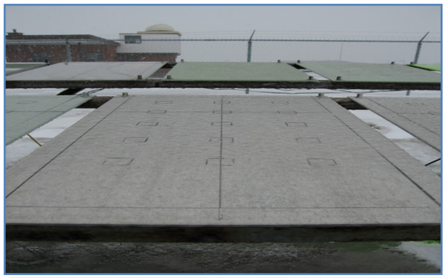
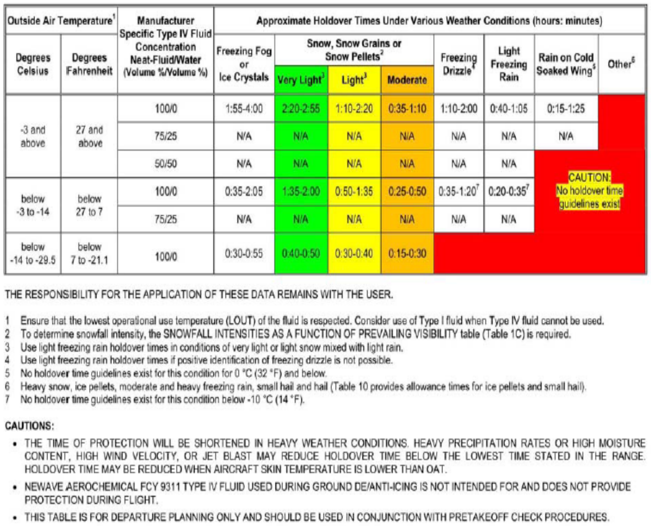
Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter





Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	
		75/25	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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20[7]	0:20-0:35[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY 9311 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Prepared for

Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

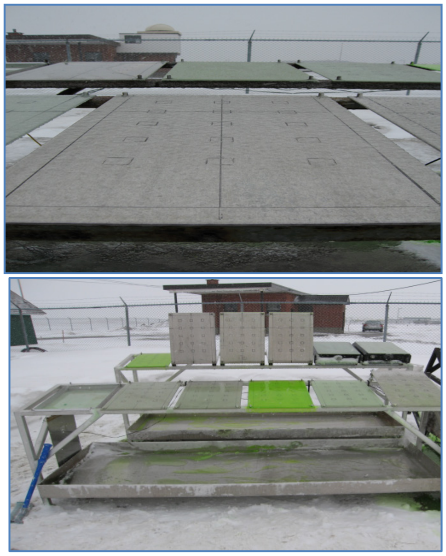
Prepared by

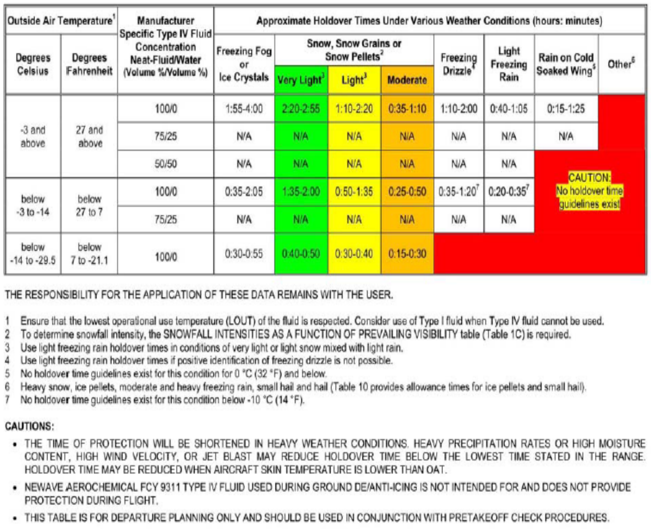
APS Aviation Inc.

January 2015
Final Version 1.0

TP 15271E

Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter





Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	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		
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20[7]	0:20-0:35[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY 9311 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

by

Stephanie Bendickson

APS Aviation Inc.

January 2015
Final Version 1.0

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:

Oct. 9, 2019

Stephanie Bendickson, B.Comm. Date
Project Leader

Reviewed by:

Oct. 11, 2019

John D'Avirro, Eng., PBDM Date
Director, Aviation Services

Approved by: **

John Detombe Date
Principal Engineer, Defence and Security
ADGA Group Consultant Inc.

Un sommaire français se trouve avant la table des matières.

This report was first provided to Transport Canada as Final Draft 1.0 in January 2015.
It has been published as Final Version 1.0 in October 2019.

***Final Draft 1.0 of this report was signed and provided to Transport Canada in January 2015. A Transport Canada technical and editorial review was subsequently completed and the report was finalized in October 2019; John Detombe 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 with support from the Federal Aviation Administration, APS Aviation Inc. has undertaken a research program to advance aircraft ground de/anti-icing technology. The specific objectives of the APS Aviation Inc. test program are the following:

- To develop holdover time data for all newly-qualified de/anti-icing fluids and update and maintain the website for the holdover time guidelines;
- To evaluate weather data from previous winters that can have an impact on the format of the holdover time guidelines;
- To conduct general and exploratory de/anti-icing research;
- To conduct tests to evaluate the effect of deployed flaps and slats prior to anti-icing;
- To conduct tests and research on surfaces treated with ice phobic products;
- To conduct tests with the snow machine to support ARP5485 changes;
- To conduct tests to evaluate holdover times in heavy snow conditions;
- To develop an SAE AIR for the evaluation of aircraft coatings;
- To support the evaluation of the National Research Council Canada propulsion icing wind tunnel to determine its flow characteristics;
- To develop holdover time guidance for operation in ice crystal conditions;
- To continue research for development of ice detection capabilities for pre-deicing, engine deicing and departing aircraft at the runway threshold;
- To develop a performance specification for electronic holdover time applications;
- To investigate pre-takeoff contamination check 5-minute allowance;
- To conduct full-scale general aviation aircraft windshield washer fluid deicing testing to substantiate and support flat plate testing results;
- To develop training and fluid failure photos/videos for global archive;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To develop guidelines on radiation cooling during taxi.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2013-14 are documented in eight reports. The titles of the reports are as follows:

- TP 15268E Winter Weather Impact on Holdover Time Table Format (1995-2014);
- TP 15269E Aircraft Ground Icing General Research Activities During the 2013-14 Winter;
- TP 15270E Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables;
- TP 15271E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter;

- TP 15272E Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 3 of 3);
- TP 15273E Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2013-14;
- TP 15274E Exploratory Wind Tunnel Aerodynamic Research Winter 2013-14; and
- TP 15275E Investigation of Ice Phobic Technologies to Reduce Aircraft Icing in Northern and Cold Climates.

In addition, the following interim report is being prepared:

- *Evaluation of Endurance Times on Extended Flaps and Slats.*

This report, TP 15271E has the following objective:

- To develop holdover time data for new de/anti-icing fluids and to document changes made to the holdover time guidelines.

The objective was met by conducting endurance time tests with fluids in simulated freezing precipitation at the National Research Council Canada Climatic Engineering Facility in Ottawa and in natural snow at the APS Aviation Inc. test site at Montreal-Trudeau Airport in Montreal.

PROGRAM ACKNOWLEDGEMENTS

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

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Yelyzaveta Asnytska, Brandon Auclair; Steven Baker, Stephanie Bendickson, John D'Avirro, Jesse Dybka, Ben Falvo, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Dany Posteraro, Marco Ruggi, Gordon Smith, James Smyth, David Youssef, Nondas Zoitakis and Victoria Zoitakis.

Special thanks are extended to Howard Posluns, Yvan Chabot, Doug Ingold, Warren Underwood and Charles J. Enders, who on behalf of the Transportation Development Centre and the Federal Aviation Administration, have participated, contributed and provided guidance in the preparation of these documents.

PROJECT ACKNOWLEDGEMENTS

APS Aviation Inc. would like to acknowledge the contributions of the following organizations to this project: Meteorological Services Canada and Aéroports de Montréal for providing an outdoor testing location, and the fluid manufacturers for providing support and funding.

Transport Canada Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 15271E	2. Project No. B14W	3. Recipient's Catalogue No.

4. Title and Subtitle

Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter

5. Publication Date

January 2015

6. Performing Organization Document No.

CM2265.003

7. Author(s)

Stephanie Bendickson

8. Transport Canada File No.

2450-BP-14

9. Performing Organization Name and Address

APS Aviation Inc.
6700 Côte-de-Liesse Rd., Suite 105
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
Transport Canada
330 Sparks St., 26th Floor
Ottawa, Ontario, K1A 0N5

13. Type of Publication and Period Covered

Final

14. Project Officer

Antoine Lacroix for Howard Posluns

15. Supplementary Notes (Funding programs, titles of related publications, etc.)

Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre. Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. This project was co-sponsored by the Federal Aviation Administration.

16. Abstract

The primary objective of the 2013-14 holdover time test program was to evaluate the performance of new deicing and anti-icing fluids over the entire range of conditions encompassed by the holdover time guidelines. The objective was met by conducting endurance time tests. The procedure for these tests consisted of pouring fluids onto clean aluminum test surfaces inclined at 10º. The onset of failure was recorded as a function of time in natural frost, natural snow, artificial snow, simulated freezing fog, simulated freezing drizzle, simulated light freezing rain, and simulated rain on a cold-soaked wing. A total of 780 tests were conducted with seven fluids.

Changes to the holdover time guidelines for the winter of 2014-15 include:

- Fluid-specific HOT guidelines were added for four new fluids: LNT Solutions P250 (Type II), Clariant Max Flight Sneg (Type IV), LNT Solutions E450 (Type IV) and Newave Aerochemical FCY 9311 (Type IV);
- Kilfrost ABC 2000 (Type II) and Lyondell Arctic Shield (Type IV) were removed from the guidelines as per the protocol for removal of obsolete data;
- Six decreases were made to the Type IV generic HOT guidelines as a result of the addition of new fluids;
- The allowance time for Type IV propylene glycol (PG) fluid in moderate ice pellets at temperatures below -16°C was removed;
- A new allowance time of 7 minutes was added for Type IV fluids in light ice pellets mixed with moderate snow at below -5 to -10°C; and
- As a result of preliminary research on endurance times on flaps and slats, the FAA published special holdover time tables (containing holdover times that are 90% of the standard holdover time table values) for use when flaps/slats are deployed prior to de/anti-icing.

It is recommended that any new Type I, Type II, Type III or Type IV fluids be evaluated over the entire range of conditions in the holdover time guidelines. It is also recommended that if a new Type III fluid is submitted for heated application testing, further research be conducted to evaluate endurance times of Type III fluids applied heated to composite surfaces.

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

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	—	xvi, 84 apps	—

CDT/TDC 79-005
Rev. 96

Transports Canada Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. Nº de la publication de Transports Canada
TP 15271E

2. Nº de l'étude
B14W

3. Nº de catalogue du destinataire

4. Titre et sous-titre
Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter

5. Date de la publication
Janvier 2015

6. Nº de document de l'organisme exécutant
CM2265.003

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 105
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
Transports Canada
330, rue Sparks, 26^{ième} étage
Ottawa (Ontario) K1A 0N5

13. Genre de publication et période visée
Final

14. Agent de projet
Antoine Lacroix pour Howard Posluns

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. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. Leur objet apparaît à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

Le principal objectif du programme d'essai sur les durées d'efficacité de l'hiver 2013-2014 était d'évaluer la performance de nouveaux liquides de dégivrage et d'antigivrage pour toute la gamme des conditions météorologiques couvertes par les lignes directrices relatives aux durées d'efficacité. Pour atteindre cet objectif, des essais d'endurance ont été menés. La procédure suivie pour ces essais consistait à verser les liquides sur des surfaces d'aluminium propres, inclinées à 10°. On notait ensuite l'amorce de la perte d'efficacité en fonction du temps, sous le givre naturel, la neige naturelle et artificielle, et dans des conditions artificielles simulant du brouillard verglaçant, de la bruine verglaçante, de la pluie verglaçante faible et de la pluie sur une aile imprégnée de froid. Un total de 780 essais ont été menés, avec sept liquides.

Parmi les changements apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2014-2015, on note ce qui suit :

- Des lignes directrices relatives aux durées d'efficacité spécifiques à quatre nouveaux liquides, soit LNT Solutions P250 (type II), Clariant Max Flight Sneg (type IV), LNT Solutions E450 (type IV) et Newave Aerochemical FCY 9311 (type IV), ont été ajoutées ;
- Les liquides Kilfrost ABC 2000 (type II) et Lyondell Arctic Shield (type IV) ont été retirés des lignes directrices, conformément au protocole régissant le retrait des données obsolètes ;
- L'ajout de nouveaux liquides a entraîné la réduction, dans six cas, des durées d'efficacité génériques des liquides de type IV ;
- La marge de tolérance pour les liquides de type IV composés de propylène glycol (PG) dans des conditions de granules de glace modérés à des températures inférieures à -16 °C a été retirée ;
- Une nouvelle marge de tolérance de 7 minutes a été ajoutée pour les liquides de type IV dans des conditions de granules de glace faibles mêlés de neige modérée à des températures au-dessous de -5 °C à -10 °C ; et
- À la suite d'une recherche préliminaire sur les durées d'endurance sur les volets et becs de bord d'attaque, la FAA a publié des tableaux spéciaux des durées d'efficacité (contenant des durées d'efficacité dont les valeurs représentent 90 % de celles du tableau standard des durées d'efficacité) conçus pour être utilisés lorsque les volets et becs de bord d'attaque sont déployés avant les opérations de dégivrage ou d'antigivrage.

Il est recommandé que tout nouveau liquide de type I, de type II, de type III ou de type IV soit évalué pour toute la gamme des conditions couvertes par les tableaux des durées d'efficacité. Il est également recommandé que dans l'éventualité où un nouveau liquide de type III serait testé pour être appliqué lorsque chauffé, des essais supplémentaires soient menés dans le but d'évaluer les durées d'efficacité des liquides de type III appliqués chauffés sur des surfaces composites.

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

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
xvi, 84 ann.

23. Prix
—

CDT/TDC 79-005
Rev. 96

EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre (TDC) of Transport Canada, with support from the Federal Aviation Administration (FAA), and several fluid manufacturers, APS Aviation Inc. (APS) has undertaken a testing and research program to further advance aircraft ground de/anti-icing technology. The program has a number of objectives, and work completed to address these objectives is documented in a series of related reports. The primary objective, the development of holdover time (HOT) guidelines for new de/anti-icing fluids, is addressed in this report. The objective was met by conducting holdover time tests with several de/anti-icing fluids. This report also documents changes made to the HOT guidelines for the winter of 2014-15.

Test Procedures

Test conditions, test parameters, and test bed specifications were determined based on the requirements of Aerospace Recommended Practice (ARP) 5485 and ARP5495, which were developed by the SAE International G-12 HOT Committee for Type II/III/IV and Type I fluids, respectively. The tests consisted of pouring freezing point depressant fluids onto clean, inclined (10°), standard flat aluminum plates. The plates were mounted on test stands and systematically exposed to a variety of natural or simulated icing conditions. For each plate, the elapsed time required to reach a predefined end condition was recorded.

The variables measured during testing included: failure time, type of precipitation, rate of precipitation, visibility, wind speed, wind direction, ambient temperature, test surface temperature, fluid brand, fluid type, and fluid concentration.

Data Collection and Testing

During the 2013-14 test season, data was collected during natural snow and natural frost events at the APS test site at Montreal-Trudeau Airport in Montreal and in simulated precipitation conditions (freezing drizzle, light freezing rain, freezing fog, rain on cold-soaked surface) at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

APS conducted 780 tests in the winter of 2013-14. The results of testing were incorporated into the winter 2014-15 HOT guidelines.

Changes to the HOT Guidelines

The changes below were made to the HOT guidelines for winter 2014-15.

1. A fluid-specific HOT guideline was added for one new Type II fluid: LNT Solutions P250.
2. Fluid-specific HOT guidelines were added for three new Type IV fluids: Clariant Max Flight Sneg, LNT Solutions E450 and Newave Aerochemical FCY 9311.
3. Kilfrost ABC 2000 (Type II) and Lyondell Arctic Shield (Type IV) were removed from the guidelines as per the protocol for removal of obsolete data.
4. Six decreases were made to the Type IV generic HOT guidelines as a result of the addition of new fluids.
5. The allowance time for Type IV propylene glycol fluid in moderate ice pellets at temperatures below -16°C was removed.
6. A new allowance time of 7 minutes was added for Type IV fluids in light ice pellets mixed with moderate snow at below -5 to -10°C.
7. As a result of preliminary research on endurance times on flaps and slats, the FAA published special HOT tables for use when flaps/slats are deployed prior to de/anti-icing. These tables contain holdover times that are 90 percent of the standard HOT table values.

Recommendations

It is recommended that any new Type I, Type II, Type III or Type IV fluids be evaluated over the entire range of conditions encompassed by the HOT tables.

It is also recommended that if a new Type III fluid is submitted for heated application testing, further research be conducted to evaluate endurance times of Type III fluids applied heated to composite surfaces.

SOMMAIRE

En vertu d'un contrat avec le Centre de développement des transports (CDT) de Transports Canada, avec l'appui de la Federal Aviation Administration (FAA) et de plusieurs fabricants de liquides, APS Aviation Inc. (APS) a entrepris des essais et un programme de recherches visant à approfondir la technologie de dégivrage et d'antigivrage d'aéronefs au sol. Le programme poursuivait plusieurs objectifs et les travaux effectués pour atteindre ces objectifs sont documentés dans une suite de rapports connexes. Le principal objectif, le développement de lignes directrices sur les durées d'efficacité (HOT) de nouveaux liquides de dégivrage et d'antigivrage, fait l'objet du présent rapport. Pour atteindre cet objectif, des essais sur les durées d'efficacité ont été menés avec plusieurs liquides de dégivrage et d'antigivrage. Le présent rapport documente également l'ensemble des changements apportés aux lignes directrices sur les durées d'efficacité pour l'hiver 2014-2015.

Procédures d'essai

Les conditions d'essai, les paramètres d'essai et les spécifications relatives au banc d'essai ont été déterminés en vertu des exigences des pratiques recommandées en aérospatiale ARP5485 et ARP5495, élaborées par le comité G-12 de la SAE International (SAE) sur les durées d'efficacité pour les liquides de types II/III/IV et de type I, respectivement. Ces tests consistaient à verser des liquides abaisseurs du point de congélation sur des plaques en aluminium et en matériaux composites standards, plates, propres et inclinées (à 10°). Les plaques étaient montées sur un support d'essai et systématiquement exposées à une gamme de conditions de givrage, naturelles ou simulées. Pour chaque plaque, on notait le temps écoulé avant l'atteinte d'un état final prédéfini.

Parmi les variables mesurées dans le cadre de ces essais, on notait : temps de défaillance, type de précipitation, taux de précipitation, visibilité, vitesse du vent, direction du vent, température ambiante, température de la surface d'essai, marque de commerce du liquide, type de liquide et concentration du liquide.

Collecte de données et essais

Les données recueillies au cours de la saison d'essai 2013-2014 concernaient des tests sous neige naturelle et givre naturel menés à l'installation d'essai d'APS, à l'aéroport Montréal-Trudeau, à Montréal, de même que des essais effectués dans des conditions de précipitations simulées (bruine verglaçante, de la pluie verglaçante faible, du brouillard verglaçant et de la pluie sur des surfaces imprégnées de froid) à l'installation de génie climatique du Conseil national de recherches du Canada (CNRC), à Ottawa.

Au cours de l'hiver 2013-2014, un total de 780 essais ont été menés par APS. Les résultats des essais effectués ont été inclus dans les lignes directrices relatives aux durées d'efficacité pour l'hiver 2014-2015.

Changements aux lignes directrices sur les durées d'efficacité

Les changements ci-dessous ont été apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2014-2015.

1. Des lignes directrices relatives aux durées d'efficacité spécifiques à un nouveau liquide de type II, LNT Solutions P250, ont été ajoutées.
2. Des lignes directrices relatives aux durées d'efficacité spécifiques à trois nouveaux liquides de type IV, soit Clariant Max Flight Sneg, LNT Solutions E450 et Newave Aerochemical FCY 9311, ont été ajoutées.
3. Les liquides Kilfrost ABC 2000 (type II) et Lyondell Arctic Shield (type IV) ont été retirés des lignes directrices, conformément au protocole régissant le retrait des données obsolètes.
4. L'ajout de nouveaux liquides a entraîné la réduction, dans six cas, des durées d'efficacité génériques des liquides de type IV.
5. La marge de tolérance pour les liquides de type IV composés de propylène glycol dans des conditions de granules de glace modérés à des températures inférieures à -16 °C a été retirée.
6. Une nouvelle marge de tolérance de 7 minutes a été ajoutée pour les liquides de type IV dans des conditions de granules de glace faibles mêlés de neige modérée à des températures au-dessous de -5 °C à -10 °C.
7. À la suite d'une recherche préliminaire sur les durées d'endurance sur les volets et becs de bord d'attaque, la FAA a publié des tableaux spéciaux des durées d'efficacité conçus pour être utilisés lorsque les volets et becs de bord d'attaque sont déployés avant les opérations de dégivrage ou d'antigivrage. Ces tableaux contiennent des durées d'efficacité dont les valeurs représentent 90 pour cent de celles du tableau standard des durées d'efficacité.

Recommandations

Il est recommandé que tout nouveau liquide de type I, de type II, de type III ou de type IV soit évalué pour toute la gamme des conditions couvertes par les tableaux des durées d'efficacité.

Il est également recommandé que dans l'éventualité où un nouveau liquide de type III serait testé pour être appliqué lorsque chauffé, des essais supplémentaires soient menés dans le but d'évaluer les durées d'efficacité des liquides de type III appliqués chauffés sur des surfaces composites.

CONTENTS Page

1. INTRODUCTION 1

1.1 Background 1
1.2 Objectives 1
1.3 Content of this Report 5
1.4 Report Format 5
1.5 Publication of HOT Guidelines 5
  1.5.1 Transport Canada 6
  1.5.2 FAA 6

2. TESTING IN 2013-14 7

2.1 Procedures 7
2.2 Test Sites 8
2.3 Fluids Tested 8
2.4 Description of Tests 11
2.5 Reporting 11
2.6 Supplemental Testing – Ice Crystals Research 11
2.7 Supplemental Testing – Ice Pellets Research 12
2.8 Supplemental Testing – Flaps and Slats Research 12

3. CHANGES TO THE TYPE I HOT GUIDELINES 13

3.1 New Fluids/Data 13
3.2 Changes to HOT Guidelines Format 13
3.3 Type I Generic Holdover Time Values 13

4. CHANGES TO THE TYPE II HOT GUIDELINES 15

4.1 New Fluids/Data 15
4.2 Removed Fluids/Data 15
4.3 Changes to HOT Guidelines Format 15
4.4 Type II Generic Holdover Time Values 15
  4.4.1 Use of Generic Holdover Times in Very Cold Snow 16
  4.4.2 Impact of New and Removed Fluids/Data 16
  4.4.3 Fluids Responsible for Type II Generic Holdover Time Values 16
  4.4.4 Evolution of Type II Generic Holdover Time Values 17

5. CHANGES TO THE TYPE III HOT GUIDELINES 43

5.1 New Fluids/Data 43
5.2 Changes to HOT Guidelines Format 43
5.3 Type III Generic Holdover Time Values 43
5.4 Future Changes to the Type III HOT Guidelines 43
5.5 Supplemental Research – Endurance Times of Type III Fluids Applied Heated to Composite Surfaces 44

6. CHANGES TO THE TYPE IV HOT GUIDELINES 47

6.1 New Fluids/Data 47
6.2 Removed Fluids/Data 47
6.3 Changes to HOT Guidelines Format 47
6.4 Type IV Generic Holdover Time Values 48
  6.4.1 Use of Generic Holdover Times in Very Cold Snow 48
  6.4.2 Impact of New and Removed Fluids/Data 48
  6.4.3 Fluids Responsible for the Type IV Generic Holdover Time Values 48

6.4.4 Evolution of Type IV Generic Holdover Time Values 51
7. OTHER CHANGES TO THE HOT GUIDELINES CONTENT 77
7.1 Active Frost HOT Guidelines 77
7.2 Ice Pellet and Small Hail Allowance Time Tables 77
7.3 FAA 90 Percent HOT Tables for Flaps and Slats 77
7.4 List of Fluids and Lowest Operational Use Temperature Table 78
7.5 Lowest On-Wing Viscosity Table 78
8. CONCLUSIONS 79
9. RECOMMENDATIONS 81
REFERENCES 83

LIST OF APPENDICES

A Transportation Development Centre Work Statement Excerpt – Aircraft & Anti-Icing Fluid Winter Testing 2013-14
B Procedures for Holdover Time Testing
C Fluid Manufacturer Report: Baltic Ground Services Defrosol ADF (Type I)
D Fluid Manufacturer Report: LNT Solutions P250 (Type II)
E Fluid Manufacturer Report: Clariant Max Flight Sneg (Type IV)
F Fluid Manufacturer Report: LNT Solutions E450 (Type IV)
G Fluid Manufacturer Report: Newave Aerochemical FCY 9311 (Type IV)
H Transport Canada and Federal Aviation Administration 2014-15 Holdover Time Guidelines

LIST OF TABLES Page

Table 1.1: Summary of APS Holdover Time Testing Activities 2
Table 2.1: Fluid Receipt Data (Commercialized Fluids) 10
Table 2.2: Fluid Characteristic Data (Commercialized Fluids).. 10
Table 2.3: Summary of Tests Conducted.. 11
Table 4.1: Fluids Responsible for Type II Generic Holdover Time Values................................... 18
Table 4.2: Type II Neat Fluid, Snow, -3°C and Above.. 19
Table 4.3: Type II 75/25 Fluid, Snow, -3°C and Above.. 20
Table 4.4: Type II 50/50 Fluid, Snow, -3°C and Above.. 21
Table 4.5: Type II Neat Fluid, Snow, Below -3°C to -14°C 22
Table 4.6: Type II 75/25 Fluid, Snow, Below -3°C to -14°C 23
Table 4.7: Type II Neat Fluid, Snow, Below -14°C to -25°C... 24
Table 4.8: Type II Neat Fluid, Freezing Drizzle, -3°C and Above 25
Table 4.9: Type II 75/25 Fluid, Freezing Drizzle, -3°C and Above 26
Table 4.10: Type II 50/50 Fluid, Freezing Drizzle, -3°C and Above 27
Table 4.11: Type II Neat Fluid, Freezing Drizzle, Below -3°C to -10°C 28
Table 4.12: Type II 75/25 Fluid, Freezing Drizzle, Below -3°C to -10°C 29
Table 4.13: Type II Neat Fluid, Light Freezing Rain, -3°C and Above.. 30
Table 4.14: Type II 75/25 Fluid, Light Freezing Rain, -3°C and Above...................................... 31
Table 4.15: Type II 50/50 Fluid, Light Freezing Rain, -3°C and Above...................................... 32
Table 4.16: Type II Neat Fluid, Light Freezing Rain, Below -3°C to -10°C 33
Table 4.17: Type II 75/25 Fluid, Light Freezing Rain, Below -3°C to -10°C 34
Table 4.18: Type II Neat Fluid, Freezing Fog, -3°C and Above 35
Table 4.19: Type II 75/25 Fluid, Freezing Fog, -3°C and Above 36
Table 4.20: Type II 50/50 Fluid, Freezing Fog, -3°C and Above 37
Table 4.21: Type II Neat Fluid, Freezing Fog, Below -3°C to -14°C 38
Table 4.22: Type II 75/25 Fluid, Freezing Fog, Below -3°C to -14°C 39
Table 4.23: Type II Neat Fluid, Freezing Fog, Below -14°C to -25°C 40
Table 4.24: Type II Neat Fluid, Rain on Cold-Soaked Wing, Above 0°C 41
Table 4.25: Type II 75/25 Fluid, Rain on Cold-Soaked Wing, Above 0°C 42
Table 6.1: Fluids Responsible for the Type IV Generic Holdover Time Values 50
Table 6.2: Type IV Neat Fluid, Snow, -3°C and Above 52
Table 6.3: Type IV 75/25 Fluid, Snow, -3°C and Above 53
Table 6.4: Type IV 50/50 Fluid, Snow, -3°C and Above 54
Table 6.5: Type IV Neat Fluid, Snow, Below -3°C to -14°C... 55
Table 6.6: Type IV 75/25 Fluid, Snow, Below -3°C to -14°C 56
Table 6.7: Type IV Neat Fluid, Snow, Below -14°C to -25°C 57
Table 6.8: Type IV Neat Fluid, Freezing Drizzle, -3°C and Above... 58
Table 6.9: Type IV 75/25 Fluid, Freezing Drizzle, -3°C and Above... 59
Table 6.10: Type IV 50/50 Fluid, Freezing Drizzle, -3°C and Above 60
Table 6.11: Type IV Neat Fluid, Freezing Drizzle, Below -3°C to -10°C..................................... 61
Table 6.12: Type IV 75/25 Fluid, Freezing Drizzle, Below -3°C to -10°C................................... 62
Table 6.13: Type IV Neat Fluid, Light Freezing Rain, -3°C and Above 63
Table 6.14: Type IV 75/25 Fluid, Light Freezing Rain, -3°C and Above 64
Table 6.15: Type IV 50/50 Fluid, Light Freezing Rain, -3°C and Above 65
Table 6.16: Type IV Neat Fluid, Light Freezing Rain, Below -3°C to -10°C 66
Table 6.17: Type IV 75/25 Fluid, Light Freezing Rain, Below -3°C to -10°C 67
Table 6.18: Type IV Neat Fluid, Freezing Fog, -3°C and Above 68
Table 6.19: Type IV 75/25 Fluid, Freezing Fog, -3°C and Above 69
Table 6.20: Type IV 50/50 Fluid, Freezing Fog, -3°C and Above 70
Table 6.21: Type IV Neat Fluid, Freezing Fog, Below -3°C to -14°C... 71

Table 6.22: Type IV 75/25 Fluid, Freezing Fog, Below -3°C to -14°C 72
Table 6.23: Type IV Neat Fluid, Freezing Fog, Below -14°C to -25°C 73
Table 6.24: Type IV Neat Fluid, Rain on a Cold-Soaked Wing, Above 0°C 74
Table 6.25: Type IV 75/25 Fluid, Rain on a Cold-Soaked Wing, Above 0°C 75

LIST OF FIGURES Page

Figure 5.1: Type III Composite vs. Aluminum Test Results (2011-12) 45
Figure 5.2: Type III Composite vs. Aluminum Test Results (2012-13) 45
Figure 5.3: Type III Composite vs. Aluminum Test Results (Freezing Precipitation 2013-14)......... 46
Figure 5.4: Type III Composite vs. Aluminum Test Results (Snow 2013-14) 46

GLOSSARY

AMS	Aerospace Material Specification
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
BGS	Baltic Ground Services
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
SAE	SAE International
TDC	Transportation Development Centre
WSET	Water Spray Endurance Test

This page intentionally left blank.

1. INTRODUCTION

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

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

Under contract to the TDC, with financial support from the FAA, APS Aviation Inc. (APS) has undertaken research activities to further advance aircraft ground de/anti-icing technology.

1.1 Background

APS has completed considerable testing related to de/anti-icing fluids on behalf of Transport Canada over the past two decades. Specifically, research has been conducted to determine fluid holdover times, to substantiate holdover time (HOT) tables, and to further the knowledge and development of deicing technology. A summary of the holdover time related research activities completed by APS is provided in Table 1.1.

1.2 Objectives

The primary objectives of the 2013-14 holdover time test program were to conduct flat plate tests under conditions of natural and simulated precipitation to determine de/anti-icing fluid endurance times for new fluids, to develop HOT guidelines based on samples of newly and previously qualified deicing and anti-icing fluids, and to document changes made to the HOT guidelines for the winter of 2014-15.

The detailed objectives of the 2013-14 test program are provided in the work statement excerpt in Appendix A.

Table 1.1: Summary of APS Holdover Time Testing Activities

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
1990-91	TP 11206E	• Natural Precipitation (mostly snow)	• Type II (100%)	Mostly Montreal Worldwide
1991-92	TP 11454E	• Natural Precipitation (mostly snow)	• Type III (first gen)	Mostly Montreal St. John's
1992-93	TP 11836E	• Natural Snow • Simulated Freezing Drizzle (prelim) • Simulated Freezing Fog (outdoor) • Artificial Snow (prelim)	• Type I • Type II (100%) • Type III (first gen)	Montreal Ottawa (NRC) Rigaud
1993-94	TP 12915E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (outdoor)	• Primarily: Type II (dilutions) • Also: Type II (neat), Type I	Montreal Ottawa (NRC)
1994-95	TP 12654E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface (prelim)	• Type I • Type II • Type IV (prelim)	Montreal Ottawa (NRC)
1995-96	TP 12896E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
1996-97	TP 13131E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type I • Type II (100%) • Type III (first gen) • Type IV	Montreal Ottawa (NRC)
1997-98	TP 13318E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type IV	Montreal Ottawa (NRC)
1998-99	TP 13477E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type IV (LV)	Montreal Ottawa (NRC)
1999-2000	TP 13659E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ)

Table 1.1: Summary of APS Holdover Time Testing Activities (cont'd)

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
2000-01	TP 13826E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ)
2001-02	TP 13991E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Val-d'Or North Bay Thompson
2002-03	TP 14144E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ) St-Alexis
2003-04	TP 14374E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow	• Type II • Type III	Montreal Ottawa (NRC) Val-d'Or Ste-Adele
2004-05	TP 14443E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2005-06	TP 14712E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
2006-07	TP 14776E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)

Table 1.1: Summary of APS Holdover Time Testing Activities (cont'd)

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
2007-08	TP 14869E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow • Ice Pellets / Mixed Conditions • Snow Pellets	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2008-09	TP 14933E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Ice Pellets / Mixed Conditions	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2009-10	TP 15050E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Ice Pellets / Mixed Conditions • Snow Pellets	• Type I • Type II • Type IV	Montreal Val-d'Or Dolbeau-Mistassini Thetford Mines St-Sauveur Ottawa (NRC)
2010-11	TP 15156E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
2011-12	TP 15156E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III	Montreal Gaspésie Rimouski St-Jovite Edmundston Ottawa (NRC)
2012-13	TP 15228E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III	Montreal Ottawa (NRC)
2013-14	TP 15271E	• Natural Snow/Frost • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III • Type IV	Montreal Val-d'Or Timmins Kuujjuaq Ottawa (NRC)

1.3 Content of this Report

APS has written a report on the holdover time test program for each year it has been carried out. In 2003-04, the report was condensed to increase readability and to present the reader with, for the most part, only new and current information over the previous year's report.

Notably, the reader is now directed to TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (1), for the detailed test methodology and individual fluid test information is provided in appendices to the report rather than within the report itself.

In the winter of 2009-10, a decision was made to include detailed test information only for fluids that are expected to be qualified and commercialized. Test information for other fluids is not included.

1.4 Report Format

The subsequent sections of this report contain the following:

a) Section 2 summarizes 2013-14 testing;

b) Section 3 documents changes to the Type I HOT guidelines;

c) Section 4 documents changes to the Type II HOT guidelines;

d) Section 5 documents changes to the Type III HOT guidelines;

e) Section 6 documents changes to the Type IV HOT guidelines;

f) Section 7 documents changes to other HOT guidelines content;

g) Section 8 presents conclusions derived from the test program; and

h) Section 9 lists recommendations for future testing.

1.5 Publication of HOT Guidelines

HOT guidelines are published annually by both Transport Canada and the FAA.

1.5.1 Transport Canada

The Transport Canada HOT guidelines are published on the following website:

- http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm

The Transport Canada HOT guidelines are intended to be used in conjunction with TP 14052E, *Guidelines for Aircraft Ground Icing Operations (Second Edition)* (2), which includes reference material related to ground icing operations. TP 14052E (2) is also available on the Transport Canada website.

1.5.2 FAA

The FAA HOT guidelines are published on the following website:

- http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/

The 2013-14 FAA HOT guidelines are intended to be used in conjunction with N 8900.275, *Revised FAA-Approved Deicing Program Updates, Winter 2014-2015* (3), which provides additional guidance and reference material. N 8900.275 (3) is also available on the FAA website.

2. TESTING IN 2013-14

An overview of the testing completed in the winter of 2013-14 is provided in this chapter.

2.1 Procedures

Test procedures for holdover time testing of Type II, III and IV fluids were developed in accordance with SAE International (SAE) Aerospace Recommended Practice (ARP) 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type II, III, and IV* (4). Test procedures for holdover time testing of Type I fluids were developed in accordance with ARP5945, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type I* (5).

Because this report serves as the publishing mechanism for the APS endurance time test program, all current endurance time test procedures are included in the report, even if they are not updated or used in a given year (for example, the Type I procedure is included even if no Type I fluids are tested). This is to ensure the most current procedure is available for reference.

The procedures valid for the 2013-14 winter are included in Appendix B. They include:

1. Test Requirements for Natural Precipitation Flat Plate Testing;
2. Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval;
3. Test Requirements for Simulated Freezing Precipitation Flat Plate Testing;
4. Overall Program of Tests at NRC, March 2014; and
5. Overall Program of Tests at NRC, April 2014.

The first two procedures provide the detailed test methodology for natural snow testing. The third procedure provides the detailed test methodology for indoor simulated light freezing rain, freezing fog, freezing drizzle and rain on cold-soaked surface testing.

The fourth procedure was developed to coordinate holdover time testing and other aircraft ground icing research projects at the annual APS indoor simulated precipitation test session. Holdover time testing and other program element testing were conducted at the same session to maximize use of the facility and resources.

The fifth procedure was developed to coordinate testing at a supplemental test session at the NRC climate chamber in April 2014.

The endurance time test methodology is described in detail in the Transport Canada report, TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (1).

Over the winters of 2012-13 and 2013-14, two software projects were completed to improve the holdover time testing process.

1. A new interface was created for the freezing precipitation (indoor) rate management program. The new interface streamlines the process for measuring and managing precipitation rates in freezing precipitation.
2. An application was created to replace the paper-based end condition data form. The application improves efficiency and accuracy in recording endurance times and adds new features to better manage the testing process.

Further details on these upgrades are provided in the Transport Canada report, TP 15269E, *Aircraft Ground Icing General Research Activities During the 2013-14 Winter* (6).

2.2 Test Sites

Simulated precipitation testing (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surfaces) was conducted at the NRC Climatic Engineering Facility (CEF) in Ottawa.

Natural snow testing was conducted primarily at the APS test site at the Pierre Elliott Trudeau Airport in Montreal. Several tests were also conducted at remote locations using a mobile test site. The remote locations included Timmons (Ontario), Kuujjuaq (Quebec), Val-d'Or (Quebec) and Ottawa (Ontario).

Artificial snow testing was required in the winter of 2013-14. It was conducted at the APS test site at the Montreal airport.

2.3 Fluids Tested

Seven fluids underwent endurance time testing in the winter of 2013-14. As described in Section 1.3, only the endurance time results of fluids that are expected to be commercialized are published in this report; the results of any other fluids that undergo testing are provided only to the fluid manufacturer(s).

One Type I fluid was tested:

- Baltic Ground Services (BGS) Defrosol ADF: This new Type I fluid underwent testing in freezing and artificial snow conditions in September 2013 and in natural frost and natural snow conditions over the winter of 2013-14. The detailed test results are provided in Appendix C.

Two Type II fluids were tested:

- LNT Solutions P250: This new Type II fluid underwent a complete set of testing in winter 2013-14 and is expected to be commercialized in future. It is a different formulation than the fluid with the same name tested in 2011-12. The detailed test results are provided in Appendix D; and
- Type II Experimental Fluid: A Type II experimental fluid was submitted for testing. This fluid will not be commercialized and therefore the detailed test results are not provided in this report.

One Type III fluid was tested:

- Clariant Safewing MP III 2031 ECO: This commercial Type III fluid was tested using the heated application (Type I) test protocol in 2012-13 and 2013-14. In June 2014, Clariant informed Transport Canada and the FAA the fluid would no longer be produced/sold. As a result, it was mutually decided by the regulators and manufacturer that the results of this testing would not be incorporated into the HOT guidelines. Therefore, the detailed test results are not provided in this report.

Three Type IV fluids were tested:

- Clariant Max Flight Sneg: This new Type IV fluid underwent a complete set of testing in winter 2013-14 and is expected to be commercialized in future. The detailed test results are provided in Appendix E;
- LNT Solutions E450: This new Type IV fluid underwent a complete set of testing in winter 2013-14 and the 100/0 fluid (only) is expected to be commercialized in future. The detailed test results are provided in Appendix F; and
- Newave Aerochemical FCY 9311: This new Type IV fluid underwent a complete set of testing in winter 2013-14 and the 100/0 fluid (only) is expected to be commercialized in future. The detailed test results are provided in Appendix G.

Additional relevant fluid receipt data for the commercialized fluids is provided in Table 2.1 (fluid receipt data) and Table 2.2 (fluid characteristic data).

