of Type I fluid and decrease the use of Type IV fluid, potentially resulting in cost and environmental savings.

1.2 Purpose

Transport Canada has supported the development of HOTDS and has taken an active role in developing regulations for HOTDS acceptance and use in Canada.

The HOTDS uses three meteorological inputs (precipitation type, temperature and precipitation intensity) to provide a single-value holdover time for any de/anti-icing fluid in measured conditions. Although the system employs meteorological inputs in the computation of holdover times, Transport Canada was of the opinion that the primary HOTDS output was an operational aviation tool for flight crew use in ground icing operations, and therefore pertained to Canadian Aviation Regulation (CAR) 622.11.

The short-term methodology employed by TC to implement the use of HOTDS outputs in Canadian air operations consisted of:

- Developing a specification defining the minimum quality assurance and performance requirements for HOTDS; and
- Developing an air carrier exemption from CAR 622.11 for the operational use of the holdover time information provided by the HOTDS.

An exemption was developed by TC for WestJet. The exemption document includes the performance standard as an appendix. The performance standard includes:

- Minimum assurance requirements (quality management system; training and qualifications; installation, siting, operation and maintenance); and
- Minimum performance specifications (system accuracy; technical requirements for data inputs and holdover time determinations for the HOTDS).

In order for HOTDS to produce holdover times, the regression equations and coefficients used to calculate the values in the currently published holdover time tables are required. As indicated in the excerpt from the exemption provided below, the regression information must be provided by Transport Canada or an equally valid source.

> *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 Transport Canada, 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.*

1.3 Objectives

The objective of this report is to document the regression coefficients and equations used to calculate the holdover times provided in the winter 2008-09 holdover time guidelines.

The detailed objectives of this project are provided in an excerpt from the Transport Canada statement of work, which has been provided in 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 data collection methodology;
- Section 4 presents the regression coefficient data;
- Section 5 presents conclusions derived from the analysis; and
- Section 6 lists recommendations for future work.

1.5 Note on Frost

Holdover time tables currently contain generic values for frost that are based on limited tests and operational experience. Research and development efforts, including substantiation of the current values, are ongoing.

As regression coefficients and equations are not currently used in the determination of frost holdover times, no information related to frost is required or included in Sections 2 and 3 of this report. The generic frost holdover times are provided in the regression coefficient tables in Section 4.

1.6 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 FAA publishes a separate set of guidelines for operators in the United States. For the most part, the Transport Canada and FAA guidelines contain the same holdover time values; however, there are several minor differences in the Type I and Type III generic holdover time tables. These differences are noted in Subsections 2.4.1 and 2.4.3, and in a footnote provided in the affected regression coefficients table in Section 4. It is the responsibility of the user to ensure the appropriate application of the data provided in this report.

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 is necessary to enable holdover time determination system programmers to properly apply the regression coefficient data presented in the next chapter.

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 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 the 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 are conducted 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 can not 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 calculating 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 holdover time 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 $\mathbf{t = 10^{I} R^{A}}$, where:

   - t = time (minutes);
   - R = rate of precipitation ($g/dm^2/h$); and
   - I, A = 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 holdover times are below 10 minutes, the numbers are rounded down as a precautionary measure. For example, 9 minutes is rounded down to 5 minutes;
   - Freezing drizzle, freezing rain, and rain on cold-soaked wing values are capped at 2 hours; and
   - Freezing fog values 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 $\mathbf{t = 10^{I} R^{A} (2-T)^{B}}$, where:

   - t = time (minutes);
   - R = rate of precipitation ($g/dm^2/h$);
   - T = temperature (°C); and
   - I, A, B = coefficients determined from the regression.

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
   - Snow 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 test 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 due to the significant body of research and testing that indicates 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 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 generic table in the winter of 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.[4] 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 conducting Type I tests in natural snow was established in the winter of 2001-02. Testing was conducted that winter with the new test protocol and a number of Type I fluids.[5] Regression analysis was conducted on the data collected to produce the snow values that have been in the Type I generic table since the winter of 2002-03.

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. **Light 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 minutes.

2.4.2 Type II Generic Holdover Times

Prior to the winter of 1998-99, holdover time data points were collected with all qualified Type II fluids and amalgamated into one Type II fluid data set. The data set was used to determine appropriate holdover times for the generic Type II guidelines. Fluid-specific guidelines did not exist, and regression analysis was not used in the calculation of holdover times.

Starting in the winter of 1998-99, holdover time data was collected with each Type II fluid submitted for testing under the complete set of conditions in the holdover time guidelines (with the exception of frost, see Subsection 1.5). Regression analysis was applied to each individual fluid data set; this analysis enabled publication of the first fluid-specific Type II guidelines.

Fluid-specific guidelines were never produced for fluids not tested after this protocol was introduced. However, these pre-1998-99 tested fluids, dubbed "grandfathered"

---

[4] The selection of freezing precipitation values for the "below -3 to -6°C" row is documented in the 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).

[5] Tests are documented in the Transport Canada report TP 13994E, *Generation of Holdover Times Using the New Type I Fluid Test Protocol* (3).

fluids, remained on the list of qualified fluids and could be used with the generic guidelines.

When fluid-specific guidelines were introduced, the protocol for determining values in the Type II generic table changed. The generic table values had to reflect the worst-case holdover time of all available Type II fluids. The fluid-specific guidelines were compared to determine the worst-case value for all new fluids, but this methodology excluded the grandfathered fluids. To account for the performance of the grandfathered fluids, the values in the 1998-99 generic guidelines were included. The 1998-99 data set is now referred to as the grandfathered fluid data set.

In addition, since SAE International (SAE) Type IV fluids also qualify as Type II fluids, all qualified Type IV fluids must also be included in the generic Type II analysis.

In summary, the shortest holdover time from each of the following data sets becomes the generic Type II holdover time for each value in the guidelines:

1. Data sets for all fluids on the list of qualified Type II fluids (given as Table 5-2 in the Transport Canada Holdover Time Guidelines), except "grandfathered" fluids;
2. The "grandfathered fluid" data set, which includes values equivalent to the 1998-99 generic Type II holdover times; and
3. All fluids included in the Type IV generic analysis (i.e. all fluids on the list of qualified Type IV fluids).

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

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 (100/0) and 2005-06 (75/25 and 50/50).

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.

At the time the current Type III guidelines were developed, regulators did not intend to produce fluid-specific tables for Type III fluids. This was because they did not believe that any new fluids would perform significantly better than Clariant Safewing 2031; they thought by reducing and rounding its test values, they could establish minimum holdover times that any new Type III fluids submitted for testing would meet.

It should be noted that the FAA Type III 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 taking the shortest holdover times of all fluids on the list of qualified Type IV fluids (given as Table 5-4 in the Transport Canada Holdover Time Guidelines). Unlike the Type II analysis, there is no grandfathered fluid data required or included in the analysis.

Each number in the generic Type IV holdover time table is evaluated individually. As a result, 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 a Type IV fluid is added or removed from the list of qualified fluids. Minor changes are made regularly.

2.5 Note on Qualified Fluids

It should be noted that when the qualification of a Type II or Type IV fluid expires and is not renewed, the fluid remains in the holdover time guidelines for four years. The fluid remains on the list of qualified fluids (Table 5 in the holdover time guidelines), its fluid-specific table remains in the guidelines, and the fluid data remains in the generic table analyses.

Expired fluids are kept in the guidelines in case operators have inventory of these fluids when the fluid qualifications lapse, and still use the fluids in operations even though they are no longer being produced. If fluids are in use, guidance must be provided for them in the holdover time guidelines.

However, after four years has elapsed the fluids are removed from the guidelines and the generic Type II and Type IV guidelines must be updated accordingly.

3. DATA COLLECTION

APS has conducted endurance time testing with many de/anti-icing fluids in many formulations over the past 17 years. Most of the resulting data has been published by Transport Canada in the reports on the holdover time test program that are written for each winter test season. Most of the electronic data has been archived.

Amassing the appropriate regression coefficients from this data was a complex task. Data collection was completed in several steps:

1. The fluids for which data was required were identified (Subsection 3.1);
2. The relevant data set(s) for each fluid were located by determining the year or years the required fluids were tested (Subsection 3.2);
3. The relevant data set(s) for each fluid were de-archived (Subsection 3.3);
4. The data sets of fluids tested in multiple years were compared to determine which data set was responsible for each holdover time value (Subsection 3.4);
5. Regression coefficients were created for cell values which were not derived directly from regression analysis (Subsection 3.5);
6. The data was amalgamated into a series of tables: one table of regression coefficients for each fluid (Subsection 3.6); and
7. Finally, a verification was completed to ensure the coefficients were correct (Subsection 3.7).

The methodology of each step is detailed in this chapter.

3.1 Fluid Selection

3.1.1 Type I Fluids

No fluid-specific data was required for Type I fluids. The 2001-02 Type I snow data set was required, as it was used to determine snow values in the Type I generic table (see Subsection 2.4.1). No Type I freezing precipitation data was required, as the freezing precipitation values in the Type I holdover time table are not derived from regression analysis.

3.1.2 Type II Fluids

Data was required for ten of the eleven Type II fluids included on the 2008-09 list of qualified fluids. Data was not required for Kilfrost ABC-3, as it is a grandfathered fluid for which regression data does not exist (see Subsection 2.4.2). Regression data was required for the grandfathered fluid data set, as it is required to calculate the generic Type II holdover times (see Subsection 2.4.2).

The required Type II regression data includes:

1. ABAX Ecowing 26;
2. Aviation Xi'an KHF-II;
3. Clariant Safewing MP II 1951;
4. Clariant Safewing MP II 2025 ECO;
5. Clariant Safewing MP II Flight;
6. Kilfrost ABC-II Plus;
7. Kilfrost ABC-2000;
8. Kilfrost ABC-K Plus;
9. Newave FCY-2;
10. Octagon E Max II; and
11. Type II "Grandfathered" Fluid Data.

It should be noted that Clariant Safewing MP II 1951 is not certified for use with fluid-specific holdover times. (A fluid-specific table for this fluid is therefore not included in the holdover time guidelines.) Therefore, although the regression coefficients for Clariant Safewing MP II 1951 are available, the Clariant Safewing MP II 1951 regression coefficients table cannot be used to derive fluid-specific values for this fluid. It can only be used in the determination of Type II generic values.

Similarly, the "grandfathered" fluid data set cannot be used to derive fluid-specific values for the one grandfathered fluid that is currently qualified, Kilfrost ABC-3.

3.1.3 Type III Fluids

Regulators had two options for publishing the regression data for Type III fluids. They could provide regression coefficients that would produce the values in the generic Type III holdover time guidelines, or, because only one Type III fluid is currently qualified and fluid-specific regression data exists for that fluid, regulators could instead provide the fluid-specific data.

Publishing the fluid-specific has operational implications. Specifically, operators using Type III fluid may be provided with longer holdover times if they are using a HOTDS rather than the holdover time guidelines. This is because the fluid-specific holdover times are longer than the generic holdover times (due to the methodology used to establish generic Type III values, see Subsection 2.4.3).

Transport Canada elected to publish the fluid-specific data. Therefore fluid-specific data for Clariant Safewing MP III 2031 ECO was required.

3.1.4 Type IV Fluids

The 2008-09 list of qualified Type IV fluids includes fourteen fluids. However, one of the fluids, Octagon Max-Flight, appears in the list twice, as the same fluid is manufactured by two companies (Octagon Process Inc. and Ely Chemical Company). Therefore, data is only required for thirteen Type IV fluids:

1. ABAX AD-480;
2. Clariant Safewing MP IV 2001;
3. Clariant Safewing MP IV 2012 Protect;
4. Clariant Safewing MP IV Launch;
5. Dow Chemical UCAR™ ADF/AAF ULTRA+;
6. Dow Chemical UCAR™ Endurance EG106;
7. Dow UCAR FlightGuard AD-480;
8. Kilfrost ABC-S;
9. Kilfrost ABC-S Plus;
10. Lyondell ARCTIC Shield®;
11. Octagon Max-Flight (listed under both Octagon Process Inc. and Ely Chemical Company);
12. Octagon Max-Flight 04; and
13. Octagon MaxFlo.

3.2 Locating Data

Once it was determined which fluids would be included in the analysis, data for each fluid had to be located. This was a somewhat complex task, as fluid data exists for approximately 15 years of testing, many fluids were tested in multiple years, and several fluids were tested in multiple formulations. It was critical that all relevant data sets were located for each fluid.

The annual Transport Canada report on holdover time testing includes “tables” which show the evolution of the Type II and Type IV holdover time guidelines. These tables show the history of all fluids included in the current holdover time guidelines, including: the year(s) in which they were tested, the test values, and the values included in the holdover time guidelines each year. The tables from the 2007-08 holdover time report, TP 14869E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter* (4), were used to determine the years in which data existed for each fluid. This information is given in Table 3.1 and Table 3.2.

Table 3.1: Fluid Test Years (Type II Fluids)

Fluid	Year Tested	Notes
ABAX Ecowing 26	2000-01	
Aviation Xi’an KHF-II	2006-07	
Clariant Safewing MP II 1951	1999-00	No fluid-specific table
Clariant Safewing MP II 2025 ECO	2002-03	Qualification expired
Clariant Safewing MP II Flight	2005-06	
Kilfrost ABC-II Plus	1998-99	Qualification expired
Kilfrost ABC-3	Prior to 1998-99	Grandfathered fluid
Kilfrost ABC-2000	2001-02	
Kilfrost ABC-K Plus	2007-08	
Newave FCY-2	2006-07	
Octagon E Max II	2001-02	

Table 3.2: Fluid Test Years (Type IV Fluids)

Fluid	Year(s) Tested	Notes
ABAX AD-480	1997-98 (NS,ZR,ZD) 1998-99 (NS) 1999-00	
Clariant Safewing MP IV 2001	1997-98 (NS,ZR,ZD) 1999-00 (ZF,CS)	Qualification expired
Clariant Safewing MP IV 2012 Protect	2000-01	Qualification expired
Clariant Safewing MP IV Launch	2005-06 (ZF,ZR,ZD,CS) 2006-07 (NS)	
Dow UCAR ADF/AAF ULTRA+	1996-97 (NS,ZR,ZD) 1998-99 (ZF, ZR,ZD, CS)	
Dow UCAR™ Endurance EG106	2005-06	
Kilfrost ABC-S	1996-97 (NS,ZR,ZD) 1997-98 (ZR,ZD,CS) 1998-99	
Kilfrost ABC-S Plus	2006-07	
Lyondell ARCTIC Shield®	2006-07	
Octagon Max-Flight	1996-97 (NS,ZR,ZD) 1997-98 (ZR,ZD,CS) 1998-99, 2000-01	Qualification expired
Octagon Max-Flight 04	2000-01	
Octagon MaxFlo	2004-05	Qualification expired

3.3 Data De-Archiving

The process for de-archiving each data set was as follows:

1. The folder containing test data and analysis for the relevant winter test program was located;

2. The regression analyses for each relevant precipitation type were located within that folder;

3. The regression coefficients for the specific fluid were copied from each precipitation type file; and

4. The process was repeated for each year the fluid was tested.

3.4 Selecting Data from Multiple Years of Testing

As can be seen in Table 3.1 and Table 3.2, most fluids tested since 2000 have been tested in one year only. However, many fluids tested in the 1990s were tested in multiple years. This was due to the evolving format of the holdover time tables and the evolving protocol for endurance time testing. The protocol for dealing with multiple data sets collected during these years was generally that the shortest holdover time measured for each table value became the value in the holdover time table. However, there are some exceptions and some data sets were eliminated from the analysis for various reasons. The history of testing with individual fluids and the selection of data sets is documented fully in Subsection 5.3 and 6.3 of the Transport Canada report TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (2).

When multiple data sets existed for a fluid in any given cell, the data had to be examined to determine which data set was responsible for the value in the fluid-specific table. In most cases this was fairly straightforward. However, in cases where upper and lower values in a cell were derived from different data sets, the regression coefficients from both data sets had to be included in the final information, with a note indicating that holdover time values had to be calculated using both sets of coefficients, and the shortest holdover time calculated taken. This is discussed in more detail in Subsection 4.1.

It should be noted that there is a possibility that the regression curves from the eliminated data sets could possibly provide shorter holdover times outside of the precipitation rate ranges which the holdover time tables are built upon, or in the case of snow, at temperatures other than the lowest temperature in each holdover time table temperature range.

3.5 Generating Coefficients for Values Not Derived Directly from Regression

As described in Subsection 2.4, some data sets provided in this report are not derived directly from regression analysis. They include:

1. Type I freezing precipitation; and
2. Type II grandfathered data.

For these table values, regression coefficients for the best-fit curves linking the values in each cell needed to be calculated. This was done by assuming each cell value was a test data point and regressing the data to determine the coefficients.

3.6 Data Amalgamation

Once all of the data had been collected, and all of the appropriate data sets identified, the data was amalgamated into a series of tables. A table of regression coefficients was created for the generic Type I holdover time table, for each Type II/IV fluid-specific holdover time table, for Clariant Safewing MP III 2031, and for data sets included in the Type II analyses that do not have fluid-specific tables (Clariant Safewing 1951, Type II "grandfathered" data). These tables are presented in Section 4.

3.7 Data Verification

In order to verify the accuracy of the data provided in the regression coefficients tables, the data provided in the tables was used to generate values for a fluid-specific holdover time table for each fluid. This information was cross-referenced to the values provided in the published fluid-specific holdover time tables. The values were the same, which ensured that the regression coefficients were correct.

This page intentionally left blank.

4. REGRESSION COEFFICIENTS AND EQUATIONS

The regression coefficients are provided in a series of tables in this chapter. A generic Type I table, fluid-specific Type II, Type III and Type IV tables, and a table for the Type II grandfathered data set are provided.

4.1 Table Format and Footnotes

Each regression coefficients table is presented in the format of its corresponding holdover time table. A footnote is provided at the top of each column 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 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.

Additional footnotes are provided for several of the tables. Two sets of coefficients are provided in some table cells because different data sets are responsible for the upper and lower values in the cell (see Subsection 3.4). A footnote on these cells indicates that each set of regression coefficients must be used to calculate a holdover time and that the shortest holdover time calculated is the value that must be used.

Footnotes are also used to highlight discrepancies that may be encountered if the regression coefficients are used to calculate the values provided in the Transport Canada Holdover Time Guidelines.

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 all Type II and Type IV fluids except Dow UCAR Ultra+.

4.2 Regression Coefficients for 2008-09 Holdover Time Tables

The regression coefficients are provided in Table 4.1 to Table 4.26. The tables are presented in alphabetical order by fluid type.

Type I

- Table 4.1: Generic Type I

Type II

- Table 4.2: ABAX Ecowing 26;
- Table 4.3: Aviation Xi'an KHF-II;
- Table 4.4: Clariant Safewing MP II 1951;[6]
- Table 4.5: Clariant Safewing MP II 2025 ECO;
- Table 4.6: Clariant Safewing MP II Flight;
- Table 4.7: Kilfrost ABC II Plus;
- Table 4.8: Kilfrost ABC-2000;
- Table 4.9: Kilfrost ABC-K Plus;
- Table 4.10: Newave FCY-2;
- Table 4.11: Octagon E Max II; and
- Table 4.12: Type II "Grandfathered" Fluid Data.[6]

Type III

- Table 4.13: Clariant Safewing MP III 2031

Type IV

- Table 4.14: ABAX AD-480;
- Table 4.15: Clariant Safewing MP IV 2001;
- Table 4.16: Clariant Safewing MP IV 2012 Protect;
- Table 4.17: Clariant Safewing MP IV Launch;
- Table 4.18: Dow UCAR ADF/AAF ULTRA+;
- Table 4.19: Dow UCAR Endurance EG106;
- Table 4.20: Dow UCAR FlightGuard AD-480;
- Table 4.21: Kilfrost ABC-S;
- Table 4.22: Kilfrost ABC-S Plus;
- Table 4.23: Lyondell ARCTIC Shield®;
- Table 4.24: Octagon Max-Flight;
- Table 4.25: Octagon Max-Flight 04; and
- Table 4.26: Octagon MaxFlo.