Table 2.1: Fluid Receipt Data (Commercialized Fluids)

Fluid Manufacturer	Fluid Name	Fluid Type	Fluid Formulation	Date Received	Batch #	Dilutions Received (%)
Baltic Ground Services	Defrosol ADF	I	Non-Glycol (Propylene Glycol and Glycerine)	24-Jul-13	56-130619	Concentrate
Clariant	Max Flight Sneg	IV	Propylene Glycol	24-Dec-13	TV534	100, 75, 50
LNT Solutions	P250	II	Propylene Glycol	12-Mar-14	C3/01/01	100, 75, 50
LNT Solutions	E450	IV	Ethylene Glycol	10-Apr-14	F4003 / 003/14	100, 75, 50
Newave Aerochemical	FCY 9311	IV	Propylene Glycol	2-Jan-14	201311 002LS	100, 75, 50

Table 2.2: Fluid Characteristic Data (Commercialized Fluids)

Fluid	Fluid Dil.	Brix (Measured)	WSET (mins)	Freeze Point (Stated, °C)	LOUT (Stated, °C)	Viscosity (Measured, mPa.s)	
						Mfr. Method	AS9968 Method
BGS Defrosol ADF	Conc.	>50°	5.0 (50/50)	-34 (60/40) -40 (65/35) -45 (70/30)	-25/-30[1]	n/a	n/a
Clariant Max Flight Sneg	100/0	36.0	101	-37	-29	8,700[2]	8,050[4]
	75/25	29.0	n/a	-20	-14	20,200[3]	21,800[5]
	50/50	20.5	n/a	-10	-3	13,600[3]	15,000[5]
LNT Solutions P250	100/0	36.25	78	not provided	not provided	2,400[6]	2,150[4]
	75/25	28.25	n/a			16,200[6]	15,200[4]
	50/50	19.25	n/a			8,150[6]	8,100[4]
LNT Solutions E450	100/0	33.5	85	not provided	not provided	45,300[7]	n/a[8]
	75/25	26.0	n/a			16,000[7]	n/a[8]
	50/50	17.75	n/a			2,600[7]	n/a[8]
Newave Aerochemical FCY 9311	100/0	37.5	100	-38	-29	14,100[5]	14,100[5]
	75/25	31.5	n/a	-21	-14	23,800[5]	23,800[5]
	50/50	21.0	n/a	-11	-3	2,200[4]	2,200[4]

[1] Low speed ramp / high speed ramp (65/35 dilution)
[2] Spindle LV1, big sample adapter, 55 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[3] Spindle LV2-disc, big sample adapter, 60 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[4] Spindle LV1 with guard leg, 600 mL low form beaker, ~575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[5] Spindle LV2-disc with guard leg, 600 mL low form beaker, ~425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[6] Spindle LV2-disc with guard leg, 200 mL tall form beaker, ~155 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[7] Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, 0°C, 0.3 rpm, for 10.0 minutes
[8] Not available: stable, reliable results could not be measured using the AIR 9968 method

2.4 Description of Tests

In total, 780 endurance time tests were conducted during the winter of 2013-14. A summary of the total number of tests conducted is shown by precipitation condition in Table 2.3. Details for each test are included in the detailed reports provided to the manufacturers (see Subsection 2.5).

Table 2.3: Summary of Tests Conducted

Precipitation Condition	**Tests Conducted**
Natural Snow	331
Artificial Snow	39
Freezing Fog	124
Freezing Drizzle	109
Light Freezing Rain	103
Rain on Cold-Soaked Surface	41
Natural Frost	33
Total	**780**

2.5 Reporting

A comprehensive report was created for each fluid tested to document its performance in detail. These reports were provided to the fluid manufacturers. As per Subsection 1.3, copies of the reports for fluids which are expected to be qualified/commercialized have been included as appendices to this report. The relevant reports can be found in Appendices C, D, E, F and G.

2.6 Supplemental Testing – Ice Crystals Research

Additional ice crystals data was collected in the winter of 2013-14. This data supported the data collected in the winter of 2012-13. The decision made previously, to include ice crystals in the freezing fog column of the HOT tables, was also supported. This research is documented in the Transport Canada report, TP 15269E, *Aircraft Ground Icing General Research Activities During the 2013-14 Winter* (6).

2.7 Supplemental Testing – Ice Pellets Research

Additional ice pellet allowance times research was conducted in the winter of 2013-14. This research is documented in the Transport Canada report, TP 15273E, *Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2013-14* (7).

Changes were made to the HOT guidelines for winter 2014-15 as a result of this research. The changes are described in Subsection 7.2.

2.8 Supplemental Testing – Flaps and Slats Research

Over the last four winters, research has been carried out to examine if endurance times on extended flaps and slats are significantly different from endurance times on wings / published holdover times. To date, conclusions indicate that endurance times on extended flaps/slats may be reduced by up to 50 percent for Type II/IV fluids and 10 percent for Type I fluids relative to aircraft wings / published holdover times.

This research is ongoing and thus far has only been documented in interim reports; it will be formally published in a future Transport Canada report.

Changes were made to the FAA HOT guidelines for winter 2014-15 as a result of this research. The changes are described in Subsection 7.3. Further testing and further analysis of existing data may result in further changes being made to the HOT guidelines and related operational guidance in future.

3. CHANGES TO THE TYPE I HOT GUIDELINES

Changes made to the Type I HOT guidelines for the winter of 2014-15 are documented in this chapter. The Transport Canada and FAA 2014-15 Type I HOT guidelines are included in Appendix H.

3.1 New Fluids/Data

A significant body of previous research and testing has indicated that all Type I fluids formulated with glycol perform in a similar manner from an endurance time perspective. As a result, regulators no longer require Type I deicing fluids formulated with propylene glycol, ethylene glycol or diethylene glycol to undergo endurance time testing. However, they do require testing of fluids formulated with other glycol bases or with non-glycol bases. This is to ensure the endurance time performance of these fluids is similar to that of the Type I fluids used to generate the current Type I holdover times.

Baltic Ground Services Defrosol ADF underwent testing in simulated precipitation and in artificial snow in September 2013. It performed similarly to Type I fluids tested in past years and therefore it was concluded it could be used with the generic Type I HOT guidelines. Natural snow testing was conducted in the winter of 2013-14 to confirm the artificial snow results. The detailed test results from both test periods are provided in Appendix C.

3.2 Changes to HOT Guidelines Format

No changes were made to the format of the Type I HOT guidelines for winter 2014-15.

3.3 Type I Generic Holdover Time Values

No changes were made to the Type I generic holdover times for the winter of 2014-15.

This page intentionally left blank.

4. CHANGES TO THE TYPE II HOT GUIDELINES

Changes made to the Type II HOT guidelines for the winter of 2014-15 are documented in this chapter. The Transport Canada and FAA 2014-15 Type II HOT guidelines are included in Appendix H.

4.1 New Fluids/Data

One new Type II fluid, **LNT Solutions P250**, was added to the HOT guidelines for the winter of 2014-15. This is a new Type II fluid that underwent endurance time testing in the winter of 2013-14. The detailed test results are provided in Appendix D.

It should be noted that LNT Solutions previously tested a different formulation of P250, which was added to the HOT guidelines in 2012-13 but removed in 2013-14 as it was never commercialized.

4.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718, *Qualification Process for SAE AMS1428 Type II, III, and IV Fluids* (8). As per the protocol, Kilfrost ABC 2000 was removed from the Type II guidelines for the winter of 2014-15. The removal of this fluid did not impact the generic Type II holdover times.

4.3 Changes to HOT Guidelines Format

No changes were made to the format of the Type II HOT Guidelines for winter 2014-15.

4.4 Type II Generic Holdover Time Values

The generic HOT guidelines for Type II fluid were developed prior to 1996-97 based on the results of endurance time tests with “grandfathered” fluids. Since 1999-2000, fluid-specific holdover times have been developed for each new Type II fluid tested, and the generic Type II holdover times have been generated each year by taking the shortest holdover times of:

1. All fluids on the Transport Canada and FAA list of Type II fluids;

2. The "grandfathered" fluid data (included to account for the performance of grandfathered fluids which do not have fluid-specific holdover time data available, i.e. Kilfrost ABC-3); and
3. All fluids on the Transport Canada and FAA list of Type IV fluids (included because all Type IV fluids also qualify as Type II fluids).

It should be noted that the Transport Canada and FAA list of fluids contains fluids whose qualifications have recently expired (i.e. within four years). Fluids are only removed from the generic analysis when they are removed from the Transport Canada and FAA list.

It should also be noted that a fluid-specific table is no longer produced for Clariant Safewing MP II 1951, but the fluid is still available for use with the generic HOT guidelines and therefore it is included in the generic analysis.

4.4.1 Use of Generic Holdover Times in Very Cold Snow

Following the winter of 2003-04, a decision was made that fluid-specific holdover times would not be provided for Type II fluids in snow at temperatures below -14°C. This was due to the limited data that exits for most fluids at these temperatures. Instead, all Type II fluids are given pre-established "generic" holdover times in very cold snow. These holdover times were determined based on historical data and analysis.

4.4.2 Impact of New and Removed Fluids/Data

The addition of the new and removed Type II fluid/data did not impact the Type II generic holdover times.

4.4.3 Fluids Responsible for Type II Generic Holdover Time Values

The fluids responsible for the values in the generic Type II HOT guidelines in 2014-15 are shown in Table 4.1. "Grandfather" is indicated where "grandfathered" fluids are responsible for times in the cells. "Type IV" is indicated where Type IV fluids are responsible for times in the cells. A "U" indicates the fluid is responsible for the upper value in the cell, an "L" indicates the fluid is responsible for the lower value in the cell, and a "B" indicates the fluid is responsible for both the upper and lower values in the cell.

Due to space limitations, the following abbreviations are used in the table:

- Clariant Safewing MP II 1951 (C-1951);

- Clariant Safewing MP II Flight (C-Flight);
- Kilfrost ABC-K Plus (ABC-K+); and
- Newave Aerochemical FCY-2 (N-FCY-2).

4.4.4 Evolution of Type II Generic Holdover Time Values

The history of Type II fluid testing and the evolution of the fluid-specific and generic Type II holdover time values are illustrated in Tables 4.2 to 4.25. Each table represents one cell in the HOT guidelines and the title of the table links the table to the appropriate cell. Fluids that are no longer used in the generic analysis (see Subsection 4.2) are not included.

The first row in each table contains the generic values from testing in 1998-99, also known as the “grandfathered” fluid data. Each subsequent set of two rows represents a winter test season and the subsequent winter’s HOT table values. The final line contains the generic and fluid-specific holdover time values for use in 2014-15 winter operations.

Underlined values indicate the fluid or fluids responsible for the generic holdover time. If the value in the first row is underlined, it indicates that the generic value is based on the “grandfathered” fluid data set.

Strikethrough values indicate endurance time test results that are not valid; this is typically a result of testing in multiple years (details are usually provided in the HOT report written in the most recent year the fluid underwent testing).

Due to space limitations, the following abbreviations are used in the tables:

- ABAX Ecowing 26 (A-E26);
- Aviation Shaanxi Hi-tech Cleanwing II (AS CII);
- Clariant Safewing MP II 1951 (C-1951);
- Clariant Safewing MP II Flight (C-Flight);
- Clariant Safewing MP II Flight Plus (C-Flight+);
- Cryotech Polar Guard II (CR-PGII);
- Kilfrost ABC-K Plus (ABC-K+);
- LNT Solutions P250 (L-P250); and
- Newave Aerochemical FCY-2 (N-FCY-2).

Table 4.1: Fluids Responsible for Type II Generic Holdover Time Values

OAT		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
°C	°F		Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100/0	Grandfather **(B)**	Grandfather **(B)** C-1951 **(B)**	Grandfather **(L)** C-1951 **(U)**	Grandfather **(B)** C-1951 **(U)**	N-FCY-2 **(L)** Grandfather **(U)**
		75/25	Grandfather **(B)**	Grandfather **(B)** C-1951 **(L)**	Grandfather **(B)** C-1951 **(U)** N-FCY-2 **(U)**	Grandfather **(B)** C-1951 **(U)** N-FCY-2 **(U)**	Grandfather **(B)** N-FCY-2 **(B)**
		50/50	Grandfather **(L)** C-1951 **(U)**	Grandfather **(B)** C-1951 **(U)** ABC-K+ **(U)** Type IV **(U)**	C-1951 **(B)**	Grandfather **(L)** C-1951 **(U)**	
below -3 to -14	below 27 to 7	100/0	Type IV **(L)** ABC-K+ **(U)**	N-FCY-2 **(B)** Grandfather **(L)**	N-FCY-2 **(B)** Type IV **(L)**	Grandfather **(L)** Type IV **(L)** N-FCY-2 **(U)**	
		75/25	Type IV **(B)** Grandfather **(L)** ABC-K+ **(L)** C-Flight **(L)**	N-FCY-2 **(B)**	N-FCY-2 **(B)** Type IV **(L)**	N-FCY-2 **(B)**	
below -14 to-25 or LOUT	below 7 to -13 or LOUT	100/0	Type IV **(L)** N-FCY-2 **(U)**	Historic Generic **(B)** Grandfather **(B)**			

LEGEND	**L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH**

Table 4.2: Type II Neat Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:20-0:45									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:20-0:45									
1999-00 ET Test Results		0:20-0:45								
2000-01 HOT Table Values	0:20-0:45	0:20-0:45								
2000-01 ET Test Results			0:40-1:00							
2001-02 HOT Table Values	0:20-0:45	0:20-0:45	0:40-1:00							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:20-0:45		0:40-1:00							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:45		0:40-1:00							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:45		0:40-1:00							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:45		0:40-1:00							
2005-06 ET Test Results				1:00-1:35						
2006-07 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35						
2006-07 ET Test Results					0:30-0:55					
2007-08 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55					
2007-08 ET Test Results						1:00-1:40				
2008-09 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40				
2008-09 ET Test Results							0:30-0:55			
2009-10 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55			
2010-11 ET Test Results									1:20-1:50	
2011-12 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55			
2011-12 ET Test Results								~~1:05-2:00~~		
2012-13 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55	1:05-2:00		
2012-13 ET Test Results								0:50-1:50		
2013-14 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55	0:50-1:50	1:20-1:50	
2013-14 ET Test Results										0:55-1:45
2014-15 HOT Table Values	0:20-0:45		0:40-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55	0:50-1:50	1:20-1:50	0:55-1:45

Table 4.3: Type II 75/25 Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:15-0:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:15-0:35								
2000-01 HOT Table Values	0:15-0:30	0:15-0:35								
2000-01 ET Test Results			0:25-0:45							
2001-02 HOT Table Values	0:15-0:30	0:15-0:35	0:25-0:45							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:30		0:25-0:45							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:25-0:45							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:25-0:45							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:25-0:45							
2005-06 ET Test Results				0:40-1:20						
2006-07 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20						
2006-07 ET Test Results					0:20-0:40					
2007-08 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40					
2007-08 ET Test Results						0:35-1:10				
2008-09 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10				
2008-09 ET Test Results							0:25-0:45			
2009-10 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45			
2009-10 ET Test Results				~~1:00-2:00~~						
2010-11 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45			
2010-11 ET Test Results									0:45-1:20	
2011-12 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45			
2011-12 ET Test Results								~~0:55-1:35~~		
2012-13 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45	0:55-1:35		
2012-13 ET Test Results								1:00-1:45		
2013-14 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45	1:00-1:45	0:45-1:20	
2013-14 ET Test Results										0:45-1:25
2014-15 HOT Table Values	0:15-0:30		0:25-0:45	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45	1:00-1:45	0:45-1:20	0:45-1:25

Table 4.4: Type II 50/50 Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII	L-P250
1998-99 HOT Table Values	0:05-0:15									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:05-0:15									
1999-00 ET Test Results		0:06-0:15								
2000-01 HOT Table Values	0:05-0:15	0:05-0:15								
2000-01 ET Test Results			0:10-0:20							
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:05-0:15		0:10-0:20							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:15		0:10-0:20							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:15		0:10-0:20							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:15		0:10-0:20							
2005-06 ET Test Results				0:10-0:25						
2006-07 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25						
2006-07 ET Test Results					0:15-0:25					
2007-08 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25					
2007-08 ET Test Results						0:07-0:15				
2008-09 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:05-0:15				
2008-09 ET Test Results							0:15-0:30			
2009-10 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:05-0:15	0:15-0:30			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:05-0:15	0:15-0:30			
2010-11 ET Test Results									0:15-0:35	
2011-12 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30			
2011-12 ET Test Results								0:15-0:25		
2012-13 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30	0:15-0:25		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30	0:15-0:25	0:15-0:35	
2013-14 ET Test Results										0:15-0:30
2014-15 HOT Table Values	0:05-0:15		0:10-0:20	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30	0:15-0:25	0:15-0:35	0:15-0:30

Table 4.5: Type II Neat Fluid, Snow, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII	L-P250
1998-99 HOT Table Values	0:150:40									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:35									
1999-00 ET Test Results		0:20-0:40								
2000-01 HOT Table Values	0:15-0:35	0:20-0:40								
2000-01 ET Test Results			0:35-0:55							
2001-02 HOT Table Values	0:15-0:35	0:20-0:40	0:35-0:55							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:35		0:35-0:55							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:35		0:35-0:55							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:35		0:35-0:55							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:35		0:35-0:55							
2005-06 ET Test Results				0:40-1:05						
2006-07 HOT Table Values	0:15-0:35		0:35-0:55	0:40-1:05						
2006-07 ET Test Results					0:150:30					
2007-08 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30					
2007-08 ET Test Results						0:50-1:25				
2008-09 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25				
2008-09 ET Test Results							0:30-0:55			
2009-10 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55			
2010-11 ET Test Results									0:55-1:15	
2011-12 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55			
2011-12 ET Test Results								~~0:15-0:30~~		
2012-13 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55	0:15-0:30		
2012-13 ET Test Results								0:35-1:15		
2013-14 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55	0:35-1:15	0:55-1:15	
2013-14 ET Test Results										0:50-1:40
2014-15 HOT Table Values	0:15-0:30		0:35-0:55	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55	0:35-1:15	0:55-1:15	0:50-1:40

Table 4.6: Type II 75/25 Fluid, Snow, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:15-0:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:25									
1999-00 ET Test Results		0:15-0:25								
2000-01 HOT Table Values	0:15-0:25	0:15-0:25								
2000-01 ET Test Results			0:25-0:40							
2001-02 HOT Table Values	0:15-0:25	0:15-0:25	0:25-0:40							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:25		0:25-0:40							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:25		0:25-0:40							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:25		0:25-0:40							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:25		0:25-0:40							
2005-06 ET Test Results				0:20-0:40						
2006-07 HOT Table Values	0:15-0:25		0:25-0:40	0:20-0:40						
2006-07 ET Test Results					~~0:10-0:20~~					
2007-08 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20					
2007-08 ET Test Results						0:35-1:05				
2008-09 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05				
2008-09 ET Test Results							0:25-0:45			
2009-10 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45			
2009-10 ET Test Results				~~1:00-2:00~~						
2010-11 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45			
2010-11 ET Test Results									0:35-1:00	
2011-12 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45			
2011-12 ET Test Results								~~0:10-0:20~~		
2012-13 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45	0:10-0:20		
2012-13 ET Test Results								0:55-1:40		
2013-14 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45	0:55-1:40	0:35-1:00	
2013-14 ET Test Results										0:45-1:25
2014-15 HOT Table Values	0:10-0:20		0:25-0:40	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45	0:55-1:40	0:35-1:00	0:45-1:25

Table 4.7: Type II Neat Fluid, Snow, Below -14°C to -25°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:150:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:20-0:35								
2000-01 HOT Table Values	0:15-0:30	0:20-0:35								
2000-01 ET Test Results			0:30-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:35	0:30-0:50							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:30		0:30-0:50							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:30-0:50							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:15-0:30*							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:15-0:30*							
2005-06 ET Test Results										
2006-07 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*						
2006-07 ET Test Results										
2007-08 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*					
2007-08 ET Test Results										
2008-09 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2008-09 ET Test Results										
2009-10 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2010-11 ET Test Results										
2011-12 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2011-12 ET Test Results										
2012-13 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	
2013-14 ET Test Results										
2014-15 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*

Table 4.8: Type II Neat Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII	L-P250
1998-99 HOT Table Values	0:30-1:00									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:30-1:00									
1999-00 ET Test Results		0:35-0:55								
2000-01 HOT Table Values	0:30-0:55	0:35-0:55								
2000-01 ET Test Results			0:50-1:35							
2001-02 HOT Table Values	0:30-0:55	0:35-0:55	0:50-1:35							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:30-0:55		0:50-1:35							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:30-0:55		0:50-1:35							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:30-0:55		0:50-1:35							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:30-0:55		0:50-1:35							
2005-06 ET Test Results				1:20-2:00						
2006-07 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00						
2006-07 ET Test Results					0:35-1:05					
2007-08 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05					
2007-08 ET Test Results						1:50-2:00				
2008-09 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00				
2008-09 ET Test Results							0:35-1:05			
2009-10 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05			
2010-11 ET Test Results									1:35-2:00	
2011-12 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05			
2011-12 ET Test Results								1:25-2:00		
2012-13 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05	1:25-2:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05	1:25-2:00	1:35-2:00	
2013-14 ET Test Results										1:35-2:00
2014-15 HOT Table Values	0:30-0:55		0:50-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05	1:25-2:00	1:35-2:00	1:35-2:00

Table 4.9: Type II 75/25 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	**C-1951**	**A-E26**	**C-Flight**	**N-FCY-2**	**ABC-K+**	**AS CII**	**C-Flight+**	**CR-PGII**	**L-P250**
1998-99 HOT Table Values	0:20-0:45									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:20-0:45									
1999-00 ET Test Results		0:25-0:45								
2000-01 HOT Table Values	0:20-0:45	0:25-0:45								
2000-01 ET Test Results			0:45-1:05							
2001-02 HOT Table Values	0:20-0:45	0:25-0:45	0:45-1:05							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:20-0:45		0:45-1:05							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:45		0:45-1:05							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:45		0:45-1:05							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:45		0:45-1:05							
2005-06 ET Test Results				~~1:15-2:00~~						
2006-07 HOT Table Values	0:20-0:45		0:45-1:05	1:15-2:00						
2006-07 ET Test Results					0:25-0:45					
2007-08 HOT Table Values	0:20-0:45		0:45-1:05	1:15-2:00	0:25-0:45					
2007-08 ET Test Results						1:25-2:00				
2008-09 HOT Table Values	0:20-0:45		0:45-1:05	1:15-2:00	0:25-0:45	1:25-2:00				
2008-09 ET Test Results							0:35-1:00			
2009-10 HOT Table Values	0:20-0:45		0:45-1:05	1:15-2:00	0:25-0:45	1:25-2:00	0:35-1:00			
2009-10 ET Test Results				1:10-1:30						
2010-11 HOT Table Values	0:20-0:45		0:45-1:05	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00			
2010-11 ET Test Results									1:40-2:00	
2011-12 HOT Table Values	0:20-0:45		0:45-1:05	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00			
2011-12 ET Test Results								1:35-2:00		
2012-13 HOT Table Values	0:20-0:45		0:45-1:05	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00	1:35-2:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20-0:45		0:45-1:05	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00	1:35-2:00	1:40-2:00	
2013-14 ET Test Results										1:20-1:35
2014-15 HOT Table Values	0:20-0:45		0:45-1:05	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00	1:35-2:00	1:40-2:00	1:20-1:35

Table 4.10: Type II 50/50 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:10-0:20									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:05-0:20									
1999-00 ET Test Results		0:08-0:15								
2000-01 HOT Table Values	0:05-0:15	0:05-0:15								
2000-01 ET Test Results			0:15-0:25							
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:15-0:25							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:05-0:15		0:15-0:25							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:15		0:15-0:25							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:15		0:15-0:25							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:15		0:15-0:25							
2005-06 ET Test Results				0:20-0:30						
2006-07 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:30						
2006-07 ET Test Results					0:10-0:20					
2007-08 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:30	0:10-0:20					
2007-08 ET Test Results						0:20-0:30				
2008-09 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30				
2008-09 ET Test Results							0:20-0:40			
2009-10 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40			
2010-11 ET Test Results									0:20-0:45	
2011-12 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40			
2011-12 ET Test Results								0:30-1:05		
2012-13 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40	0:30-1:05		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40	0:30-1:05	0:20-0:45	
2013-14 ET Test Results										0:20-0:35
2014-15 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40	0:30-1:05	0:20-0:45	0:20-0:35

Table 4.11: Type II Neat Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:30-1:00									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:45									
1999-00 ET Test Results		0:25-0:50								
2000-01 HOT Table Values	0:15-0:45	0:25-0:50								
2000-01 ET Test Results			0:30-1:10							
2001-02 HOT Table Values	0:15-0:45	0:25-0:50	0:30-1:10							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:45		0:30-1:10							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:45		0:30-1:10							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:45		0:30-1:10							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:45		0:30-1:10							
2005-06 ET Test Results				0:35-1:30						
2006-07 HOT Table Values	0:15-0:45		0:30-1:10	0:35-1:30						
2006-07 ET Test Results					0:20-0:45					
2007-08 HOT Table Values	0:15-0:45		0:30-1:10	0:35-1:30	0:20-0:45					
2007-08 ET Test Results						0:25-1:00				
2008-09 HOT Table Values	0:15-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00				
2008-09 ET Test Results							0:30-0:55			
2009-10 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55			
2010-11 ET Test Results									0:35-1:35	
2011-12 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55			
2011-12 ET Test Results								0:35-1:25		
2012-13 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55	0:35-1:25		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55	0:35-1:25	0:35-1:35	
2013-14 ET Test Results										0:25-1:20
2014-15 HOT Table Values	0:20-0:45		0:30-1:10	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55	0:35-1:25	0:35-1:35	0:25-1:20

Table 4.12: Type II 75/25 Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII	L-P250
1998-99 HOT Table Values	0:20-0:45									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:20-0:35								
2000-01 HOT Table Values	0:15-0:30	0:20-0:35								
2000-01 ET Test Results			0:20-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:35	0:20-0:50							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:30		0:20-0:50							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:20-0:50							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:20-0:50							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:20-0:50							
2005-06 ET Test Results				0:25-1:10						
2006-07 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10						
2006-07 ET Test Results					~~0:15-0:30~~					
2007-08 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30					
2007-08 ET Test Results						0:20-0:55				
2008-09 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55				
2008-09 ET Test Results							0:35-0:40			
2009-10 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40			
2009-10 ET Test Results				~~0:25-1:15~~						
2010-11 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40			
2010-11 ET Test Results									0:25-1:05	
2011-12 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40			
2011-12 ET Test Results								0:25-1:10		
2012-13 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40	0:25-1:10		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40	0:25-1:10	0:25-1:05	
2013-14 ET Test Results										0:20-1:15
2014-15 HOT Table Values	0:15-0:30		0:20-0:50	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40	0:25-1:10	0:25-1:05	0:20-1:15

Table 4.13: Type II Neat Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:15-0:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:20-0:30								
2000-01 HOT Table Values	0:15-0:30	0:20-0:30								
2000-01 ET Test Results			0:40-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:30	0:40-0:50							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:30		0:40-0:50							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:40-0:50							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:40-0:50							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:40-0:50							
2005-06 ET Test Results				0:45-1:25						
2006-07 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25						
2006-07 ET Test Results					0:25-0:35					
2007-08 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35					
2007-08 ET Test Results						1:00-1:25				
2008-09 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25				
2008-09 ET Test Results							0:25-0:35			
2009-10 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35			
2010-11 ET Test Results									1:15-1:30	
2011-12 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35			
2011-12 ET Test Results								0:45-1:00		
2012-13 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35	0:45-1:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35	0:45-1:00	1:15-1:30	
2013-14 ET Test Results										0:50-1:25
2014-15 HOT Table Values	0:15-0:30		0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35	0:45-1:00	1:15-1:30	0:50-1:25

Table 4.14: Type II 75/25 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII	L-P250
1998-99 HOT Table Values	0:10-0:25									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:10-0:25									
1999-00 ET Test Results		0:15-0:25								
2000-01 HOT Table Values	0:10-0:25	0:15-0:25								
2000-01 ET Test Results			0:25-0:35							
2001-02 HOT Table Values	0:10-0:25	0:15-0:25	0:25-0:35							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:10-0:25		0:25-0:35							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:25		0:25-0:35							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:25		0:25-0:35							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:25		0:25-0:35							
2005-06 ET Test Results				~~0:30-0:55~~						
2006-07 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55						
2006-07 ET Test Results					0:15-0:25					
2007-08 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25					
2007-08 ET Test Results						0:50-1:10				
2008-09 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10				
2008-09 ET Test Results							0:20-0:30			
2009-10 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30			
2009-10 ET Test Results				0:30-0:55						
2010-11 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30			
2010-11 ET Test Results									0:40-1:10	
2011-12 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30			
2011-12 ET Test Results								0:50-1:15		
2012-13 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30	0:50-1:15		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30	0:50-1:15	0:40-1:10	
2013-14 ET Test Results										0:40-1:00
2014-15 HOT Table Values	0:10-0:25		0:25-0:35	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30	0:50-1:15	0:40-1:10	0:40-1:00

Table 4.15: Type II 50/50 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:05-0:10									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:05-0:10									
1999-00 ET Test Results		0:06-0:09								
2000-01 HOT Table Values	0:05-0:10	0:05-0:10								
2000-01 ET Test Results			0:08-0:10							
2001-02 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:10							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:05-0:10		0:05-0:10							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:10		0:05-0:10							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:10		0:05-0:10							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:10		0:05-0:10							
2005-06 ET Test Results				0:10-0:15						
2006-07 HOT Table Values	0:05-0:10		0:05-0:10	0:10-0:15						
2006-07 ET Test Results					0:07-0:10					
2007-08 HOT Table Values	0:05-0:10		0:05-0:10	0:10-0:15	0:05-0:10					
2007-08 ET Test Results						0:10-0:15				
2008-09 HOT Table Values	0:05-0:10		0:05-0:10	0:10-0:15	0:05-0:10	0:10-0:15				
2008-09 ET Test Results							0:10-0:20			
2009-10 HOT Table Values	0:05-0:10		0:05-0:10	0:10-0:15	0:05-0:10	0:10-0:15	0:10-0:20			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:10		0:05-0:10	0:10-0:15	0:05-0:10	0:10-0:15	0:10-0:20			
2010-11 ET Test Results									0:09-0:20	
2011-12 HOT Table Values	0:05-0:09		0:08-0:10	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20			
2011-12 ET Test Results								0:15-0:20		
2012-13 HOT Table Values	0:05-0:09		0:08-0:10	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20	0:15-0:20		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:09		0:08-0:10	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20	0:15-0:20	0:09-0:20	
2013-14 ET Test Results										0:15-0:20
2014-15 HOT Table Values	0:05-0:09		0:08-0:10	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20	0:15-0:20	0:09-0:20	0:15-0:20

Table 4.16: Type II Neat Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:10-0:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:10-0:30									
1999-00 ET Test Results		0:15-0:30								
2000-01 HOT Table Values	0:10-0:30	0:15-0:30								
2000-01 ET Test Results			0:15-0:35							
2001-02 HOT Table Values	0:10-0:25	0:15-0:30	0:15-0:35							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:10-0:25		0:15-0:35							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:25		0:15-0:35							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:25		0:15-0:35							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:25		0:15-0:35							
2005-06 ET Test Results				0:25-0:45						
2006-07 HOT Table Values	0:10-0:25		0:15-0:35	0:25-0:45						
2006-07 ET Test Results					0:15-0:20					
2007-08 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20					
2007-08 ET Test Results						0:15-0:35				
2008-09 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35				
2008-09 ET Test Results							0:20-0:25			
2009-10 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25			
2010-11 ET Test Results									0:35-0:45	
2011-12 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25			
2011-12 ET Test Results								0:35-0:55		
2012-13 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25	0:35-0:55		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25	0:35-0:55	0:35-0:45	
2013-14 ET Test Results										0:25-0:35
2014-15 HOT Table Values	0:10-0:20		0:15-0:35	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25	0:35-0:55	0:35-0:45	0:25-0:35

Table 4.17: Type II 75/25 Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:10-0:25									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:10-0:20									
1999-00 ET Test Results		0:15-0:20								
2000-01 HOT Table Values	0:10-0:20	0:15-0:20								
2000-01 ET Test Results			0:15-0:25							
2001-02 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:10-0:20		0:15-0:25							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:20		0:15-0:25							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:20		0:15-0:25							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:20		0:15-0:25							
2005-06 ET Test Results				~~0:30-0:40~~						
2006-07 HOT Table Values	0:10-0:20		0:15-0:25	0:30-0:40						
2006-07 ET Test Results					~~0:08-0:15~~					
2007-08 HOT Table Values	0:05-0:15		0:15-0:25	0:30-0:40	0:05-0:15					
2007-08 ET Test Results						0:09-0:30				
2008-09 HOT Table Values	0:05-0:15		0:15-0:25	0:30-0:40	0:05-0:15	0:05-0:30				
2008-09 ET Test Results							0:20-0:25			
2009-10 HOT Table Values	0:05-0:15		0:15-0:25	0:30-0:40	0:05-0:15	0:05-0:30	0:20-0:25			
2009-10 ET Test Results				0:20-0:35						
2010-11 HOT Table Values	0:05-0:15		0:15-0:25	0:20-0:35	0:05-0:15	0:05-0:30	0:20-0:25			
2010-11 ET Test Results									0:35-0:45	
2011-12 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25			
2011-12 ET Test Results								0:30-0:45		
2012-13 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25	0:30-0:45		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25	0:30-0:45	0:35-0:45	
2013-14 ET Test Results										0:20-0:30
2014-15 HOT Table Values	0:08-0:15		0:15-0:25	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25	0:30-0:45	0:35-0:45	0:20-0:30

Table 4.18: Type II Neat Fluid, Freezing Fog, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:35-1:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:35-1:30									
1999-00 ET Test Results		0:55-1:40								
2000-01 HOT Table Values	0:35-1:30	0:55-1:40								
2000-01 ET Test Results			1:25-2:35							
2001-02 HOT Table Values	0:35-1:30	0:55-1:40	1:25-2:35							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:35-1:30		1:25-2:35							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:35-1:30		1:25-2:35							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:35-1:30		1:25-2:35							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:35-1:30		1:25-2:35							
2005-06 ET Test Results				3:30-4:00						
2006-07 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00						
2006-07 ET Test Results					1:15-2:25					
2007-08 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25					
2007-08 ET Test Results						2:15-3:45				
2008-09 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45				
2008-09 ET Test Results							0:55-1:50			
2009-10 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50			
2010-11 ET Test Results									2:50-4:00	
2011-12 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50			
2011-12 ET Test Results								2:40-4:00		
2012-13 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50	2:40-4:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50	2:40-4:00	2:50-4:00	
2013-14 ET Test Results										2:10-4:00
2014-15 HOT Table Values	0:35-1:30		1:25-2:35	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50	2:40-4:00	2:50-4:00	2:10-4:00

Table 4.19: Type II 75/25 Fluid, Freezing Fog, -3°C and Above

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:25-1:00									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:25-1:00									
1999-00 ET Test Results		0:45-1:15								
2000-01 HOT Table Values	0:25-1:00	0:45-1:15								
2000-01 ET Test Results			1:05-1:55							
2001-02 HOT Table Values	0:25-1:00	0:45-1:15	1:05-1:55							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:25-1:00		1:05-1:55							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:25-1:00		1:05-1:55							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:25-1:00		1:05-1:55							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:25-1:00		1:05-1:55							
2005-06 ET Test Results				~~2:30-4:00~~						
2006-07 HOT Table Values	0:25-1:00		1:05-1:55	2:30-4:00						
2006-07 ET Test Results					0:50-1:30					
2007-08 HOT Table Values	0:25-1:00		1:05-1:55	2:30-4:00	0:50-1:30					
2007-08 ET Test Results						1:40-2:30				
2008-09 HOT Table Values	0:25-1:00		1:05-1:55	2:30-4:00	0:50-1:30	1:40-2:30				
2008-09 ET Test Results							0:50-1:20			
2009-10 HOT Table Values	0:25-1:00		1:05-1:55	2:30-4:00	0:50-1:30	1:40-2:30	0:50-1:20			
2009-10 ET Test Results				1:50-2:45						
2010-11 HOT Table Values	0:25-1:00		1:05-1:55	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20			
2010-11 ET Test Results									2:30-4:00	
2011-12 HOT Table Values	0:25-1:00		1:05-1:55	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20			
2011-12 ET Test Results								2:35-4:00		
2012-13 HOT Table Values	0:25-1:00		1:05-1:55	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20	2:35-4:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:25-1:00		1:05-1:55	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20	2:35-4:00	2:30-4:00	
2013-14 ET Test Results										1:50-2:35
2014-15 HOT Table Values	0:25-1:00		1:05-1:55	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20	2:35-4:00	2:30-4:00	1:50-2:35

Table 4.20: Type II 50/50 Fluid, Freezing Fog, -3°C and Above

	GENERIC	**C-1951**	**A-E26**	**C-Flight**	**N-FCY-2**	**ABC-K +**	**AS CII**	**C-Flight +**	**CR-PGII**	**L-P250**
1998-99 HOT Table Values	0:150:45									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:35									
1999-00 ET Test Results		0:20-0:30								
2000-01 HOT Table Values	0:15-0:30	0:20-0:30								
2000-01 ET Test Results			0:30-0:45							
2001-02 HOT Table Values	0:15-0:30	0:20-0:30	0:30-0:45							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:30		0:30-0:45							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:30-0:45							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:30-0:45							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:30-0:45							
2005-06 ET Test Results				0:55-1:45						
2006-07 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45						
2006-07 ET Test Results					0:25-0:35					
2007-08 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35					
2007-08 ET Test Results						0:35-1:05				
2008-09 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05				
2008-09 ET Test Results							0:35-1:00			
2009-10 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00			
2010-11 ET Test Results									0:50-1:25	
2011-12 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00			
2011-12 ET Test Results								1:05-2:20		
2012-13 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00	1:05-2:20		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00	1:05-2:20	0:50-1:25	
2013-14 ET Test Results										0:35-0:50
2014-15 HOT Table Values	0:15-0:30		0:30-0:45	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00	1:05-2:20	0:50-1:25	0:35-0:50

Table 4.21: Type II Neat Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:35-1:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:30-1:05									
1999-00 ET Test Results		0:45-1:25								
2000-01 HOT Table Values	0:20*-1:05	0:45-1:25								
2000-01 ET Test Results			0:45-2:15							
2001-02 HOT Table Values	0:20*-1:05	0:45-1:25	0:45-2:15							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:20*-1:05		0:45-2:15							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20*-1:05		0:45-2:15							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20*-1:05		0:45-2:15							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20*-1:05		0:45-2:15							
2005-06 ET Test Results				0:55-1:45						
2006-07 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45						
2006-07 ET Test Results					0:45-1:30					
2007-08 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30					
2007-08 ET Test Results						0:30-1:05				
2008-09 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05				
2008-09 ET Test Results							0:45-1:50			
2009-10 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50			
2010-11 ET Test Results									0:55-2:30	
2011-12 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50			
2011-12 ET Test Results								0:40-2:20		
2012-13 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50	0:40-2:20		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50	0:40-2:20	0:55-2:30	
2013-14 ET Test Results										0:45-2:20
2014-15 HOT Table Values	0:20*-1:05		0:45-2:15	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50	0:40-2:20	0:55-2:30	0:45-2:20

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.22: Type II 75/25 Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:25-1:00									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:20-0:55									
1999-00 ET Test Results		0:35-1:00								
2000-01 HOT Table Values	0:20-0:55	0:35-1:00								
2000-01 ET Test Results			0:35-1:15							
2001-02 HOT Table Values	0:20-0:55	0:35-1:00	0:35-1:15							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:20-0:55		0:35-1:15							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:55		0:35-1:15							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:55		0:35-1:15							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:55		0:35-1:15							
2005-06 ET Test Results				~~0:40-1:10~~						
2006-07 HOT Table Values	0:20-0:55		0:35-1:15	0:40-1:10						
2006-07 ET Test Results					0:30-1:05					
2007-08 HOT Table Values	0:20-0:55		0:35-1:15	0:40-1:10	0:30-1:05					
2007-08 ET Test Results						0:25-1:25				
2008-09 HOT Table Values	0:20-0:55		0:35-1:15	0:40-1:10	0:30-1:05	0:25-1:25				
2008-09 ET Test Results							0:40-1:45			
2009-10 HOT Table Values	0:25-0:50*		0:35-1:15	0:40-1:10	0:30-1:05	0:25-1:25	0:40-1:45			
2009-10 ET Test Results				0:25-1:05						
2010-11 HOT Table Values	0:25-0:50*		0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45			
2010-11 ET Test Results									0:40-1:30	
2011-12 HOT Table Values	0:25-0:50*		0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45			
2011-12 ET Test Results								0:30-1:45		
2012-13 HOT Table Values	0:25-0:50*		0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45	0:30-1:45		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:25-0:50*		0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45	0:30-1:45	0:40-1:30	
2013-14 ET Test Results										0:35-1:45
2014-15 HOT Table Values	0:25-0:50*		0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45	0:30-1:45	0:40-1:30	0:35-1:45

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.23: Type II Neat Fluid, Freezing Fog, Below -14ºC to -25ºC

	GENERIC	**C-1951**	**A-E26**	**C-Flight**	**N-FCY-2**	**ABC-K+**	**AS CII**	**C-Flight+**	**CR-PGII**	**L-P250**
1998-99 HOT Table Values	0:20-1:30									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:15-0:20									
1999-00 ET Test Results		0:20-0:40								
2000-01 HOT Table Values	0:15-0:20	0:20-0:40								
2000-01 ET Test Results			0:25-0:45							
2001-02 HOT Table Values	0:15-0:20	0:20-0:40	0:25-0:45							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:15-0:20		0:25-0:45							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:20		0:25-0:45							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:20		0:25-0:45							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:20		0:25-0:45							
2005-06 ET Test Results				0:30-0:50						
2006-07 HOT Table Values	0:15-0:20		0:25-0:45	0:30-0:50						
2006-07 ET Test Results					0:25-0:35					
2007-08 HOT Table Values	0:15-0:20		0:25-0:45	0:30-0:50	0:25-0:35					
2007-08 ET Test Results						0:30-0:55				
2008-09 HOT Table Values	0:15-0:20		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55				
2008-09 ET Test Results							0:20-0:50			
2009-10 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50			
2010-11 ET Test Results									0:25-0:50	
2011-12 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50			
2011-12 ET Test Results								0:20-0:40		
2012-13 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50	0:20-0:40		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50	0:20-0:40	0:25-0:50	
2013-14 ET Test Results										0:20-0:50
2014-15 HOT Table Values	0:15*-0:35		0:25-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50	0:20-0:40	0:25-0:50	0:20-0:50

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.24: Type II Neat Fluid, Rain on Cold-Soaked Wing, Above 0°C

	GENERIC	C-1951	A-E26	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII	L-P250
1998-99 HOT Table Values	0:100:40									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:05-0:40									
1999-00 ET Test Results		0:10-0:50								
2000-01 HOT Table Values	0:05-0:40	0:10-0:50								
2000-01 ET Test Results			0:20-1:25							
2001-02 HOT Table Values	0:05-0:40	0:10-0:50	0:20-1:25							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:05-0:40		0:20-1:25							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:40		0:20-1:25							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:40		0:20-1:25							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:40		0:20-1:25							
2005-06 ET Test Results				0:10-1:30						
2006-07 HOT Table Values	0:05-0:40		0:20-1:25	0:10-1:30						
2006-07 ET Test Results					0:08-0:45					
2007-08 HOT Table Values	0:05-0:40		0:20-1:25	0:10-1:30	0:05-0:45					
2007-08 ET Test Results						0:20-2:00				
2008-09 HOT Table Values	0:05-0:40		0:20-1:25	0:10-1:30	0:05-0:45	0:20-2:00				
2008-09 ET Test Results							0:10-0:55			
2009-10 HOT Table Values	0:05-0:40		0:20-1:25	0:10-1:30	0:05-0:45	0:20-2:00	0:10-0:55			
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:40		0:20-1:25	0:10-1:30	0:05-0:45	0:20-2:00	0:10-0:55			
2010-11 ET Test Results									0:15-2:00	
2011-12 HOT Table Values	0:08-0:40		0:20-1:25	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55			
2011-12 ET Test Results								0:15-2:00		
2012-13 HOT Table Values	0:08-0:40		0:20-1:25	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55	0:15-2:00		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:40		0:20-1:25	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55	0:15-2:00	0:15-2:00	
2013-14 ET Test Results										0:15-2:00
2014-15 HOT Table Values	0:08-0:40		0:20-1:25	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55	0:15-2:00	0:15-2:00	0:15-2:00

Table 4.25: Type II 75/25 Fluid, Rain on Cold-Soaked Wing, Above 0°C

	GENERIC	**C-1951**	**A-E26**	**C-Flight**	**N-FCY-2**	**ABC-K +**	**AS CII**	**C-Flight +**	**CR-PGII**	**L-P250**
1998-99 HOT Table Values	0:05-0:25									
1998-99 ET Test Results										
1999-00 HOT Table Values	0:05-0:25									
1999-00 ET Test Results		0:07-0:40								
2000-01 HOT Table Values	0:05-0:25	0:05-0:40								
2000-01 ET Test Results			0:10-1:00							
2001-02 HOT Table Values	0:05-0:25	0:05-0:40	0:10-1:00							
2001-02 ET Test Results										
2002-03 HOT Table Values	0:05-0:25		0:10-1:00							
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:25		0:10-1:00							
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:25		0:10-1:00							
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:25		0:10-1:00							
2005-06 ET Test Results				~~0:07-1:20~~						
2006-07 HOT Table Values	0:05-0:25		0:10-1:00	0:05-1:20						
2006-07 ET Test Results					0:05-0:25					
2007-08 HOT Table Values	0:05-0:25		0:10-1:00	0:05-1:20	0:05-0:25					
2007-08 ET Test Results						0:15-2:00				
2008-09 HOT Table Values	0:05-0:25		0:10-1:00	0:05-1:20	0:05-0:25	0:15-2:00				
2008-09 ET Test Results							0:07-0:50			
2009-10 HOT Table Values	0:05-0:25		0:10-1:00	0:05-1:20	0:05-0:25	0:15-2:00	0:05-0:50			
2009-10 ET Test Results				0:06-0:50						
2010-11 HOT Table Values	0:05-0:25		0:10-1:00	0:05-0:50	0:05-0:25	0:15-2:00	0:05-0:50			
2010-11 ET Test Results									0:09-1:40	
2011-12 HOT Table Values	0:05-0:25		0:10-1:00	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50			
2011-12 ET Test Results								0:15-1:15		
2012-13 HOT Table Values	0:05-0:25		0:10-1:00	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50	0:15-1:15		
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:25		0:10-1:00	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50	0:15-1:15	0:09-1:40	
2013-14 ET Test Results										0:10-1:50
2014-15 HOT Table Values	0:05-0:25		0:10-1:00	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50	0:15-1:15	0:09-1:40	0:10-1:50

5. CHANGES TO THE TYPE III HOT GUIDELINES

Changes made to the Type III HOT guidelines for the winter of 2014-15 are documented in this chapter. The Transport Canada and FAA 2014-15 Type III HOT guidelines are included in Appendix H.