[6] These tables can not be used to derived fluid-specific values for any fluid; they are only to be used in the calculation of generic Type II holdover times. See Subsection 3.1.2.

Table 4.1: Generic Type I

Outside Air Temperature		Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**	**Active Frost**	**Freezing Fog[1]**	**Snow or Snow Grains[2,3]** V.Light/Light/Mod.	**Freezing Drizzle[1]**	**Light Freezing Rain[1,4]**	**Rain on Cold Soaked Wing[1]**	**Other**
-3 and above	27 and above	45 mins	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	45 mins	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	45 mins	I = 1.1678 A = -0.5575		I = 1.2545 A = -0.5857	I = 2.2598 A = -1.4012		
below -10	below 14	45 mins	I = 1.1473 A = -0.6415					

[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 (°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 4.2: ABAX Ecowing 26

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**	**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	8 hours	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	5 hours	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	3 hours	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	8 hours	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	5 hours	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	below 7 to -13	100/0	8 hours	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: $t = 10^I R^A (2-T)^B$, where R = rate (g/dm²/h) and T = temperature (°C)

Table 4.3: Aviation Xi'an KHF-II

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.3076 A = -0.6004	I = 2.6239 A = -0.5936 B = -0.1965	I = 2.3723 A = -0.6076	I = 2.2358 A = -0.5358	I = 2.3521 A = -0.6723	
		75/25	5 hours	I = 1.8926 A = -0.3695	I = 2.3890 A = -0.5522 B = -0.3127	I = 2.0098 A = -0.5277	I = 2.4102 A = -0.9057	I = 2.1732 A = -0.7748	
		50/50	3 hours	I = 1.6153 A = -0.4676	I = 2.0895 A = -0.6802 B = -0.0385	I = 1.5310 A = -0.4446	I = 2.0917 A = -0.9811		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.4647 A = -0.8764	I = 2.6239 A = -0.5936 B = -0.1965	I = 3.0544 A = -1.5316	I = 2.2370 A = -0.5743	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.0865 A = -0.6423	I = 2.3890 A = -0.5522 B = -0.3127	I = 2.2656 A = -0.8827	I = 2.0661 A = -0.6835		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8204 A = -0.4264	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 (°C)

Table 4.4: Clariant Safewing MP II 1951

(to be used for generic calculations only)[3]

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.1983 A = -0.6306	I = 2.4921 A = -0.7197 B = -0.1457	I = 2.1302 A = -0.5579	I = 2.0690 A = -0.5228	I = 2.1024 A = -0.5666	
		75/25	5 hours	I = 2.0535 A = -0.5710	I = 2.4196 A = -0.7591 B = -0.1914	I = 2.0792 A = -0.6250	I = 1.9155 A = -0.5042	I = 2.0174 A = -0.6000	
		50/50	3 hours	I = 1.5607 A = -0.3896	I = 2.3542 A = -0.9691 B = -0.3207	I = 1.6283 A = -0.6320	I = 1.6164 A = -0.5744		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.1272 A = -0.6673	I = 2.4921 A = -0.7197 B = -0.1457	I = 2.1765 A = -0.6919	I = 2.3569 A = -0.8074	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 1.9549 A = -0.6133	I = 2.4196 A = -0.7591 B = -0.1914	I = 1.9187 A = -0.5179	I = 1.9149 A = -0.5296		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8859 A = -0.8776	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 (°C)
[3] The Clariant Safewing MP II 1951 regression information is only to be used in the calculation of Type II generic holdover times. The information can not be used to deduce fluid-specific holdover times for Clariant Safewing MP II 1951.

Table 4.5: Clariant Safewing MP II 2025 ECO

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1,3]	Light Freezing Rain[1,3]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	8 hours	I = 2.2170 A = -0.3761	I = 2.5814 A = -0.6515 B = -0.1227	I = 2.0815 A = -0.4337	I = 1.9352 A = -0.3644	I = 2.3766 A = -0.6988	
		75/25	5 hours	I = 2.2154 A = -0.6580	I = 2.3101 A = -0.6381 B = -0.0207	I = 2.0114 A = -0.5227	I = 2.0417 A = -0.5535	I = 2.1628 A = -0.6547	
		50/50	3 hours	I = 1.7239 A = -0.5878	I = 1.9823 A = -0.6443 B = -0.1369	I = 1.6305 A = -0.5588	I = 1.6662 A = -0.5666		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.3481 A = -1.0089	I = 2.5814 A = -0.6515 B = -0.1227	I = 2.3325 A = -0.7221	I = 2.3161 A = -0.7245		CAUTION: No holdover time guidelines exist
		75/25	5 hours	I = 2.1350 A = -0.7781	I = 2.3101 A = -0.6381 B = -0.0207	I = 1.8741 A = -0.3913	I = 1.9634 A = -0.5459		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8729 A = -0.6740	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 (°C)
[3] Freezing drizzle and light freezing rain values were calculated at 12.7 g/dm²/h the year the holdover time table for this fluid was produced. Since they are now calculated at 13.0 g/dm²/h, values in the holdover time table may differ slightly from those calculated using these coefficients.

Table 4.6: Clariant Safewing MP II Flight

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.4369 A = -0.1630	I = 2.7425 A = -0.5435 B = -0.3120	I = 2.6541 A = -0.6697	I = 2.9080 A = -0.8860	I = 2.4810 A = -0.7583	
		75/25	5 hours	I = 2.5510 A = -0.5352	I = 3.0163 A = -0.7162 B = -0.5615	I = 2.5845 A = -0.6398	I = 2.6717 A = -0.8305	I = 2.5884 A = -0.9638	
		50/50	3 hours	I = 2.2250 A = -0.6732	I = 2.2879 A = -0.7080 B = -0.2971	I = 1.7413 A = -0.3693	I = 1.9070 A = -0.6463		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.2233 A = -0.6827	I = 2.7425 A = -0.5435 B = -0.3120	I = 2.6220 A = -0.9557	I = 2.5701 A = -0.8095		CAUTION: No holdover time guidelines exist
		75/25	5 hours	I = 2.0461 A = -0.6512	I = 3.0163 A = -0.7162 B = -0.5615	I = 2.6085 A = -1.0800	I = 2.2911 A = -0.5972		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8996 A = -0.6356	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 (°C)

Table 4.7: Kilfrost ABC II Plus

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.3862 A = -0.7676	I = 2.8701 A = -0.8472 B = -0.3856	I = 2.3487 A = -0.7209	I = 2.2136 A = -0.5470	I = 2.3434 A = -0.8125	
		75/25	5 hours	I = 2.3844 A = -0.7612	I = 2.6810 A = -0.7451 B = -0.3429	I = 2.3746 A = -0.8332	I = 2.5992 A = -0.9103	I = 2.2098 A = -0.7345	
		50/50	3 hours	I = 2.0733 A = -1.3477	I = 2.3568 A = -0.7288 B = -0.1569	I = 2.4726 A = -1.5003	I = 2.8950 A = -1.5416		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.0675 A = -0.8227	I = 2.8701 A = -0.8472 B = -0.3856	I = 2.4745 A = -1.1754	I = 3.0873 A = -1.4700	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.0597 A = -1.0188	I = 2.6810 A = -0.7451 B = -0.3429	I = 2.0383 A = -0.7627	I = 2.4646 A = -1.0720		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.3335 A = -0.2770	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 (°C)

Table 4.8: Kilfrost ABC-2000

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.5017 A = -0.7918	I = 2.6793 A = -0.7155 B = -0.2475	I = 2.3530 A = -0.5406	I = 2.1752 A = -0.4212	I = 2.2715 A = -0.6219	
		75/25	5 hours	I = 2.5693 A = -0.8090	I = 2.6945 A = -0.7473 B = -0.2060	I = 2.2641 A = -0.5653	I = 2.0107 A = -0.2793	I = 2.5276 A = -0.7483	
		50/50	3 hours	I = 2.3546 A = -0.8144	I = 2.3633 A = -0.8758 B = 0.0000	I = 1.7696 A = -0.5811	I = 1.8264 A = -0.6348		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.1872 A = -0.8952	I = 2.6793 A = -0.7155 B = -0.2475	I = 2.2482 A = -0.7642	I = 2.8779 A = -1.2797	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.1388 A = -0.8953	I = 2.6945 A = -0.7473 B = -0.2060	I = 2.2588 A = -0.7609	I = 2.5694 A = -0.9881		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.9361 A = -0.8977	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 (°C)

Table 4.9: Kilfrost ABC-K Plus

Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Fluid Dilution	Active Frost	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	8 hours	I = 2.5148 A = -0.5532	I = 2.6804 A = -0.5771 B = -0.1414	I = 2.2527 A = -0.1978	I = 2.5473 A = -0.5588	I = 2.6523 A = -0.7393	
		75/25	5 hours	I = 2.3020 A = -0.4342	I = 2.5273 A = -0.6849 B = -0.0149	I = 2.3200 A = -0.3522	I = 2.4709 A = -0.5601	I = 2.5956 A = -0.7470	
		50/50	3 hours	I = 1.9950 A = -0.6463	I = 2.3972 A = -0.8261 B = -0.5288	I = 1.7256 A = -0.3910	I = 2.0364 A = -0.7354		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.0780 A = -0.8928	I = 2.6804 A = -0.5771 B = -0.1414	I = 2.4865 A = -0.9979	I = 3.2510 A = -1.5260	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.3405 A = -1.3357	I = 2.5273 A = -0.6849 B = -0.0149	I = 2.4921 A = -1.0863	I = 3.6906 A = -1.9574		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.9498 A = -0.6590	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 (°C)