5.1 New Fluids/Data

No new Type III fluids/data were incorporated into the HOT guidelines for 2013-14. However, consideration was given to research conducted in past winters which showed that, in some conditions, Type III fluid applied heated has shorter endurance times than fluid applied at ambient temperature. Since the holdover times in the current Type III generic table were obtained from testing conducted with fluid applied at ambient temperature, it was concluded that they may not be valid for fluid applied heated. Therefore, a note was added to the Type III generic HOT guideline restricting the use of the Type III generic holdover times to fluids applied at ambient temperature.

5.2 Changes to HOT Guidelines Format

No changes were made to the format of the Type III HOT Guidelines for winter 2014-15.

5.3 Type III Generic Holdover Time Values

The current Type III generic holdover time values are based on the endurance times of Clariant Safewing MP III 2031 ECO, which was the first fluid qualified as a new generation Type III fluid. The testing was conducted in 2003-04 and 2004-05 using the Type II/IV test protocol (fluid applied at ambient temperature). The fluid-specific endurance times calculated for Clariant Safewing MP III 2031 ECO were reduced by 10 percent and changed to reasonably round values to obtain the generic values.

No changes have since been made to the Type III generic holdover time values. However, for the winter of 2014-15, their use was limited to fluids applied at ambient temperature.

5.4 Future Changes to the Type III HOT Guidelines

Tests have shown fluid temperature at the time of application can affect the endurance times of Type III fluids. Endurance times are generally longer when fluid is applied heated and shorter when fluid is applied at ambient temperature. However, the effect of heat is not the same in all conditions and heated fluid was found to have shorter endurance times in some conditions.

A review of this research is documented in the Transport Canada report, TP 14936E, *Aircraft Ground Icing General Research Activities During the 2008-09 Winter* (9). The review concluded that Type III fluids should be tested applied at ambient temperature, applied heated, or both, depending on how the fluid will be used in operations, and that regulators should publish fluid-specific and application temperature-specific HOT tables for Type III fluids accordingly.

Heated application testing with the only currently commercialized Type III fluid (Clariant Safewing MP III 2031 ECO) was completed in the winter of 2013-14. However, as production/commercialization of the fluid was discontinued in 2014, a joint decision was made by Clariant and regulators not to incorporate this data into the HOT guidelines. This decision was made in June 2014 after the data had already been presented to the SAE G-12 HOT Committee at its annual meeting in May 2014. The detailed test results were subsequently provided to the Clariant, Transport Canada and the FAA in a separate report.

In future, any new Type III fluid submitted for endurance time testing will be tested using the test protocol for the fluid application temperature(s) it will be used with operationally. Fluid-specific / application temperature-specific table(s) will be published accordingly.

5.5 Supplemental Research – Endurance Times of Type III Fluids Applied Heated to Composite Surfaces

Over the winters of 2011-12, 2012-13 and 2013-14, limited tests were conducted to investigate the impact of test surface material on endurance time of Type III fluids applied heated. Each run consisted of a baseline test (Type III fluid applied heated to aluminum surface) and a comparative test (same fluid applied heated to a composite surface). The results are shown as follows:

- Figure 5.1: 2011-12 Freezing Precipitation Results (5 runs, Sample A);
- Figure 5.2: 2012-13 Freezing Precipitation Results (6 runs, Sample B);
- Figure 5.3: 2013-14 Freezing Precipitation Results (3 runs, Sample B); and
- Figure 5.4: 2013-14 Natural Snow Results (11 runs, Sample B).

Due to the limited tests performed, no final conclusions can be drawn. However, the results seem to indicate there are no significant differences in Type III endurance times on aluminum and composite surfaces: endurance times are similar in freezing precipitation conditions and slightly shorter on composite surfaces in natural snow conditions. As no Type III fluids are currently qualified to be applied heated, no immediate action is required. Further tests are recommended if another Type III fluid is submitted for heated application endurance time testing.

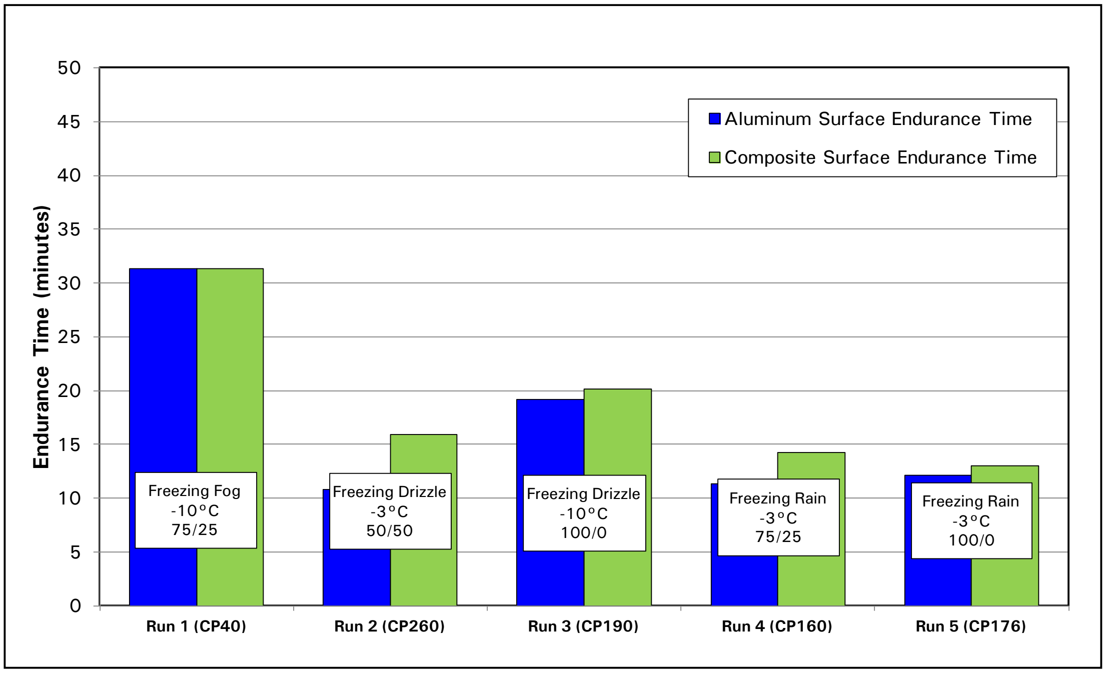


Figure 5.1: Type III Composite vs. Aluminum Test Results (2011-12)

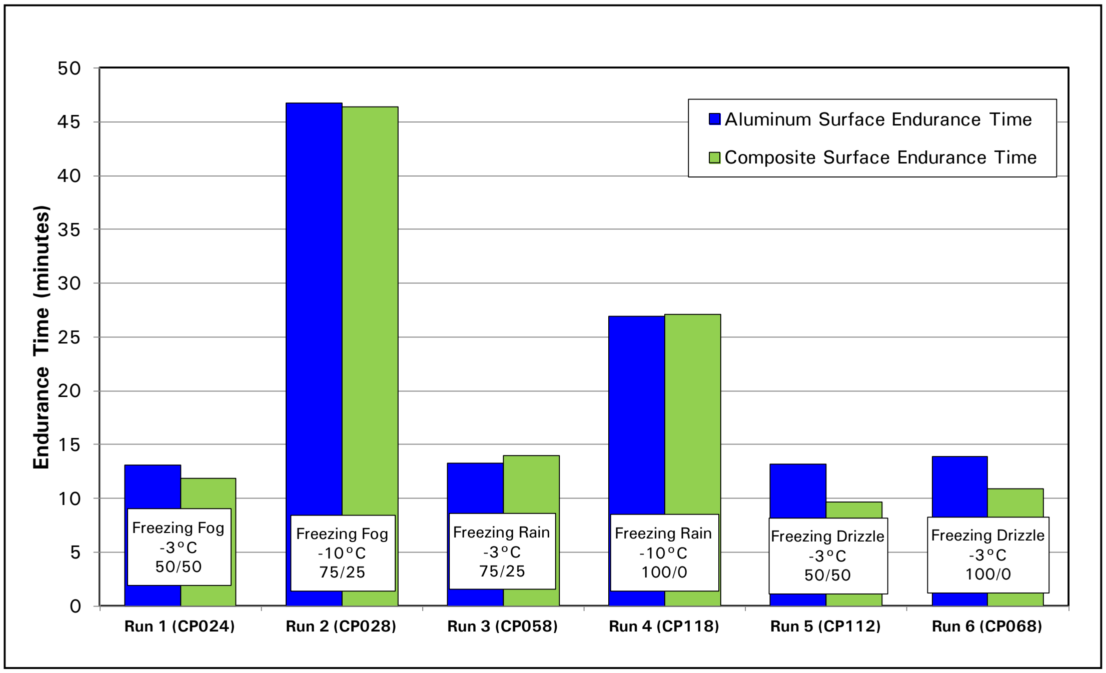


Figure 5.2: Type III Composite vs. Aluminum Test Results (2012-13)

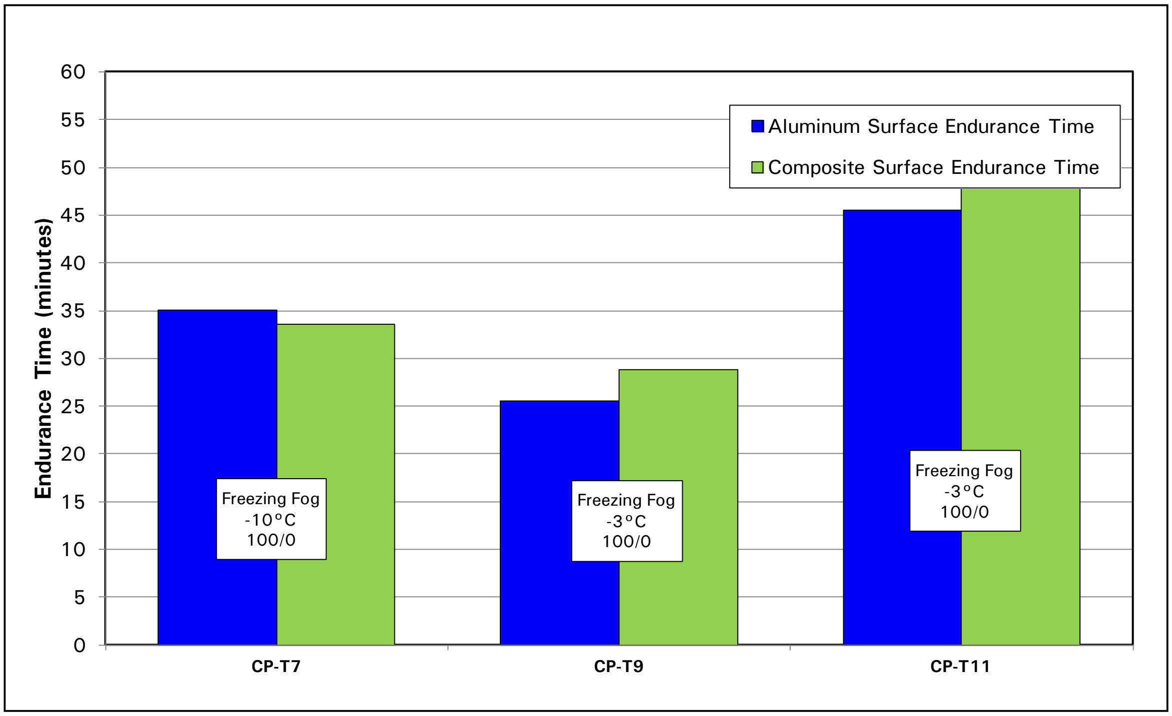


Figure 5.3: Type III Composite vs. Aluminum Test Results (Freezing Precipitation 2013-14)

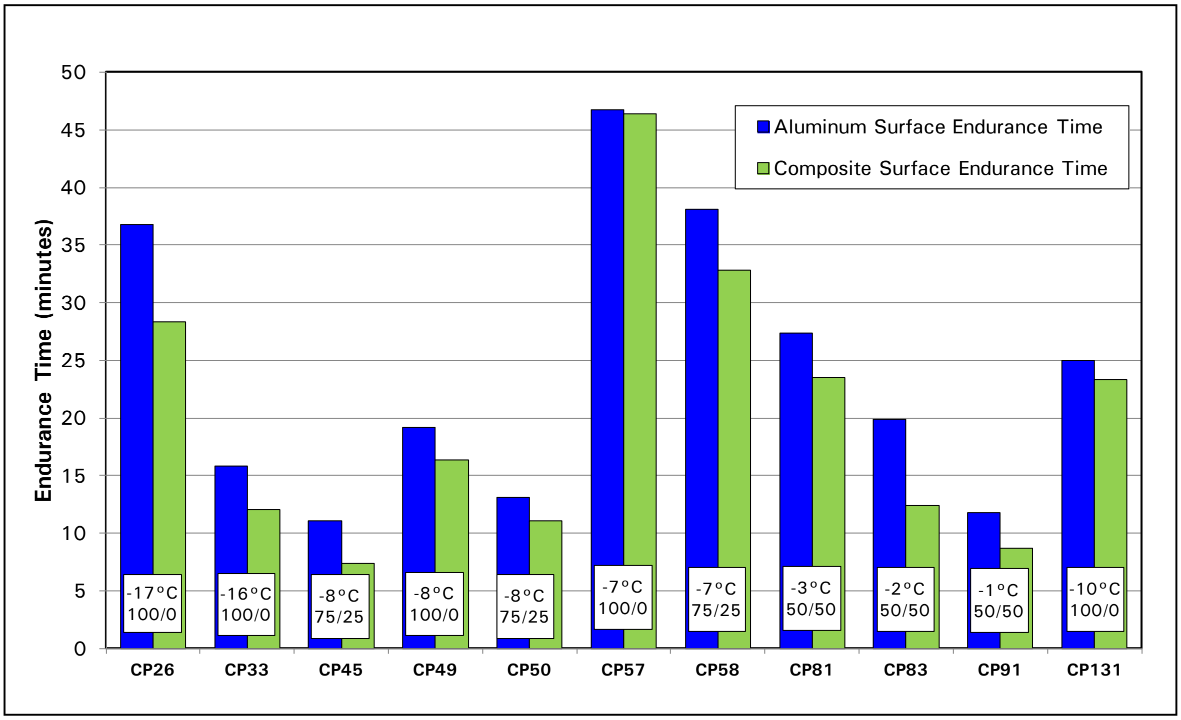


Figure 5.4: Type III Composite vs. Aluminum Test Results (Snow 2013-14)

6. CHANGES TO THE TYPE IV HOT GUIDELINES

Changes made to the Type IV HOT guidelines for the winter of 2014-15 are documented in this chapter. The Transport Canada and FAA 2014-15 Type IV HOT guidelines are included in Appendix H.

6.1 New Fluids/Data

Three new Type IV fluids were added to the HOT guidelines for the winter of 2014-15: **Clariant Max Flight Sneg**, **LNT Solutions E450** and **Newave Aerochemical FCY 9311**. These are all new fluids that underwent endurance time testing in the winter of 2013-14. The detailed test results are provided in Appendices E (Max Flight Sneg), F (E450), and G (FCY 9311).

It should be noted that the manufacturers of E450 and FCY 9311 elected to have data for only 100/0 fluid included in the HOT Guidelines. Data for the 75/25 and 50/50 dilutions was not included.

It should also be noted that E450 was given generic holdover times for snow for the winter of 2014-15. This was due to the late submission of the fluid in the winter season and inability to collect sufficient natural snow data to derive fluid-specific holdover times. Testing with an artificial snow machine supported the use of providing generic Type IV holdover times for the snow cells. It is expected additional natural snow data will produce fluid-specific holdover times for winter 2015-16.

The addition of E450 and FCY 9311 resulted in several reductions to the generic Type IV holdover times (see Subsection 6.4.1).

6.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718 (8). As per the protocol, Lyondell Arctic Shield was removed from the Type IV guidelines for the winter of 2014-15. Its removal impacted the generic Type IV holdover times (see Subsection 6.4.1).

6.3 Changes to HOT Guidelines Format

No changes were made to the format of the Type IV HOT Guidelines for winter 2014-15.

6.4 Type IV Generic Holdover Time Values

The values in the Type IV generic HOT table are generated each year by taking the shortest holdover times of all fluids on the Transport Canada and FAA list of Type IV fluids. It should be noted that the Transport Canada and FAA list of fluids contains fluids whose qualifications have recently expired (i.e. within four years). Fluids are only removed from the generic analysis when they are removed from the Transport Canada and FAA lists.

6.4.1 Use of Generic Holdover Times in Very Cold Snow

Following the winter of 2003-04, a decision was made that fluid-specific holdover times would not be provided for Type IV fluids in snow at temperatures below -14°C. This was due to the limited data that exits for most fluids at these temperatures. Instead, all Type IV fluids are given pre-established “generic” holdover times in very cold snow. These holdover times were determined based on historical data and analysis.

6.4.2 Impact of New and Removed Fluids/Data

The addition of new fluids E450 and FCY 9311 resulted in six decreases to the Type IV generic holdover times: four 5 minute decreases, one 10-minute decrease, and one 15-minute decrease. All changes were made to 100/0 fluid cells.

- Freezing Fog, -3°C and above: from 1:55-3:10 to 1:50-2:55
- Snow, -3°C and above: from 0:40-1:20 to 0:35-1:10
- Snow, below -3 to -14°C: from 0:30-0:55 to 0:25-0:50

6.4.3 Fluids Responsible for the Type IV Generic Holdover Time Values

The fluids responsible for the values in the 2014-15 Type IV generic HOT guidelines are shown in Table 6.1. A “U” indicates a fluid is responsible for the upper value in the cell; an “L” indicates a fluid is responsible for the lower value in the cell; and a “B” indicates the fluid is responsible for both the upper and lower values in the cell.

Due to space limitations, the following abbreviations are used in the table:

- ABAX AD-480 / Dow UCAR FlightGuard AD-480 (A/D-480);
- ABAX Ecowing AD-49 / Dow UCAR FlightGuard AD-49 (A/D-49);

- Clariant Safewing MP IV Launch Plus (C-L+);
- Clariant Max Flight Sneg (C-Max-S);
- Cryotech Polar Guard (CR-PG);
- Cryotech Polar Guard Advance (CR-PGA);
- Dow UCAR Endurance EG106 (D-E106);
- Kilfrost ABC-S (K-ABCS);
- Kilfrost ABC-S PLUS (K-ABCS+);
- LNT Solutions E450 (L-E450); and
- Newave Aerochemical FCY 9311 (N-9311).

Table 6.1: Fluids Responsible for the Type IV Generic Holdover Time Values

OAT		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
°C	°F		Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100/0	L-E450 **(B)**	N-9311 **(B)**	A/D-480 **(B)**	A/D-480 **(B)**	A/D-49 **(L)** K-ABCS **(U)**
		75/25	K-ABCS **(B)**	K-ABCS **(B)** A/D-480 **(L)**	K-ABCS **(B)**	A/D-480 **(B)** K-ABCS+ **(L)**	CR-PGA **(L)** K-ABCS **(U)**
		50/50	K-ABCS **(B)**	K-ABCS **(B)** CR-PG **(U)**	K-ABCS **(B)** K-ABCS+ **(L)** A/D-480 **(L)** A/D-49 **(L)** CR-PG **(L)**	K-ABCS **(B)**	
below -3 to -14	below 27 to 7	100/0	A/D-480 **(B)** A/D-49 **(L)**	N-9311 **(B)**	K-ABCS **(B)**	K-ABCS **(L)** A/D-49 **(U)**	
		75/25	A/D-480 **(B)** K-ABCS **(L)**	CR-PG **(B)** A/D-480 **(L)**	A/D-49 **(B)** A/D-480 **(U)** CR-PG **(U)** CR-PGA **(U)** C-L+ **(U)** C-Max-S **(U)**	K-ABCS **(L)** K-ABCS+ **(U)** A/D-49 **(U)**	
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	A/D-480 **(B)** K-ABCS **(U)** A/D-49 **(U)** CR-PG **(U)**	Historic Generic **(B)**			

LEGEND	L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH

6.4.4 Evolution of Type IV Generic Holdover Time Values

The history of testing with Type IV fluids and the evolution of the fluid-specific and generic Type IV holdover time values are illustrated through a series of tables given in Tables 6.2 to 6.25. Each table represents one cell in the HOT guidelines and the title of each table links the table to the appropriate cell. Fluids that are no longer used in the generic analysis (see Subsection 6.2) are not included.

The first row in each table contains the values obtained in testing in 1996-97. These values were used as the holdover time values in 1997-98 winter operations. Each subsequent set of two rows represents a winter test season and the subsequent winter's holdover time values. The final line contains the generic and fluid-specific holdover time values for use in 2014-15 winter operations. It should be noted that because no Type IV fluids were tested in the winter of 2001-02 and the generic values did not change, no line has been included for the 2001-02 winter test season or the 2002-03 holdover time values.

Underlined values indicate the fluid(s) responsible for the generic holdover time. Strikethrough values indicate endurance time test results that are no longer valid. If a fluid has been tested on multiple occasions, then only one test result, usually the shortest endurance time, is valid for a given fluid in a given cell. Details are typically provided in the HOT report written in the most recent year the fluid underwent testing.

Due to space limitations, the following abbreviations are used in the tables:

- ABAX AD-480 / Dow UCAR FlightGuard AD-480 (A/D-480);
- ABAX Ecowing AD-49 / Dow UCAR FlightGuard AD-49 (A/D-49);
- Clariant Max Flight 04 (C-Max 04);
- Clariant Max Flight Sneg (C-Max-S);
- Clariant Safewing MP IV Launch (C-Launch);
- Clariant Safewing MP IV Launch Plus (C-L+);
- Cryotech Polar Guard (CR-PG);
- Cryotech Polar Guard Advance (CR-PGA);
- Dow UCAR Endurance EG106 (D-E106);
- Kilfrost ABC-S (K-ABCS);
- Kilfrost ABC-S PLUS (K-ABCS+);
- LNT Solutions E450 (L-E450); and
- Newave Aerochemical FCY 9311 (N-9311).

Table 6.2: Type IV Neat Fluid, Snow, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:35-1:00	1:00-1:40												
1997-98 ET Test Results			~~1:05-2:00~~											
1998-99 HOT Table Values	0:35-1:00	1:00-1:40	1:05-2:00											
1998-99 ETTest Results		1:00-1:40	~~1:05-1:50~~											
1999-00 HOT Table Values	0:30-0:55	1:00-1:40	1:05-1:50											
1999-00 ET Test Results			0:40-1:20											
2000-01 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20											
2000-01 ET Test Results				1:25-2:45										
2001-02 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20	1:25-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00										
2005-06 ET Test Results					~~1:00-1:35~~	0:40-1:20	~~0:45-1:25~~							
2006-07 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:00-1:35	0:40-1:20	0:45-1:25							
2006-07 ET Test Results					1:05-1:45		1:15-2:05							
2007-08 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00							
2008-09 ET Test Results								1:10-1:50						
2009-10 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50						
2009-10 ET Test Results									0:50-1:30					
2010-11 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50	0:50-1:30					
2010-11 ET Test Results										1:20-1:50				
2011-12 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50	0:50-1:30	1:20-1:50				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50	0:50-1:30	1:20-1:50				
2012-13 ET Test Results											0:55-2:00			
2013-14 HOT Table Values (TC)	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:00			
2013-14 HOT Table Values	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:45	1:05-1:45	0:40-1:20	1:15-2:05	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:05			
2013-14 ET Test Results												1:05-1:40		0:35-1:10
2014-15 HOT Table Values (TC)	0:35-1:10	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:00	1:05-1:40	0:35-1:10	0:35-1:10
2014-15 HOT Table Values	0:35-1:10	1:00-1:40	0:40-1:20	1:25-2:45	1:05-1:45	0:40-1:20	1:15-2:05	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:05	1:05-1:40	0:35-1:10	0:35-1:10

Table 6.3: Type IV 75/25 Fluid, Snow, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:20-0:35	~~0:35-1:05~~												
1997-98 ET Test Results			~~0:45-1:25~~											
1998-99 HOT Table Values	0:20-0:35	0:35-1:05	0:45-1:25											
1998-99 ETTest Results		0:30-0:55	~~0:45-1:25~~											
1999-00 HOT Table Values	0:20-0:35	0:30-0:55	0:45-1:25											
1999-00 ET Test Results			0:30-1:05											
2000-01 HOT Table Values	0:20-0:35	0:30-0:55	0:30-1:05											
2000-01 ET Test Results				~~1:05-2:00~~										
2001-02 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05	1:05-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00										
2005-06 ET Test Results					~~0:40-1:20~~		~~0:25-0:55~~							
2006-07 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	0:40-1:20		0:25-0:55							
2006-07 ET Test Results					1:00-1:45		0:45-1:15							
2007-08 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15							
2008-09 ET Test Results								1:20-1:40						
2009-10 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	1:20-1:40						
2009-10 ET Test Results									0:35-1:10					
2010-11 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	1:20-1:40	0:35-1:10					
2010-11 ET Test Results										0:45-1:20				
2011-12 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	1:20-1:40	0:35-1:10	0:45-1:20				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	1:20-1:40	0:35-1:10	0:45-1:20				
2012-13 ET Test Results											0:50-1:55			
2013-14 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05		1:00-1:45		0:45-1:15	1:20-1:40	0:35-1:10	0:45-1:20	0:50-1:55			
2013-14 ET Test Results												0:55-1:30		
2014-15 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05		1:00-1:45		0:45-1:15	1:20-1:40	0:35-1:10	0:45-1:20	0:50-1:55	0:55-1:30		

Table 6.4: Type IV 50/50 Fluid, Snow, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:05-0:15	~~0:05-0:15~~												
1997-98 ET Test Results			~~0:10-0:30~~											
1998-99 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:30											
1998-99 ETTest Results	0:05-0:15	0:07-0:15												
1999-00 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:30											
1999-00 ET Test Results			0:09-0:20											
2000-01 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20											
2000-01 ET Test Results				~~0:25-1:15~~										
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15										
2005-06 ET Test Results					~~0:10-0:25~~		~~0:05-0:15~~							
2006-07 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:10-0:25		0:05-0:15							
2006-07 ET Test Results					0:25-0:45		0:15-0:30							
2007-08 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30							
2008-09 ET Test Results								0:15-0:25						
2009-10 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:15-0:25						
2009-10 ET Test Results									0:100:15					
2010-11 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:15-0:25	0:10-0:15					
2010-11 ET Test Results										0:15-0:35				
2011-12 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:15-0:25	0:10-0:15	0:15-0:35				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:15-0:25	0:10-0:15	0:15-0:35				
2012-13 ET Test Results											0:20-0:45			
2013-14 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20		0:25-0:45		0:15-0:30	0:15-0:25	0:10-0:15	0:15-0:35	0:20-0:45			
2013-14 ET Test Results												0:20-0:45		
2014-15 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20		0:25-0:45		0:15-0:30	0:15-0:25	0:10-0:15	0:15-0:35	0:20-0:45	0:20-0:45		

Table 6.5: Type IV Neat Fluid, Snow, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:20-0:40	0:45-1:20												
1997-98 ET Test Results			~~0:20-0:40~~											
1998-99 HOT Table Values	0:20-0:40	0:45-1:20	0:20-0:40											
1998-99 ETTest Results		0:45-1:20	0:30-0:55											
1999-00 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55											
1999-00 ET Test Results			0:30-0:55											
2000-01 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55											
2000-01 ET Test Results				0:35-1:10										
2001-02 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10										
2005-06 ET Test Results					~~0:40-1:05~~	0:30-1:05	~~0:35-1:00~~							
2006-07 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:40-1:05	0:30-1:05	0:35-1:00							
2006-07 ET Test Results					0:50-1:20		1:00-1:45							
2007-08 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45							
2008-09 ET Test Results								1:10-1:50						
2009-10 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50						
2009-10 ET Test Results									0:30-0:55					
2010-11 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50	0:30-0:55					
2010-11 ET Test Results										0:55-1:15				
2011-12 HOT Table Values	0:25-0:50	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50	0:30-0:55	0:55-1:15				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:30-0:55	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50	0:30-0:55	0:55-1:15				
2012-13 ET Test Results											0:40-1:25			
2013-14 HOT Table Values	0:30-0:55	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50	0:30-0:55	0:55-1:15	0:40-1:25			
2013-14 ET Test Results												0:45-1:15		0:25-0:50
2014-15 HOT Table Values	0:25-0:50	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	1:10-1:50	0:30-0:55	0:55-1:15	0:40-1:25	0:45-1:15	0:25-0:50	0:25-0:50

Table 6.6: Type IV 75/25 Fluid, Snow, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	~~0:35-1:05~~												
1997-98 ET Test Results			~~0:15-0:25~~											
1998-99 HOT Table Values	0:15-0:25	0:35-1:05	0:15-0:25											
1998-99 ETTest Results		0:25-0:50	~~0:25-0:45~~											
1999-00 HOT Table Values	0:15-0:25	0:25-0:50	0:25-0:45											
1999-00 ET Test Results			0:20-0:45											
2000-01 HOT Table Values	0:15-0:25	0:25-0:50	0:20-0:45											
2000-01 ET Test Results				~~0:40-1:20~~										
2001-02 HOT Table Values	0:15-0:25	0:25-0:50	0:20-0:45											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45	0:40-1:20										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20										
2005-06 ET Test Results					~~0:20-0:40~~		~~0:25-0:50~~							
2006-07 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:20-0:40		0:25-0:50							
2006-07 ET Test Results					0:45-1:25		0:35-1:00							
2007-08 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00							
2008-09 ET Test Results								1:20-1:40						
2009-10 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	1:20-1:40						
2009-10 ET Test Results									0:20-0:40					
2010-11 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	1:20-1:40	0:20-0:40					
2010-11 ET Test Results										0:35-1:00				
2011-12 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	1:20-1:40	0:20-0:40	0:35-1:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:20-0:40	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	1:20-1:40	0:20-0:40	0:35-1:00				
2012-13 ET Test Results											0:30-1:15			
2013-14 HOT Table Values	0:20-0:40	0:25-0:50	0:20-0:45		0:45-1:25		0:35-1:00	1:20-1:40	0:20-0:40	0:35-1:00	0:30-1:15			
2013-14 ET Test Results												0:40-1:00		
2014-15 HOT Table Values	0:20-0:40	0:25-0:50	0:20-0:45		0:45-1:25		0:35-1:00	1:20-1:40	0:20-0:40	0:35-1:00	0:30-1:15	0:40-1:00		

Table 6.7: Type IV Neat Fluid, Snow, Below -14ºC to -25ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:150:30	0:40-1:10												
1997-98 ET Test Results			~~0:15-0:30~~											
1998-99 HOT Table Values	0:15-0:30	0:40-1:10	0:15-0:30											
1998-99 ETTest Results		0:40-1:10	0:25-0:40											
1999-00 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40											
1999-00 ET Test Results			~~0:25-0:50~~											
2000-01 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40											
2000-01 ET Test Results				0:25-0:50										
2001-02 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*										
2005-06 ET Test Results					~~0:35-0:55~~		~~0:30-0:50~~							
2006-07 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*							
2006-07 ET Test Results					0:45-1:10		0:55-1:35							
2007-08 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*							
2008-09 ET Test Results														
2009-10 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*						
2009-10 ET Test Results														
2010-11 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*					
2010-11 ET Test Results														
2011-12 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2012-13 ET Test Results														
2013-14 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2013-14 ET Test Results														
2014-15 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*

*Generic HOT values used in this cell

Table 6.8: Type IV Neat Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:40-1:00	1:20-1:50												
1997-98 ET Test Results		~~1:55-2:00~~	~~1:05-2:00~~											
1998-99 HOT Table Values	0:40-1:00	1:20-1:50	1:05-2:00											
1998-99 ETTest Results		~~2:00-2:00~~												
1999-00 HOT Table Values	0:40-1:00	1:20-1:50	1:05-2:00											
1999-00 ET Test Results			0:50-1:30											
2000-01 HOT Table Values	0:40-1:00	1:20-1:50	0:50-1:30											
2000-01 ET Test Results				2:00-2:00										
2001-02 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00										
2005-06 ET Test Results					1:30-2:00	1:10-2:00	~~1:15-1:55~~							
2006-07 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:15-1:55							
2006-07 ET Test Results							1:50-2:00							
2007-08 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00							
2008-09 ET Test Results								1:25-2:00						
2009-10 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00						
2009-10 ET Test Results									1:15-2:00					
2010-11 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00	1:15-2:00					
2010-11 ET Test Results										1:35-2:00				
2011-12 HOT Table Values	0:45-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00	1:15-2:00	1:35-2:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:50-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00	1:15-2:00	1:35-2:00				
2012-13 ET Test Results											2:00-2:00			
2013-14 HOT Table Values	0:50-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00	1:15-2:00	1:35-2:00	2:00-2:00			
2013-14 ET Test Results												2:00-2:00	1:35-2:00	1:10-2:00
2014-15 HOT Table Values	0:50-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	1:25-2:00	1:15-2:00	1:35-2:00	2:00-2:00	2:00-2:00	1:35-2:00	1:10-2:00

Table 6.9: Type IV 75/25 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	~~0:50-1:25~~												
1997-98 ET Test Results		~~0:50-1:10~~	~~0:50-1:20~~											
1998-99 HOT Table Values	0:30-1:00	0:50-1:10	0:50-1:20											
1998-99 ETTest Results		~~0:45-1:10~~												
1999-00 HOT Table Values	0:30-1:00	0:45-1:10	0:50-1:20											
1999-00 ET Test Results			0:50-1:15											
2000-01 HOT Table Values	0:30-1:00	0:45-1:10	0:50-1:15											
2000-01 ET Test Results				~~1:50-2:00~~										
2001-02 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00										
2005-06 ET Test Results					1:40-2:00		~~0:45-1:10~~							
2006-07 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		0:45-1:10							
2006-07 ET Test Results							1:00-1:20							
2007-08 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20							
2008-09 ET Test Results								1:55-2:00						
2009-10 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	1:55-2:00						
2009-10 ET Test Results									1:05-1:25					
2010-11 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	1:55-2:00	1:05-1:25					
2010-11 ET Test Results										1:40-2:00				
2011-12 HOT Table Values	0:35-1:05	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	1:55-2:00	1:05-1:25	1:40-2:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:40-1:05	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	1:55-2:00	1:05-1:25	1:40-2:00				
2012-13 ET Test Results											2:00-2:00			
2013-14 HOT Table Values	0:45-1:10	0:45-1:10	0:50-1:15		1:40-2:00		1:00-1:20	1:55-2:00	1:05-1:25	1:40-2:00	2:00-2:00			
2013-14 ET Test Results												1:30-2:00		
2014-15 HOT Table Values	0:45-1:10	0:45-1:10	0:50-1:15		1:40-2:00		1:00-1:20	1:55-2:00	1:05-1:25	1:40-2:00	2:00-2:00	1:30-2:00		

Table 6.10: Type IV 50/50 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:10-0:20	0:15~~0:25~~												
1997-98 ET Test Results		0:150:20	~~0:15-0:35~~											
1998-99 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:35											
1998-99 ETTest Results		0:150:20												
1999-00 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:35											
1999-00 ET Test Results			0:150:25											
2000-01 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25											
2000-01 ET Test Results				~~0:35-1:10~~										
2001-02 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10										
2005-06 ET Test Results					0:30-0:50		~~0:10-0:20~~							
2006-07 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:10-0:20							
2006-07 ET Test Results							0:150:40							
2007-08 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40							
2008-09 ET Test Results								0:150:30						
2009-10 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:15-0:30						
2009-10 ET Test Results									0:150:25					
2010-11 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:15-0:30	0:15-0:25					
2010-11 ET Test Results										0:20-0:45				
2011-12 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:15-0:30	0:15-0:25	0:20-0:45				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:15-0:30	0:15-0:25	0:20-0:45				
2012-13 ET Test Results											0:25-1:00			
2013-14 HOT Table Values	0:15-0:20	0:15-0:20	0:15-0:25		0:30-0:50		0:15-0:40	0:15-0:30	0:15-0:25	0:20-0:45	0:25-1:00			
2013-14 ET Test Results												0:35-1:10		
2014-15 HOT Table Values	0:15-0:20	0:15-0:20	0:15-0:25		0:30-0:50		0:15-0:40	0:15-0:30	0:15-0:25	0:20-0:45	0:25-1:00	0:35-1:10		

Table 6.11: Type IV Neat Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	~~0:35-1:00~~												
1997-98 ET Test Results		~~0:40-1:20~~	0:25-1:20											
1998-99 HOT Table Values	0:25-1:00	0:35-1:00	0:25-1:20											
1998-99 ETTest Results		~~0:20-1:30~~												
1999-00 HOT Table Values	0:20-0:55	0:20-1:00	0:25-1:20											
1999-00 ET Test Results			0:25-1:20											
2000-01 HOT Table Values	0:20-0:55	0:20-1:00	0:25-1:20											
2000-01 ET Test Results				0:25-1:30										
2001-02 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30										
2005-06 ET Test Results					0:35-1:40	0:55-1:50	~~0:30-1:35~~							
2006-07 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:30-1:35							
2006-07 ET Test Results							0:25-1:35							
2007-08 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35							
2008-09 ET Test Results								0:25-1:25						
2009-10 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25						
2009-10 ET Test Results									0:25-1:10					
2010-11 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25	0:25-1:10					
2010-11 ET Test Results										0:35-1:35				
2011-12 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25	0:25-1:10	0:35-1:35				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25	0:25-1:10	0:35-1:35				
2012-13 ET Test Results											0:25-1:35			
2013-14 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25	0:25-1:10	0:35-1:35	0:25-1:35			
2013-14 ET Test Results												0:30-1:25	1:45-2:00	0:35-1:20
2014-15 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:25	0:25-1:10	0:35-1:35	0:25-1:35	0:30-1:25	1:45-2:00	0:35-1:20

Table 6.12: Type IV 75/25 Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	~~0:50-1:25~~												
1997-98 ET Test Results		~~0:30-~~1:10	~~0:30-1:15~~											
1998-99 HOT Table Values	0:30-1:00	0:30-1:10	0:30-1:15											
1998-99 ETTest Results		0:20~~-1:30~~												
1999-00 HOT Table Values	0:20-0:55	0:20-1:10	0:30-1:15											
1999-00 ET Test Results			0:25~~-~~1:05											
2000-01 HOT Table Values	0:20-0:50	0:20-1:10	0:25-1:05											
2000-01 ET Test Results				~~0:20-1:00~~										
2001-02 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00										
2005-06 ET Test Results					0:25-1:10		~~0:25-1:15~~							
2006-07 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:25-1:15							
2006-07 ET Test Results							0:20-1:10							
2007-08 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10							
2008-09 ET Test Results								0:15~~-~~1:05						
2009-10 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:15-1:05						
2009-10 ET Test Results									0:25~~-~~1:05					
2010-11 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:15-1:05	0:25-1:05					
2010-11 ET Test Results										0:25~~-~~1:05				
2011-12 HOT Table Values	0:15-1:00	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:15-1:05	0:25-1:05	0:25-1:05				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:15-1:00	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:15-1:05	0:25-1:05	0:25-1:05				
2012-13 ET Test Results											0:20~~-~~1:05			
2013-14 HOT Table Values	0:15-1:05	0:20-1:10	0:25-1:05		0:25-1:10		0:20-1:10	0:15-1:05	0:25-1:05	0:25-1:05	0:20-1:05			
2013-14 ET Test Results												0:20~~-~~1:05		
2014-15 HOT Table Values	0:15-1:05	0:20-1:10	0:25-1:05		0:25-1:10		0:20-1:10	0:15-1:05	0:25-1:05	0:25-1:05	0:20-1:05	0:20-1:05		

Table 6.13: Type IV Neat Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:35-0:55	1:00-1:25												
1997-98 ET Test Results		~~1:20-2:00~~	~~0:50-1:10~~											
1998-99 HOT Table Values	0:35-0:55	1:00-1:25	0:50-1:10											
1998-99 ETTest Results		~~1:20-2:00~~												
1999-00 HOT Table Values	0:25-0:40	1:00-1:25	0:50-1:10											
1999-00 ET Test Results			0:35-0:55											
2000-01 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55											
2000-01 ET Test Results				1:10-1:30										
2001-02 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30										
2005-06 ET Test Results					1:00-1:40	0:50-1:15	~~0:50-1:10~~							
2006-07 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	0:50-1:10							
2006-07 ET Test Results							1:05-2:00							
2007-08 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00							
2008-09 ET Test Results								1:00-1:25						
2009-10 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25						
2009-10 ET Test Results									0:50-1:15					
2010-11 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25	0:50-1:15					
2010-11 ET Test Results										1:15-1:30				
2011-12 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25	0:50-1:15	1:15-1:30				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:35-0:55	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25	0:50-1:15	1:15-1:30				
2012-13 ET Test Results											1:00-2:00			
2013-14 HOT Table Values	0:35-0:55	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25	0:50-1:15	1:15-1:30	1:00-2:00			
2013-14 ET Test Results												0:50-1:40	0:55-1:20	0:40-1:05
2014-15 HOT Table Values	0:35-0:55	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	1:00-1:25	0:50-1:15	1:15-1:30	1:00-2:00	0:50-1:40	0:55-1:20	0:40-1:05

Table 6.14: Type IV 75/25 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	0:35-0:50												
1997-98 ET Test Results		~~0:40-0:55~~	~~0:35-0:50~~											
1998-99 HOT Table Values	0:15-0:30	0:35-0:50	0:35-0:50											
1998-99 ETTest Results		0:35-0:50												
1999-00 HOT Table Values	0:15-0:30	0:35-0:50	0:35-0:50											
1999-00 ET Test Results			0:30-0:45											
2000-01 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45											
2000-01 ET Test Results				~~1:00-1:20~~										
2001-02 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20										
2005-06 ET Test Results					0:45-1:15		~~0:30-0:45~~							
2006-07 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:45							
2006-07 ET Test Results							0:30-0:50							
2007-08 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50							
2008-09 ET Test Results								0:50-1:30						
2009-10 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:50-1:30						
2009-10 ET Test Results									0:35-1:00					
2010-11 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:50-1:30	0:35-1:00					
2010-11 ET Test Results										0:40-1:10				
2011-12 HOT Table Values	0:25-0:35	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:50-1:30	0:35-1:00	0:40-1:10				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:25-0:40	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:50-1:30	0:35-1:00	0:40-1:10				
2012-13 ET Test Results											1:20-1:25			
2013-14 HOT Table Values	0:30-0:45	0:35-0:50	0:30-0:45		0:45-1:15		0:30-0:50	0:50-1:30	0:35-1:00	0:40-1:10	1:20-1:25			
2013-14 ET Test Results												1:05-1:20		
2014-15 HOT Table Values	0:30-0:45	0:35-0:50	0:30-0:45		0:45-1:15		0:30-0:50	0:50-1:30	0:35-1:00	0:40-1:10	1:20-1:25	1:05-1:20		

Table 6.15: Type IV 50/50 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:05-0:10	~~0:10-0:15~~												
1997-98 ET Test Results	0:05-0:10	~~0:10-0:15~~	~~0:10-0:25~~											
1998-99 HOT Table Values	0:05-0:10	0:10-0:15	0:10-0:25											
1998-99 ETTest Results	0:05-0:10	0:08-0:10												
1999-00 HOT Table Values	0:05-0:10	0:05-0:10	0:10-0:25											
1999-00 ET Test Results			0:09-0:15											
2000-01 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15											
2000-01 ET Test Results				~~0:25-0:35~~										
2001-02 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35										
2005-06 ET Test Results					0:20-0:25		~~0:05-0:10~~							
2006-07 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:05-0:10							
2006-07 ET Test Results							0:15-0:20							
2007-08 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20							
2008-09 ET Test Results								0:10-0:15						
2009-10 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15						
2009-10 ET Test Results									0:10-0:15					
2010-11 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15					
2010-11 ET Test Results										0:09-0:20				
2011-12 HOT Table Values	0:07-0:10	0:08-0:10	0:09-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:09-0:20				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:07-0:10	0:08-0:10	0:09-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:09-0:20				
2012-13 ET Test Results											0:15-0:20			
2013-14 HOT Table Values	0:08-0:10	0:08-0:10	0:09-0:15		0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:09-0:20	0:15-0:20			
2013-14 ET Test Results												0:15-0:30		
2014-15 HOT Table Values	0:08-0:10	0:08-0:10	0:09-0:15		0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:09-0:20	0:15-0:20	0:15-0:30		

Table 6.16: Type IV Neat Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:30-0:45	~~0:30-0:45~~												
1997-98 ET Test Results		~~0:20-0:40~~	~~0:20-0:40~~											
1998-99 HOT Table Values	0:15-0:30	0:20-0:40	0:20-0:40											
1998-99 ETTest Results		0:10-0:30												
1999-00 HOT Table Values	0:10-0:30	0:10-0:30	0:20-0:40											
1999-00 ET Test Results			0:15-0:30											
2000-01 HOT Table Values	0:10-0:30	0:10-0:30	0:15-0:30											
2000-01 ET Test Results				0:20-0:40										
2001-02 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40										
2005-06 ET Test Results					0:25-0:45	0:45-1:10	~~0:25-0:35~~							
2006-07 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:25-0:35							
2006-07 ET Test Results							0:20-0:30							
2007-08 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30							
2008-09 ET Test Results								0:20-0:25						
2009-10 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25						
2009-10 ET Test Results									0:15-0:35					
2010-11 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25	0:15-0:35					
2010-11 ET Test Results										0:35-0:45				
2011-12 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25	0:15-0:35	0:35-0:45				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25	0:15-0:35	0:35-0:45				
2012-13 ET Test Results											0:25-0:40			
2013-14 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25	0:15-0:35	0:35-0:45	0:25-0:40			
2013-14 ET Test Results												0:25-0:40	1:05-1:40	0:20-0:35
2014-15 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:20-0:25	0:15-0:35	0:35-0:45	0:25-0:40	0:25-0:40	1:05-1:40	0:20-0:35

Table 6.17: Type IV 75/25 Fluid, Light Freezing Rain, Below -3ºC to -10ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	~~0:35-0:50~~												
1997-98 ET Test Results		~~0:25~~0:35	~~0:20-0:35~~											
1998-99 HOT Table Values	0:15-0:30	0:25-0:35	0:20-0:35											
1998-99 ETTest Results		0:100:35												
1999-00 HOT Table Values	0:10-0:30	0:10-0:35	0:20-0:35											
1999-00 ET Test Results			0:15-0:30											
2000-01 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30											
2000-01 ET Test Results				~~0:15-0:30~~										
2001-02 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30										
2005-06 ET Test Results					0:25-0:45		~~0:30-0:40~~							
2006-07 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:30-0:40							
2006-07 ET Test Results							0:150:25							
2007-08 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25							
2008-09 ET Test Results								0:150:25						
2009-10 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:15-0:25						
2009-10 ET Test Results									0:20-0:30					
2010-11 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:15-0:25	0:20-0:30					
2010-11 ET Test Results										0:35-0:45				
2011-12 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:15-0:25	0:20-0:30	0:35-0:45				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:15-0:25	0:20-0:30	0:35-0:45				
2012-13 ET Test Results											0:20-0:30			
2013-14 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30		0:25-0:45		0:15-0:25	0:15-0:25	0:20-0:30	0:35-0:45	0:20-0:30			
2013-14 ET Test Results												0:20-0:40		
2014-15 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30		0:25-0:45		0:15-0:25	0:15-0:25	0:20-0:30	0:35-0:45	0:20-0:30	0:20-0:40		

Table 6.18: Type IV Neat Fluid, Freezing Fog, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	2:20-3:00													
1997-98 ET Test Results														
1998-99 HOT Table Values	2:00-3:00													
1998-99 ETTest Results		2:35-4:00												
1999-00 HOT Table Values	1:05-2:15	2:35-4:00	1:05-2:15											
1999-00 ET Test Results			2:00-3:30											
2000-01 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30											
2000-01 ET Test Results				2:40-4:00										
2001-02 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30											
2002-03 ET Test Results														
2003-04 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30											
2003-04 ET Test Results														
2004-05 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30	2:40-4:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00										
2005-06 ET Test Results					4:00-4:00	2:05-3:10	~~1:50-3:40~~							
2006-07 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	1:50-3:40							
2006-07 ET Test Results							2:10-4:00							
2007-08 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00							
2008-09 ET Test Results								3:20-4:00						
2009-10 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00						
2009-10 ET Test Results									2:15-3:30					
2010-11 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00	2:15-3:30					
2010-11 ET Test Results										2:50-4:00				
2011-12 HOT Table Values	1:20-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00	2:15-3:30	2:50-4:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	1:45-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00	2:15-3:30	2:50-4:00				
2012-13 ET Test Results											3:55-4:00			
2013-14 HOT Table Values	1:55-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00	2:15-3:30	2:50-4:00	3:55-4:00			
2013-14 ET Test Results												2:25-4:00	~~1:502:55~~	1:55-4:00
2014-15 HOT Table Values	1:50-2:55	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	3:20-4:00	2:15-3:30	2:50-4:00	3:55-4:00	2:25-4:00	1:50-2:55	1:55-4:00

Table 6.19: Type IV 75/25 Fluid, Freezing Fog, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	1:05-2:00													
1997-98 ET Test Results														
1998-99 HOT Table Values	1:05-2:00													
1998-99 ETTest Results		1:05-1:45												
1999-00 HOT Table Values	1:05-1:45	1:05-1:45	1:05-1:45											
1999-00 ET Test Results			1:30-2:45											
2000-01 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45											
2000-01 ET Test Results				~~2:05-3:15~~										
2001-02 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45											
2002-03 ET Test Results														
2003-04 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45											
2003-04 ET Test Results														
2004-05 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15										
2004-05 ET Test Results														
2005-06 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15										
2005-06 ET Test Results					3:40-4:00		~~1:10-2:10~~							
2006-07 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:10-2:10							
2006-07 ET Test Results							1:25-2:40							
2007-08 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40							
2007-08 ET Test Results														
2008-09 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40							
2008-09 ET Test Results								2:25-4:00						
2009-10 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	2:25-4:00						
2009-10 ET Test Results									1:40-2:40					
2010-11 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	2:25-4:00	1:40-2:40					
2010-11 ET Test Results										2:30-4:00				
2011-12 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	2:25-4:00	1:40-2:40	2:30-4:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	2:25-4:00	1:40-2:40	2:30-4:00				
2012-13 ET Test Results											3:55-4:00			
2013-14 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45		3:40-4:00		1:25-2:40	2:25-4:00	1:40-2:40	2:30-4:00	3:55-4:00			
2013-14 ET Test Results												4:00-4:00		
2014-15 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45		3:40-4:00		1:25-2:40	2:25-4:00	1:40-2:40	2:30-4:00	3:55-4:00	4:00-4:00		

Table 6.20: Type IV 50/50 Fluid, Freezing Fog, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:20-0:45													
1997-98 ET Test Results														
1998-99 HOT Table Values	0:20-0:45													
1998-99 ETTest Results		~~0:20-0:35~~												
1999-00 HOT Table Values	0:20-0:35	0:20-0:35	0:20-0:35											
1999-00 ET Test Results			0:30-0:45											
2000-01 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45											
2000-01 ET Test Results				~~0:55-1:45~~										
2001-02 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45										
2005-06 ET Test Results					1:25-2:45		~~0:20-0:40~~							
2006-07 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:20-0:40							
2006-07 ET Test Results							0:30-0:55							
2007-08 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55							
2008-09 ET Test Results								0:25-0:50						
2009-10 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:25-0:50						
2009-10 ET Test Results									0:25-0:40					
2010-11 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:25-0:50	0:25-0:40					
2010-11 ET Test Results										0:50-1:25				
2011-12 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:25-0:50	0:25-0:40	0:50-1:25				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:20-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:25-0:50	0:25-0:40	0:50-1:25				
2012-13 ET Test Results											1:15-1:50			
2013-14 HOT Table Values	0:20-0:35	0:20-0:35	0:30-0:45		1:25-2:45		0:30-0:55	0:25-0:50	0:25-0:40	0:50-1:25	1:15-1:50			
2013-14 ET Test Results												1:30-3:30		
2014-15 HOT Table Values	0:20-0:35	0:20-0:35	0:30-0:45		1:25-2:45		0:30-0:55	0:25-0:50	0:25-0:40	0:50-1:25	1:15-1:50	1:30-3:30		

Table 6.21: Type IV Neat Fluid, Freezing Fog, Below -3ºC to -14ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:40-3:00													
1997-98 ET Test Results														
1998-99 HOT Table Values	0:40-3:00													
1998-99 ETTest Results		0:45-2:05												
1999-00 HOT Table Values	0:40-1:30	0:45-2:05	0:40-1:30											
1999-00 ET Test Results			0:20-1:20											
2000-01 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20											
2000-01 ET Test Results				0:50-2:30										
2001-02 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30										
2005-06 ET Test Results					1:00-1:55	1:50-3:20	~~0:40-1:25~~							
2006-07 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:40-1:25							
2006-07 ET Test Results							0:55-3:30							
2007-08 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30							
2008-09 ET Test Results								0:20-1:35						
2009-10 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35						
2009-10 ET Test Results									0:45-1:45					
2010-11 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35	0:45-1:45					
2010-11 ET Test Results										0:55-2:30				
2011-12 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35	0:45-1:45	0:55-2:30				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35	0:45-1:45	0:55-2:30				
2012-13 ET Test Results											0:55-2:15			
2013-14 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35	0:45-1:45	0:55-2:30	0:55-2:15			
2013-14 ET Test Results												0:45-2:20	1:30-3:55	0:35-2:05
2014-15 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	0:20-1:35	0:45-1:45	0:55-2:30	0:55-2:15	0:45-2:20	1:30-3:55	0:35-2:05

Table 6.22: Type IV 75/25 Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:35-2:00													
1997-98 ET Test Results														
1998-99 HOT Table Values	0:30-2:00													
1998-99 ETTest Results		0:25-1:00												
1999-00 HOT Table Values	0:25-1:00	0:25-1:00	0:25-1:00											
1999-00 ET Test Results			0:25-0:50											
2000-01 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50											
2000-01 ET Test Results				~~0:30-1:05~~										
2001-02 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05										
2005-06 ET Test Results					0:40-1:20		~~0:40-1:15~~							
2006-07 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:40-1:15							
2006-07 ET Test Results							0:45-1:50							
2007-08 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50							
2008-09 ET Test Results								0:30-1:10						
2009-10 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:30-1:10						
2009-10 ET Test Results									0:35-1:30					
2010-11 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:30-1:10	0:35-1:30					
2010-11 ET Test Results										0:40-1:30				
2011-12 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:30-1:10	0:35-1:30	0:40-1:30				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:30-1:10	0:35-1:30	0:40-1:30				
2012-13 ET Test Results											0:40-2:00			
2013-14 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50		0:40-1:20		0:45-1:50	0:30-1:10	0:35-1:30	0:40-1:30	0:40-2:00			
2013-14 ET Test Results												0:30-1:25		
2014-15 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50		0:40-1:20		0:45-1:50	0:30-1:10	0:35-1:30	0:40-1:30	0:40-2:00	0:30-1:25		

Table 6.23: Type IV Neat Fluid, Freezing Fog, Below -14°C to -25°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	0:20-2:00													
1997-98 ET Test Results														
1998-99 HOT Table Values	0:20-2:00													
1998-99 ETTest Results		0:20-0:40												
1999-00 HOT Table Values	0:20-0:40	0:20-0:40	0:20-0:40											
1999-00 ET Test Results			0:15-0:40											
2000-01 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40											
2000-01 ET Test Results				0:20-0:45										
2001-02 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45										
2005-06 ET Test Results					0:30-0:50	0:30-1:05	~~0:20-0:45~~							
2006-07 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:20-0:45							
2006-07 ET Test Results							0:40-1:00							
2007-08 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00							
2008-09 ET Test Results								0:25-0:40						
2009-10 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40						
2009-10 ET Test Results									0:20-0:40					
2010-11 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40	0:20-0:40					
2010-11 ET Test Results										0:25-0:50				
2011-12 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40	0:20-0:40	0:25-0:50				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40	0:20-0:40	0:25-0:50				
2012-13 ET Test Results											0:25-0:50			
2013-14 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40	0:20-0:40	0:25-0:50	0:25-0:50			
2013-14 ET Test Results												0:20-0:50	0:35-1:05	0:30-0:55
2014-15 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:40	0:20-0:40	0:25-0:50	0:25-0:50	0:20-0:50	0:35-1:05	0:30-0:55

Table 6.24: Type IV Neat Fluid, Rain on a Cold-Soaked Wing, Above 0°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	~~0:10-0:50~~													
1997-98 ET Test Results		0:20~~-1:~~15												
1998-99 HOT Table Values	0:10-0:50													
1998-99 ETTest Results		~~0:30-2:00~~												
1999-00 HOT Table Values	0:10-0:50	0:20-1:15	0:10-0:50											
1999-00 ET Test Results			0:15-1:35											
2000-01 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35											
2000-01 ET Test Results				0:20-2:00										
2001-02 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00										
2005-06 ET Test Results					0:15-1:40	0:20-2:00	~~0:15-1:40~~							
2006-07 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:15-1:40							
2006-07 ET Test Results							0:25-2:00							
2007-08 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00							
2008-09 ET Test Results								~~0:10~~1:55						
2009-10 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55						
2009-10 ET Test Results									0:15-1:25					
2010-11 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55	0:15-1:25					
2010-11 ET Test Results										0:15-2:00				
2011-12 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55	0:15-1:25	0:15-2:00				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55	0:15-1:25	0:15-2:00				
2012-13 ET Test Results											0:20-2:00			
2013-14 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55	0:15-1:25	0:15-2:00	0:20-2:00			
2013-14 ET Test Results												0:20-1:30	0:25-2:00	0:15-1:25
2014-15 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:10-1:55	0:15-1:25	0:15-2:00	0:20-2:00	0:20-1:30	0:25-2:00	0:15-1:25

Table 6.25: Type IV 75/25 Fluid, Rain on a Cold-Soaked Wing, Above 0ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	A/D-49	CR-PG	CR-PGA	C-L+	C-Max-S	L-E450	N-9311
1996-97 Test Results and Table Values used in 97-98	~~0:05-0:35~~													
1997-98 ET Test Results		0:100:50												
1998-99 HOT Table Values	0:05-0:35													
1998-99 ETTest Results		~~0:10-1:15~~												
1999-00 HOT Table Values	0:05-0:35	0:10-0:50	0:05-0:35											
1999-00 ET Test Results			0:10-1:15											
2000-01 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15											
2000-01 ET Test Results				~~0:20-2:00~~										
2001-02 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15											
2002-03 ET Test Results														
2003-04 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15											
2003-04 ET Test Results														
2004-05 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00										
2004-05 ET Test Results														
2005-06 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00										
2005-06 ET Test Results					0:10-1:45		~~0:05-1:00~~							
2006-07 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:05-1:00							
2006-07 ET Test Results							0:10-1:20							
2007-08 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20							
2007-08 ET Test Results														
2008-09 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20							
2008-09 ET Test Results								0:10-1:40						
2009-10 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:10-1:40						
2009-10 ET Test Results									0:10-1:15					
2010-11 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:10-1:40	0:10-1:15					
2010-11 ET Test Results										0:09-1:40				
2011-12 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:10-1:40	0:10-1:15	0:09-1:40				
2011-12 ET Test Results														
2012-13 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:10-1:40	0:10-1:15	0:09-1:40				
2012-13 ET Test Results											0:20-1:50			
2013-14 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15		0:10-1:45		0:10-1:20	0:10-1:40	0:10-1:15	0:09-1:40	0:20-1:50			
2013-14 ET Test Results												0:15-1:45		
2014-15 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15		0:10-1:45		0:10-1:20	0:10-1:40	0:10-1:15	0:09-1:40	0:20-1:50	0:15-1:45		

This page intentionally left blank.

7. OTHER CHANGES TO THE HOT GUIDELINES CONTENT

In addition to the changes made to the Type I, II, III and IV HOT Guidelines, a number of other changes were made to the HOT Guidelines for winter 2014-15. These changes are documented in this chapter.

7.1 Active Frost HOT Guidelines

Endurance time testing in frost was conducted with all fluids submitted for endurance time testing in the winter of 2013-14. The test durations were compared to the related generic holdover times: all completed (“failed”) tests surpassed the generic holdover times, as did all tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates that the generic frost holdover times can be considered substantiated for all fluids added to the HOT guidelines for winter 2014-15.

No content or formatting changes were made to the active frost HOT guidelines for winter 2014-15.

7.2 Ice Pellet and Small Hail Allowance Time Tables

As described in Subsection 2.7, additional testing was conducted in the winter of 2013-14 in support of the ice pellet allowance times. This research, combined with previously conducted research, led to several changes:

- A new allowance time table was created for Type III fluids;
- The allowance time for Type IV propylene glycol based fluid in moderate ice pellets at temperatures below -16°C was removed; and
- An allowance time (7 minutes) was added for Type IV fluids in light ice pellets mixed with moderate snow at temperatures below -5 to -10°C.

In addition, it was determined that “small hail” is meteorologically equivalent to moderate ice pellets. As a result, small hail was added to the “moderate ice pellets” row in both the Type III and Type IV allowance time tables.

7.3 FAA 90 Percent HOT Tables for Flaps and Slats

As described in Subsection 2.8, research to examine endurance times on flaps and slats has been ongoing for the last four winters. In response to the preliminary conclusions of this testing, FAA included special HOT tables for use when flaps/slats are deployed prior to de/anti-icing in their 2014-15 HOT guidelines. These tables – one created for each existing (standard) HOT table – contain holdover times that are 90 percent of the standard HOT table values (10 percent reduction in holdover times).

It should be noted that Transport Canada elected not to make changes related to flaps/slats for winter 2014-15.

7.4 List of Fluids and Lowest Operational Use Temperature Table

The list of fluids (tested for anti-icing performance and aerodynamic acceptance) and the lowest operational use temperature table published in the HOT guidelines are updated annually based on new information provided by the fluid manufacturers. A number of changes were made to these tables accordingly for winter 2014-15.

7.5 Lowest On-Wing Viscosity Table

The lowest on-wing viscosity (LOWV) table was updated with viscosity values for the four new Type II/IV fluids added to the HOT Guidelines in 2014-15: LNT Solutions P250, LNT Solutions E450, Clariant Max Flight Sneg and Newave Aerochemical FCY 9311. It should be noted that no viscosities were included for 75/25 and 50/50 dilutions of E450 and FCY 9311 as no holdover times are provided for these fluids/dilutions.

8. CONCLUSIONS

Endurance time testing was carried out with seven de/anti-icing fluids in the winter of 2013-14. The results of this testing, plus the results of supplemental testing, resulted in several changes being made to the HOT guidelines. The changes, described below, were included in the winter 2014-15 HOT guidelines.

Type I Fluids

- No changes were made to the Type I fluid HOT guidelines.

Type II Fluids

- A fluid-specific HOT table was added for the new fluid LNT Solutions P250.
- Kilfrost ABC 2000 was removed as per the protocol for removing obsolete data.
- The Type II generic fluid holdover times did not change.

Type III Fluids

- No changes were made to the Type III fluid HOT guideline values; however, a note was added to the table indicating the holdover times in the table are only valid for fluids applied unheated.

Type IV Fluids

- Fluid-specific HOT tables were added for three new fluids: Clariant Max Flight Sneg, LNT Solutions E450 and Newave Aerochemical FCY 9311.
- Obsolete fluid Lyondell Arctic Shield was removed from the HOT guidelines.
- Six decreases were made to the Type IV generic holdover times as a result of the addition of E450 and FCY 9311.

Allowance Time Tables

- A new allowance time table was added for Type III fluids.
- Small hail was added to the allowance time tables as it was determined to be meteorologically equivalent to moderate ice pellets.
- The allowance time for propylene glycol fluid in moderate ice pellets at temperatures below -16°C was removed.
- An allowance time (7 minutes) was added for Type IV fluid in light ice pellets mixed with moderate snow at temperatures below -5 to -10°C.

Frost Table

- No changes were made to the active frost HOT guidelines.

Other Changes

- The list of fluids and the lowest operational use temperatures table were updated with new information provided by the fluid manufacturers.
- The lowest on-wing viscosity table was updated with information for new Type II and Type IV fluids.
- FAA published special HOT tables for use when deicing is conducted with flaps/slats extended. The tables include values that are 90 percent of the standard HOT table values.

9. RECOMMENDATIONS

It is recommended that any new Type I, II, III or IV fluids be evaluated over the entire range of conditions of the HOT tables.

It is also recommended that if a new Type III fluid is submitted for heated application testing, further research be conducted to evaluate endurance times of Type III fluids applied heated to composite surfaces.

This page intentionally left blank.

REFERENCES

1. 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).

2. *Guidelines for Aircraft Ground Icing Operations (Second Edition)*, Transport Canada, April 2005, TP 14052E.

3. Federal Aviation Administration N 8900.275, *Revised FAA-Approved Deicing Program Updates, Winter 2014-2015*, October 2014.

4. Society of Automotive Engineers Aerospace Recommended Practice 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type II, III, and IV*, July 2004.

5. SAE International Aerospace Recommended Practice 5945, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type I*, July 2007.

6. Youssef, D., *Aircraft Ground Icing General Research Activities During the 2013-14 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2014, TP 15269E, XX (to be published).

7. Ruggi, M., *Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2013-14,* APS Aviation Inc., Transportation Development Centre, Montreal, February 2015, TP 15273E, XX (to be published).

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

9. Bendickson, S., Dawson, P., Pineau, M., Zoitakis, V., *Aircraft Ground Icing General Research Activities During the 2008-09 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2009, TP 14936E, XX (to be published).

This page intentionally left blank.

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2013-14

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2013-14

5.9 Holdover Time Testing for New Fluids

This program element is funded by the fluid manufacturers. The extent of effort for this program element will be determined by the number of new fluids submitted for testing.

a) Conduct flat plate tests with samples of Type I, Type II, Type III and Type IV fluids supplied by fluid manufacturers. Testing will be conducted using the methodology provided in Aerospace Recommended Practice (ARP) 5485 and/or 5945 under conditions of:

   I. Natural snow and two frost events at the P.E.T. test site (under a wide range of temperature, precipitation rate, precipitation type, and wind conditions); and

   II. Simulated freezing precipitation at the NRC CEF (in freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface).

b) Record individual fluid endurance times; and

c) Analyze the data collected, report the findings, and prepare presentation material for the SAE G-12 annual meeting.

5.10 Completion of Testing and Development of Guidance for Heated Type III Fluid Holdover Times

a) Complete previously started testing with newly submitted Type III fluids using the Type I test protocol (heated fluid) in addition to the Type II/IV test protocol (ambient fluid) with aluminum and composite surfaces. Testing shall be conducted in Natural snow and frost at the P.E.T test site;

b) Analyze data and results;

c) Develop proposed changes to ARP5485 and ARP5718;

d) Consult with the fluid manufacturer and SAE G-12 HOT working group regarding integration of results into the holdover time guidelines; and

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

5.11 Infrastructure for FAA/TC Guideline Development

This program element does not include the actual endurance time testing of newly submitted fluids; the description of the fluid endurance time testing has been included in a previous section of this document and will be funded by the fluid manufacturers.

Preparation and Setup for Natural Snow Testing at Trudeau International Airport

a) Prepare the P.E.T. test site at Trudeau International Airport (YUL) for conducting tests;

b) Upgrade test site infrastructure (i.e.: trailer, shed) to ensure personnel safety and adhere to environmental guidelines;

c) Prepare an updated procedure for testing fluids outdoors during snow events;

d) Evaluate current methods for measuring snowfall intensity or holdover times; and

e) Develop improved, more efficient methods to measure snowfall intensity or holdover times, if appropriate.

Preparation and Setup for Simulated Precipitation Testing at NRC

a) Prepare a test plan to coordinate all simulated precipitation required by the research program. Testing will be conducted at the NRC Climatic Environment Facility (CEF) in U89 at Uplands, Ottawa;

   Note: The NRC facility costs associated with testing at U89 are not included in this task and are dealt with directly with TC through a M.O.U. agreement with NRC;

b) Coordinate scheduling and test plans with NRC CEF personnel;

c) Prepare a test procedure for the conduct of endurance time tests in simulated precipitation at the NRC CEF;

d) Conduct calibration to attain appropriate test conditions for each weather condition represented in the holdover time tables; and

e) As the cost for this activity is highly weighted on calibration of precipitation rates, evaluate and, if possible, develop an improved, more efficient method to measure intensity of precipitation.

General Activities

a) Analyze individual fluid HOT data for in order to develop generic table HOTs;

b) Maintain data to ensure continuity;

c) Present material and data at SAE G-12 meeting; and

d) Prepare report.

This page intentionally left blank.

APPENDIX B

PROCEDURES FOR HOLDOVER TIME TESTING

- Test Requirements for Natural Precipitation Flat Plate Testing
- Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval
- Test Requirements for Simulated Freezing Precipitation Flat Plate Testing
- Overall Program of Tests at NRC, March 2014
- Overall Program of Tests at NRC, April 2014
  (Special Testing for Type II/IV Fluids)

TEST REQUIREMENTS
FOR NATURAL PRECIPITATION FLAT PLATE TESTING

CM1892.001

TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

Winter 2004-05

Prepared for

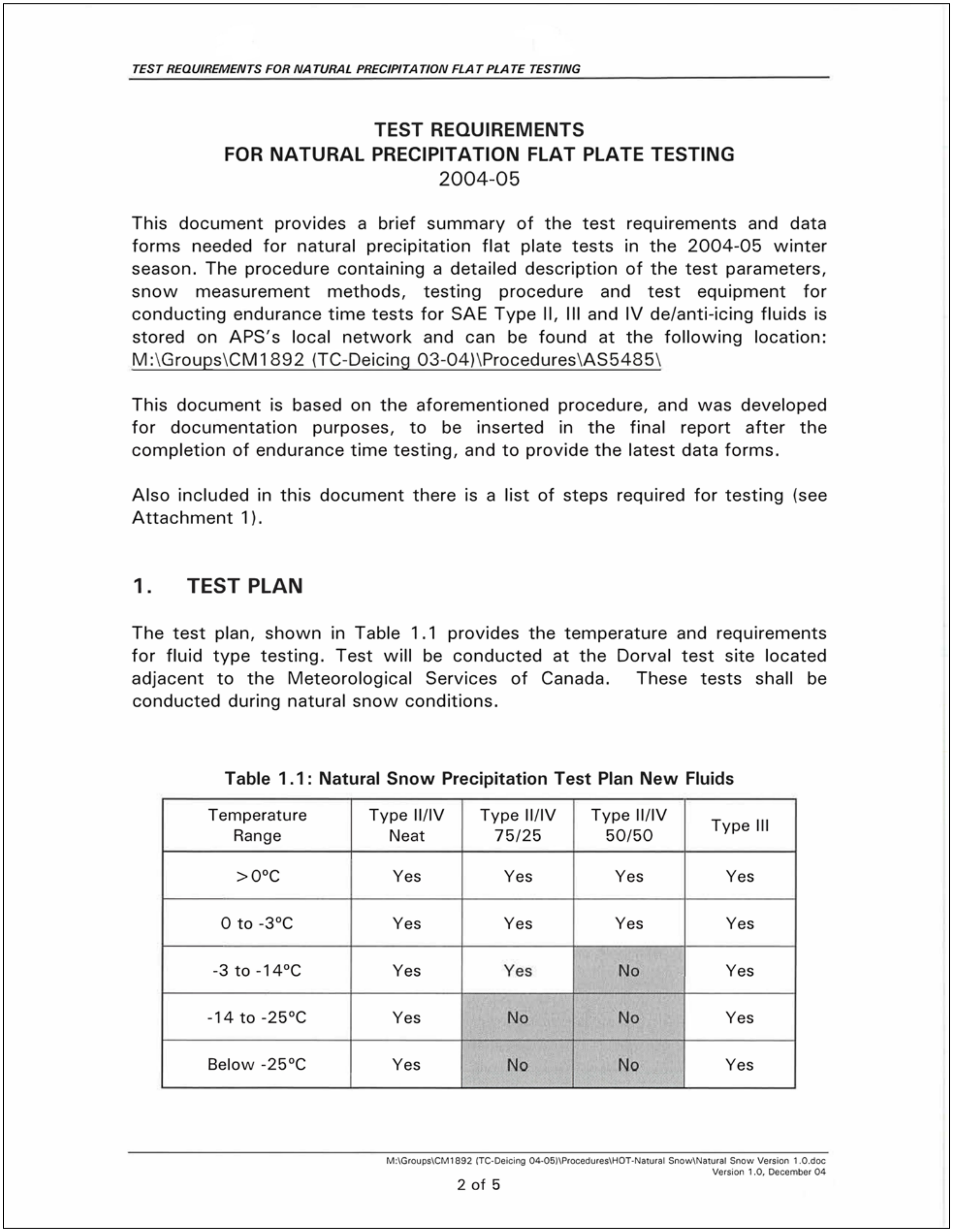
Transportation Development Centre
Transport Canada

Prepared by: Nicoara Moc

Reviewed by: John D'Avirro

APS Aviation Inc.

December 23, 2004
Version 1.0



TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

2004-05

This document provides a brief summary of the test requirements and data forms needed for natural precipitation flat plate tests in the 2004-05 winter season. The procedure containing a detailed description of the test parameters, snow measurement methods, testing procedure and test equipment for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids is stored on APS's local network and can be found at the following location: M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\AS5485\

This document is based on the aforementioned procedure, and was developed for documentation purposes, to be inserted in the final report after the completion of endurance time testing, and to provide the latest data forms.

Also included in this document there is a list of steps required for testing (see Attachment 1).

1. TEST PLAN

The test plan, shown in Table 1.1 provides the temperature and requirements for fluid type testing. Test will be conducted at the Dorval test site located adjacent to the Meteorological Services of Canada. These tests shall be conducted during natural snow conditions.

Table 1.1: Natural Snow Precipitation Test Plan New Fluids

Temperature Range	Type II/IV Neat	Type II/IV 75/25	Type II/IV 50/50	Type III
>0°C	Yes	Yes	Yes	Yes
0 to -3°C	Yes	Yes	Yes	Yes
-3 to -14°C	Yes	Yes	No	Yes
-14 to -25°C	Yes	No	No	Yes
Below -25°C	Yes	No	No	Yes

2. DATA FORMS

The data forms are included in Tables 2.1 to 2.4. Table 2.1 represents the data form developed for the end-condition tester. Table 2.2 shows the data form for the meteo/video tester. Table 2.3 and Table 2.4 present two data forms to be filled in each testing session and winter season, respectively.