Table 4.10: Newave FCY-2

Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Fluid Dilution	Active Frost	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	8 hours	I = 2.3831 A = -0.7394	I = 2.7862 A = -0.6652 B = -0.5351	I = 2.3424 A = -0.7349	I = 2.1756 A = -0.5685	I = 2.0886 A = -0.6241	
		75/25	5 hours	I = 2.1617 A = -0.6765	I = 2.6255 A = -0.6413 B = -0.5531	I = 2.1241 A = -0.6856	I = 2.6154 A = -1.0787	I = 1.8312 A = -0.6039	
		50/50	3 hours	I = 1.6808 A = -0.3883	I = 2.1561 A = -0.7445 B = 0.0000	I = 1.7656 A = -0.6698	I = 1.6020 A = -0.5128		
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.1844 A = -0.7552	I = 2.7862 A = -0.6652 B = -0.5351	I = 2.2637 A = -0.8968	I = 1.6935 A = -0.3738	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.0300 A = -0.7545	I = 2.6255 A = -0.6413 B = -0.5531	I = 2.0031 A = -0.7745	I = 2.0994 A = -0.8524		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.7388 A = -0.5485	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 (°C)

Table 4.11: Octagon E Max II

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	8 hours	I = 2.5459 A = -0.6373	I = 2.6668 A = -0.6858 B = -0.1217	I = 2.5718 A = -0.8425	I = 2.2283 A = -0.5498	I = 2.4284 A = -0.6853	
		75/25	5 hours	I = 2.4583 A = -0.7527	I = 2.6369 A = -0.8175 B = -0.1119	I = 2.2245 A = -0.5480	I = 2.0418 A = -0.4936	I = 2.3114 A = -0.7004	
		50/50	3 hours	I = 1.9264 A = -0.6775	I = 2.3965 A = -0.9103 B = -0.0736	I = 1.9337 A = -0.7031	I = 1.6119 A = -0.4530	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.2755 A = -0.8543	I = 2.6668 A = -0.6858 B = -0.1217	I = 2.2209 A = -0.6158	I = 2.2141 A = -0.6418		
		75/25	5 hours	I = 2.2071 A = -0.9994	I = 2.6369 A = -0.8175 B = -0.1119	I = 2.3457 A = -0.7362	I = 2.4525 A = -0.8693		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.7407 A = -0.6333	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 (°C)
Note: The upper value in "below -3 to -14", 75/25 freezing drizzle is 67.8 minutes. Due to a rounding error, the value in the holdover time table is 65 minutes.

Table 4.12: Type II "Grandfathered" Fluid Data
(to be used for generic calculations only)[2]

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog[1]	Snow or Snow Grains[1]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	8 hours	I = 2.2645 A = -1.0307	I = 2.5382 A = -0.8850	I = 2.2851 A = -0.7254	I = 2.6578 A = -1.0599	I = 1.9599 A = -0.5119	
		75/25	5 hours	I = 2.0657 A = -0.9554	I = 2.2336 A = -0.7565	I = 2.2464 A = -0.8486	I = 2.9588 A = -1.4012	I = 1.8133 A = -0.5943	
		50/50	3 hours	I = 2.0141 A = -1.1989	I = 2.3751 A = -1.1990	I = 1.8080 A = -0.7254	I = 2.1807 A = -1.0599	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.2645 A = -1.0307	I = 2.6725 A = -1.0704	I = 2.2851 A = -0.7254	I = 3.3485 A = -1.6800		
		75/25	5 hours	I = 2.0657 A = -0.9554	I = 2.2336 A = -0.7565	I = 2.2464 A = -0.8486	I = 2.9588 A = -1.4012		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 2.4483 A = -1.6414	I = 2.2336 A = -0.7565				

[1] Regression Equation: $t = 10^I R^A$, where R = rate (g/dm²/h)
[2] The "Grandfathered" fluid regression information is only to be used in the calculation of Type II generic holdover times. The information can not be used to deduce fluid-specific holdover times for any fluid.

Table 4.13: Clariant Safewing MP III 2031

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**	**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	120	I = 1.8574 A = -0.6489	I = 2.1115 A = -0.6963 B = -0.1456	I = 1.9299 A = -0.7118	I = 1.7185 A = -0.5394	I = 1.7197 A = -0.4605	
		75/25	60	I = 1.7259 A = -0.6144	I = 1.9882 A = -0.6441 B = -0.1563	I = 1.7700 A = -0.6803	I = 1.8560 A = -0.7070	I = 1.5307 A = -0.5484	
		50/50	30	I = 1.5142 A = -0.6078	I = 1.7655 A = -0.6226 B = -0.259	I = 1.3637 A = -0.5187	I = 1.4971 A = -0.5838	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	120	I = 1.7495 A = -0.4928	I = 2.1115 A = -0.6963 B = -0.1456	I = 1.7755 A = -0.5900	I = 1.6118 A = -0.4205		
		75/25	60	I = 1.7409 A = -0.758	I = 1.9882 A = -0.6441 B = -0.1563	I = 1.3372 A = -0.2919	I = 1.6085 A = -0.5431		
below -10	below 14	100/0	120	I = 1.8547 A = -0.6749	I = 2.1115 A = -0.6963 B = -0.1456				

[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 (°C)

Table 4.14: ABAX AD-480

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**	**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	12 hours	I = 2.5155 A = -0.6296	I = 2.8771 A = -0.7459 B = -0.3169	I = 2.4133 A = -0.6465	I = 2.3229 A = -0.5386	I = 2.5009 A = -0.7370	
		75/25	5 hours	I = 2.4258 A = -0.6912	I = 2.8157 A = -0.8148 B = -0.2892	I = 2.2256 A = -0.4857	I = 2.2663 A = -0.5461	I = 2.3778 A = -0.7322	
		50/50	3 hours	I = 1.7682 A = -0.3911	I = 2.4274 A = -0.8852 B = -0.2983	I = 1.8484 A = -0.6021	I = 1.7714 A = -0.5857	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.3324 A = -1.4027	I = 2.8771 A = -0.7459 B = -0.3169	I = 2.7690 A = -1.2527	I = 2.2782 A = -0.7465		
		75/25	5 hours	I = 1.9626 A = -0.8214	I = 2.8157 A = -0.8148 B = -0.2892	I = 2.5153 A = -1.0108	I = 2.4335 A = -0.8683		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8643 A = -0.8914	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 (°C)

Table 4.15: Clariant Safewing MP IV 2001

Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Fluid Dilution	Active Frost	Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1,3]	Light Freezing Rain[1,3]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	12 hours	I = 2.5974 A = -0.9950	I = 3.2166 A = -0.6746 B = -0.6934	I = 2.6152 A = -0.7861	I = 2.3028 A = -0.4885	I = 2.9330 A = -0.9192	
		75/25	5 hours	I = 2.2129 A = -0.4268	I = 2.6088 A = -0.5463 B = -0.4332	I = 2.2946 A = -0.6552	I = 2.0960 A = -0.5183	I = 2.4682 A = -0.7776	
		50/50	3 hours	I = 1.8446 A = -0.8754	I = 1.9195 A = -0.6775 B = 0.0446	I = 1.8109 A = -0.6826	I = 1.9408 A = -0.7410	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.2514 A = -0.8912	I = 3.2166 A = -0.6746 B = -0.6934	I = 2.4071 A = -0.6057	I = 2.3361 A = -0.6177		
		75/25	5 hours	I = 2.0040 A = -0.7493	I = 2.6088 A = -0.5463 B = -0.4332	I = 2.3116 A = -0.6459	I = 2.2208 A = -0.6513		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.9535 A = -0.9662	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 (°C)
[3] Freezing drizzle and light freezing rain values were calculated at 12.7 g/dm²/h the year the holdover time table for this fluid was produced. Since they are now calculated at 13.0 g/dm²/h, values in the holdover time table may differ slightly from those calculated using these coefficients.

Note: The lower value in "below -3 to -14", 100/0, snow is 27.45 minutes. Due to a rounding error, the value in the holdover time table is 30 minutes.

Table 4.16: Clariant Safewing MP IV 2012 Protect

Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Fluid Dilution	Active Frost	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	8 hours	I = 2.4162 A = -0.7740	I = 2.9261 A = -0.6725 B = -0.5399	I = 2.2617 A = -0.6058	I = 2.6728 A = -0.9024	I = 2.2260 A = -0.6133	
		75/25	5 hours	I = 2.2814 A = -0.6038	I = 2.7240 A = -0.7768 B = -0.3020	I = 2.0140 A = -0.4253	I = 2.3105 A = -0.7659	I = 2.0789 A = -0.6561	
		50/50	3 hours	I = 1.8790 A = -0.7412	I = 1.9610 A = -0.6065 B = 0.0080	I = 1.5838 A = -0.3913	I = 1.7499 A = -0.6403	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	8 hours	I = 2.3070 A = -0.9577	I = 2.9261 A = -0.6725 B = -0.5399	I = 2.0559 A = -0.5619	I = 2.1217 A = -0.6374		
		75/25	5 hours	I = 2.1045 A = -1.0145	I = 2.7240 A = -0.7768 B = -0.3020	I = 2.0469 A = -0.8034	I = 2.1825 A = -0.8178		
below -14 to -25	below 7 to -13	100/0	8 hours	I = 1.8720 A = -0.7608	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 (°C)

Table 4.17: Clariant Safewing MP IV Launch

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	12 hours	I = 2.3942 A = 0.0152	I = 2.7218 A = -0.5330 B = -0.2408	I = 2.7789 A = -0.7426	I = 2.9492 A = -0.8489	I = 2.5170 A = -0.7291	
		75/25	5 hours	I = 2.4388 A = -0.1431	I = 2.7841 A = -0.6180 B = -0.2044	I = 2.7945 A = -0.7101	I = 2.7548 A = -0.7917	I = 2.6192 A = -0.8499	
		50/50	3 hours	I = 2.4323 A = -0.7333	I = 2.3978 A = -0.6703 B = -0.1021	I = 2.0818 A = -0.5727	I = 1.7686 A = -0.3607		
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.2823 A = -0.7333	I = 2.7218 A = -0.5330 B = -0.2408	I = 2.7424 A = -1.0767	I = 2.6379 A = -0.8846	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.1203 A = -0.7220	I = 2.7841 A = -0.6180 B = -0.2044	I = 2.6204 A = -1.0940	I = 2.4901 A = -0.7708		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8894 A = -0.6349	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 (°C)

Table 4.18: Dow UCAR ADF/AAF ULTRA+

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	12 hours	I = 2.5966 A = -0.8735	I = 2.8804 A = -0.7939 B = -0.3039	I = 2.5269 A = -0.7811	I = 2.2847 A = -0.6144	I = 2.4056 A = -0.7072	
		75/25	5 hours	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	n/a n/a	
		50/50	3 hours	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	12 hours	I = 2.4990 A = -0.8182	I = 2.8804 A = -0.7939 B = -0.3039	I = 2.4562 A = -0.7408	I = 2.4117 A = -0.6918	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	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	12 hours	I = 2.4726 A = -1.2125	I = 2.8804 A = -0.7939 B = -0.3039				

[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 (°C)

Table 4.19: Dow UCAR Endurance EG106

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	12 hours	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	5 hours	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	n/a n/a	
		50/50	3 hours	n/a n/a	n/a n/a n/a	n/a n/a	n/a n/a	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	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	5 hours	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	12 hours	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 = rate (g/dm²/h)
[2] Regression Equation: $t = 10^I R^A (2-T)^B$, where R = rate (g/dm²/h) and T = temperature (°C)

Table 4.20: Dow UCAR FlightGuard AD-480

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	12 hours	I = 2.5155 A = -0.6296	I = 2.8771 A = -0.7459 B = -0.3169	I = 2.4133 A = -0.6465	I = 2.3229 A = -0.5386	I = 2.5009 A = -0.7370	
		75/25	5 hours	I = 2.4258 A = -0.6912	I = 2.8157 A = -0.8148 B = -0.2892	I = 2.2256 A = -0.4857	I = 2.2663 A = -0.5461	I = 2.3778 A = -0.7322	
		50/50	3 hours	I = 1.7682 A = -0.3911	I = 2.4274 A = -0.8852 B = -0.2983	I = 1.8484 A = -0.6021	I = 1.7714 A = -0.5857	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.3324 A = -1.4027	I = 2.8771 A = -0.7459 B = -0.3169	I = 2.7690 A = -1.2527	I = 2.2782 A = -0.7465		
		75/25	5 hours	I = 1.9626 A = -0.8214	I = 2.8157 A = -0.8148 B = -0.2892	I = 2.5153 A = -1.0108	I = 2.4335 A = -0.8683		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8643 A = -0.8914	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 (°C)

Table 4.21: Kilfrost ABC-S

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**	**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	12 hours	I = 2.7032 A = -0.7245	I = 2.7666 A = -0.6013 B = -0.2217	I = 2.2743 A = -0.3333	I = 2.5227 A = -0.5326	I = 2.2207 A = -0.4813	
		75/25	5 hours	I = 2.1889 A = -0.5545	I = 2.5569 A = -0.7273 B = -0.1092	I = 2.1721 A = -0.4710	I = 2.3286 A = -0.5836	I = 2.0484 A = -0.5136	
		50/50	3 hours	I = 1.6863 A = -0.5068	I = 2.3232 A = -0.8869 B = -0.2936	I = 1.7499 A = -0.5783	I = 1.6395 A = -0.4931		
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.4307 A = -1.1131	I = 2.7666 A = -0.6013 B = -0.2217	I = 2.1724 A = -0.5641 or[3] I = 3.0193 A = -1.5395	I = 3.1764 A = -1.5258	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.0461 A = -0.9024	I = 2.5569 A = -0.7273 B = -0.1092	I = 2.4843 A = -0.9047 or[3] I = 3.0881 A = -1.6196	I = 3.5272 A = -1.7987		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8469 A = -0.7299	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 (°C)
[3] Calculate value using both sets of coefficients; take shortest holdover time calculated

Table 4.22: Kilfrost ABC-S Plus

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**	**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	12 hours	I = 2.5882 A = -0.6773	I = 2.7997 A = -0.5886 B = -0.1639	I = 2.1349 A = -0.0810	I = 3.2080 A = -1.0102	I = 2.5437 A = -0.6337	
		75/25	5 hours	I = 2.4204 A = -0.6975	I = 2.5586 A = -0.5815 B = -0.1638	I = 2.1108 A = -0.2951	I = 2.5019 A = -0.7097	I = 2.4230 A = -0.7288	
		50/50	3 hours	I = 1.8988 A = -0.5888	I = 2.1742 A = -0.6668 B = 0.0000	I = 2.2203 A = -0.8993	I = 1.7490 A = -0.4516		
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.7468 A = -1.4224	I = 2.7997 A = -0.5886 B = -0.1639	I = 2.9992 A = -1.4676	I = 2.3542 A = -0.7931	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.3554 A = -1.0359	I = 2.5586 A = -0.5815 B = -0.1638	I = 2.8273 A = -1.3891	I = 2.1553 A = -0.6538		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.9370 A = -0.5185	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 (°C)

Table 4.23: Lyondell ARCTIC Shield®

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	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	12 hours	I = 2.4454 A = -0.5452	I = 2.6137 A = -0.5939 B = -0.1143	I = 2.4067 A = -0.5864	I = 2.5402 A = -0.6454	I = 2.3859 A = -0.6640	
		75/25	5 hours	I = 2.3152 A = -0.5992	I = 2.4438 A = -0.5642 B = -0.1089	I = 2.2230 A = -0.4318	I = 2.4152 A = -0.6779	I = 2.4635 A = -0.7899	
		50/50	3 hours	I = 1.7122 A = -0.2153	I = 2.1743 A = -0.6196 B = 0.0000	I = 1.8862 A = -0.5423	I = 1.9811 A = -0.6662		
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.4503 A = -0.9456	I = 2.6137 A = -0.5939 B = -0.1143	I = 2.8685 A = -1.2952	I = 1.9544 A = -0.4082	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.2491 A = -0.7644	I = 2.4438 A = -0.5642 B = -0.1089	I = 2.5673 A = -0.9868	I = 2.0026 A = -0.4621		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8254 A = -0.6370	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 (°C)

Table 4.24: Octagon Max-Flight

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[3]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	12 hours	I = 2.5102 A = -0.4343	I = 3.0573 A = -0.7256 B = -0.5146	I = 3.0698 A = -0.9598 B = -0.5585	I = 2.5186 A = -0.6844	I = 2.279 A = -0.5774	
		75/25	5 hours	I = 2.4469 A = -0.5051	I = 3.3865 A = -0.9216 B = -0.6492	I = 2.8321 A = -0.6194 B = -0.5809	I = 3.0384 A = -1.0798	I = 1.946 A = -0.4734	
		50/50	3 hours	I = 2.2247 A = -0.7089	I = 3.4155 A = -1.1786 B = -0.5058	I = 2.2175 A = -0.614 B = 0.0000	I = 2.5443 A = -0.9509		
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.5385 A = -1.1945	I = 3.0573 A = -0.7256 B = -0.5146	I = 2.8956 A = -1.3456 B = 0.0000 or[4] I = 3.0698 A = -0.9598 B = -0.5585	I = 2.8529 A = -1.1429	CAUTION: No holdover time guidelines exist	
		75/25	5 hours	I = 2.044 A = -0.7653	I = 3.3865 A = -0.9216 B = -0.6492	I = 2.576 A = -1.1285 B = 0.0000	I = 2.6096 A = -1.0396		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8804 A = -0.7843	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 (°C)
[3] Regression Equation: $t = 10^I R^A (-T)^B$, where R = rate (g/dm²/h) and T = temperature (°C)
[4] Calculate value using both sets of coefficients; take shortest holdover time calculated
Note: The lower value in "-3 and above", 100/0, light freezing rain is 57.0 minutes. Due to a rounding error, the value in the holdover time table is 60 minutes.

Table 4.25: Octagon Max-Flight 04

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1,3]	Light Freezing Rain[1,3]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	12 hours	I = 2.5102 A = -0.4343	I = 3.4634 A = -0.7407 B = -0.7275	I = 2.0949 A = -0.0224	I = 2.4117 A = -0.4124	I = 2.6420 A = -0.6956	
		75/25	5 hours	I = 2.4469 A = -0.5051	I = 3.2319 A = -0.7946 B = -0.4320	I = 2.1376 A = -0.0817	I = 2.4010 A = -0.4561	I = 2.6645 A = -0.7412	
		50/50	3 hours	I = 2.2247 A = -0.7089	I = 3.4155 A = -1.1786 B = -0.5058	I = 2.3099 A = -0.6733	I = 2.1734 A = -0.5565	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.5385 A = -1.1945	I = 3.4634 A = -0.7407 B = -0.7275	I = 2.8956 A = -1.3456	I = 2.8529 A = -1.1429		
		75/25	5 hours	I = 2.0440 A = -0.7653	I = 3.2319 A = -0.7946 B = -0.4320	I = 2.5760 A = -1.1285	I = 2.6096 A = -1.0396		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.8804 A = -0.7843	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 (°C)
[3] Freezing drizzle and light freezing rain values were calculated at 12.7 g/dm²/h the year the holdover time table for this fluid was produced. Since they are now calculated at 13.0 g/dm²/h, values in the holdover time table may differ slightly from those calculated using these coefficients.