Table 2.1: End Condition Data Form for Natural Snow

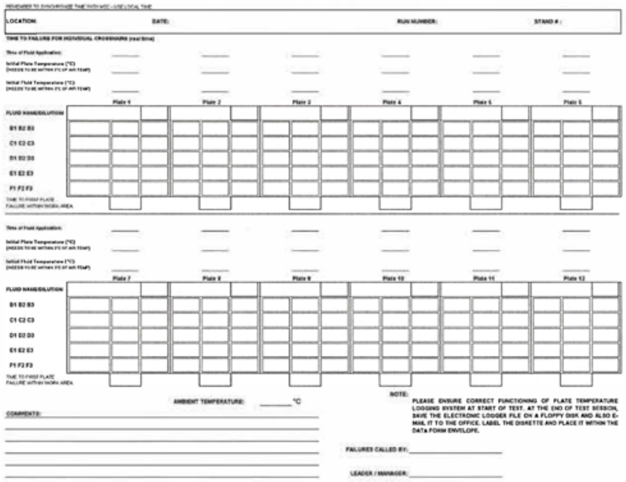
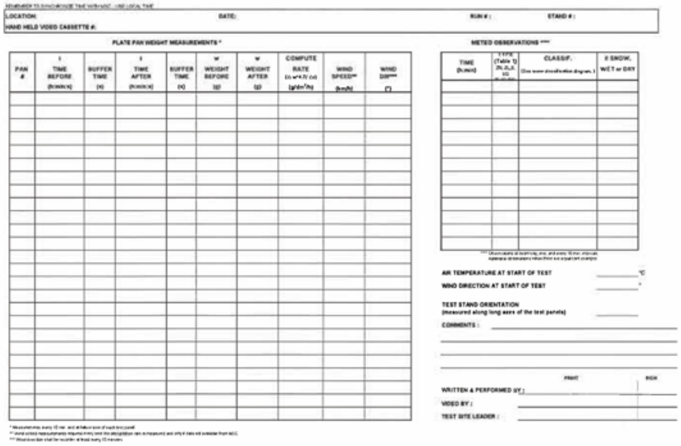
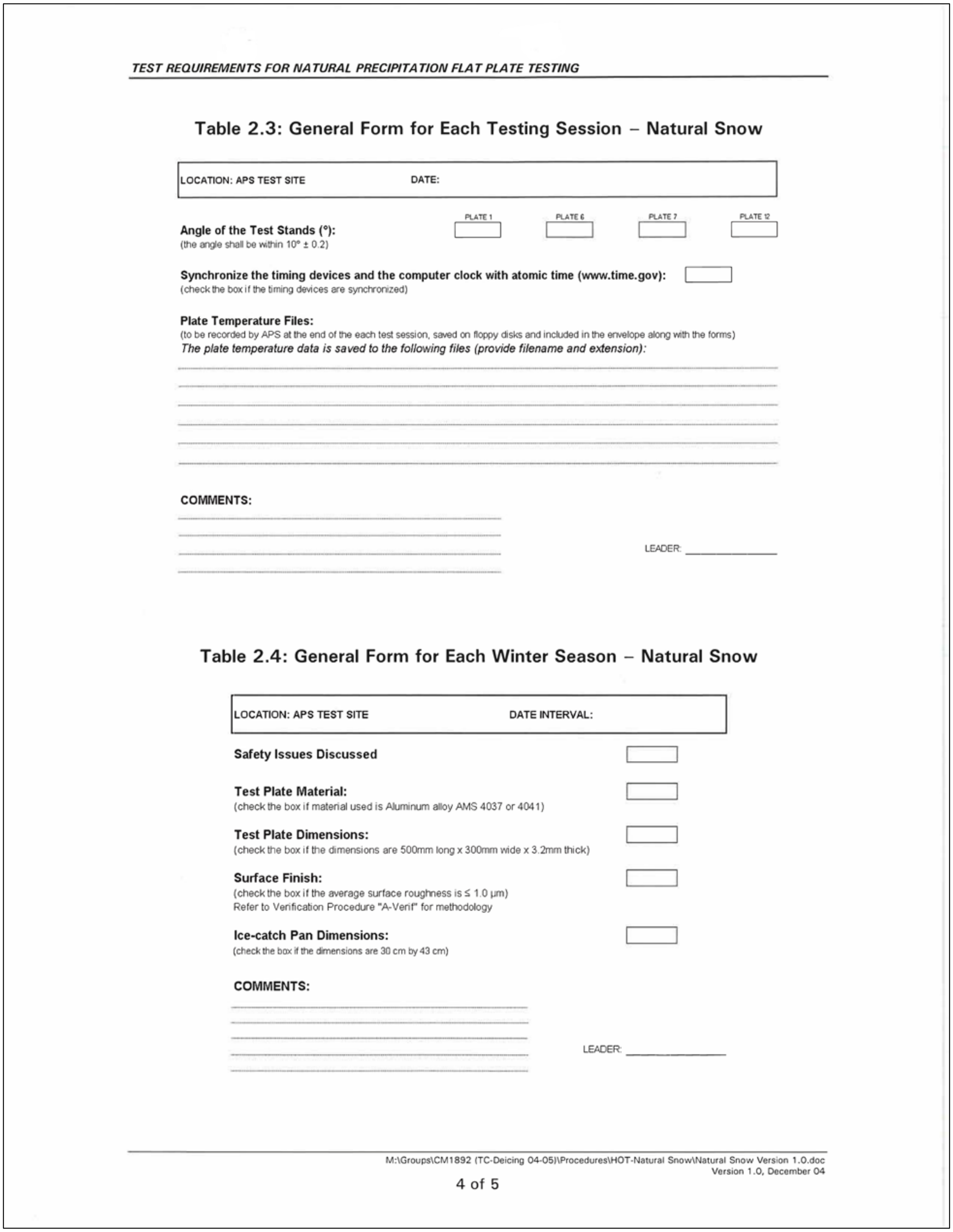


Table 2.2: Meteorological and Precipitation Rate Data Form





TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

Table 2.3: General Form for Each Testing Session – Natural Snow

LOCATION: APS TEST SITE DATE:

Angle of the Test Stands (°):
(the angle shall be within 10° ± 0.2)

PLATE 1 ☐ PLATE 6 ☐ PLATE 7 ☐ PLATE 12 ☐

Synchronize the timing devices and the computer clock with atomic time (www.time.gov): ☐
(check the box if the timing devices are synchronized)

Plate Temperature Files:
(to be recorded by APS at the end of the each test session, saved on floppy disks and included in the envelope along with the forms)
The plate temperature data is saved to the following files (provide filename and extension):

COMMENTS:

LEADER: ______________

Table 2.4: General Form for Each Winter Season – Natural Snow

LOCATION: APS TEST SITE DATE INTERVAL:

Safety Issues Discussed ☐

Test Plate Material: ☐
(check the box if material used is Aluminum alloy AMS 4037 or 4041)

Test Plate Dimensions: ☐
(check the box if the dimensions are 500mm long x 300mm wide x 3.2mm thick)

Surface Finish: ☐
(check the box if the average surface roughness is ≤ 1.0 μm)
Refer to Verification Procedure "A-Verif" for methodology

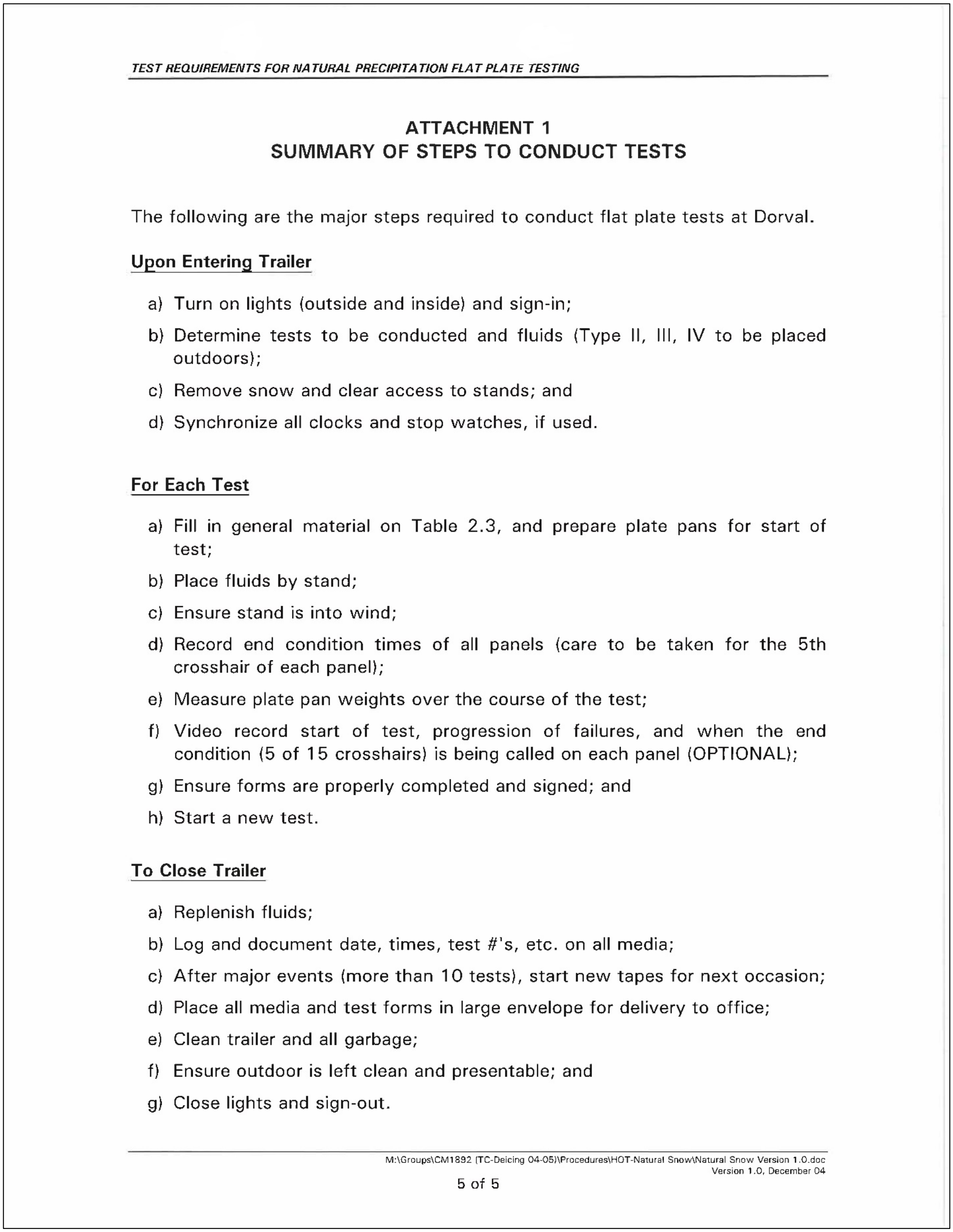
Ice-catch Pan Dimensions: ☐
(check the box if the dimensions are 30 cm by 43 cm)

COMMENTS:

LEADER: ______________

M:\Groups\CM1892 (TC-Deicing 04-05)\Procedures\HOT-Natural Snow\Natural Snow Version 1.0.doc
Version 1.0, December 04

4 of 5



ATTACHMENT 1
SUMMARY OF STEPS TO CONDUCT TESTS

The following are the major steps required to conduct flat plate tests at Dorval.

Upon Entering Trailer

a) Turn on lights (outside and inside) and sign-in;

b) Determine tests to be conducted and fluids (Type II, III, IV to be placed outdoors);

c) Remove snow and clear access to stands; and

d) Synchronize all clocks and stop watches, if used.

For Each Test

a) Fill in general material on Table 2.3, and prepare plate pans for start of test;

b) Place fluids by stand;

c) Ensure stand is into wind;

d) Record end condition times of all panels (care to be taken for the 5th crosshair of each panel);

e) Measure plate pan weights over the course of the test;

f) Video record start of test, progression of failures, and when the end condition (5 of 15 crosshairs) is being called on each panel (OPTIONAL);

g) Ensure forms are properly completed and signed; and

h) Start a new test.

To Close Trailer

a) Replenish fluids;

b) Log and document date, times, test #'s, etc. on all media;

c) After major events (more than 10 tests), start new tapes for next occasion;

d) Place all media and test forms in large envelope for delivery to office;

e) Clean trailer and all garbage;

f) Ensure outdoor is left clean and presentable; and

g) Close lights and sign-out.

This page intentionally left blank.

DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

CM2103.001 (07-08)

EXPERIMENTAL PROGRAM

DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

Winter 2007-08

Prepared for

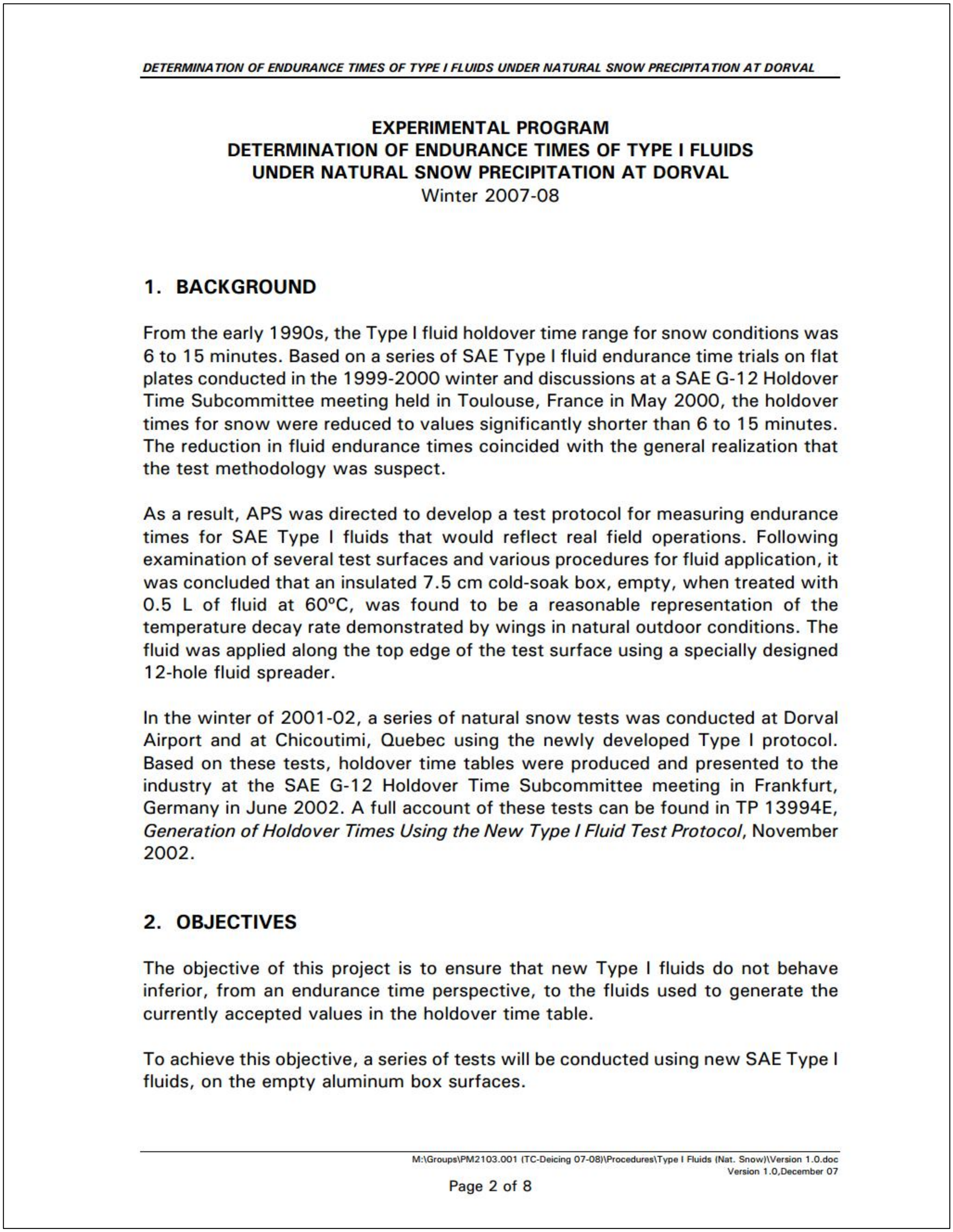
Transportation Development Centre
Transport Canada

Prepared by: John D'Avirro

Reviewed by: John D'Avirro

APS Aviation Inc.

December 14, 2007
Version 1.0



EXPERIMENTAL PROGRAM
DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL
Winter 2007-08

1. BACKGROUND

From the early 1990s, the Type I fluid holdover time range for snow conditions was 6 to 15 minutes. Based on a series of SAE Type I fluid endurance time trials on flat plates conducted in the 1999-2000 winter and discussions at a SAE G-12 Holdover Time Subcommittee meeting held in Toulouse, France in May 2000, the holdover times for snow were reduced to values significantly shorter than 6 to 15 minutes. The reduction in fluid endurance times coincided with the general realization that the test methodology was suspect.

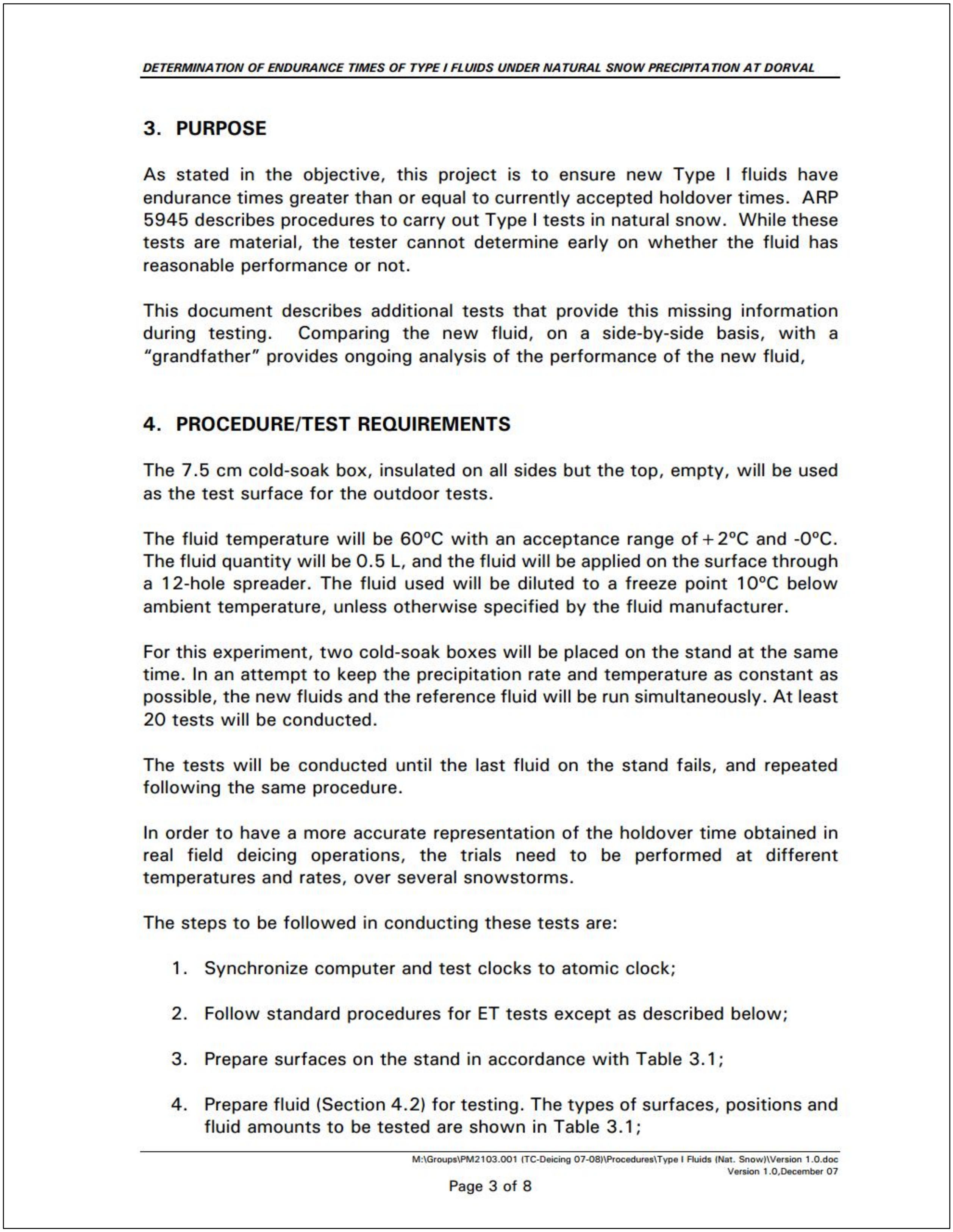
As a result, APS was directed to develop a test protocol for measuring endurance times for SAE Type I fluids that would reflect real field operations. Following examination of several test surfaces and various procedures for fluid application, it was concluded that an insulated 7.5 cm cold-soak box, empty, when treated with 0.5 L of fluid at 60ºC, was found to be a reasonable representation of the temperature decay rate demonstrated by wings in natural outdoor conditions. The fluid was applied along the top edge of the test surface using a specially designed 12-hole fluid spreader.

In the winter of 2001-02, a series of natural snow tests was conducted at Dorval Airport and at Chicoutimi, Quebec using the newly developed Type I protocol. Based on these tests, holdover time tables were produced and presented to the industry at the SAE G-12 Holdover Time Subcommittee meeting in Frankfurt, Germany in June 2002. A full account of these tests can be found in TP 13994E, *Generation of Holdover Times Using the New Type I Fluid Test Protocol*, November 2002.

2. OBJECTIVES

The objective of this project is to ensure that new Type I fluids do not behave inferior, from an endurance time perspective, to the fluids used to generate the currently accepted values in the holdover time table.

To achieve this objective, a series of tests will be conducted using new SAE Type I fluids, on the empty aluminum box surfaces.



3. PURPOSE

As stated in the objective, this project is to ensure new Type I fluids have endurance times greater than or equal to currently accepted holdover times. ARP 5945 describes procedures to carry out Type I tests in natural snow. While these tests are material, the tester cannot determine early on whether the fluid has reasonable performance or not.

This document describes additional tests that provide this missing information during testing. Comparing the new fluid, on a side-by-side basis, with a "grandfather" provides ongoing analysis of the performance of the new fluid,

4. PROCEDURE/TEST REQUIREMENTS

The 7.5 cm cold-soak box, insulated on all sides but the top, empty, will be used as the test surface for the outdoor tests.

The fluid temperature will be 60ºC with an acceptance range of +2ºC and -0ºC. The fluid quantity will be 0.5 L, and the fluid will be applied on the surface through a 12-hole spreader. The fluid used will be diluted to a freeze point 10ºC below ambient temperature, unless otherwise specified by the fluid manufacturer.

For this experiment, two cold-soak boxes will be placed on the stand at the same time. In an attempt to keep the precipitation rate and temperature as constant as possible, the new fluids and the reference fluid will be run simultaneously. At least 20 tests will be conducted.

The tests will be conducted until the last fluid on the stand fails, and repeated following the same procedure.

In order to have a more accurate representation of the holdover time obtained in real field deicing operations, the trials need to be performed at different temperatures and rates, over several snowstorms.

The steps to be followed in conducting these tests are:

1. Synchronize computer and test clocks to atomic clock;
2. Follow standard procedures for ET tests except as described below;
3. Prepare surfaces on the stand in accordance with Table 3.1;
4. Prepare fluid (Section 4.2) for testing. The types of surfaces, positions and fluid amounts to be tested are shown in Table 3.1;

Table 3.1

Test Stand Positions

STAND POS.	SURFACE TYPE	FLUID		Fluid Conc.	Fluid Type
		AMOUNT (L)	TEMP (°C)		
1	RATE PAN				
2	7.5 cm box (empty)	0.5	60	10° Buffer	Battelle D3 ADF Type I
3	7.5 cm box (empty)	0.5	60	10° Buffer	Reference Fluid (E or P)*

* E – Ethylene (UCAR EG ADF)
P – Propylene (PG ADF)

5. Pour required amount of heated fluid into thermos containers for application;

6. Apply the fluid to the cold-soak boxes on the stand. Pour the fluid on the test surfaces in quick succession to avoid cooling of the spreader between pours. The spreader is modified (taped) to allow fluid to come out through only 12 holes. Just before pouring, the box surfaces should be cleaned according to the following procedure:

   - Clean the surface of all contamination with scraper and squeegee; and
   - Whenever surface wetting is found to be deficient, a clean wiper cloth with fluid at ambient temperature can be used to wipe the plate over its entire surface. (This is intended to ensure that the surface is wetted as well as clean, to assist in complete coverage with the applied fluid.)

7. Standing behind the stand, place a shield device to deflect the air and pour the test fluid from the thermos into the spreader. Remove the shield when the spreader has emptied;

8. Determine failure times on test surfaces, and record using standard ET data forms (Attachment I);

9. Measure precipitation rates and record using the Meteo/Plate data form (Attachment II); and

10. Record rates. As per Table 3.1, position 1 on the stand will be used for measuring snow deposition rates. Use two rate pans in a 5 minute routine. At the time that a measurement is required, the pan that needs to be weighed will be replaced on the stand by the other pan. This cycle will continue until the last surface failed. While pouring the fluid on the test surfaces care should be taken that no contamination falls in the rate pans (use a shield device if necessary). The bottom and sides of the pan MUST BE WETTED (before each pre-test weighing) with Type IV anti-icing fluid to prevent blowing snow from escaping the pan.

5. EQUIPMENT AND FLUIDS

5.1 Equipment

Use the same equipment that is used for ET trials. Candidate test surfaces used for these trials will be:

- Two 7.5 cm cold-soak boxes (empty)

A wind shield and fluid spreader device will be used for applying fluids.

5.2 Fluids

Tests shall be conducted with the following Type I fluids:

- Battelle D3 ADF Type I; and
- PG ADF or UCAR EG ADF (reference fluid).

Fluids are to be mixed to a freeze point 10ºC below OAT. The dilution table for these three fluids is presented in Attachment III.

Fluids to be applied to the cold soak box test surfaces will be heated to 60ºC.

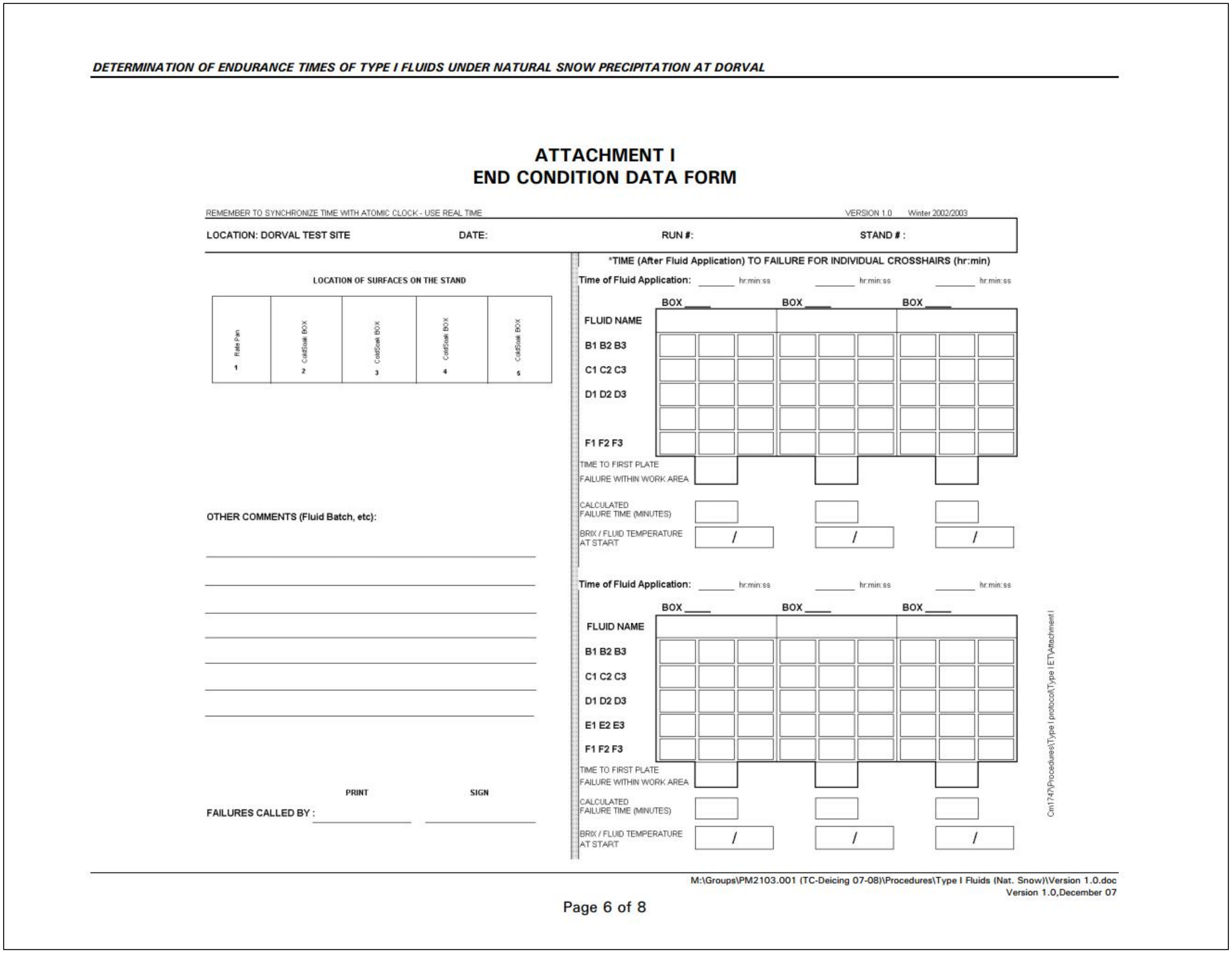
6. PERSONNEL

Three technicians are needed to conduct the tests:

- First calls failures, prepares fluid samples;
- Second helps prepare and pour fluids; and
- Third measures rates and wind.

7. DATA FORMS

Use end condition forms from standard Endurance Time procedure (Attachment I). For rate measurements, see Attachment II.



ATTACHMENT I
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH ATOMIC CLOCK - USE REAL TIME

VERSION 1.0 Winter 2002/2003

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

LOCATION OF SURFACES ON THE STAND

Rate Pan 1	ColdSoak BOX 2	ColdSoak BOX 3	ColdSoak BOX 4	ColdSoak BOX 5

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

FAILURES CALLED BY : PRINT ________________ SIGN ________________

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

Time of Fluid Application: ______ hr:min:ss ______ hr:min:ss ______ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
F1 F2 F3									

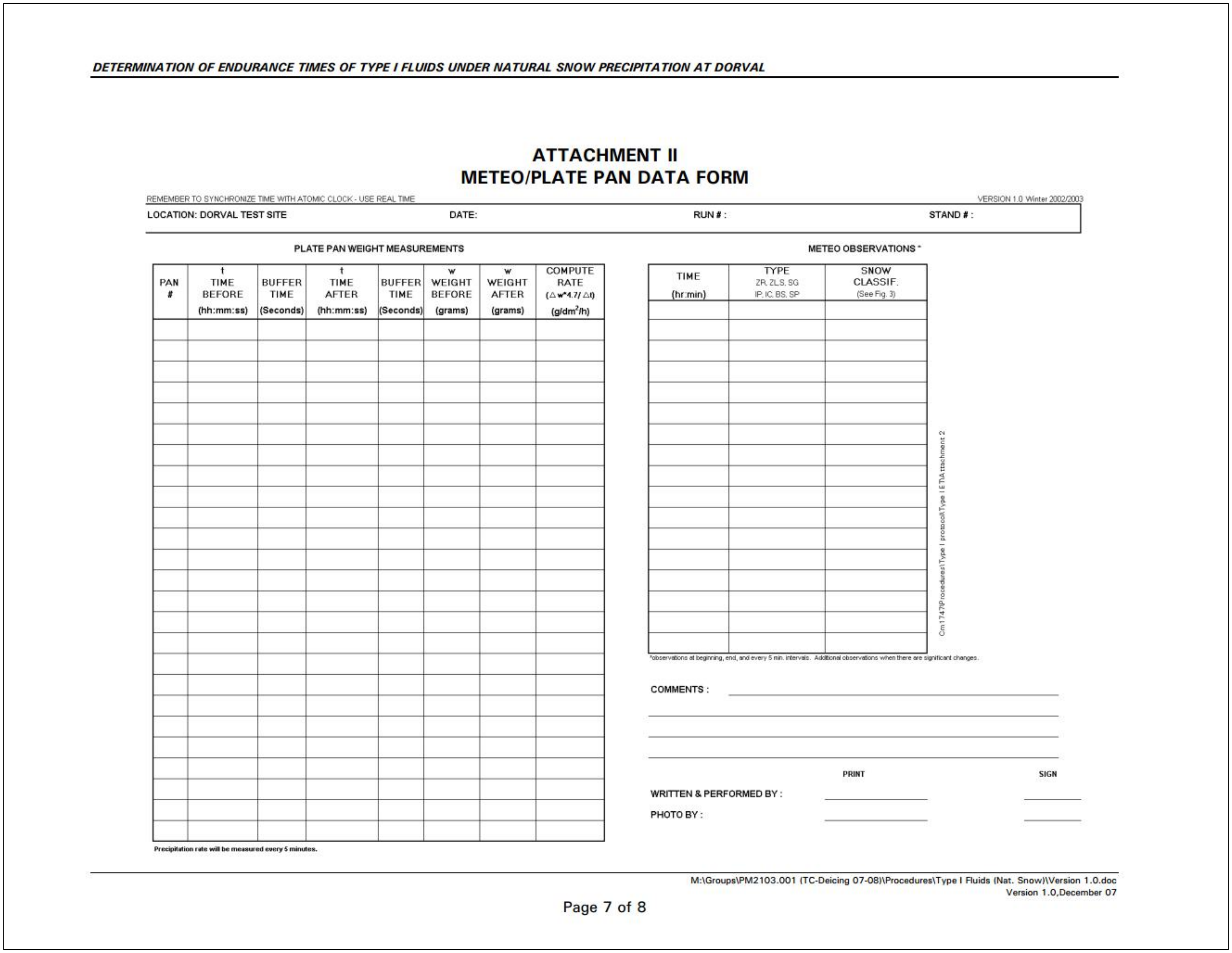
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA			
CALCULATED FAILURE TIME (MINUTES)			
BRIX / FLUID TEMPERATURE AT START	/	/	/

Time of Fluid Application: ______ hr:min:ss ______ hr:min:ss ______ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									

TIME TO FIRST PLATE FAILURE WITHIN WORK AREA			
CALCULATED FAILURE TIME (MINUTES)			
BRIX / FLUID TEMPERATURE AT START	/	/	/

Cm1747\Procedures\Type I protocol\Type I ET\Attachment I



DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

ATTACHMENT II
METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH ATOMIC CLOCK - USE REAL TIME

VERSION 1.0 Winter 2002/2003

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

PLATE PAN WEIGHT MEASUREMENTS

PAN #	t TIME BEFORE (hh:mm:ss)	BUFFER TIME (Seconds)	t TIME AFTER (hh:mm:ss)	BUFFER TIME (Seconds)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE $(\Delta w*4.7/\Delta t)$ $(g/dm^2/h)$

Precipitation rate will be measured every 5 minutes.

METEO OBSERVATIONS *

TIME (hr:min)	TYPE ZR, ZLS, SG IP, IC, BS, SP	SNOW CLASSIF. (See Fig. 3)

*observations at beginning, end, and every 5 min. intervals. Additional observations when there are significant changes.

Cm1747\Procedures\Type I protocol\Type I ET\Attachment 2

COMMENTS : ______________________________

____

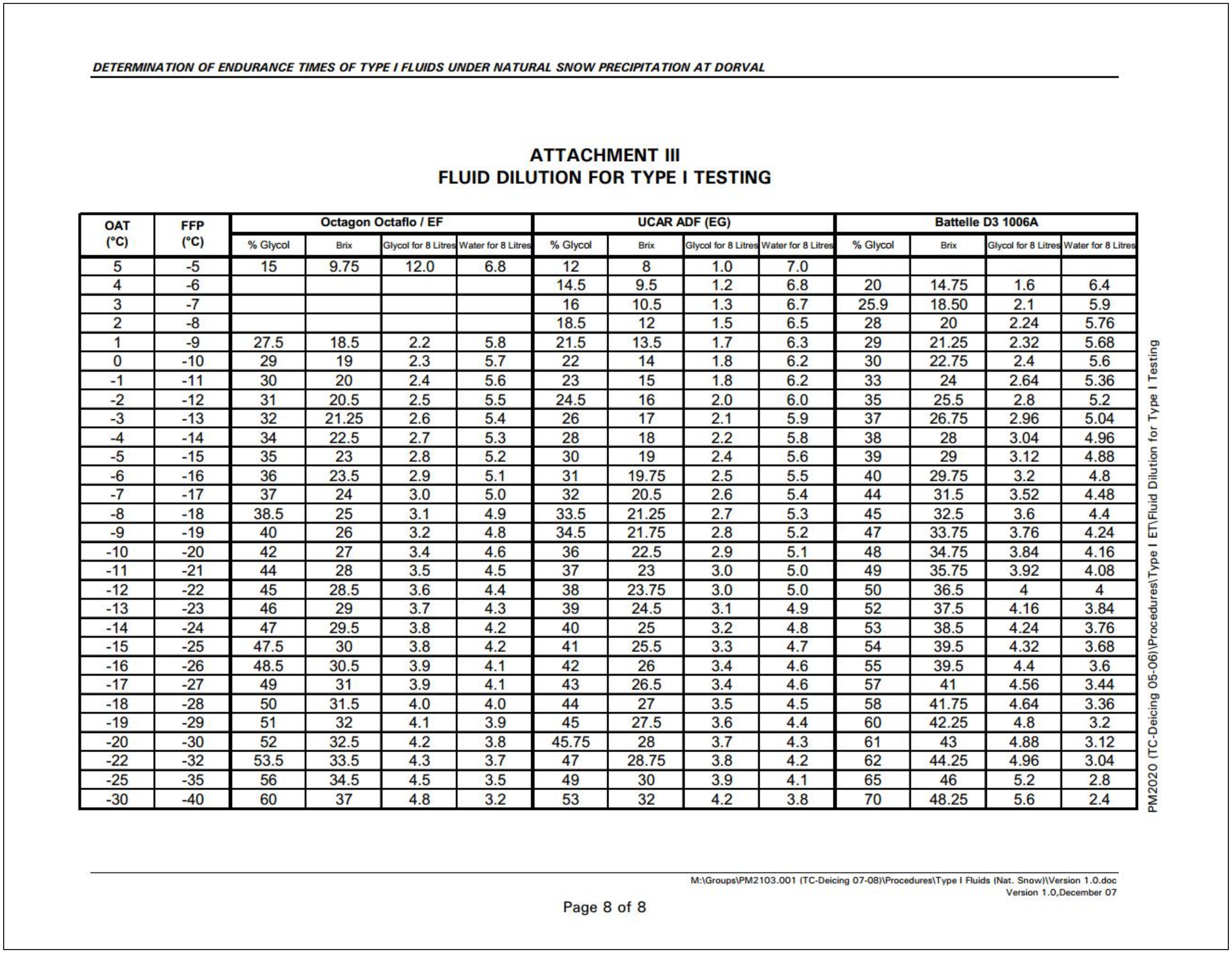
____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	________	________
PHOTO BY :	________	________

M:\Groups\PM2103.001 (TC-Deicing 07-08)\Procedures\Type I Fluids (Nat. Snow)\Version 1.0.doc
Version 1.0,December 07

Page 7 of 8



ATTACHMENT III
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Octagon Octaflo / EF				UCAR ADF (EG)				Battelle D3 1006A			
		% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5	15	9.75	12.0	6.8	12	8	1.0	7.0				
4	-6					14.5	9.5	1.2	6.8	20	14.75	1.6	6.4
3	-7					16	10.5	1.3	6.7	25.9	18.50	2.1	5.9
2	-8					18.5	12	1.5	6.5	28	20	2.24	5.76
1	-9	27.5	18.5	2.2	5.8	21.5	13.5	1.7	6.3	29	21.25	2.32	5.68
0	-10	29	19	2.3	5.7	22	14	1.8	6.2	30	22.75	2.4	5.6
-1	-11	30	20	2.4	5.6	23	15	1.8	6.2	33	24	2.64	5.36
-2	-12	31	20.5	2.5	5.5	24.5	16	2.0	6.0	35	25.5	2.8	5.2
-3	-13	32	21.25	2.6	5.4	26	17	2.1	5.9	37	26.75	2.96	5.04
-4	-14	34	22.5	2.7	5.3	28	18	2.2	5.8	38	28	3.04	4.96
-5	-15	35	23	2.8	5.2	30	19	2.4	5.6	39	29	3.12	4.88
-6	-16	36	23.5	2.9	5.1	31	19.75	2.5	5.5	40	29.75	3.2	4.8
-7	-17	37	24	3.0	5.0	32	20.5	2.6	5.4	44	31.5	3.52	4.48
-8	-18	38.5	25	3.1	4.9	33.5	21.25	2.7	5.3	45	32.5	3.6	4.4
-9	-19	40	26	3.2	4.8	34.5	21.75	2.8	5.2	47	33.75	3.76	4.24
-10	-20	42	27	3.4	4.6	36	22.5	2.9	5.1	48	34.75	3.84	4.16
-11	-21	44	28	3.5	4.5	37	23	3.0	5.0	49	35.75	3.92	4.08
-12	-22	45	28.5	3.6	4.4	38	23.75	3.0	5.0	50	36.5	4	4
-13	-23	46	29	3.7	4.3	39	24.5	3.1	4.9	52	37.5	4.16	3.84
-14	-24	47	29.5	3.8	4.2	40	25	3.2	4.8	53	38.5	4.24	3.76
-15	-25	47.5	30	3.8	4.2	41	25.5	3.3	4.7	54	39.5	4.32	3.68
-16	-26	48.5	30.5	3.9	4.1	42	26	3.4	4.6	55	39.5	4.4	3.6
-17	-27	49	31	3.9	4.1	43	26.5	3.4	4.6	57	41	4.56	3.44
-18	-28	50	31.5	4.0	4.0	44	27	3.5	4.5	58	41.75	4.64	3.36
-19	-29	51	32	4.1	3.9	45	27.5	3.6	4.4	60	42.25	4.8	3.2
-20	-30	52	32.5	4.2	3.8	45.75	28	3.7	4.3	61	43	4.88	3.12
-22	-32	53.5	33.5	4.3	3.7	47	28.75	3.8	4.2	62	44.25	4.96	3.04
-25	-35	56	34.5	4.5	3.5	49	30	3.9	4.1	65	46	5.2	2.8
-30	-40	60	37	4.8	3.2	53	32	4.2	3.8	70	48.25	5.6	2.4

PM2020 (TC-Deicing 05-06)\Procedures\Type I ET\Fluid Dilution for Type I Testing

TEST REQUIREMENTS
FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

CM1892.001

TEST REQUIREMENTS
FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

- Freezing Fog
- Freezing Drizzle and Light Freezing Rain
- Rain on a Cold-Soaked Surface

Winter 2003-04

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Richard Campbell

Reviewed by: John D'Avirro

APS Aviation Inc.

January 15, 2004
Version 1.0

TEST REQUIREMENTS
FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

Winter 2003-04

This document provides a brief summary of the test requirements and data forms needed for the conduct of simulated freezing fog, freezing drizzle, light freezing rain and rain on a cold-soaked surface holdover time tests. The list of tests and schedule of tests are described in the separate document "Overall Program of Tests at NRC, April, 2004". These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa. The procedure containing a detailed description of the test parameters, precipitation measurement methods, testing procedure and test equipment for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids is stored on APS's local network and can be found at the following location: M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\AS5485\

This document is based on the aforementioned procedure, and was developed for documentation purposes, to be inserted in the final report after the completion of endurance time testing, and to provide the latest data forms.

1. CHARACTERISTICS OF SIMULATED PRECIPITATION PRODUCED

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog are collected:

1. Freezing Drizzle:
   High precipitation rate: 13 g/dm²/h;
   Droplet median volume diameter: 350 µm;
   Air temperature: -3 and -10°C.

   Low Precipitation rate: 5 g/dm²/h;
   Droplet median volume diameter: 250 µm;
   Air temperature: -3 and -10°C.

2. Light Freezing Rain:
   High precipitation rate: 25 g/dm²/h;
   Droplet median volume diameter: 1 000 µm;
   Air temperature: -3 and -10°C.

   Low precipitation rate: 13 g/dm²/h;
   Droplet median volume diameter: 1 000 µm;
   Air temperature: -3 and -10°C.

3. Drizzle on Cold-Soaked Surface:
   Precipitation rate: 5 g/dm²/h;
   Droplet median volume diameter: 250 µm;
   Air temperature: +1°C.

4. Moderate Rain on Cold-Soaked Surface:
   Precipitation rate: 75 g/dm²/h;
   Droplet median volume diameter: 1 400 µm;
   Air temperature: +1°C.

5. Freezing Fog:
   Precipitation rate: 2 and 5 g/dm²/h;
   Droplet median volume diameter: 30 µm; and
   Air temperature: -3°C, -14°C and -25°C.

2. DATA FORMS

The data forms used for tests conducted in simulated conditions are as follows:

Figure 2.1: Test Stand Location for Each Condition at NRC;

Figure 2.2: General Form for Each Session at NRC;

Figure 2.3: General Form for Each Condition at NRC;

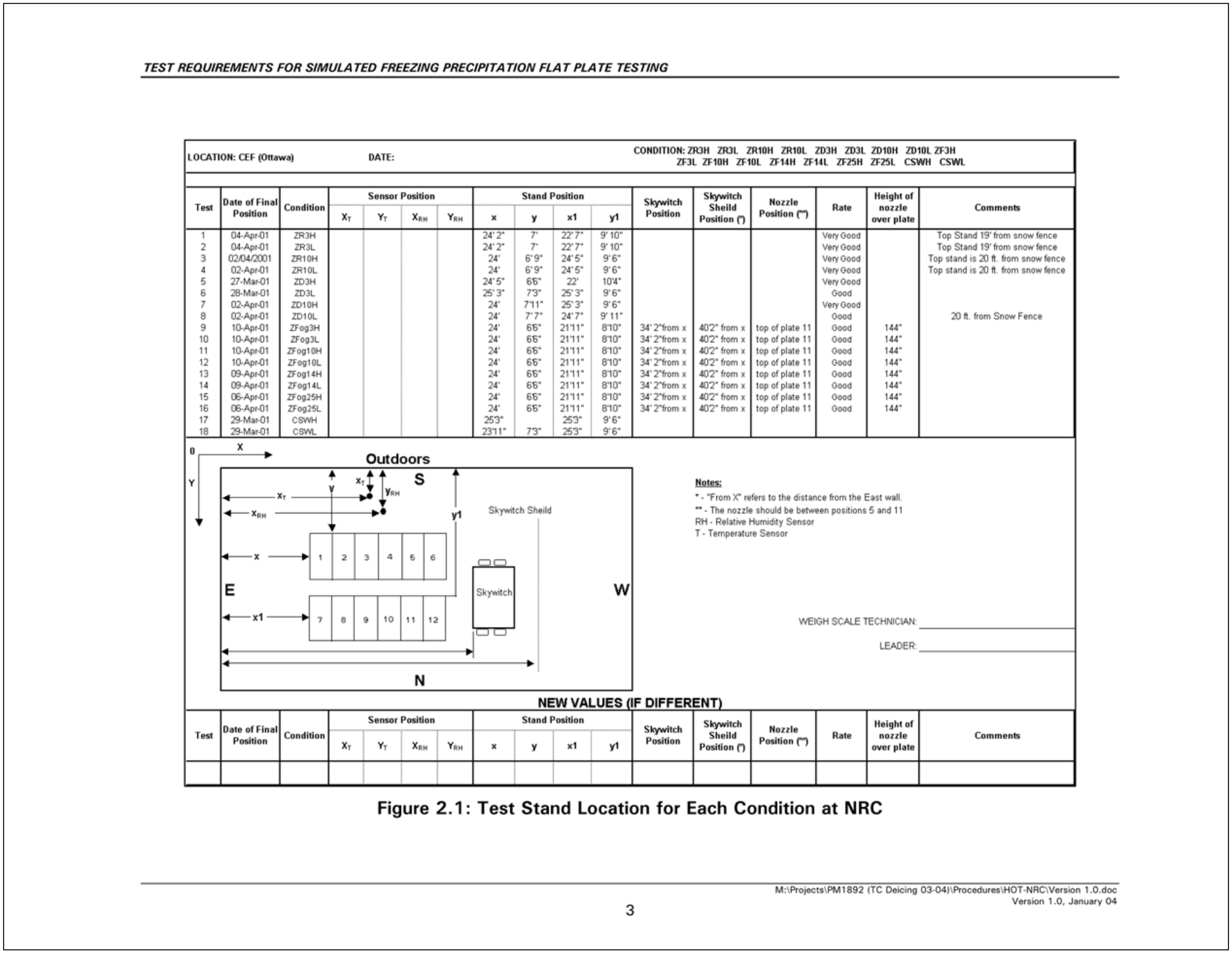
Figure 2.4: De/Anti-icing Data Form for Freezing Precipitation at NRC;

Figure 2.5: De/Anti-icing Data Form for Cold Soak Box;

Figure 2.6: Chamber Setting for Each Condition at NRC;

Figure 2.7: Rate Management Form at NRC, and;

Table 2.1: Condition Checklist



TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

LOCATION: CEF (Ottawa) **DATE:**

CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						
1	04-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	04-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	02/04/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	02-Apr-01	ZR10L					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
5	27-Mar-01	ZD3H					24' 5"	6'6"	22'	10'4"				Very Good		
6	28-Mar-01	ZD3L					25' 3"	7'3"	25' 3"	9' 6"				Good		
7	02-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	02-Apr-01	ZD10L					24'	7' 7"	24' 7"	9' 11"				Good		20 ft. from Snow Fence
9	10-Apr-01	ZFog3H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
10	10-Apr-01	ZFog3L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
11	10-Apr-01	ZFog10H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
12	10-Apr-01	ZFog10L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
13	09-Apr-01	ZFog14H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
14	09-Apr-01	ZFog14L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
15	06-Apr-01	ZFog25H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
16	06-Apr-01	ZFog25L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
17	29-Mar-01	CSWH					25'3"		25'3"	9' 6"						
18	29-Mar-01	CSWL					23'11"	7'3"	25'3"	9' 6"						

Notes:

* - "From X" refers to the distance from the East wall.

** - The nozzle should be between positions 5 and 11

RH - Relative Humidity Sensor

T - Temperature Sensor

WEIGH SCALE TECHNICIAN: ____________________

LEADER: ____________________

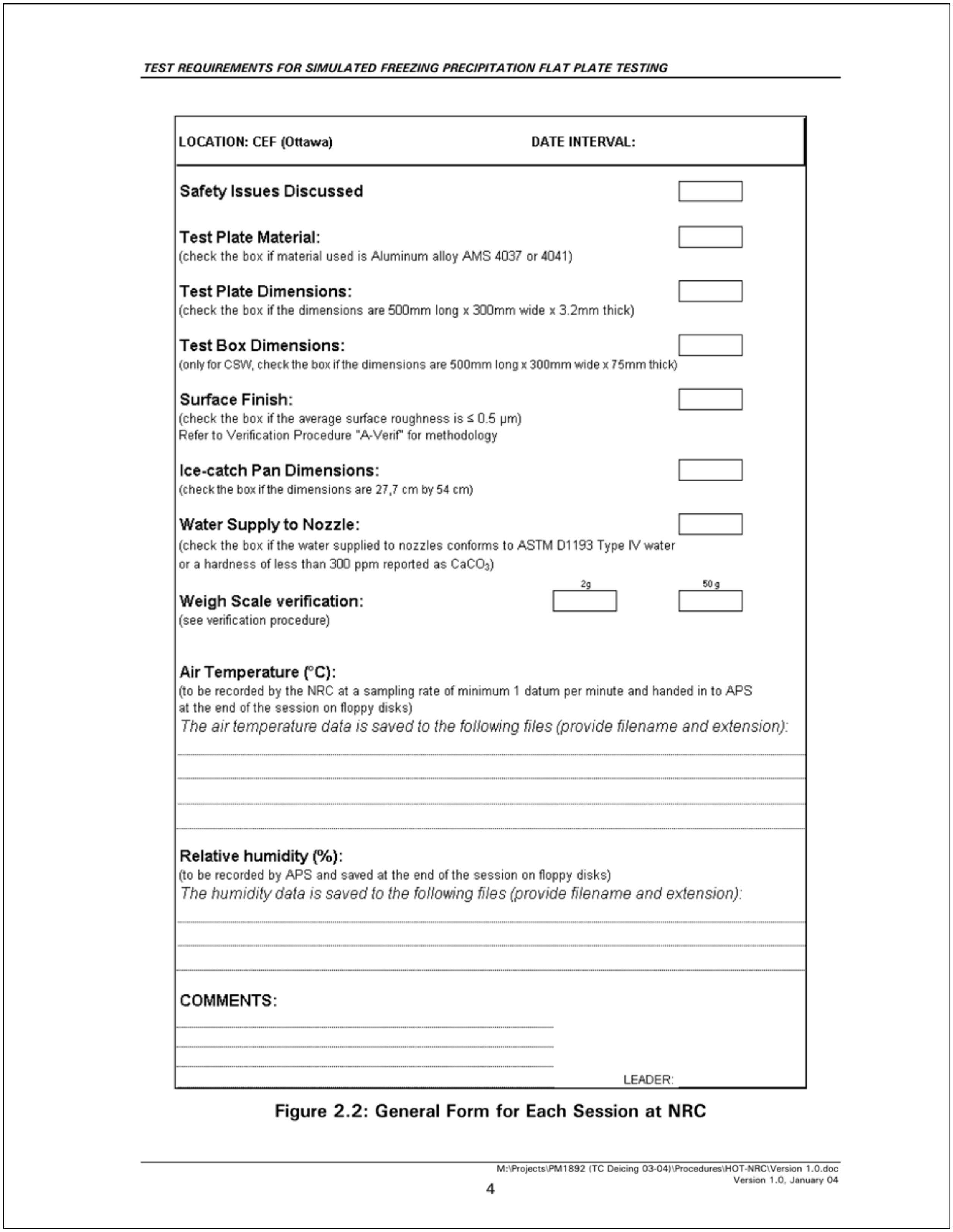
NEW VALUES (IF DIFFERENT)

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						

Figure 2.1: Test Stand Location for Each Condition at NRC

M:\Projects\PM1892 (TC Deicing 03-04)\Procedures\HOT-NRC\Version 1.0.doc
Version 1.0, January 04

3



LOCATION: CEF (Ottawa) **DATE INTERVAL:**

Safety Issues Discussed ☐

Test Plate Material: ☐
(check the box if material used is Aluminum alloy AMS 4037 or 4041)

Test Plate Dimensions: ☐
(check the box if the dimensions are 500mm long x 300mm wide x 3.2mm thick)

Test Box Dimensions: ☐
(only for CSW, check the box if the dimensions are 500mm long x 300mm wide x 75mm thick)

Surface Finish: ☐
(check the box if the average surface roughness is ≤ 0.5 µm)
Refer to Verification Procedure "A-Verif" for methodology

Ice-catch Pan Dimensions: ☐
(check the box if the dimensions are 27,7 cm by 54 cm)

Water Supply to Nozzle: ☐
(check the box if the water supplied to nozzles conforms to ASTM D1193 Type IV water or a hardness of less than 300 ppm reported as $CaCO_3$)

Weigh Scale verification: 2g ☐ 50 g ☐
(see verification procedure)

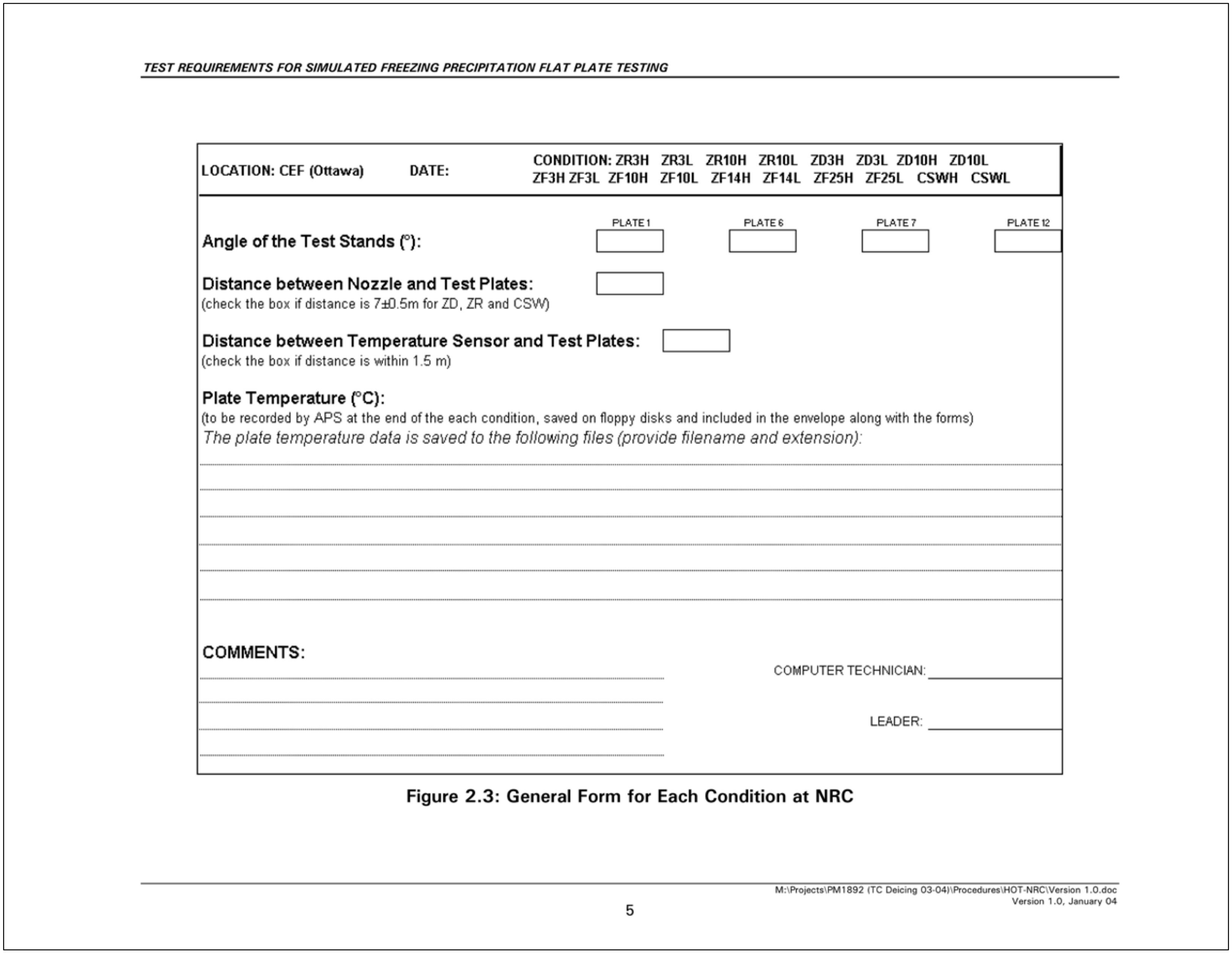
Air Temperature (°C):
(to be recorded by the NRC at a sampling rate of minimum 1 datum per minute and handed in to APS at the end of the session on floppy disks)
The air temperature data is saved to the following files (provide filename and extension):

Relative humidity (%):
(to be recorded by APS and saved at the end of the session on floppy disks)
The humidity data is saved to the following files (provide filename and extension):

COMMENTS:

LEADER: ____

Figure 2.2: General Form for Each Session at NRC



LOCATION: CEF (Ottawa) **DATE:** **CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL**

	PLATE 1	PLATE 6	PLATE 7	PLATE 12
Angle of the Test Stands (°):	☐	☐	☐	☐

Distance between Nozzle and Test Plates: ☐
(check the box if distance is 7±0.5m for ZD, ZR and CSW)

Distance between Temperature Sensor and Test Plates: ☐
(check the box if distance is within 1.5 m)

Plate Temperature (°C):
(to be recorded by APS at the end of the each condition, saved on floppy disks and included in the envelope along with the forms)
The plate temperature data is saved to the following files (provide filename and extension):

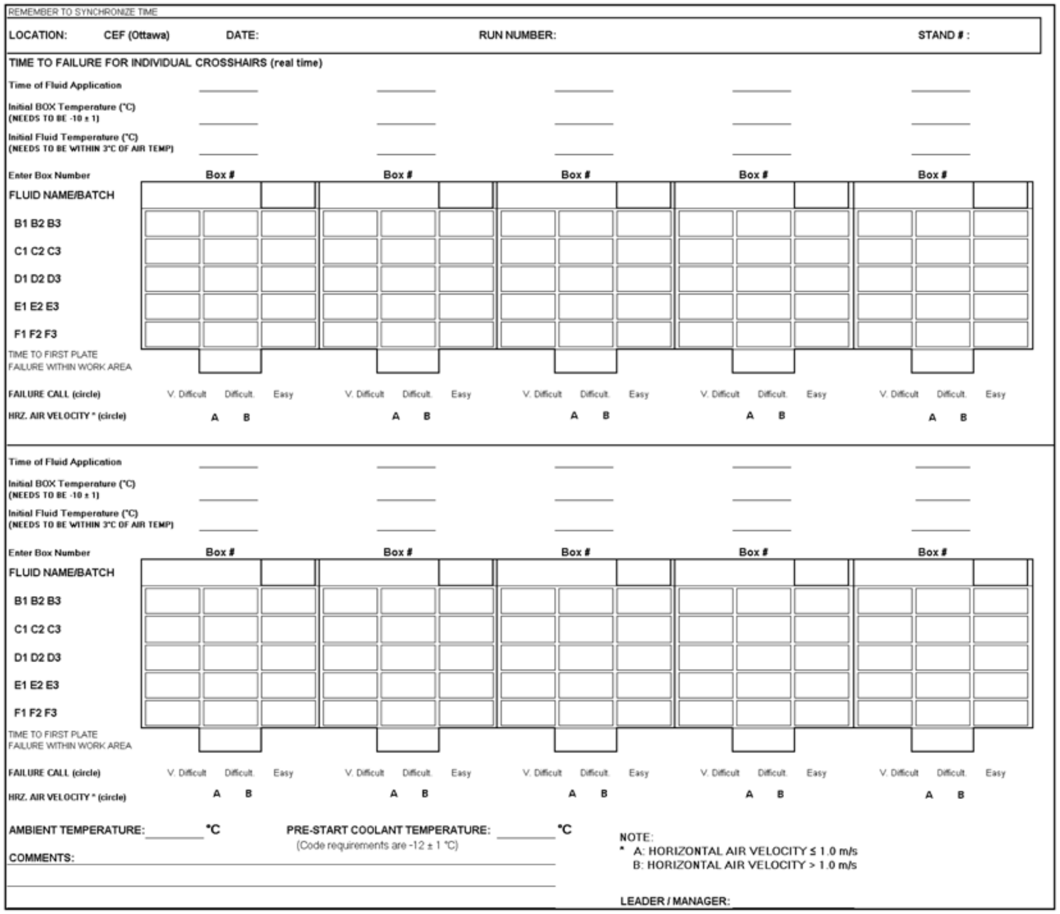
COMMENTS:

COMPUTER TECHNICIAN: ____________

LEADER: ____________

Figure 2.3: General Form for Each Condition at NRC

TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING



REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application	________	________	________	________	________
Initial BOX Temperature (°C) (NEEDS TO BE -10 ± 1)	________	________	________	________	________
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)	________	________	________	________	________
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B	A B	A B	A B	A B

Time of Fluid Application	________	________	________	________	________
Initial BOX Temperature (°C) (NEEDS TO BE -10 ± 1)	________	________	________	________	________
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)	________	________	________	________	________
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B	A B	A B	A B	A B

AMBIENT TEMPERATURE:________ **°C**

PRE-START COOLANT TEMPERATURE: ________ **°C**
(Code requirements are -12 ± 1 °C)

COMMENTS:

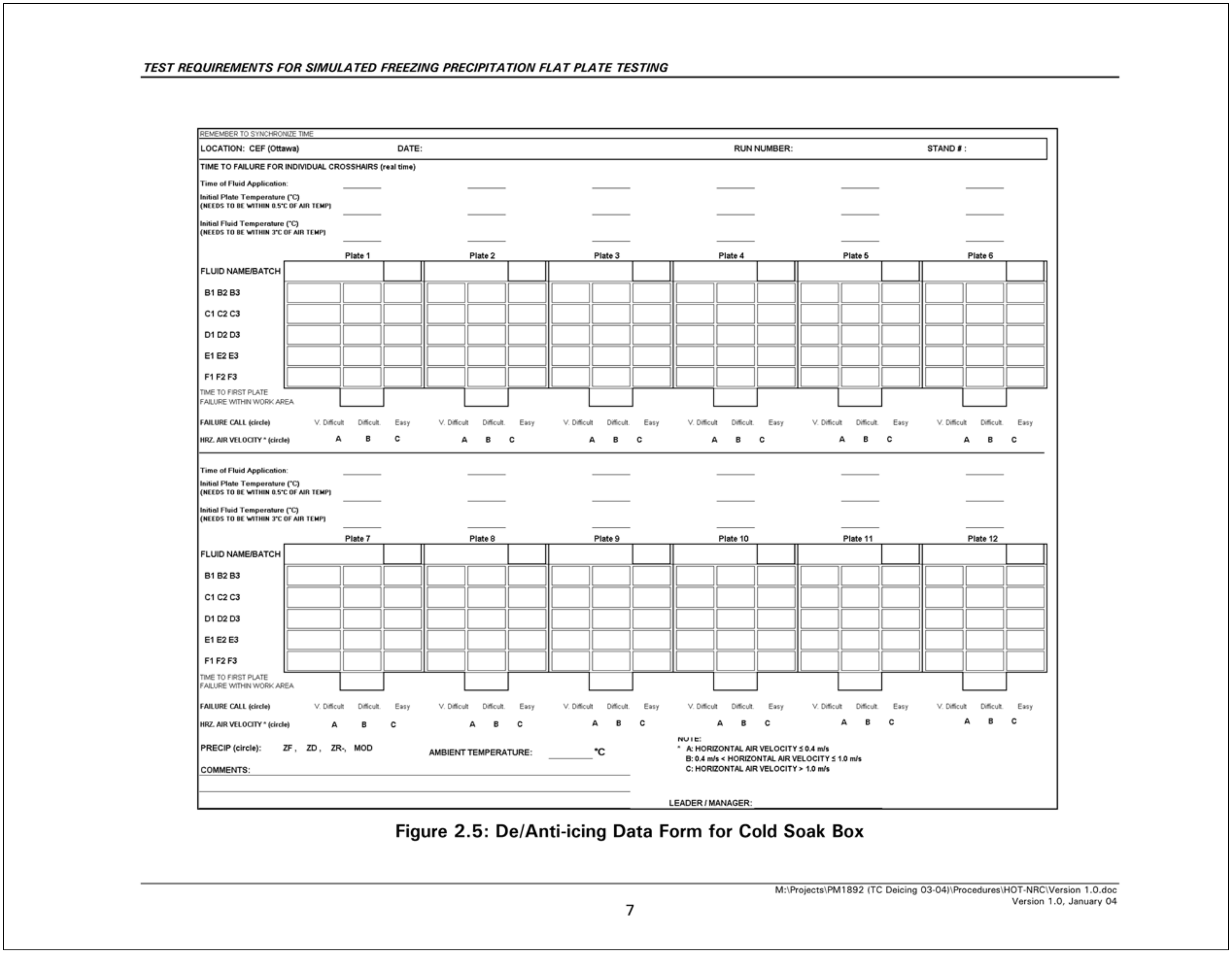
NOTE:
* A: HORIZONTAL AIR VELOCITY ≤ 1.0 m/s
B: HORIZONTAL AIR VELOCITY > 1.0 m/s

LEADER / MANAGER:

Figure 2.4: De/Anti-icing Data Form for Freezing Precipitation at NRC

M:\Projects\PM1892 (TC Deicing 03-04)\Procedures\HOT-NRC\Version 1.0.doc
Version 1.0, January 04

6



TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) DATE: RUN NUMBER: STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

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

AMBIENT TEMPERATURE: ________ °C

COMMENTS:

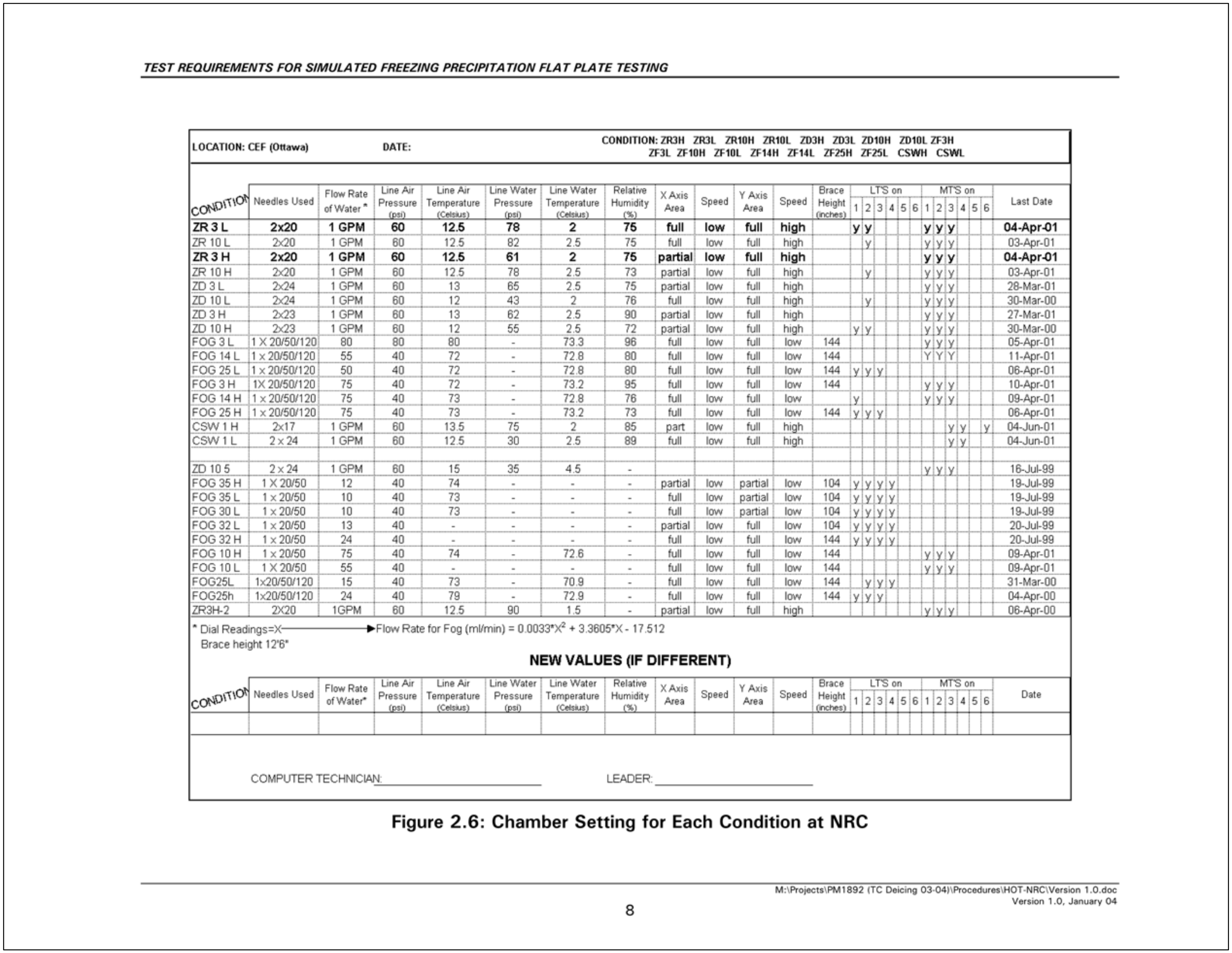
NOTE:
* A: HORIZONTAL AIR VELOCITY ≤ 0.4 m/s
B: 0.4 m/s < HORIZONTAL AIR VELOCITY ≤ 1.0 m/s
C: HORIZONTAL AIR VELOCITY > 1.0 m/s

LEADER / MANAGER:

Figure 2.5: De/Anti-icing Data Form for Cold Soak Box

M:\Projects\PM1892 (TC Deicing 03-04)\Procedures\HOT-NRC\Version 1.0.doc
Version 1.0, January 04

7



TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

LOCATION: CEF (Ottawa)   DATE: CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H
ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

CONDITION	Needles Used	Flow Rate of Water *	Line Air Pressure (psi)	Line Air Temperature (Celsius)	Line Water Pressure (psi)	Line Water Temperature (Celsius)	Relative Humidity (%)	X Axis Area	Speed	Y Axis Area	Speed	Brace Height (inches)	LT'S on						MT'S on						Last Date
													1	2	3	4	5	6	1	2	3	4	5	6	
ZR 3 L	**2x20**	**1 GPM**	**60**	**12.5**	**78**	**2**	**75**	**full**	**low**	**full**	**high**		**y**	**y**					**y**	**y**	**y**				**04-Apr-01**
ZR 10 L	2x20	1 GPM	60	12.5	82	2.5	75	full	low	full	high			y					y	y	y				03-Apr-01
ZR 3 H	**2x20**	**1 GPM**	**60**	**12.5**	**61**	**2**	**75**	**partial**	**low**	**full**	**high**								**y**	**y**	**y**				**04-Apr-01**
ZR 10 H	2x20	1 GPM	60	12.5	78	2.5	73	partial	low	full	high			y					y	y	y				03-Apr-01
ZD 3 L	2x24	1 GPM	60	13	65	2.5	75	partial	low	full	high								y	y	y				28-Mar-01
ZD 10 L	2x24	1 GPM	60	12	43	2	76	full	low	full	high			y					y	y	y				30-Mar-00
ZD 3 H	2x23	1 GPM	60	13	62	2.5	90	partial	low	full	high								y	y	y				27-Mar-01
ZD 10 H	2x23	1 GPM	60	12	55	2.5	72	partial	low	full	high		y	y					y	y	y				30-Mar-00
FOG 3 L	1 X 20/50/120	80	80	80	-	73.3	96	full	low	full	low	144							y	y	y				05-Apr-01
FOG 14 L	1 x 20/50/120	55	40	72	-	72.8	80	full	low	full	low	144							Y	Y	Y				11-Apr-01
FOG 25 L	1 x 20/50/120	50	40	72	-	72.8	80	full	low	full	low	144	y	y	y										06-Apr-01
FOG 3 H	1X 20/50/120	75	40	72	-	73.2	95	full	low	full	low	144							y	y	y				10-Apr-01
FOG 14 H	1 x 20/50/120	75	40	73	-	72.8	76	full	low	full	low		y						y	y	y				09-Apr-01
FOG 25 H	1 x 20/50/120	75	40	73	-	73.2	73	full	low	full	low	144	y	y	y										06-Apr-01
CSW 1 H	2x17	1 GPM	60	13.5	75	2	85	part	low	full	high										y	y		y	04-Jun-01
CSW 1 L	2 x 24	1 GPM	60	12.5	30	2.5	89	full	low	full	high										y	y			04-Jun-01
ZD 10 5	2 x 24	1 GPM	60	15	35	4.5	-												y	y	y				16-Jul-99
FOG 35 H	1 X 20/50	12	40	74	-	-	-	partial	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 35 L	1 x 20/50	10	40	73	-	-	-	full	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 30 L	1 x 20/50	10	40	73	-	-	-	full	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 32 L	1 x 20/50	13	40	-	-	-	-	partial	low	full	low	104	y	y	y	y									20-Jul-99
FOG 32 H	1 x 20/50	24	40	-	-	-	-	full	low	full	low	144	y	y	y	y									20-Jul-99
FOG 10 H	1 x 20/50	75	40	74	-	72.6	-	full	low	full	low	144							y	y	y				09-Apr-01
FOG 10 L	1 X 20/50	55	40	-	-	-	-	full	low	full	low	144							y	y	y				09-Apr-01
FOG25L	1x20/50/120	15	40	73	-	70.9	-	full	low	full	low	144		y	y	y									31-Mar-00
FOG25h	1x20/50/120	24	40	79	-	72.9	-	full	low	full	low	144	y	y	y										04-Apr-00
ZR3H-2	2X20	1GPM	60	12.5	90	1.5	-	partial	low	full	high								y	y	y				06-Apr-00

* Dial Readings=X ⟶ Flow Rate for Fog (ml/min) = 0.0033*X^2 + 3.3605*X - 17.512
Brace height 12'6"

NEW VALUES (IF DIFFERENT)

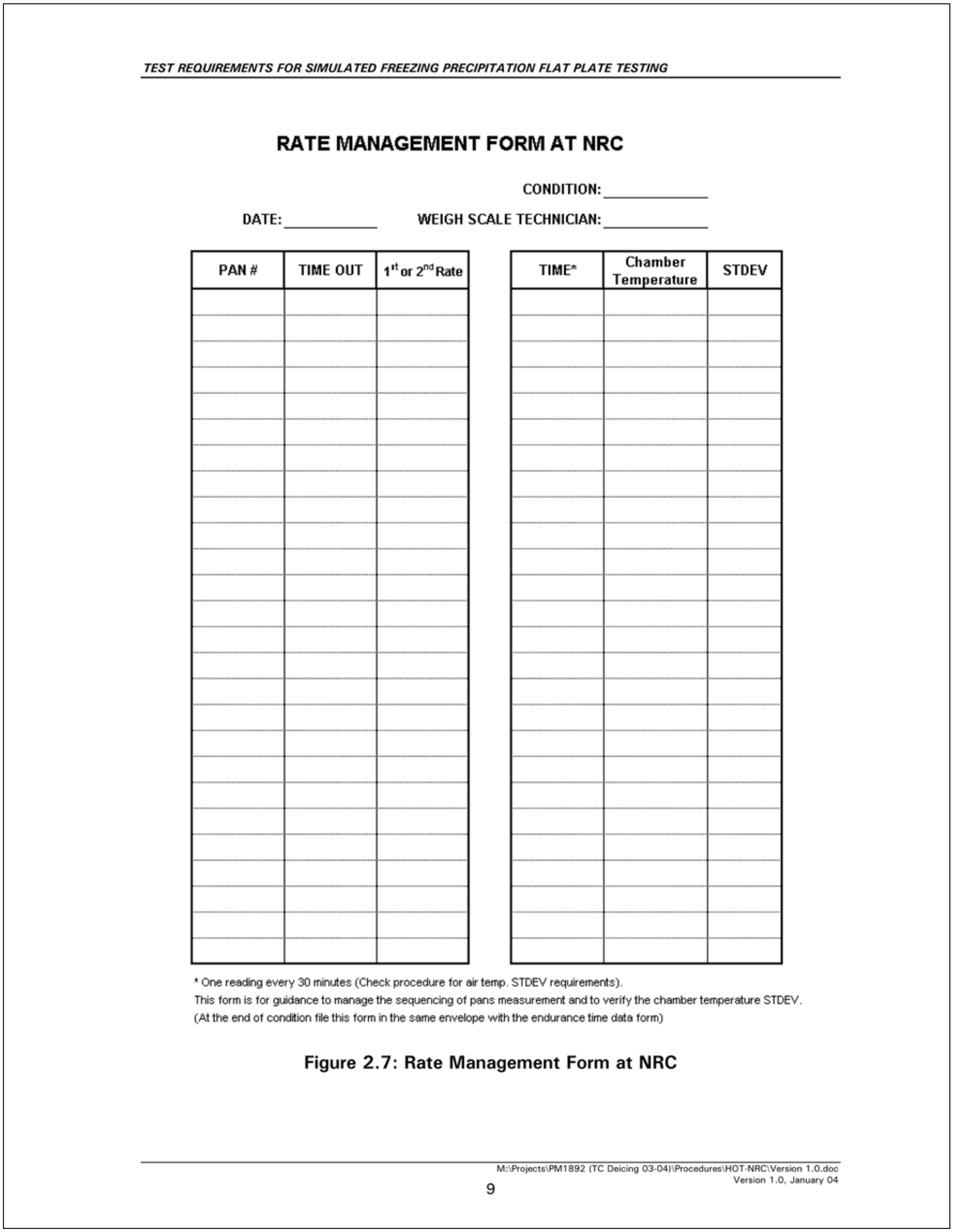
CONDITION	Needles Used	Flow Rate of Water*	Line Air Pressure (psi)	Line Air Temperature (Celsius)	Line Water Pressure (psi)	Line Water Temperature (Celsius)	Relative Humidity (%)	X Axis Area	Speed	Y Axis Area	Speed	Brace Height (inches)	LT'S on						MT'S on						Date
													1	2	3	4	5	6	1	2	3	4	5	6	

COMPUTER TECHNICIAN: ______________________   LEADER: ______________________

Figure 2.6: Chamber Setting for Each Condition at NRC

M:\Projects\PM1892 (TC Deicing 03-04)\Procedures\HOT-NRC\Version 1.0.doc
Version 1.0, January 04

8



RATE MANAGEMENT FORM AT NRC

CONDITION: ____________

DATE: ___________ WEIGH SCALE TECHNICIAN: ____________

PAN #	TIME OUT	1^{st} or 2^{nd} Rate

TIME*	Chamber Temperature	STDEV

* One reading every 30 minutes (Check procedure for air temp. STDEV requirements).

This form is for guidance to manage the sequencing of pans measurement and to verify the chamber temperature STDEV.

(At the end of condition file this form in the same envelope with the endurance time data form)

Figure 2.7: Rate Management Form at NRC

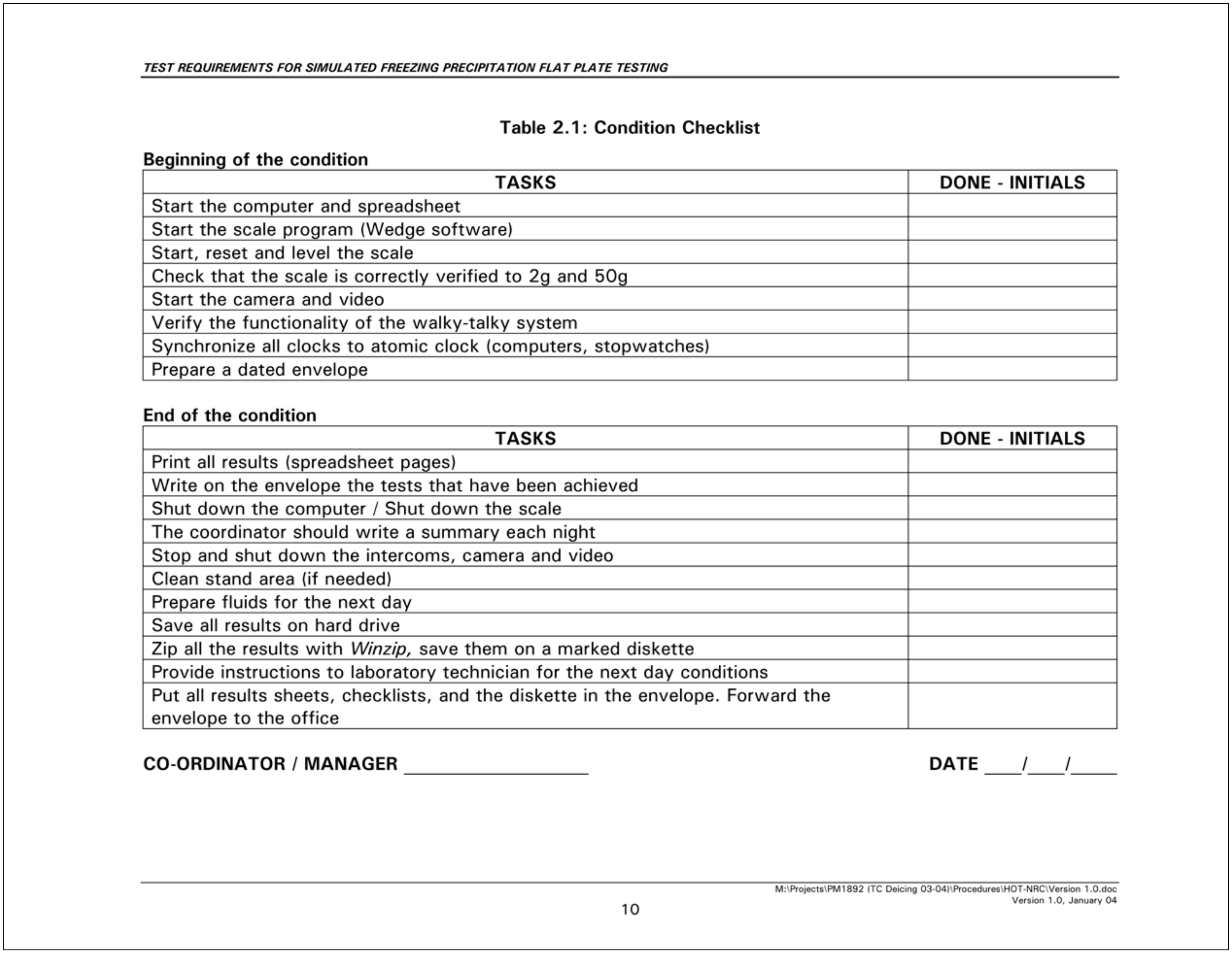


Table 2.1: Condition Checklist

Beginning of the condition

TASKS	DONE - INITIALS
Start the computer and spreadsheet	
Start the scale program (Wedge software)	
Start, reset and level the scale	
Check that the scale is correctly verified to 2g and 50g	
Start the camera and video	
Verify the functionality of the walky-talky system	
Synchronize all clocks to atomic clock (computers, stopwatches)	
Prepare a dated envelope	

End of the condition

TASKS	DONE - INITIALS
Print all results (spreadsheet pages)	
Write on the envelope the tests that have been achieved	
Shut down the computer / Shut down the scale	
The coordinator should write a summary each night	
Stop and shut down the intercoms, camera and video	
Clean stand area (if needed)	
Prepare fluids for the next day	
Save all results on hard drive	
Zip all the results with *Winzip,* save them on a marked diskette	
Provide instructions to laboratory technician for the next day conditions	
Put all results sheets, checklists, and the diskette in the envelope. Forward the envelope to the office	

CO-ORDINATOR / MANAGER ___________________ **DATE** ____/____/_____

This page intentionally left blank.

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

CM2265.003 (13-14)

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

Winter 2013-14

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Stephanie Bendickson

Reviewed by: John D'Avirro

March 17, 2014
Version 1.0

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

Winter 2013-14

1. INTRODUCTION

This document was prepared to bring together several projects that require testing at the National Research Council Climactic Engineering Facility (NRC) in Ottawa. Tests will be carried out from March 19-26, 2014.

The primary objective of the test session is to measure the endurance times of new de/anti-icing fluids. Testing for several other related research projects will be scheduled around the endurance time tests as time and space permit. This document provides the schedule, personnel, fluid, and equipment requirements for each of the projects involved.

A tentative test schedule is included in Figure 1.

2. PROJECTS, PROCEDURES AND OBJECTIVES

The projects that will be carried out at the March 2014 NRC test session are listed in this section. Each project has been given a shortened name (shown in brackets following full title) which is used in subsequent sections of this document. A description of each project, its objective and its test procedure are provided. The test procedures for several projects are provided in separate detailed documents, which are referenced in the appropriate subsection and listed in Section 9.

General comments on procedures and setup:

- Endurance time tests will be carried out according to the protocol provided in Aerospace Recommended Practice 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids SAE Type II, III, and IV* (1), except as noted.
- There will be two test stands positioned under the sprayer (main stand with two 6-position stands and side stand with one 3-position stand) and a third stand that will be positioned outside the spray area in the small area of the climate chamber. The test stands should be situated in the cold chamber as per the measurements provided in Figure 2.
- A complex rate management program was developed in the early 2000s to assist in managing the measurement of precipitation rates. This program will be used. A guide to the rate management program is available to help with training of new rate station managers.

2.1 Endurance Times of New Fluids (New Fluid ETs)

The objective of this project is to measure endurance times of new fluids. This will include Type II and Type IV tests, as listed below. Each fluid will be tested over the entire range of freezing precipitation conditions encompassed by the Type II/IV HOT tables.

- Clariant Max Flight Sneg (Type IV)
- Newave Aerochemical FCY 9311 (Type II)
- LNT Solutions P250-2 (Type II)

The procedure for conducting endurance time tests is given in the document *Test Requirements for Simulated Freezing Precipitation Flat Plate Testing* (2). Cold soak boxes should be prepared using the procedure provided in Attachment 1.