Table 4.26: Octagon MaxFlo

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog[1]	Snow or Snow Grains[2]	Freezing Drizzle[1,3]	Light Freezing Rain[1,3]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	12 hours	I = 2.4846 A = -0.4922	I = 3.0846 A = -0.8545 B = -0.3781	I = 2.4245 A = -0.4699	I = 2.8724 A = -0.9952	I = 2.6663 A = -0.8382	
		75/25	5 hours	I = 2.2072 A = -0.3970	I = 2.8627 A = -0.9548 B = -0.2641	I = 2.2235 A = -0.5883	I = 2.5582 A = -0.9296	I = 2.4413 A = -0.8179	
		50/50	3 hours	I = 1.7958 A = -0.7062	I = 2.3140 A = -0.8662 B = -0.3908	I = 1.8698 A = -0.7747	I = 1.8497 A = -0.7307	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	12 hours	I = 2.3907 A = -0.7901	I = 3.0846 A = -0.8545 B = -0.3781	I = 2.8619 A = -1.2156	I = 2.4742 A = -0.7046		
		75/25	5 hours	I = 2.1868 A = -0.8254	I = 2.8627 A = -0.9548 B = -0.2641	I = 2.5001 A = -0.8903	I = 2.5267 A = -0.9331		
below -14 to -25	below 7 to -13	100/0	12 hours	I = 1.9902 A = -0.7098	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 (°C)
[3] Freezing drizzle and light freezing rain values were calculated at 12.7 g/dm²/h the year the holdover time table for this fluid was produced. Since they are now calculated at 13.0 g/dm²/h, values in the holdover time table may differ slightly from those calculated using these coefficients.

4.3 Calculating Generic Type II/Type IV Holdover Times

Generic Type II and Type IV holdover times are used when a flight crew is unaware of the specific fluid brand that has been used to de/anti-ice their aircraft. The generic values represent the shortest possible holdover time of either all Type II or all Type IV fluids available.

The methodology used to determine generic Type II and Type IV holdover times is provided in Subsections 2.4.2 and 2.4.4, respectively. This methodology is used to build the generic Type II and Type IV holdover time tables that are published annually by Transport Canada and the FAA. The methodology must be applied to HOTDS programming to enable the systems to determine generic Type II and Type IV holdover times.

4.3.1 Type II

To calculate Type II generic holdover times, HOTDS should be programmed to calculate holdover times for each of the following under the specific weather condition:

1. Each Type II fluid on the list of qualified fluids, with the exception of “grandfathered” fluids;
2. The “grandfathered fluid” data set, and
3. Each Type IV fluid on the list of qualified fluids.

The HOTDS should return the shortest holdover time calculated from each of these data sets. This is the generic Type II holdover time.

This methodology must also be followed if either Kilfrost ABC-3 or Clariant Safewing MP II 1951 is being used, as neither of these fluids is qualified for use with a fluid-specific table and operators must use the generic Type II holdover times with these fluids.

4.3.2 Type IV

To calculate Type IV generic holdover times, HOTDS should be programmed to calculate the holdover time for each Type IV fluid on the list of qualified fluids and return the shortest holdover time calculated. This is the generic Type IV holdover time.

4.4 Data Limitations

One limitation of the regression data provided in this report is that the regression equations which include a temperature coefficient cannot 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 using the regression equations to calculate holdover times outside of the precipitation rate limits used in the development of holdover time tables (see Subsection 2.2). 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. Therefore, these values are not necessarily accurate. Caution must especially be exercised in applying the regression coefficients at precipitation rates below the lower precipitation rate limit, where the power-law curves give much longer holdover times. This is illustrated in Figure 4.1.

Figure 4.1 shows a sample regression. This example illustrates that at precipitation rates below the lower rate limit at which tests are conducted (5 g/dm^2/h in this example), derived holdover times can increase substantially with a small decrease in precipitation rate. For example: at the lower rate limit of 5 g/dm^2/h, the endurance time is approximately 82 minutes; at a slightly lower rate of 3 g/dm^2/h, the endurance time jumps to 122 minutes.

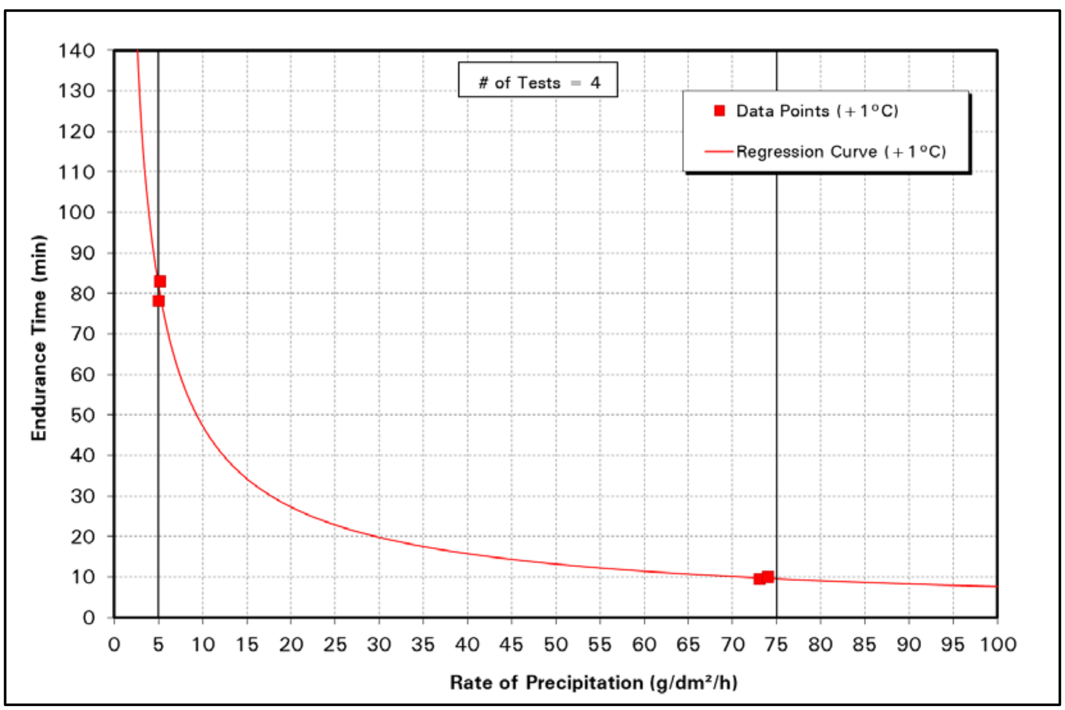


Figure 4.1: Sample Regression Curve – Cold-Soaked Wing

4.5 Matrices for Data Verification

Verification tables have been included in Appendix B for each of the regression coefficients tables given in Subsection 4.2. The values in these tables were calculated using the regression coefficients provided in this report. Values are provided for the boundary conditions for each cell in the associated holdover time table.

In addition, verification tables for the generic Type II and generic Type IV values have been included in Appendix B. The values in these tables were determined using the methodologies for calculating Type II and Type IV generic holdover times detailed in Subsections 2.4.2 and 2.4.4. The methodologies require that the shortest holdover time from a number of data sets be taken as the generic holdover time in each cell (two values per cell). The data sets required are:

1. Type II: all Type II fluid-specific data sets, the Type II grandfathered data seta, and all Type IV fluid-specific data sets; and
2. Type IV: all Type IV fluid-specific data sets.

The values in the verification tables for these data sets were used in the comparison.

The verification tables can be used as an aid for the HOTDS manufacturers during the development process. These tables are not all encompassing and the HOTDS manufacturers are cautioned that they must develop comprehensive verification and validation methods (covering normal and exceptional conditions (e.g. values outside of the temperature range) to ensure the adequacy of their software algorithms.

5. CONCLUSIONS

The regression coefficients provided in this report can be used as inputs in HOTDS, as required by the Transport Canada exemption to CAR 622.11. However, care must be taken in their application. There are a number of rules, exceptions, data inclusions and cautions, detailed in both this report and in the holdover time guidelines themselves, that must be considered. It is also important to note that there may be other guidelines, exceptions, etc. that are imposed by regulators (for example by the Transport Canada exemption document) and that these also need to be considered when determining holdover times.

Each winter, a new version of the holdover time guidelines is published. The annual changes made to the guidelines include the addition of newly qualified fluids, the removal of unavailable fluids, changes to the generic tables and more. Because the holdover time guidelines change on an annual basis, the regression coefficients required by HOTDS will also change on an annual basis.

This page intentionally left blank.

6. RECOMMENDATIONS

Due to the dynamic nature of the holdover time tables, it is recommended that the information contained in this report be updated and published on an annual basis.

As HOTDS progress, further analysis may become necessary and/or desired. This work may include the following:

1. Analysis to determine the feasibility of regressing existing data to provide temperature coefficients for cells where they currently do not exist (i.e. freezing precipitation);
2. Further examination of the holdover times produced by the regression tables:
   (a) Outside of the precipitation rate ranges which the holdover time tables are built upon; and
   (b) In snow at temperatures other than the lowest temperature in each holdover time table temperature range.

   Special attention should be given to fluids with multiple data sets; and/or
3. Producing guidance material for HOTDS to allow the systems to operate in ice pellet conditions, according to the currently published ice pellet allowance times.