The test plan for new fluid endurance time tests is given in Table 1. All tests will be conducted on the main test stand.

2.2 Type III Tests (Type III)

Tests will be conducted with a Type III fluid to achieve several objectives. All tests will be carried out using the Type I test protocol (i.e. fluids applied at 20°C) using Clariant Safewing MP III 2031 ECO.

1. Testing with this fluid in April 2013 resulted in somewhat surprising results in freezing fog at -10°C; the endurance times in this condition were longer than in freezing fog at -3 and -25°C. The freezing fog tests at -10°C will be repeated to confirm the 2013 findings.
2. As a continuation of previous research, several tests will be conducted to evaluate the effect of composite surfaces on endurance times of Type III fluids applied heated. Detailed temperature and Brix measurements will be taken as part of these tests.

The test plan for Type III tests is given in Table 2. All tests will be conducted on the main test stand.

2.3 Thickness of New Fluids (Fluid Thickness)

The objective of these tests is to measure the thickness new fluids on flat plates. The procedure for these tests is entitled *Experimental Program to*

Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates (3) and can be found in Transport Canada Report TP 13991E, Appendix I. All tests will be conducted with fluid at -3°C.

The test plan for Fluid Thickness tests is given in Table 3. The tests will be conducted at the small end of the chamber outside of the spray area.

2.4 Inspection Immediately Prior to Takeoff (5 Minute Rule)

These tests are a continuation of previous work which examined the appropriateness of guidance which allows takeoff for five minutes following a contamination inspection. Tests were previously conducted in March 2012 and April 2013. The objective of 2014 testing is to collect additional data and measurements.

This project will be carried out by conducting additional observations on tests being conducted for other projects. There is no formal procedure; the following will be used as guidance:

- After fluid failure is recorded for a selected test, the test plate will be left under the freezing precipitation spray for five minutes;
- At the five minute mark the percentage of the plate covered with fluid failure will be recorded; and
- Brix measurements, thickness measurements and photos will be taken:
  - every 5 minutes for tests < 20 minutes;
  - every 10 minutes for tests > 20 minutes; and
  - at failure and 5 minutes past failure for all tests.

The test plan for the 5 minute rule tests is given in Table 4.

2.5 Evaluation of Ice Phobic Products (Ice Phobic)

The objective of this project is to continue the evaluation of newly developed ice phobic products. The project has four sub-objectives as described below.

1. **Endurance Times:** Evaluation of impact of ice phobic products on fluid endurance times. Tests will be conducted with two coatings. The procedure for the conduct of these tests is provided in the document *Effect of Ice Phobic Products on HOTs* (4). The test plan is given in Table 5.

2. **Thickness:** Evaluation of ice phobic products on fluid thickness. The standard procedure for measuring fluid thickness will be used (see Subsection 2.3). Notably, thickness (Type IV fluid) or percent wetted (Type I fluid) will be measured at 15 cm line at time of application and 2, 5, 15, and 30 minutes after. The test plan is given in Table 6. Tests will be conducted at the small end of the chamber outside of the spray area.
3. **Adhesion:** Evaluation of impact of ice phobic products on fluid adhesion. These tests will be conducted without fluid. The test plan is given in Table 7.
4. **Hot Water:** Evaluate the potential for using only hot water as a deicer for end of runway or deicing only type applications. Some coatings may delay the onset of adherence of precipitation and therefore may result in equal or longer protection times than Type I fluid. The test plan is given in Table 8.
5. **Rust-oleum Never Wet**: Research will be conducted with this product on an ad-hoc basis to determine if it is a true ice phobic product. Testing will be conducted in the spray area during light freezing rain, -3°C, low rate. This is noted in the test schedule.

Except where noted, tests will be conducted on the main and/or side stand.

2.6 Endurance Times on Flaps/Slats (Flaps/Slats ETs)

The objective of this project is to continue the evaluation of endurance time performance of anti-icing fluids on wing surfaces with deployed flaps. Testing with Type I, Type II and Type III fluids will being carried out to supplement previously collected data.

The procedure for the conduct of these tests is provided in the document *Evaluation of Endurance Times on Deployed Flaps* (5). The procedure was written for testing in outdoor conditions; changes to the procedure required for indoor testing and the indoor test plan are provided herein.

Tests will be conducted using standard holdover time testing procedures. Each comparative test will include a baseline test (conducted on plate inclined to a 10° slope) and two non-nested flap tests (conducted on plates inclined to a 20° and 35° slope).

The test plan for Deployed Flaps tests is given in Table 9. The tests will be conducted on the main and/or side stand. Tests requiring plates oriented to 20° or 35° must be positioned on the lower main stand or on the side stand.

2.7 Flap/Slat Extension Tests (Flap/Slat Extension)

Tests will be conducted to investigate the effects of extending a flap or slat during the holdover time. This will be achieved by overlapping two plates in either a flap or a slat configuration and fully separating them midway during the expected holdover time. Particular attention will be given to investigating how the bare areas on the plates behave with the precipitation.

The test plan for the flap/slat extension tests is provided in Table 10. The tests will be conducted on the main and/or side stand.

2.8 Ice Pellet Testing (Ice Pellets)

Wind tunnel tests were conducted during the winter of 2013-14 to develop allowance times for Type III fluid. Testing conducted with heated or warm Type III fluid showed signs of adhered contamination, and it was suggested that flat plate testing be conducted to understand this occurrence and to further validate the results observed in the wind tunnel.

The objective of this project is to verify the level of adhered contamination at the end of the allowance time for Type III heated fluids and to compare the severity to a Type IV heated fluid. There is no formal procedure for this project; however, the following points are of importance:

- The level of heat will be varied to represent heated application, as well as involuntary heating scenarios i.e. truck parked indoors, poor insulation in double tank trunk, etc.

- Testing will target proposed allowance times developed based on data collected at the wind tunnel during the winter of 2013-14 and existing allowance times. An additional five minutes can be applied to the allowance time of all tests to investigate potential safety buffers in the allowance times.

The test plan for Ice Pellets is given in Table 11. Testing will be done outside the test spray area to minimize the impact on the testing schedule.

2.9 Windshield Washer Fluid (WWF)

Previous testing in 2011-12 indicated windshield washer fluid does not provide adequate protection time and causes ice to form shortly after spraying. In addition, windshield washer fluid may be hazardous in operations because as it freezes, the wing surface still appears wet. A taxi test indicated that the fluid would likely freeze before the takeoff. Isopropyl alcohol has been identified as another alternative to windshield washer fluid.

The objective of this project is to evaluate the protection time of isopropyl alcohol as compared to standard Type I fluid and windshield washer fluid. Tests will be carried out using the standard endurance time test procedure, including 1 litre of test fluid applied at 20°C.

The test plan for Windshield Washer Fluid is given in Table 12. The tests will be conducted on the main and/or side stand.

2.10 Update of NRC Rate Calculation Software (Rate Software)

The software currently being used to manage the precipitation rate station at NRC is more than 10 years old. Several key areas for improvement were identified which could streamline, simplify and increase efficiency of the rate station. A computer programmer was retained to implement these changes. The updated software will be tested at the March 2014 test session.

The updated software will be run concurrently with the existing software the first day of testing. Issues and areas of improvement will be documented during this day. The computer programmer will come to NRC the following day to discuss the items and will then have several days to implement the changes. The updated software will be tested again the second week of the test session; this may require concurrent running of old and new software until there is full confidence in the new software.

2.11 Develop Fluid Failure Photos (Failure Photos)

A project was undertaken in winter 2013-14 to obtain photos of de/anti-icing fluids failing in all conditions encompassed by the holdover time guidelines. Review of existing materials indicated some of the needed photos do not exist.

A photographer will attend the test session and take the needed photos, including photos of the beginning of each test, first failure, and actual failure.

The majority of photos will be taken of tests being conducted for other projects. Fifteen unique Type I and Type III tests will also be conducted (test numbers P1 to P15). Table 13 lists the tests to be photographed in each condition.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel responsibilities are listed below.

1. New Fluid ETs:
    - Manager: JD (pours fluids, calls failures)
    - Assistant: VZ (preps fluids/data forms)
    - Rates Team
2. Type III:
    - Manager: JD (pours fluids, calls failures)
    - Assistant: VZ (preps fluids/data forms)
    - Rates Team
3. Fluid Thickness:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
4. 5 Minute Rule:
    - Manager: VZ (tracks timing, records measurements)
    - Failure Calls: JD
    - Photographer: BG
    - Rates Team
5. Ice Phobic:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements, assists as needed)
    - Rates Team
6. Flaps/Slats ETs:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
    - Rates Team
7. Flaps/Slats Extension:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
    - Rates Team
8. Ice Pellets:
    - Manager: DY
    - Assistant: YOW3 (make/dispense ice pellets)

9. WWF:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
    - Rates Team

10. Rate Software:
    - Manager: SB
    - Programmer: BF
    - Rate Manager Alternate: DY

11. Failure Photos:
    - Manager: JD
    - Assistant: VZ
    - Photographer: BG

The Rates Team will consist of:

- Rate Manager: SB (runs rate station)
- Rate Manager Alternate: DY (runs rate station)
- Rate Assistant: YOW1 (runs pans, refills fluids)

In the condition of Cold Soak Wing, additional personnel will be required:

- Box Prep Manager: MR
- Box Prep Assistants: YOW2, YOW3

In addition, personnel will be designated responsible for:

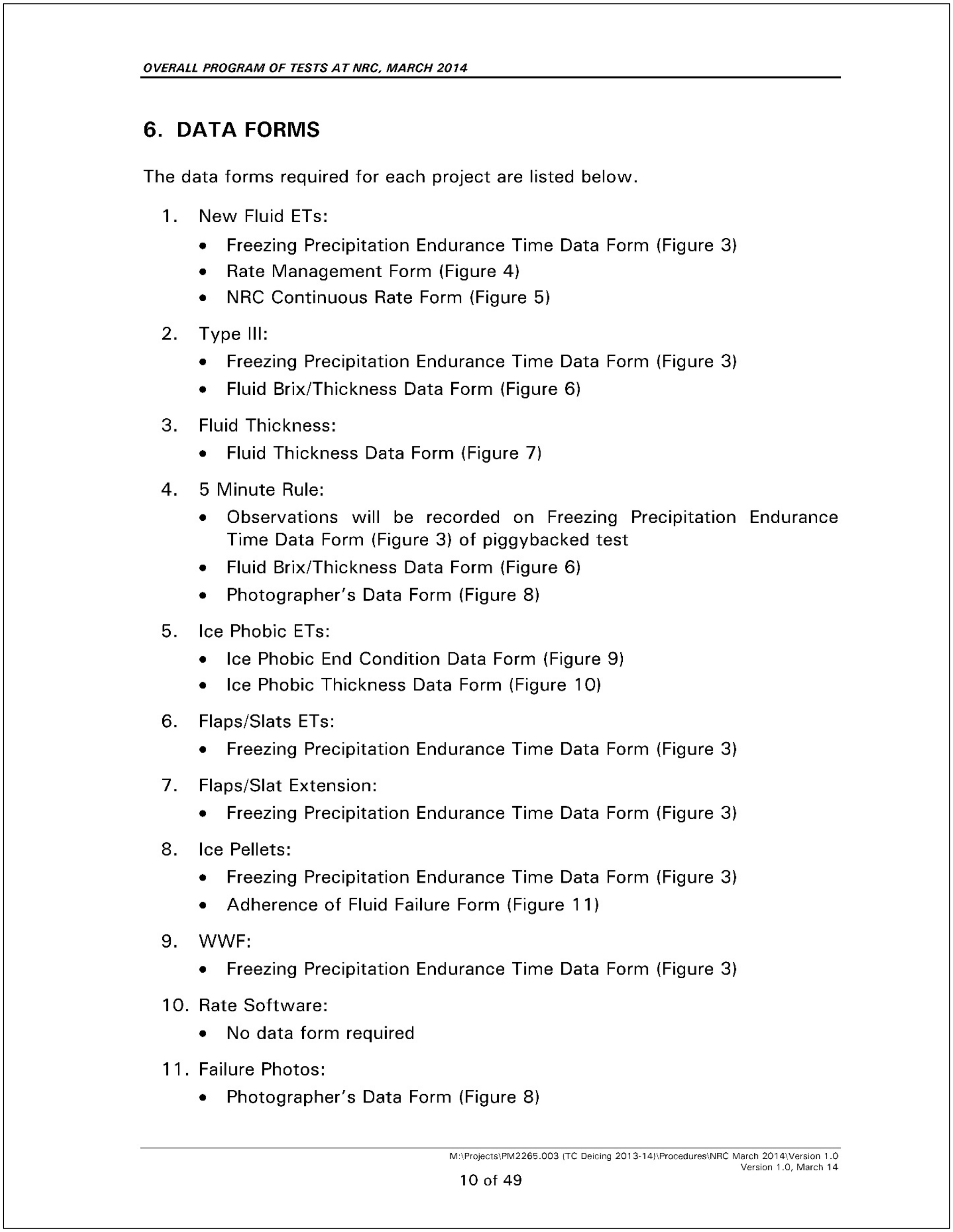
- Equipment: MR
- Pre-test Setup: MR/DP
- Data Form Manager: VZ
- Fluid Management: VZ/SB

4. FLUIDS

The required fluids and fluid quantities are shown in Table 14. Type I fluids will be diluted prior to testing using the dilution tables provided in Table 15. Fluids that will be used the first day of testing should be packed into coolers at the APS test site and plugged into power overnight.

5. EQUIPMENT

Table 16 provides a list of required equipment.



6. DATA FORMS

The data forms required for each project are listed below.

1. New Fluid ETs:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
   - Rate Management Form (Figure 4)
   - NRC Continuous Rate Form (Figure 5)
2. Type III:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
   - Fluid Brix/Thickness Data Form (Figure 6)
3. Fluid Thickness:
   - Fluid Thickness Data Form (Figure 7)
4. 5 Minute Rule:
   - Observations will be recorded on Freezing Precipitation Endurance Time Data Form (Figure 3) of piggybacked test
   - Fluid Brix/Thickness Data Form (Figure 6)
   - Photographer's Data Form (Figure 8)
5. Ice Phobic ETs:
   - Ice Phobic End Condition Data Form (Figure 9)
   - Ice Phobic Thickness Data Form (Figure 10)
6. Flaps/Slats ETs:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
7. Flaps/Slat Extension:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
8. Ice Pellets:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
   - Adherence of Fluid Failure Form (Figure 11)
9. WWF:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
10. Rate Software:
    - No data form required
11. Failure Photos:
    - Photographer's Data Form (Figure 8)

7. PRE–TEST SET–UP ACTIVITIES

The following activities need to be completed prior to arrival at the NRC:

1. Mark plates with plate numbers (MR/DP)
2. ~~Check rate pans: check quantity, check for holes, and check all pans are properly labelled~~
3. Ensure plates and boxes are equipped with operational and verified thermistors or smart buttons (MR/DP)
4. Prepare labels for pour containers (VZ)
5. Ensure fluids are prepared in advance according to Table 14 (DP)
6. Clean and label 1 litre pour containers (DP)
7. Check laptops (2) work for rate station (MR)
8. ~~Rent cube van (VZ)~~
9. ~~Book hotel (VZ)~~
10. Update and print chamber settings file (DY)
11. Print data forms and procedures (SB/EA)
12. Print chamber condition sheets (SB/VZ)
13. ~~Contact Medhat (SB)~~
    - ~~confirm availability of NRC camera system~~
    - ~~waste tote~~
    - ~~cold soak fluid + wooden stand + pump~~
    - ~~coffee~~
    - ~~cell repeater~~
    - ~~rate monitoring system~~
14. ~~Speak to BG re testing schedule (MR)~~
15. ~~Install Trendreader on all laptops (MR/VZ)~~
16. ~~Talk to BF re rate station observation (SB)~~
17. ~~Find personnel for ice pellets (MR/VZ)~~
18. The following items should be purchased prior to NRC (MR/VZ):
    - Rate station computer
    - Boot dryer
    - Inclinometer x 2
    - Small canon camera x1

- Printer & Ink Cartridge
- Ice for IP fabrication
- Rust-oleum Never Wet
- Smart Buttons Adhesives
- Vise grip (large) + rubber opener
- Windshield Washer Fluid (same as Rockcliffe)

8. SAFETY ISSUES

Managers of each subproject must ensure that personnel involved in the set-up and conduct of their respective projects are aware of the following:

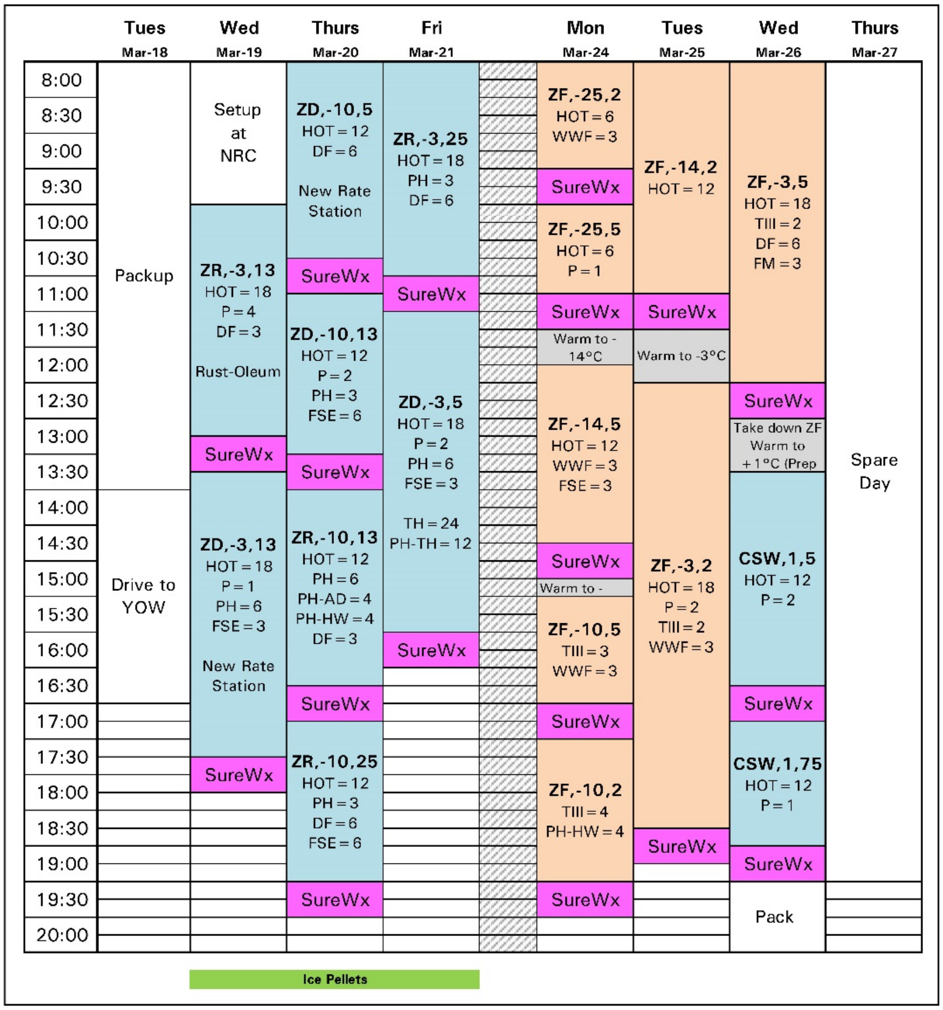
1. Fluid MSDS sheets are available for review.
2. Waterproof clothing and gloves are available.
3. Rubber mats must be properly placed in and around the test area and cleaned as necessary.
4. Care should be taken when circulating near the test stand due to slipperiness.
5. First aid kit, water and fire extinguisher are available.
6. All NRC safety guidelines must be followed.

9. REFERENCES

1. SAE Aerospace Recommended Practice 5485, Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids: SAE Type II, III, and IV, July 2004.
2. Test Requirements For Simulated Freezing Precipitation Flat Plate Testing, Version 1.0, January 15, 2004.
3. Experimental Program to Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates, Version 1.0, April 3, 2002.
4. Effect of Ice Phobic Products on Holdover Times, Final Version 1.0, December 24, 2009.
5. Evaluation of Endurance Times on Deployed Flaps, Final Version 1.0, January 25, 2012.

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

FIGURE 1: TEST SCHEDULE



	Tues Mar-18	Wed Mar-19	Thurs Mar-20	Fri Mar-21	Mon Mar-24	Tues Mar-25	Wed Mar-26	Thurs Mar-27
8:00	Packup	Setup at NRC	**ZD,-10,5** HOT=12 DF=6 New Rate Station	**ZR,-3,25** HOT=18 PH=3 DF=6	**ZF,-25,2** HOT=6 WWF=3	**ZF,-14,2** HOT=12	**ZF,-3,5** HOT=18 TIII=2 DF=6 FM=3	Spare Day
8:30								
9:00								
9:30					SureWx			
10:00		**ZR,-3,13** HOT=18 P=4 DF=3 Rust-Oleum			**ZF,-25,5** HOT=6 P=1			
10:30			SureWx					
11:00			**ZD,-10,13** HOT=12 P=2 PH=3 FSE=6	SureWx	SureWx	SureWx		
11:30				**ZD,-3,5** HOT=18 P=2 PH=6 FSE=3 TH=24 PH-TH=12	Warm to -14°C	Warm to -3°C		
12:00					**ZF,-14,5** HOT=12 WWF=3 FSE=3			
12:30						**ZF,-3,2** HOT=18 P=2 TIII=2 WWF=3	SureWx	
13:00		SureWx					Take down ZF Warm to +1°C (Prep	
13:30		**ZD,-3,13** HOT=18 P=1 PH=6 FSE=3 New Rate Station	SureWx				**CSW,1,5** HOT=12 P=2	
14:00	Drive to YOW		**ZR,-10,13** HOT=12 PH=6 PH-AD=4 PH-HW=4 DF=3					
14:30					SureWx			
15:00					Warm to -			
15:30					**ZF,-10,5** TIII=3 WWF=3			
16:00				SureWx				
16:30			SureWx				SureWx	
17:00			**ZR,-10,25** HOT=12 PH=3 DF=6 FSE=6		SureWx		**CSW,1,75** HOT=12 P=1	
17:30		SureWx			**ZF,-10,2** TIII=4 PH-HW=4			
18:00								
18:30						SureWx		
19:00							SureWx	
19:30			SureWx		SureWx		Pack	
20:00								

🟩 Ice Pellets

Project Abbreviations

HOT = HOT of New Fluids
DF = Deployed Flaps
FSE = Flaps / Slats Extension
PH = Phobic ET Testing
PH-AD = Phobic Adherence
PH-HW = Phobic Hot Water
TIII = Type III Latent Heat + HOT
WWWF = Windshield Washer Fluid
P = Photo Documentation of Failure

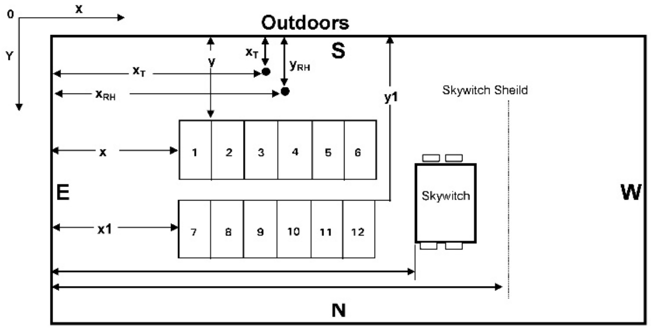
M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

13 of 49

FIGURE 2: TEST STAND LOCATION MEASUREMENTS

LOCATION: CEF (Ottawa) DATE: CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						
1	04-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	04-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	02/04/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	02-Apr-01	ZR10L					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
5	27-Mar-01	ZD3H					24' 5"	6'6"	22'	10'4"				Very Good		
6	28-Mar-01	ZD3L					25' 3"	7'3"	25' 3"	9' 6"				Good		
7	02-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	02-Apr-01	ZD10L					24'	7' 7"	24' 7"	9' 11"				Good		20 ft. from Snow Fence
9	10-Apr-01	ZFog3H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
10	10-Apr-01	ZFog3L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
11	10-Apr-01	ZFog10H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
12	10-Apr-01	ZFog10L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
13	09-Apr-01	ZFog14H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
14	09-Apr-01	ZFog14L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
15	06-Apr-01	ZFog25H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
16	06-Apr-01	ZFog25L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
17	29-Mar-01	CSWH					25'3"		25'3"	9' 6"						
18	29-Mar-01	CSWL					23'11"	7'3"	25'3"	9' 6"						



Notes:

* - "From X" refers to the distance from the East wall.

** - The nozzle should be between positions 5 and 11

RH - Relative Humidity Sensor

T - Temperature Sensor

WEIGH SCALE TECHNICIAN: ____________________

LEADER: ____________________

NEW VALUES (IF DIFFERENT)

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						

ATTACHMENT 1: COLD SOAK BOX PREPARATION PROCEDURE

1. Put containers (20 L) of CSW box fluid (propylene 65/35) in cold (-30±5°C) freezer overnight. Freezers to be kept in large end of the chamber.
2. Put all filled CSW boxes in warmer (-11±1°C) freezer overnight.
3. Next morning, if freezer in step (2) does not provide fluid and box temperature of -11±1°C, then empty boxes in pail and achieve fluid at -12±1°C in pail.
4. Prepare step (3) in corner of large chamber that is at +1°C; ensure boxes are cooled to about -11°C. Go to step (6).
5. After first series of tests, empty fluid from boxes into separate pail. Put empty boxes in freezer to keep cool at -11±2°C.
6. Prepare fluid to -12±1°C by mixing (use small amounts of hot water and/or cold fluid). Agitate fluid mixture frequently.
7. Fill boxes, ensure -11±1°C on surface of box. This process shall be done while rates are being measured.
8. Position on stand with cover, but no insulation on top surface. Connect thermocouples.
9. Allow warming to -10±0.5°C. This process needs monitoring with rates measurement to not overshoot temperature (place insulation on top surface if required).
10. Start test.
11. At end of test, remove box from stand, measure rates, and go to step (5).

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
1	Freezing Fog	-25	2	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
2	Freezing Fog	-25	2	Clariant Max Flight Sneg	100	Al. Plate	
3	Freezing Fog	-25	2	Newave FCY 9311	100	Al. Plate	
4	Freezing Fog	-25	2	Newave FCY 9311	100	Al. Plate	
5	Freezing Fog	-25	2	LNT P250-2	100	Al. Plate	PHOTOS
6	Freezing Fog	-25	2	LNT P250-2	100	Al. Plate	
7	Freezing Fog	-25	5	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
8	Freezing Fog	-25	5	Clariant Max Flight Sneg	100	Al. Plate	
9	Freezing Fog	-25	5	Newave FCY 9311	100	Al. Plate	
10	Freezing Fog	-25	5	Newave FCY 9311	100	Al. Plate	
11	Freezing Fog	-25	5	LNT P250-2	100	Al. Plate	PHOTOS
12	Freezing Fog	-25	5	LNT P250-2	100	Al. Plate	
13	Freezing Fog	-14	2	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
14	Freezing Fog	-14	2	Clariant Max Flight Sneg	100	Al. Plate	
15	Freezing Fog	-14	2	Newave FCY 9311	100	Al. Plate	
16	Freezing Fog	-14	2	Newave FCY 9311	100	Al. Plate	
17	Freezing Fog	-14	2	LNT P250-2	100	Al. Plate	PHOTOS
18	Freezing Fog	-14	2	LNT P250-2	100	Al. Plate	
19	Freezing Fog	-14	2	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
20	Freezing Fog	-14	2	Clariant Max Flight Sneg	75	Al. Plate	
21	Freezing Fog	-14	2	Newave FCY 9311	75	Al. Plate	
22	Freezing Fog	-14	2	Newave FCY 9311	75	Al. Plate	
23	Freezing Fog	-14	2	LNT P250-2	75	Al. Plate	PHOTOS
24	Freezing Fog	-14	2	LNT P250-2	75	Al. Plate	
25	Freezing Fog	-14	5	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
26	Freezing Fog	-14	5	Clariant Max Flight Sneg	100	Al. Plate	
27	Freezing Fog	-14	5	Newave FCY 9311	100	Al. Plate	
28	Freezing Fog	-14	5	Newave FCY 9311	100	Al. Plate	
29	Freezing Fog	-14	5	LNT P250-2	100	Al. Plate	PHOTOS
30	Freezing Fog	-14	5	LNT P250-2	100	Al. Plate	
31	Freezing Fog	-14	5	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
32	Freezing Fog	-14	5	Clariant Max Flight Sneg	75	Al. Plate	
33	Freezing Fog	-14	5	Newave FCY 9311	75	Al. Plate	
34	Freezing Fog	-14	5	Newave FCY 9311	75	Al. Plate	
35	Freezing Fog	-14	5	LNT P250-2	75	Al. Plate	
36	Freezing Fog	-14	5	LNT P250-2	75	Al. Plate	PHOTOS
37	Freezing Fog	-3	2	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
38	Freezing Fog	-3	2	Clariant Max Flight Sneg	100	Al. Plate	
39	Freezing Fog	-3	2	Newave FCY 9311	100	Al. Plate	
40	Freezing Fog	-3	2	Newave FCY 9311	100	Al. Plate	
41	Freezing Fog	-3	2	LNT P250-2	100	Al. Plate	PHOTOS
42	Freezing Fog	-3	2	LNT P250-2	100	Al. Plate	
43	Freezing Fog	-3	2	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
44	Freezing Fog	-3	2	Clariant Max Flight Sneg	75	Al. Plate	
45	Freezing Fog	-3	2	Newave FCY 9311	75	Al. Plate	
46	Freezing Fog	-3	2	Newave FCY 9311	75	Al. Plate	
47	Freezing Fog	-3	2	LNT P250-2	75	Al. Plate	PHOTOS

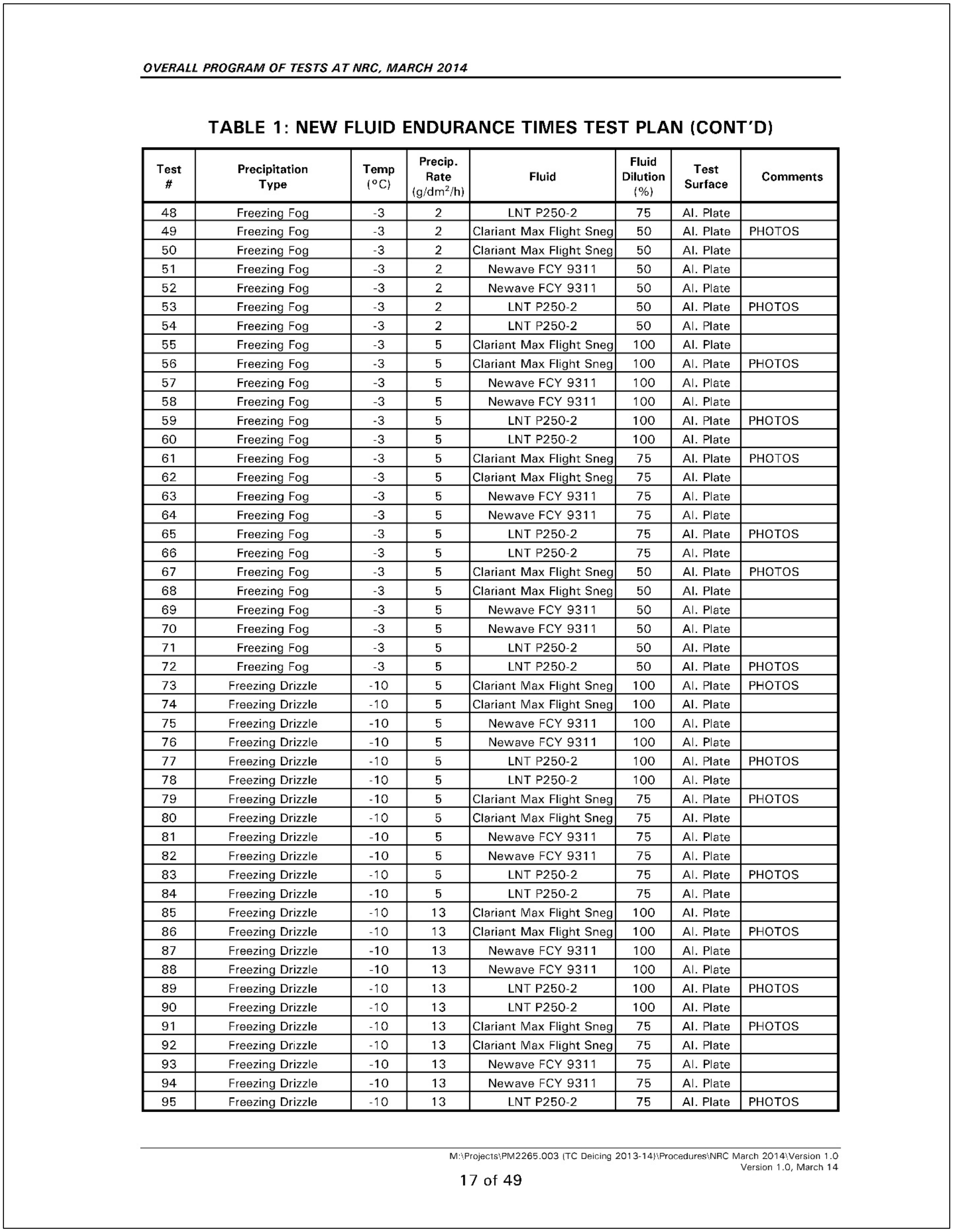


TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
48	Freezing Fog	-3	2	LNT P250-2	75	Al. Plate	
49	Freezing Fog	-3	2	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
50	Freezing Fog	-3	2	Clariant Max Flight Sneg	50	Al. Plate	
51	Freezing Fog	-3	2	Newave FCY 9311	50	Al. Plate	
52	Freezing Fog	-3	2	Newave FCY 9311	50	Al. Plate	
53	Freezing Fog	-3	2	LNT P250-2	50	Al. Plate	PHOTOS
54	Freezing Fog	-3	2	LNT P250-2	50	Al. Plate	
55	Freezing Fog	-3	5	Clariant Max Flight Sneg	100	Al. Plate	
56	Freezing Fog	-3	5	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
57	Freezing Fog	-3	5	Newave FCY 9311	100	Al. Plate	
58	Freezing Fog	-3	5	Newave FCY 9311	100	Al. Plate	
59	Freezing Fog	-3	5	LNT P250-2	100	Al. Plate	PHOTOS
60	Freezing Fog	-3	5	LNT P250-2	100	Al. Plate	
61	Freezing Fog	-3	5	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
62	Freezing Fog	-3	5	Clariant Max Flight Sneg	75	Al. Plate	
63	Freezing Fog	-3	5	Newave FCY 9311	75	Al. Plate	
64	Freezing Fog	-3	5	Newave FCY 9311	75	Al. Plate	
65	Freezing Fog	-3	5	LNT P250-2	75	Al. Plate	PHOTOS
66	Freezing Fog	-3	5	LNT P250-2	75	Al. Plate	
67	Freezing Fog	-3	5	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
68	Freezing Fog	-3	5	Clariant Max Flight Sneg	50	Al. Plate	
69	Freezing Fog	-3	5	Newave FCY 9311	50	Al. Plate	
70	Freezing Fog	-3	5	Newave FCY 9311	50	Al. Plate	
71	Freezing Fog	-3	5	LNT P250-2	50	Al. Plate	
72	Freezing Fog	-3	5	LNT P250-2	50	Al. Plate	PHOTOS
73	Freezing Drizzle	-10	5	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
74	Freezing Drizzle	-10	5	Clariant Max Flight Sneg	100	Al. Plate	
75	Freezing Drizzle	-10	5	Newave FCY 9311	100	Al. Plate	
76	Freezing Drizzle	-10	5	Newave FCY 9311	100	Al. Plate	
77	Freezing Drizzle	-10	5	LNT P250-2	100	Al. Plate	PHOTOS
78	Freezing Drizzle	-10	5	LNT P250-2	100	Al. Plate	
79	Freezing Drizzle	-10	5	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
80	Freezing Drizzle	-10	5	Clariant Max Flight Sneg	75	Al. Plate	
81	Freezing Drizzle	-10	5	Newave FCY 9311	75	Al. Plate	
82	Freezing Drizzle	-10	5	Newave FCY 9311	75	Al. Plate	
83	Freezing Drizzle	-10	5	LNT P250-2	75	Al. Plate	PHOTOS
84	Freezing Drizzle	-10	5	LNT P250-2	75	Al. Plate	
85	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	100	Al. Plate	
86	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
87	Freezing Drizzle	-10	13	Newave FCY 9311	100	Al. Plate	
88	Freezing Drizzle	-10	13	Newave FCY 9311	100	Al. Plate	
89	Freezing Drizzle	-10	13	LNT P250-2	100	Al. Plate	PHOTOS
90	Freezing Drizzle	-10	13	LNT P250-2	100	Al. Plate	
91	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
92	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	75	Al. Plate	
93	Freezing Drizzle	-10	13	Newave FCY 9311	75	Al. Plate	
94	Freezing Drizzle	-10	13	Newave FCY 9311	75	Al. Plate	
95	Freezing Drizzle	-10	13	LNT P250-2	75	Al. Plate	PHOTOS

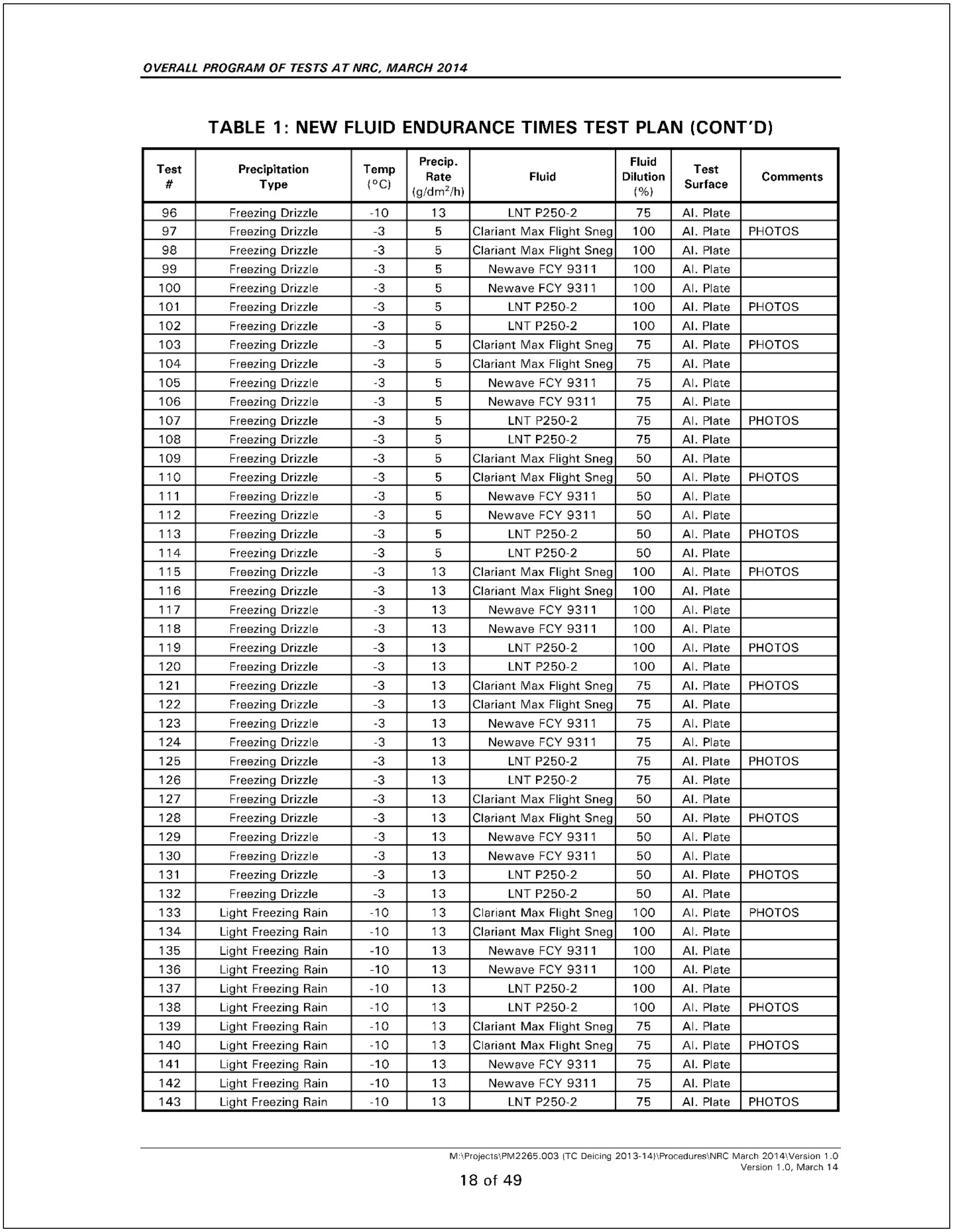


TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
96	Freezing Drizzle	-10	13	LNT P250-2	75	Al. Plate	
97	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
98	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	100	Al. Plate	
99	Freezing Drizzle	-3	5	Newave FCY 9311	100	Al. Plate	
100	Freezing Drizzle	-3	5	Newave FCY 9311	100	Al. Plate	
101	Freezing Drizzle	-3	5	LNT P250-2	100	Al. Plate	PHOTOS
102	Freezing Drizzle	-3	5	LNT P250-2	100	Al. Plate	
103	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
104	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	75	Al. Plate	
105	Freezing Drizzle	-3	5	Newave FCY 9311	75	Al. Plate	
106	Freezing Drizzle	-3	5	Newave FCY 9311	75	Al. Plate	
107	Freezing Drizzle	-3	5	LNT P250-2	75	Al. Plate	PHOTOS
108	Freezing Drizzle	-3	5	LNT P250-2	75	Al. Plate	
109	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	50	Al. Plate	
110	Freezing Drizzle	-3	5	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
111	Freezing Drizzle	-3	5	Newave FCY 9311	50	Al. Plate	
112	Freezing Drizzle	-3	5	Newave FCY 9311	50	Al. Plate	
113	Freezing Drizzle	-3	5	LNT P250-2	50	Al. Plate	PHOTOS
114	Freezing Drizzle	-3	5	LNT P250-2	50	Al. Plate	
115	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
116	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	100	Al. Plate	
117	Freezing Drizzle	-3	13	Newave FCY 9311	100	Al. Plate	
118	Freezing Drizzle	-3	13	Newave FCY 9311	100	Al. Plate	
119	Freezing Drizzle	-3	13	LNT P250-2	100	Al. Plate	PHOTOS
120	Freezing Drizzle	-3	13	LNT P250-2	100	Al. Plate	
121	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
122	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	75	Al. Plate	
123	Freezing Drizzle	-3	13	Newave FCY 9311	75	Al. Plate	
124	Freezing Drizzle	-3	13	Newave FCY 9311	75	Al. Plate	
125	Freezing Drizzle	-3	13	LNT P250-2	75	Al. Plate	PHOTOS
126	Freezing Drizzle	-3	13	LNT P250-2	75	Al. Plate	
127	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	50	Al. Plate	
128	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
129	Freezing Drizzle	-3	13	Newave FCY 9311	50	Al. Plate	
130	Freezing Drizzle	-3	13	Newave FCY 9311	50	Al. Plate	
131	Freezing Drizzle	-3	13	LNT P250-2	50	Al. Plate	PHOTOS
132	Freezing Drizzle	-3	13	LNT P250-2	50	Al. Plate	
133	Light Freezing Rain	-10	13	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
134	Light Freezing Rain	-10	13	Clariant Max Flight Sneg	100	Al. Plate	
135	Light Freezing Rain	-10	13	Newave FCY 9311	100	Al. Plate	
136	Light Freezing Rain	-10	13	Newave FCY 9311	100	Al. Plate	
137	Light Freezing Rain	-10	13	LNT P250-2	100	Al. Plate	
138	Light Freezing Rain	-10	13	LNT P250-2	100	Al. Plate	PHOTOS
139	Light Freezing Rain	-10	13	Clariant Max Flight Sneg	75	Al. Plate	
140	Light Freezing Rain	-10	13	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
141	Light Freezing Rain	-10	13	Newave FCY 9311	75	Al. Plate	
142	Light Freezing Rain	-10	13	Newave FCY 9311	75	Al. Plate	
143	Light Freezing Rain	-10	13	LNT P250-2	75	Al. Plate	PHOTOS