Finally, a number of minor discrepancies were found between the values in the published holdover time guidelines and the values calculated by using the regression coefficients. The discrepancies are the result of either minor rounding errors or the change made to the precipitation rate boundary for freezing rain and freezing drizzle (from 12.7 $g/dm^2/h$ to 13.0 $g/dm^2/h$) several years ago. It is recommended that regulators consider making changes to the holdover time guideline values to address these discrepancies.

This page intentionally left blank.

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.

4. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2008, TP 14869E, XX (to be published).

This page intentionally left blank.

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPTS – AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2006-07 & 2007-08

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2006-07

6.7.3 Documentation of Equations Used for HOT Guideline Tables

a) Retrieve archived data dating back from the mid-1990's that relates to the development of the fluid-specific and generic tables; and

b) Document the data and analytical regressions for each fluid that has a fluid-specific table and also for the generic tables.

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

7.7.5 Update: Regression Coefficients Used to Develop Holdover Times

a) Further review contents of interim report;

b) Conduct additional verification and validation analysis;

c) Update report with any additional data collected in 2007-08; and

d) Prepare final report.

This page intentionally left blank.

APPENDIX B

REGRESSION COEFFICIENTS VERIFICATION TABLES

APPENDIX B: REGRESSION COEFFICIENTS VERIFICATION TABLES

This page intentionally left blank.

Table 1: Type I – Generic

Outside Air Temp. (°C)	HOTDS Verification 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						

*These values are valid for the Transport Canada guidelines. The values will be different if the coefficients for the FAA guidelines are applied. See report Section 1.6.

Table 2: Type II – ABAX Ecowing 26

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification 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	86.5	154.8	37.9	60.5	51.3	97.5	39.9	48.4	19.3	86.2
	75/25	66.0	115.1	27.2	47.2	44.2	65.4	23.8	32.6	11.6	60.1
	50/50	27.5	43.9	11.7	22.1	13.5	22.6	8.1	11.3		
-14°C*	100/0	43.5	134.7	33.8	54.0	31.8*	68.9*	15.5*	32.3*		
	75/25	35.3	76.5	24.1	41.8	21.7*	48.6*	14.2*	25.1*		
-25°C	100/0	24.0	45.5	15.0	30.0						

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

Table 3: Type II – Aviation Xi'an KHF-II

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification 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	77.3	133.9	45.4	78.2	49.6	88.6	30.7	43.5	12.3	76.2
	75/25	43.1	60.4	25.0	41.5	26.4	43.7	13.9	25.2	5.3	42.8
	50/50	19.4	29.8	12.9	24.1	10.9	16.6	5.3	10.0		
-14°C*	100/0	71.1	158.8	36.1	62.2	22.3*	96.4*	27.2*	39.6*		
	75/25	43.4	78.2	17.4	28.9	19.2*	44.5*	12.9*	20.2*		
-25°C	100/0	33.3	49.2	15.0	30.0						

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

Table 4: Type II – Clariant Safewing MP II 1951
(to be used for generic calculations only)[1]

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification 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	57.2	102.0	24.2	46.8	32.3	55.0	21.8	30.7	11.0	50.9
	75/25	45.1	76.1	16.8	33.6	24.2	43.9	16.2	22.6	7.8	39.6
	50/50	19.4	27.8	6.0	14.5	8.4	15.4	6.5	9.5		
-14°C*	100/0	45.8	84.4	20.4	39.5	25.5*	49.3*	16.9*	28.7*		
	75/25	33.6	58.9	13.4	26.9	22.0*	36.0*	14.9*	21.1*		
-25°C	100/0	18.7	41.9	15.0	30.0						

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

[1] *The Clariant Safewing MP II 1951 regression information is only to be used in the calculation of Type II generic holdover times. The information can not be used to deduce fluid-specific holdover times for Clariant Safewing MP II 1951.*

Table 5: Type II – Clariant Safewing MP II 2025 ECO

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification 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	90.0	127.0	38.4	69.8	39.7	60.0	26.7	33.8	11.6	77.3
	75/25	56.9	104.1	25.3	45.4	26.9	44.3	18.5	26.6	8.6	50.7
	50/50	20.6	35.2	9.7	17.5	10.2	17.4	7.5	10.8		
-14°C*	100/0	43.9	110.8	33.3	60.6	33.7*	67.3*	20.1*	32.3*		
	75/25	39.0	79.6	24.7	44.4	27.4*	39.9*	15.9*	22.7*		
-25°C	100/0	25.2	46.8	15.0	30.0						

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

Table 6: Type II – Clariant Safewing MP II Flight

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification 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	210.4	244.2	58.2	95.7	80.9	153.5	46.7	83.4	11.5	89.3
	75/25	150.3	245.4	41.9	80.8	74.4	137.2	32.4	55.8	6.0	82.2
	50/50	56.8	105.3	12.3	23.6	21.4	30.4	10.1	15.4		
-14°C*	100/0	55.7	104.2	40.5	66.6	36.1*	89.9*	27.4*	46.6*		
	75/25	39.0	70.8	21.8	42.1	25.4*	71.4*	28.6*	42.3*		
-25°C	100/0	28.5	51.1	15.0	30.0						

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

Table 7: Type II – Kilfrost ABC II PLUS

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	70.7	142.9	26.1	56.7	35.1	70.0	28.1	40.2	6.6	59.6
	75/25	71.2	143.0	25.1	49.7	28.0	62.0	21.2	38.5	6.8	49.7
	50/50	13.5	46.5	16.9	33.0	6.3	26.5	5.5	15.1		
-14°C*	100/0	31.1	66.0	16.7	36.2	14.6*	45.0*	10.8*	28.2*		
	75/25	22.3	56.6	16.8	33.3	15.4*	32.0*	9.2*	18.6*		
-25°C	100/0	13.8	17.8	15.0	30.0						

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

Table 8: Type II – Kilfrost ABC-2000

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	88.8	183.4	32.1	61.8	56.3	94.4	38.6	50.8	12.7	68.7
	75/25	100.9	211.7	32.1	63.6	43.1	74.0	41.7	50.1	13.3	101.1
	50/50	61.0	128.7	13.8	30.7	13.3	23.1	8.7	13.2		
-14°C*	100/0	36.4	82.7	24.0	46.3	24.9*	51.8*	12.3*	28.3*		
	75/25	32.6	74.0	25.2	50.0	25.8*	53.3*	15.4*	29.4*		
-25°C	100/0	20.4	46.3	15.0	30.0						

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

Table 9: Type II – Kilfrost ABC-K PLUS

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	134.3	223.0	59.5	101.0	107.7	130.1	58.4	84.1	18.5	136.6
	75/25	99.7	148.4	36.3	67.9	84.7	118.5	48.7	70.3	15.7	118.4
	50/50	34.9	63.2	7.5	15.9	19.5	28.3	10.2	16.5		
-14°C*	100/0	28.4	64.5	50.5	85.7	23.7*	61.5*	13.1*	35.6*		
	75/25	25.5	86.8	35.6	66.8	19.1*	54.1*	9.0*	32.4*		
-25°C	100/0	30.8	56.4	15.0	30.0						

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

Table 10: Type II – Newave FCY-2

Outside Air Temp. (°C)	Fluid Dilution	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	73.5	144.7	30.4	55.8	33.4	67.4	24.0	34.9	8.3	44.9
	75/25	48.8	90.8	22.0	39.6	22.9	44.1	12.8	25.9	5.0	25.7
	50/50	25.7	36.6	13.0	25.8	10.5	19.8	7.7	10.7		
-14°C*	100/0	45.3	90.6	16.3	30.0	18.4*	43.3*	14.8*	18.9*		
	75/25	31.8	63.5	11.6	20.8	13.8*	29.0*	8.1*	14.1*		
-25°C	100/0	22.7	37.5	15.0	30.0						

HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients

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

Table 11: Type II – Octagon E Max II

Outside Air Temp. (°C)	Fluid Dilution	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	126.0	226.0	42.0	78.7	43.0	96.1	28.8	41.3	13.9	89.0
	75/25	85.5	170.5	26.1	55.1	41.1	69.4	22.5	31.0	10.0	66.4
	50/50	28.4	52.8	11.8	27.2	14.1	27.7	9.5	12.8		
-14°C*	100/0	47.7	104.3	36.4	68.3	34.3*	61.7*	20.7*	31.6*		
	75/25	32.3	80.6	22.9	48.4	33.5*	67.8*	17.3*	30.5*		
-25°C	100/0	19.9	35.5	15.0	30.0						

HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients

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

Table 12: Type II – "Grandfathered" Fluid Data
(to be used for generic calculations only)[1]

Outside Air Temp. (°C)	Fluid Dilution	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	35.0	90.0	20.0	45.0	30.0	60.0	15.0	30.0	10.0	40.0
	75/25	25.0	60.0	15.0	30.0	20.0	45.0	10.0	25.0	5.0	25.0
	50/50	15.0	45.0	5.0	15.0	10.0	20.0	5.0	10.0		
-14°C*	100/0	35.0	90.0	15.0	40.0	30.0*	60.0*	10.0*	30.0*		
	75/25	25.0	60.0	15.0	30.0	20.0*	45.0*	10.0*	25.0*		
-25°C	100/0	20.0	90.0	15.0	30.0						

HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients

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

[1] The "Grandfathered" fluid regression information is only to be used in the calculation of Type II generic holdover times. The information can not be used to deduce fluid-specific holdover times for any fluid.

Table 13: Type II – Generic

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	35.0	90.0	20.0	45.0	30.0	55.0	15.0	30.0	6.6	40.0
	75/25	25.0	60.0	15.0	30.0	20.0	43.7	10.0	22.6	5.0	25.0
	50/50	13.5	27.8	5.0	14.5	6.3	15.4	5.0	9.5		
-14°C*	100/0	22.5	64.5	15.0	30.0	14.6*	43.3*	10.0*	18.9*		
	75/25	22.3	51.9	11.6	20.8	13.8*	29.0*	8.1*	14.1*		
-25°C	100/0	13.8	17.8	15.0	30.0						

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

Table 14: Type III – Clariant Safewing MP III 2031 ECO

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) *As Calculated from Regression Coefficients*										
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)			Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	4	13	5	25	13	75	5
-3°C	100/0	25.3	45.9	10.9	20.6	39.0	13.7	27.1	9.2	13.1	7.2	25.0
	75/25	19.8	34.7	9.5	17.2	31.0	10.3	19.7	7.4	11.7	3.2	14.0
	50/50	12.3	21.4	5.2	9.2	16.2	6.1	10.0	4.8	7.0		
-10°C	100/0	25.4	39.9	9.6	18.1	34.3	13.1	23.1	10.6	13.9		
	75/25	16.3	32.6	8.3	15.0	27.0	10.3	13.6	7.1	10.1		
-25°C	100/0	24.2	44.8	8.5	16.1	30.5						

Table 15: Type IV – ABAX AD-480

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	119.0	211.8	41.0	81.2	49.3	91.5	37.2	52.8	13.2	96.8
	75/25	87.6	165.1	29.8	62.9	48.4	76.9	31.8	45.5	10.1	73.5
	50/50	31.2	44.7	9.6	21.6	15.1	26.8	9.0	13.2		
-14°C*	100/0	22.5	81.3	28.4	56.2	23.6*	78.2*	17.2*	28.0*		
	75/25	24.5	51.9	21.3	44.9	24.5*	64.4*	16.6*	29.3*		
-25°C	100/0	17.4	39.4	15.0	30.0						

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

Table 16: Type IV – Clariant Safewing MP IV 2001

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	79.8	198.6	61.5	114.1	54.9	116.3	41.7	57.4	16.2	195.2
	75/25	82.1	121.5	34.9	57.5	36.7	68.6	23.5	33.0	10.2	84.1
	50/50	17.1	38.1	10.1	18.8	11.2	21.6	8.0	13.0		
-14°C*	100/0	42.5	96.2	27.5	50.9	54.0*	96.3*	29.7*	44.5*		
	75/25	30.2	60.0	21.1	34.7	39.1*	72.5*	20.4*	31.3*		
-25°C	100/0	19.0	46.0	15.0	30.0						

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

Table 17: Type IV – Clariant Safewing MP IV 2012 Protect

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	75.0	152.5	40.6	75.2	38.6	68.9	25.8	46.5	11.9	62.7
	75/25	72.3	125.8	26.7	54.5	34.7	52.1	17.4	28.7	7.1	41.7
	50/50	23.0	45.3	13.1	22.9	14.1	20.4	7.2	10.9		
-14°C*	100/0	43.4	104.4	21.7	40.1	26.9*	46.0*	17.0*	25.8*		
	75/25	24.9	63.0	18.8	38.3	14.2*	30.6*	10.9*	18.7*		
-25°C	100/0	21.9	44.0	15.0	30.0						

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

Table 18: Type IV – Clariant Safewing MP IV Launch

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	254.0	250.5	64.3	104.8	89.5	181.9	57.9	100.8	14.1	101.7
	75/25	218.2	248.7	59.9	105.5	100.8	198.7	44.5	74.6	10.6	106.0
	50/50	83.1	162.8	24.5	45.3	27.8	48.0	18.4	23.3		
-14°C*	100/0	58.8	115.2	48.6	79.2	34.9*	97.7*	25.2*	44.9*		
	75/25	41.3	80.0	47.2	83.2	25.2*	71.7*	25.9*	42.8*		
-25°C	100/0	27.9	49.9	15.0	30.0						

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

Table 19: Type IV – Dow UCAR ADF/AAF ULTRA+

Outside Air Temp. (°C)	**Fluid Dilution**	**HOTDS Verification 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	96.8	215.6	36.2	74.8	45.4	95.7	26.7	39.8	12.0	81.5
	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	84.5	178.9	25.4	52.5	42.8*	86.8*	27.8*	43.8*		
	75/25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
-25°C	100/0	42.2	128.1	21.7	44.8						

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

Table 20: Type IV – Dow UCAR Endurance EG106

Outside Air Temp. (°C)	**Fluid Dilution**	**HOTDS Verification 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 21: Type IV – Dow UCAR FlightGuard AD-480

Outside Air Temp. (°C)	**Fluid Dilution**	**HOTDS Verification 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	119.0	211.8	41.0	81.2	49.3	91.5	37.2	52.8	13.2	96.8
	75/25	87.6	165.1	29.8	62.9	48.4	76.9	31.8	45.5	10.1	73.5
	50/50	31.2	44.7	9.6	21.6	15.1	26.8	9.0	13.2		
-14°C*	100/0	22.5	81.3	28.4	56.2	23.6*	78.2*	17.2*	28.0*		
	75/25	24.5	51.9	21.3	44.9	24.5*	64.4*	16.6*	29.3*		
-25°C	100/0	17.4	39.4	15.0	30.0						

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

Table 22: Type IV – Kilfrost ABC-S

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	157.3	305.6	59.0	102.4	80.0	110.0	60.0	85.0	20.8	76.6
	75/25	63.3	105.2	29.1	56.7	44.4	69.6	32.6	47.7	12.2	48.9
	50/50	21.5	34.2	7.6	17.0	12.8	22.2	8.9	12.3		
-14°C*	100/0	44.9	124.6	45.6	79.1	20.2*	60.0*	11.1*	30.0*		
	75/25	26.0	59.5	25.6	49.9	19.2*	71.1*	10.3*	33.4*		
-25°C	100/0	21.7	42.4	15.0	30.0						

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

Table 23: Type IV – Kilfrost ABC-S PLUS

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	130.3	242.3	72.8	124.9	110.8	119.8	62.5	121.0	22.7	126.1
	75/25	85.7	162.3	42.8	72.9	60.5	80.3	32.3	51.4	11.4	82.0
	50/50	30.7	52.7	17.5	32.2	16.5	39.1	13.1	17.6		
-14°C*	100/0	56.6	208.3	60.2	103.2	23.1*	94.1*	17.6*	29.6*		
	75/25	42.8	110.6	35.4	60.2	19.1*	71.8*	17.4*	26.7*		
-25°C	100/0	37.5	60.4	15.0	30.0						

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

Table 24: Type IV – Lyondell ARCTIC Shield®

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	116.0	191.1	50.5	87.1	56.7	99.3	43.4	66.3	13.8	83.5
	75/25	78.8	136.4	37.9	63.6	55.2	83.4	29.3	45.7	9.6	81.5
	50/50	36.5	44.4	20.3	35.9	19.1	32.1	11.2	17.3		
-14°C*	100/0	61.6	146.4	44.2	76.2	26.7*	91.9*	24.2*	31.6*		
	75/25	51.9	104.5	33.4	56.0	29.4*	75.4*	22.7*	30.8*		
-25°C	100/0	24.0	43.0	15.0	30.0						

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

Table 25: Type IV – Octagon Max-Flight

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	160.9	239.6	48.2	93.8	54.2	135.7	36.5	57.0	15.7	75.1
	75/25	124.1	197.2	44.1	102.6	73.3	132.4	33.8	68.5	11.4	41.2
	50/50	53.6	102.6	26.0	76.4	34.2	61.4	16.4	30.6		
-14°C*	100/0	50.5	151.0	26.5	51.5	24.9*	69.3*	18.0*	38.0*		
	75/25	32.3	65.1	20.7	48.2	20.8*	61.3*	14.3*	28.3*		
-25°C	100/0	21.5	44.1	15.0	30.0						

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

Table 26: Type IV – Octagon Max-Flight 04

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	160.9	239.6	83.1	163.8	117.5	120.0	68.4	89.6	21.8	143.2
	75/25	124.1	197.2	65.9	136.6	111.3	120.4	58.0	78.2	18.8	140.1
	50/50	53.6	102.6	26.0	76.4	36.3	69.1	24.9	35.8		
-14°C*	100/0	50.5	151.0	35.6	70.3	24.9*	90.2*	18.0*	38.0*		
	75/25	32.3	65.1	39.9	82.6	20.8*	61.3*	14.3*	28.3*		
-25°C	100/0	21.5	44.1	15.0	30.0						

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

Table 27: Type IV – Octagon MaxFlo

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	138.2	217.0	42.2	92.4	79.6	124.8	30.3	58.1	12.4	120.3
	75/25	85.1	122.4	22.0	52.9	37.0	64.9	18.1	33.3	8.1	74.1
	50/50	20.1	38.3	6.8	15.0	10.2	21.3	6.7	10.9		
-14°C*	100/0	68.9	142.2	27.2	59.5	32.2*	102.9*	30.8*	48.9*		
	75/25	40.7	86.8	16.2	38.9	32.2*	75.5*	16.7*	30.7*		
-25°C	100/0	31.2	59.8	15.0	30.0						

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

Table 28: Type IV – Generic

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) As Calculated from Regression Coefficients									
		Freezing Fog (g/dm²/h)		Snow (g/dm²/h)		Freezing Drizzle (g/dm²/h)		Freezing Rain (g/dm²/h)		Cold-Soaked Wing (g/dm²/h)	
		5	2	25	10	13	5	25	13	75	5
-3°C	100/0	75.0	152.5	36.2	74.8	38.6	68.9	25.8	39.8	11.9	62.7
	75/25	63.3	105.2	22.0	52.9	34.7	52.1	17.4	28.7	7.1	41.2
	50/50	17.1	34.2	6.8	15.0	10.2	20.4	6.7	10.9		
-14°C*	100/0	22.5	81.3	21.7	40.1	20.2*	46.0*	11.1*	25.8*		
	75/25	24.5	51.9	16.2	34.7	14.2*	30.6*	10.3*	18.7*		
-25°C	100/0	17.4	39.4	15.0	30.0						

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