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
144	Light Freezing Rain	-10	13	LNT P250-2	75	Al. Plate	
145	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	100	Al. Plate	
146	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
147	Light Freezing Rain	-10	25	Newave FCY 9311	100	Al. Plate	
148	Light Freezing Rain	-10	25	Newave FCY 9311	100	Al. Plate	
149	Light Freezing Rain	-10	25	LNT P250-2	100	Al. Plate	PHOTOS
150	Light Freezing Rain	-10	25	LNT P250-2	100	Al. Plate	
151	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	75	Al. Plate	
152	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
153	Light Freezing Rain	-10	25	Newave FCY 9311	75	Al. Plate	
154	Light Freezing Rain	-10	25	Newave FCY 9311	75	Al. Plate	
155	Light Freezing Rain	-10	25	LNT P250-2	75	Al. Plate	
156	Light Freezing Rain	-10	25	LNT P250-2	75	Al. Plate	PHOTOS
157	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
158	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	100	Al. Plate	
159	Light Freezing Rain	-3	13	Newave FCY 9311	100	Al. Plate	
160	Light Freezing Rain	-3	13	Newave FCY 9311	100	Al. Plate	
161	Light Freezing Rain	-3	13	LNT P250-2	100	Al. Plate	PHOTOS
162	Light Freezing Rain	-3	13	LNT P250-2	100	Al. Plate	
163	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
164	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	75	Al. Plate	
165	Light Freezing Rain	-3	13	Newave FCY 9311	75	Al. Plate	
166	Light Freezing Rain	-3	13	Newave FCY 9311	75	Al. Plate	
167	Light Freezing Rain	-3	13	LNT P250-2	75	Al. Plate	PHOTOS
168	Light Freezing Rain	-3	13	LNT P250-2	75	Al. Plate	
169	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
170	Light Freezing Rain	-3	13	Clariant Max Flight Sneg	50	Al. Plate	
171	Light Freezing Rain	-3	13	Newave FCY 9311	50	Al. Plate	
172	Light Freezing Rain	-3	13	Newave FCY 9311	50	Al. Plate	
173	Light Freezing Rain	-3	13	LNT P250-2	50	Al. Plate	
174	Light Freezing Rain	-3	13	LNT P250-2	50	Al. Plate	PHOTOS
175	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	100	Al. Plate	PHOTOS
176	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	100	Al. Plate	
177	Light Freezing Rain	-3	25	Newave FCY 9311	100	Al. Plate	
178	Light Freezing Rain	-3	25	Newave FCY 9311	100	Al. Plate	
179	Light Freezing Rain	-3	25	LNT P250-2	100	Al. Plate	PHOTOS
180	Light Freezing Rain	-3	25	LNT P250-2	100	Al. Plate	
181	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	75	Al. Plate	PHOTOS
182	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	75	Al. Plate	
183	Light Freezing Rain	-3	25	Newave FCY 9311	75	Al. Plate	
184	Light Freezing Rain	-3	25	Newave FCY 9311	75	Al. Plate	
185	Light Freezing Rain	-3	25	LNT P250-2	75	Al. Plate	PHOTOS
186	Light Freezing Rain	-3	25	LNT P250-2	75	Al. Plate	
187	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	50	Al. Plate	PHOTOS
188	Light Freezing Rain	-3	25	Clariant Max Flight Sneg	50	Al. Plate	
189	Light Freezing Rain	-3	25	Newave FCY 9311	50	Al. Plate	
190	Light Freezing Rain	-3	25	Newave FCY 9311	50	Al. Plate	
191	Light Freezing Rain	-3	25	LNT P250-2	50	Al. Plate	

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
192	Light Freezing Rain	-3	25	LNT P250-2	50	Al. Plate	PHOTOS
193	Cold Soak Box	1	5	Clariant Max Flight Sneg	100	Al. Box	PHOTOS
194	Cold Soak Box	1	5	Clariant Max Flight Sneg	100	Al. Box	
195	Cold Soak Box	1	5	Newave FCY 9311	100	Al. Box	
196	Cold Soak Box	1	5	Newave FCY 9311	100	Al. Box	
197	Cold Soak Box	1	5	LNT P250-2	100	Al. Box	PHOTOS
198	Cold Soak Box	1	5	LNT P250-2	100	Al. Box	
199	Cold Soak Box	1	5	Clariant Max Flight Sneg	75	Al. Box	PHOTOS
200	Cold Soak Box	1	5	Clariant Max Flight Sneg	75	Al. Box	
201	Cold Soak Box	1	5	Newave FCY 9311	75	Al. Box	
202	Cold Soak Box	1	5	Newave FCY 9311	75	Al. Box	
203	Cold Soak Box	1	5	LNT P250-2	75	Al. Box	PHOTOS
204	Cold Soak Box	1	5	LNT P250-2	75	Al. Box	
205	Cold Soak Box	1	75	Clariant Max Flight Sneg	100	Al. Box	PHOTOS
206	Cold Soak Box	1	75	Clariant Max Flight Sneg	100	Al. Box	
207	Cold Soak Box	1	75	Newave FCY 9311	100	Al. Box	
208	Cold Soak Box	1	75	Newave FCY 9311	100	Al. Box	
209	Cold Soak Box	1	75	LNT P250-2	100	Al. Box	PHOTOS
210	Cold Soak Box	1	75	LNT P250-2	100	Al. Box	
211	Cold Soak Box	1	75	Clariant Max Flight Sneg	75	Al. Box	PHOTOS
212	Cold Soak Box	1	75	Clariant Max Flight Sneg	75	Al. Box	
213	Cold Soak Box	1	75	Newave FCY 9311	75	Al. Box	
214	Cold Soak Box	1	75	Newave FCY 9311	75	Al. Box	
215	Cold Soak Box	1	75	LNT P250-2	75	Al. Box	PHOTOS
216	Cold Soak Box	1	75	LNT P250-2	75	Al. Box	

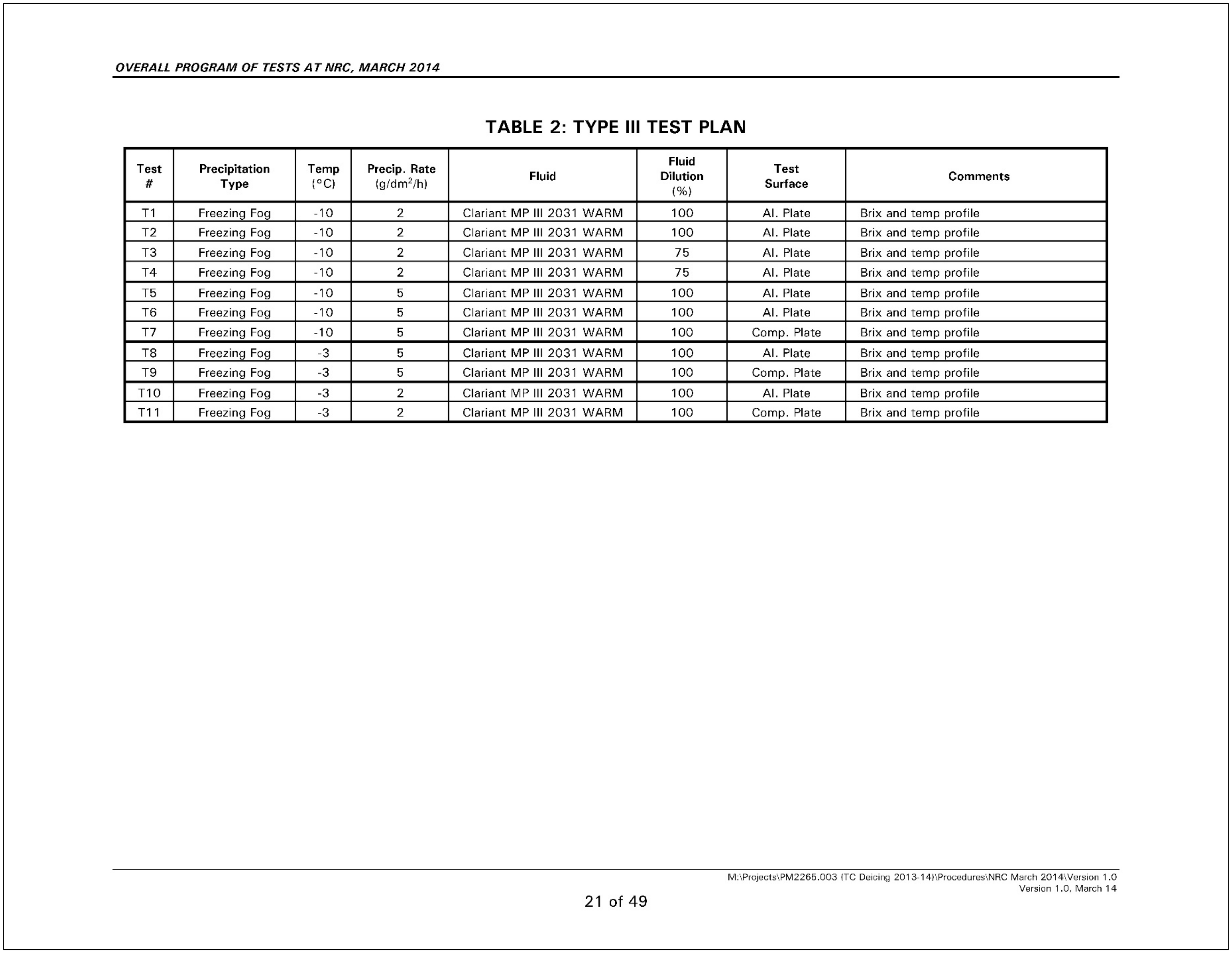


TABLE 2: TYPE III TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm^2/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
T1	Freezing Fog	-10	2	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T2	Freezing Fog	-10	2	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T3	Freezing Fog	-10	2	Clariant MP III 2031 WARM	75	Al. Plate	Brix and temp profile
T4	Freezing Fog	-10	2	Clariant MP III 2031 WARM	75	Al. Plate	Brix and temp profile
T5	Freezing Fog	-10	5	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T6	Freezing Fog	-10	5	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T7	Freezing Fog	-10	5	Clariant MP III 2031 WARM	100	Comp. Plate	Brix and temp profile
T8	Freezing Fog	-3	5	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T9	Freezing Fog	-3	5	Clariant MP III 2031 WARM	100	Comp. Plate	Brix and temp profile
T10	Freezing Fog	-3	2	Clariant MP III 2031 WARM	100	Al. Plate	Brix and temp profile
T11	Freezing Fog	-3	2	Clariant MP III 2031 WARM	100	Comp. Plate	Brix and temp profile

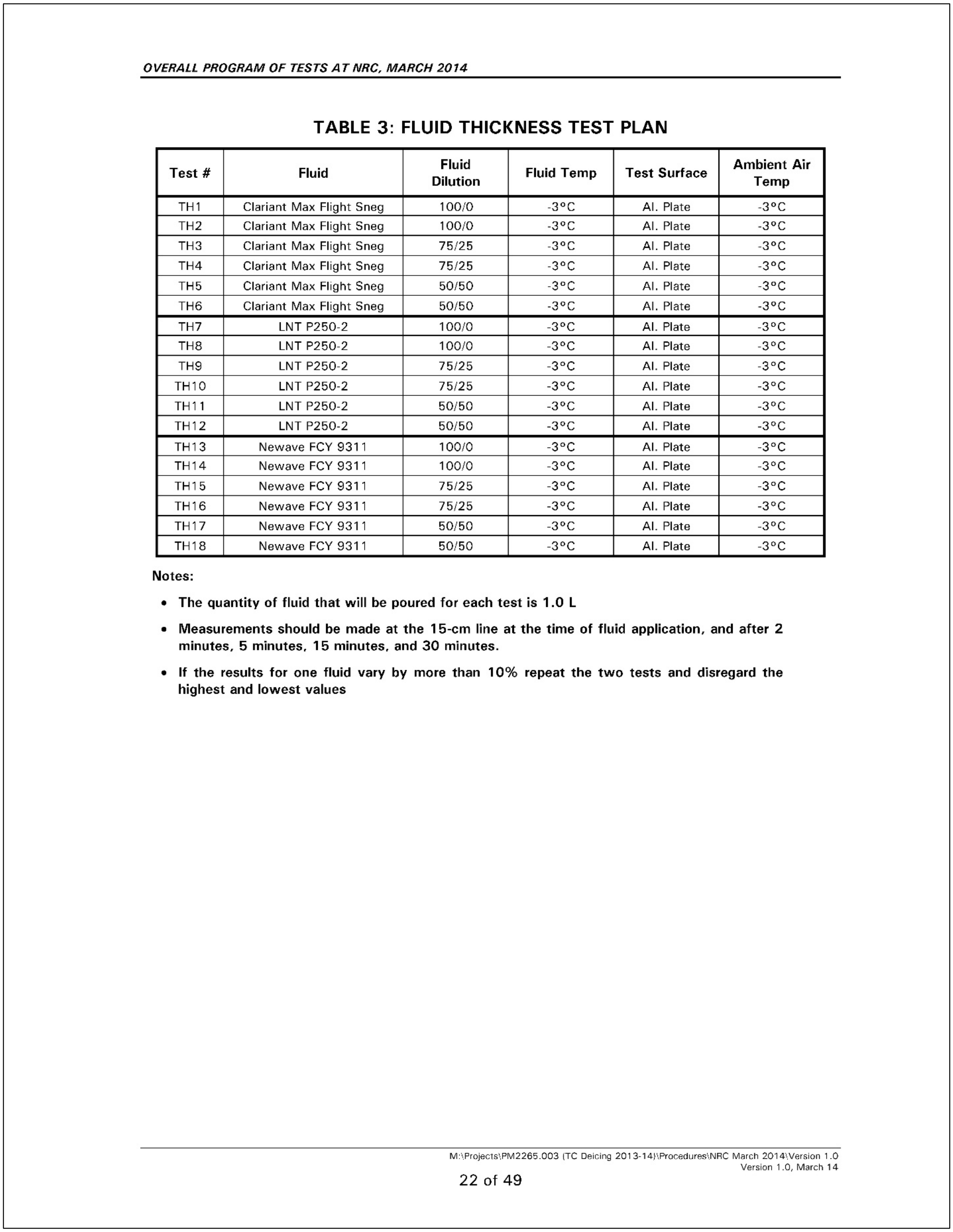


TABLE 3: FLUID THICKNESS TEST PLAN

Test #	Fluid	Fluid Dilution	Fluid Temp	Test Surface	Ambient Air Temp
TH1	Clariant Max Flight Sneg	100/0	-3°C	Al. Plate	-3°C
TH2	Clariant Max Flight Sneg	100/0	-3°C	Al. Plate	-3°C
TH3	Clariant Max Flight Sneg	75/25	-3°C	Al. Plate	-3°C
TH4	Clariant Max Flight Sneg	75/25	-3°C	Al. Plate	-3°C
TH5	Clariant Max Flight Sneg	50/50	-3°C	Al. Plate	-3°C
TH6	Clariant Max Flight Sneg	50/50	-3°C	Al. Plate	-3°C
TH7	LNT P250-2	100/0	-3°C	Al. Plate	-3°C
TH8	LNT P250-2	100/0	-3°C	Al. Plate	-3°C
TH9	LNT P250-2	75/25	-3°C	Al. Plate	-3°C
TH10	LNT P250-2	75/25	-3°C	Al. Plate	-3°C
TH11	LNT P250-2	50/50	-3°C	Al. Plate	-3°C
TH12	LNT P250-2	50/50	-3°C	Al. Plate	-3°C
TH13	Newave FCY 9311	100/0	-3°C	Al. Plate	-3°C
TH14	Newave FCY 9311	100/0	-3°C	Al. Plate	-3°C
TH15	Newave FCY 9311	75/25	-3°C	Al. Plate	-3°C
TH16	Newave FCY 9311	75/25	-3°C	Al. Plate	-3°C
TH17	Newave FCY 9311	50/50	-3°C	Al. Plate	-3°C
TH18	Newave FCY 9311	50/50	-3°C	Al. Plate	-3°C

Notes:

- **The quantity of fluid that will be poured for each test is 1.0 L**
- **Measurements should be made at the 15-cm line at the time of fluid application, and after 2 minutes, 5 minutes, 15 minutes, and 30 minutes.**
- **If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values**

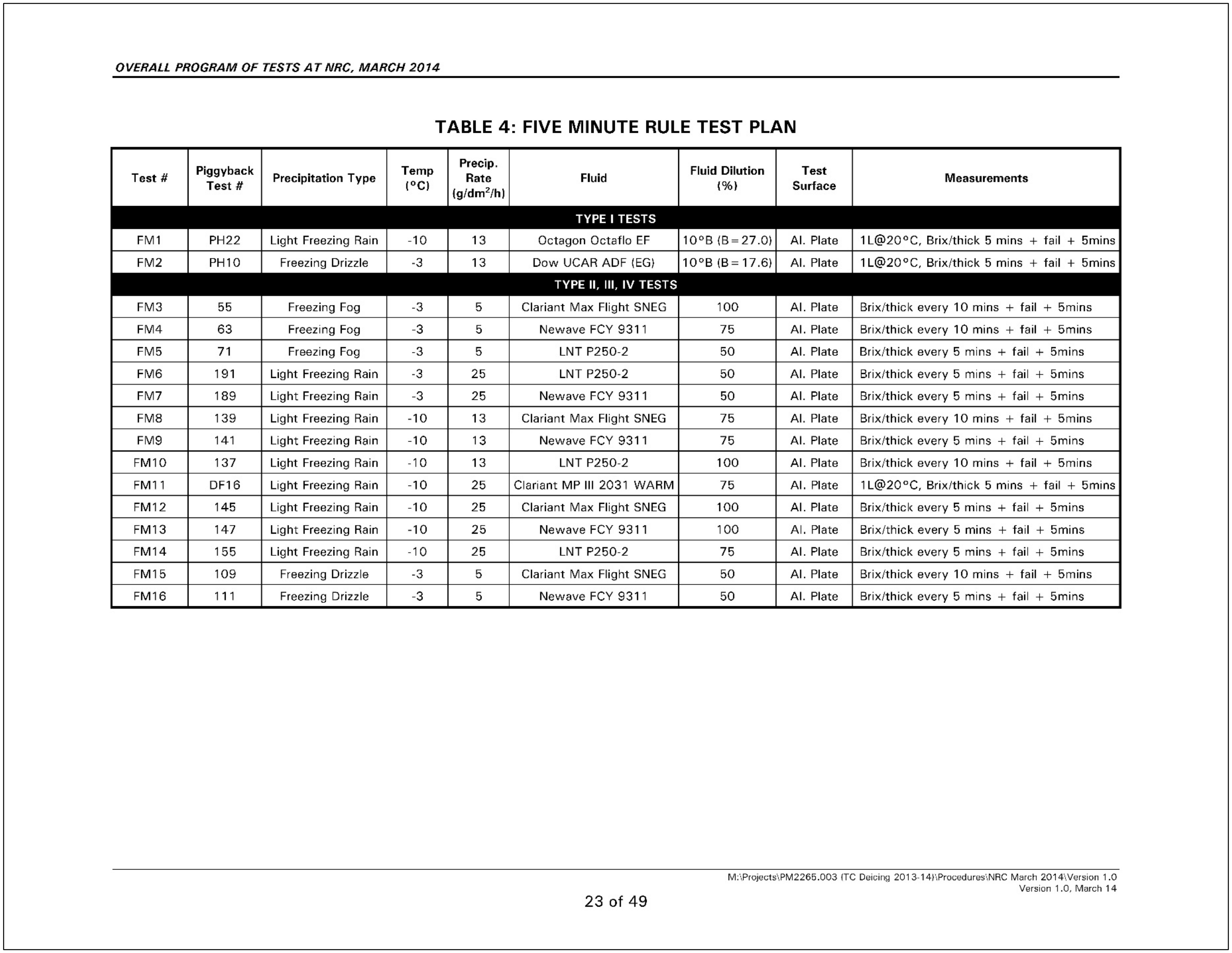
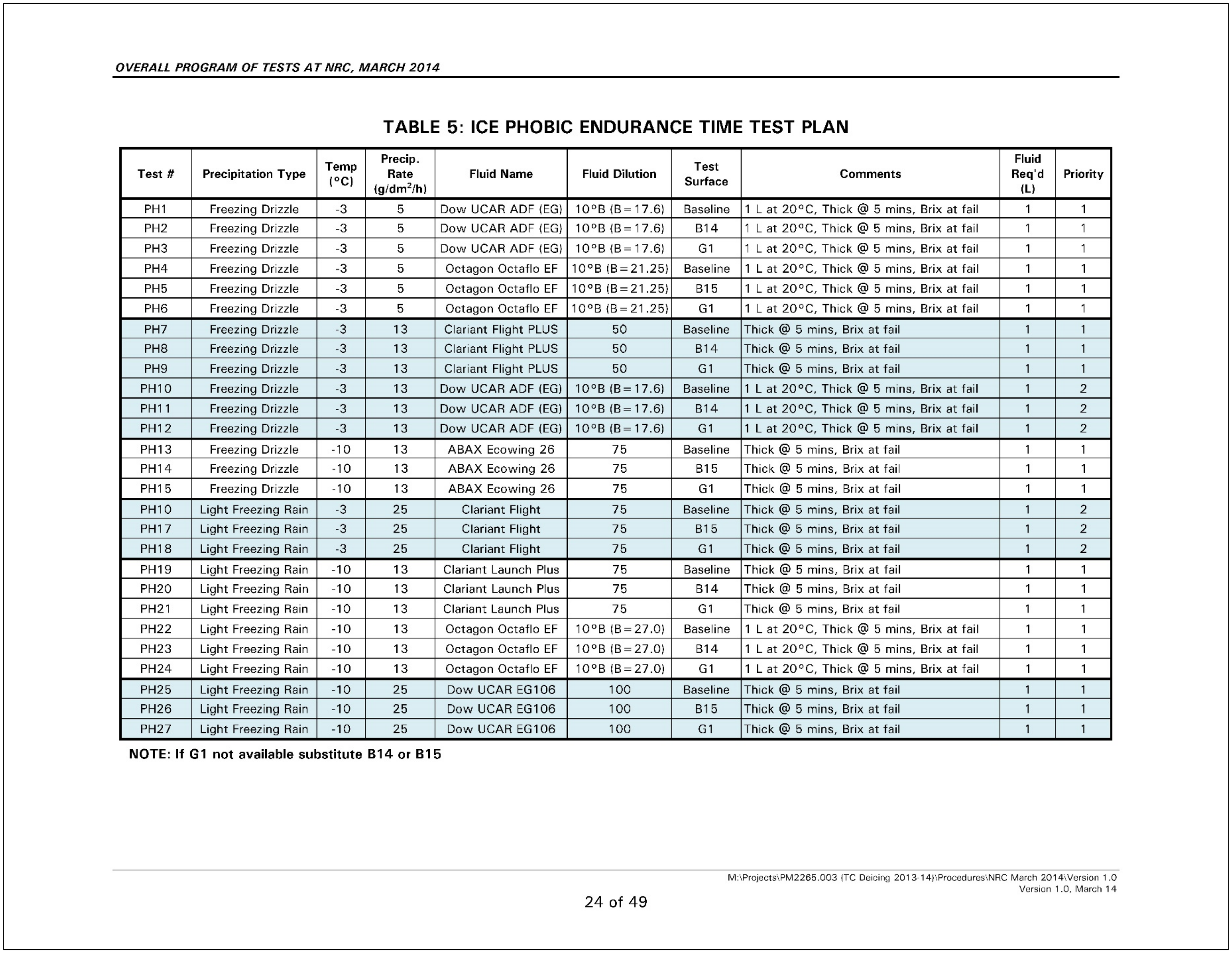


TABLE 4: FIVE MINUTE RULE TEST PLAN

Test #	Piggyback Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm^2/h)	Fluid	Fluid Dilution (%)	Test Surface	Measurements
TYPE I TESTS								
FM1	PH22	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	Al. Plate	1L@20°C, Brix/thick 5 mins + fail + 5mins
FM2	PH10	Freezing Drizzle	-3	13	Dow UCAR ADF (EG)	10°B (B=17.6)	Al. Plate	1L@20°C, Brix/thick 5 mins + fail + 5mins
TYPE II, III, IV TESTS								
FM3	55	Freezing Fog	-3	5	Clariant Max Flight SNEG	100	Al. Plate	Brix/thick every 10 mins + fail + 5mins
FM4	63	Freezing Fog	-3	5	Newave FCY 9311	75	Al. Plate	Brix/thick every 10 mins + fail + 5mins
FM5	71	Freezing Fog	-3	5	LNT P250-2	50	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM6	191	Light Freezing Rain	-3	25	LNT P250-2	50	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM7	189	Light Freezing Rain	-3	25	Newave FCY 9311	50	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM8	139	Light Freezing Rain	-10	13	Clariant Max Flight SNEG	75	Al. Plate	Brix/thick every 10 mins + fail + 5mins
FM9	141	Light Freezing Rain	-10	13	Newave FCY 9311	75	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM10	137	Light Freezing Rain	-10	13	LNT P250-2	100	Al. Plate	Brix/thick every 10 mins + fail + 5mins
FM11	DF16	Light Freezing Rain	-10	25	Clariant MP III 2031 WARM	75	Al. Plate	1L@20°C, Brix/thick 5 mins + fail + 5mins
FM12	145	Light Freezing Rain	-10	25	Clariant Max Flight SNEG	100	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM13	147	Light Freezing Rain	-10	25	Newave FCY 9311	100	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM14	155	Light Freezing Rain	-10	25	LNT P250-2	75	Al. Plate	Brix/thick every 5 mins + fail + 5mins
FM15	109	Freezing Drizzle	-3	5	Clariant Max Flight SNEG	50	Al. Plate	Brix/thick every 10 mins + fail + 5mins
FM16	111	Freezing Drizzle	-3	5	Newave FCY 9311	50	Al. Plate	Brix/thick every 5 mins + fail + 5mins



OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

TABLE 5: ICE PHOBIC ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution	Test Surface	Comments	Fluid Req'd (L)	Priority
PH1	Freezing Drizzle	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH2	Freezing Drizzle	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	B14	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH3	Freezing Drizzle	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	G1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH4	Freezing Drizzle	-3	5	Octagon Octaflo EF	10°B (B=21.25)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH5	Freezing Drizzle	-3	5	Octagon Octaflo EF	10°B (B=21.25)	B15	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH6	Freezing Drizzle	-3	5	Octagon Octaflo EF	10°B (B=21.25)	G1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH7	Freezing Drizzle	-3	13	Clariant Flight PLUS	50	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH8	Freezing Drizzle	-3	13	Clariant Flight PLUS	50	B14	Thick @ 5 mins, Brix at fail	1	1
PH9	Freezing Drizzle	-3	13	Clariant Flight PLUS	50	G1	Thick @ 5 mins, Brix at fail	1	1
PH10	Freezing Drizzle	-3	13	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH11	Freezing Drizzle	-3	13	Dow UCAR ADF (EG)	10°B (B=17.6)	B14	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH12	Freezing Drizzle	-3	13	Dow UCAR ADF (EG)	10°B (B=17.6)	G1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH13	Freezing Drizzle	-10	13	ABAX Ecowing 26	75	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH14	Freezing Drizzle	-10	13	ABAX Ecowing 26	75	B15	Thick @ 5 mins, Brix at fail	1	1
PH15	Freezing Drizzle	-10	13	ABAX Ecowing 26	75	G1	Thick @ 5 mins, Brix at fail	1	1
PH10	Light Freezing Rain	-3	25	Clariant Flight	75	Baseline	Thick @ 5 mins, Brix at fail	1	2
PH17	Light Freezing Rain	-3	25	Clariant Flight	75	B15	Thick @ 5 mins, Brix at fail	1	2
PH18	Light Freezing Rain	-3	25	Clariant Flight	75	G1	Thick @ 5 mins, Brix at fail	1	2
PH19	Light Freezing Rain	-10	13	Clariant Launch Plus	75	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH20	Light Freezing Rain	-10	13	Clariant Launch Plus	75	B14	Thick @ 5 mins, Brix at fail	1	1
PH21	Light Freezing Rain	-10	13	Clariant Launch Plus	75	G1	Thick @ 5 mins, Brix at fail	1	1
PH22	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH23	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	B14	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH24	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	G1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH25	Light Freezing Rain	-10	25	Dow UCAR EG106	100	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH26	Light Freezing Rain	-10	25	Dow UCAR EG106	100	B15	Thick @ 5 mins, Brix at fail	1	1
PH27	Light Freezing Rain	-10	25	Dow UCAR EG106	100	G1	Thick @ 5 mins, Brix at fail	1	1

NOTE: If G1 not available substitute B14 or B15

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

24 of 49

TABLE 6: ICE PHOBIC THICKNESS TEST PLAN

Test #	Priority	Fluid Name	Fluid Type	Fluid Dilution	Test Surface Treatment*	Ambient Air Temperature
PH-TH1	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	Baseline	-3°C
PH-TH2	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	B14	-3°C
PH-TH3	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	B15	-3°C
PH-TH4	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	G1	-3°C
PH-TH5	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	Baseline	-3°C
PH-TH6	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	B14	-3°C
PH-TH7	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	B15	-3°C
PH-TH8	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	G1	-3°C
PH-TH9	1	Clariant Max Flight Sneg	Type IV PG	100	Baseline	-3°C
PH-TH10	1	Clariant Max Flight Sneg	Type IV PG	100	B14	-3°C
PH-TH11	1	Clariant Max Flight Sneg	Type IV PG	100	B15	-3°C
PH-TH12	1	Clariant Max Flight Sneg	Type IV PG	100	G1	-3°C

Procedure: Measure thickness (TII) at 15 cm line or % wetted (TI) at application and 2, 5, 15, and 30 minutes after pouring

TABLE 7: ICE PHOBIC ADHERENCE TEST PLAN

Test #	Priority	Precipitation Type	Temp (°C)	Precip. Rate (g/dm^2/h)	Fluid	Fluid Dilution	Test Surface	Comments
PH-AD1	1	Light Freezing Rain	-10	13	No fluid	n/a	Baseline	Measure time of adherence
PH-AD2	1	Light Freezing Rain	-10	13	No fluid	n/a	B14	Measure time of adherence
PH-AD3	1	Light Freezing Rain	-10	13	No fluid	n/a	B15	Measure time of adherence
PH-AD4	1	Light Freezing Rain	-10	13	No fluid	n/a	G1	Measure time of adherence

TABLE 8: ICE PHOBIC HOT WATER TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm^2/h)	Fluid Name	Fluid Dilution (%)	Test Surface	Comments	Fluid Required (L)	Priority
PH-HW1	Freezing Fog	-10	2	Octagon Octaflo EF	10°B (B=27.0)	Baseline	Measure time of adherence	10	2
PH-HW2	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	B14	Measure time of adherence	10	2
PH-HW3	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	B15	Measure time of adherence	10	2
PH-HW4	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	G1	Measure time of adherence	10	2
PH-HW7	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	Baseline	Measure time of adherence	5	2
PH-HW8	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	B14	Measure time of adherence	5	2
PH-HW9	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	B15	Measure time of adherence	5	2
PH-HW9	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	G1	Measure time of adherence	5	2

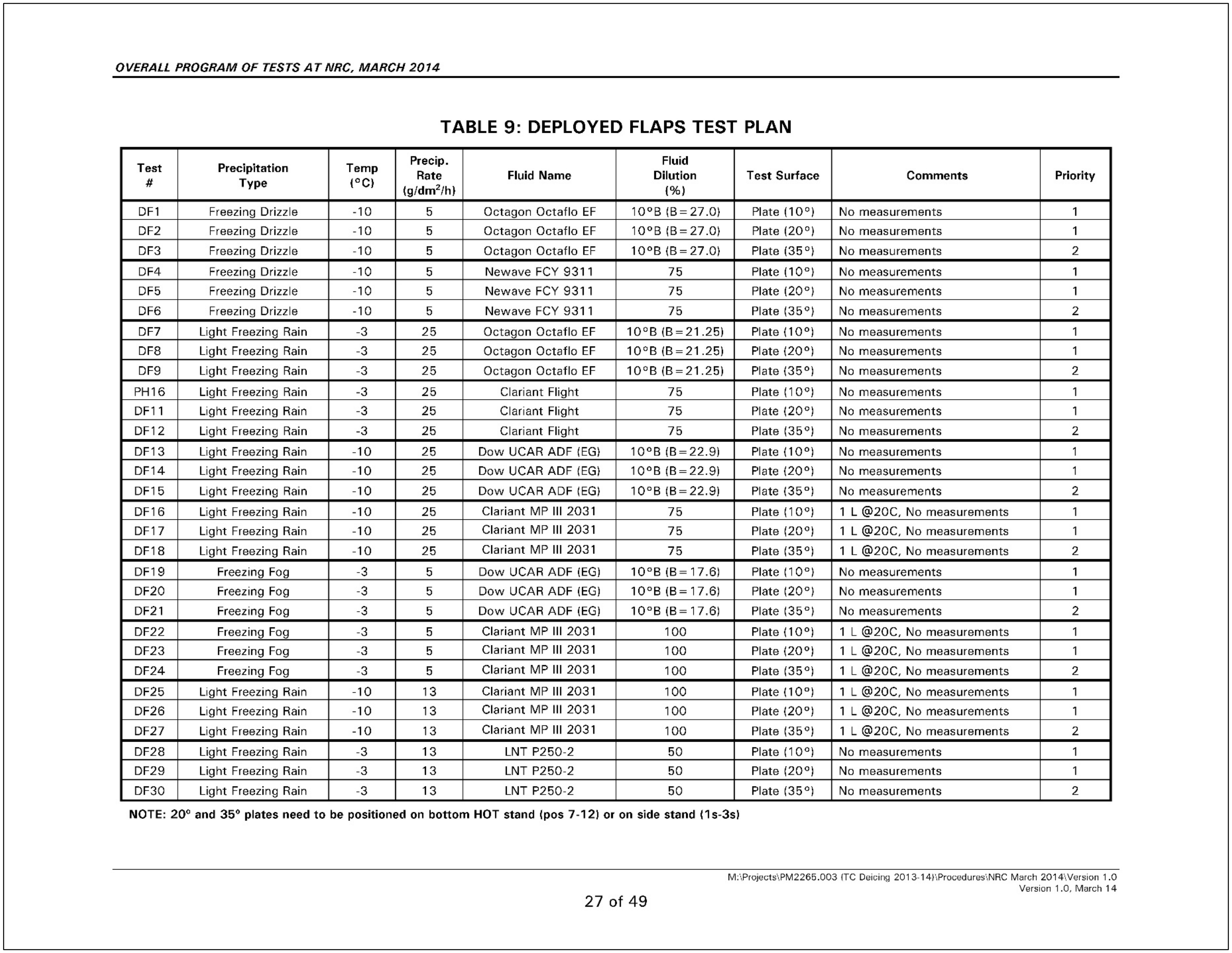


TABLE 9: DEPLOYED FLAPS TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution (%)	Test Surface	Comments	Priority
DF1	Freezing Drizzle	-10	5	Octagon Octaflo EF	10°B (B=27.0)	Plate (10°)	No measurements	1
DF2	Freezing Drizzle	-10	5	Octagon Octaflo EF	10°B (B=27.0)	Plate (20°)	No measurements	1
DF3	Freezing Drizzle	-10	5	Octagon Octaflo EF	10°B (B=27.0)	Plate (35°)	No measurements	2
DF4	Freezing Drizzle	-10	5	Newave FCY 9311	75	Plate (10°)	No measurements	1
DF5	Freezing Drizzle	-10	5	Newave FCY 9311	75	Plate (20°)	No measurements	1
DF6	Freezing Drizzle	-10	5	Newave FCY 9311	75	Plate (35°)	No measurements	2
DF7	Light Freezing Rain	-3	25	Octagon Octaflo EF	10°B (B=21.25)	Plate (10°)	No measurements	1
DF8	Light Freezing Rain	-3	25	Octagon Octaflo EF	10°B (B=21.25)	Plate (20°)	No measurements	1
DF9	Light Freezing Rain	-3	25	Octagon Octaflo EF	10°B (B=21.25)	Plate (35°)	No measurements	2
PH16	Light Freezing Rain	-3	25	Clariant Flight	75	Plate (10°)	No measurements	1
DF11	Light Freezing Rain	-3	25	Clariant Flight	75	Plate (20°)	No measurements	1
DF12	Light Freezing Rain	-3	25	Clariant Flight	75	Plate (35°)	No measurements	2
DF13	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10°B (B=22.9)	Plate (10°)	No measurements	1
DF14	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10°B (B=22.9)	Plate (20°)	No measurements	1
DF15	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10°B (B=22.9)	Plate (35°)	No measurements	2
DF16	Light Freezing Rain	-10	25	Clariant MP III 2031	75	Plate (10°)	1 L @20C, No measurements	1
DF17	Light Freezing Rain	-10	25	Clariant MP III 2031	75	Plate (20°)	1 L @20C, No measurements	1
DF18	Light Freezing Rain	-10	25	Clariant MP III 2031	75	Plate (35°)	1 L @20C, No measurements	2
DF19	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	Plate (10°)	No measurements	1
DF20	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	Plate (20°)	No measurements	1
DF21	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	Plate (35°)	No measurements	2
DF22	Freezing Fog	-3	5	Clariant MP III 2031	100	Plate (10°)	1 L @20C, No measurements	1
DF23	Freezing Fog	-3	5	Clariant MP III 2031	100	Plate (20°)	1 L @20C, No measurements	1
DF24	Freezing Fog	-3	5	Clariant MP III 2031	100	Plate (35°)	1 L @20C, No measurements	2
DF25	Light Freezing Rain	-10	13	Clariant MP III 2031	100	Plate (10°)	1 L @20C, No measurements	1
DF26	Light Freezing Rain	-10	13	Clariant MP III 2031	100	Plate (20°)	1 L @20C, No measurements	1
DF27	Light Freezing Rain	-10	13	Clariant MP III 2031	100	Plate (35°)	1 L @20C, No measurements	2
DF28	Light Freezing Rain	-3	13	LNT P250-2	50	Plate (10°)	No measurements	1
DF29	Light Freezing Rain	-3	13	LNT P250-2	50	Plate (20°)	No measurements	1
DF30	Light Freezing Rain	-3	13	LNT P250-2	50	Plate (35°)	No measurements	2

NOTE: 20° and 35° plates need to be positioned on bottom HOT stand (pos 7-12) or on side stand (1s-3s)

TABLE 10: FLAPS/SLATS EXTENSION TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dil. (%)	Test Surface	Comments	Fluid Required (L)	Priority
FSE1	Freezing Drizzle	-3	5	Newave FCY 9311	50	Plate (10°)	Thickness at 5 mins, Brix at fail	1	1
FSE2	Freezing Drizzle	-3	5	Newave FCY 9311	50	2 Plates (20°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE3	Freezing Drizzle	-3	5	Newave FCY 9311	50	2 Plates (20°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE4	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	50	Plate (10°)	Thickness at 5 mins, Brix at fail	1	1
FSE5	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	50	2 Plates (20°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE6	Freezing Drizzle	-3	13	Clariant Max Flight Sneg	50	2 Plates (20°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE7	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	100	Plate (10°)	Thickness at 5 mins, Brix at fail	1	1
FSE8	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	100	2 Plates (20°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE9	Freezing Drizzle	-10	13	Clariant Max Flight Sneg	100	2 Plates (20°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE10	Freezing Drizzle	-10	13	Octagon Octaflo EF	10°B (B=27.0)	Plate (10°)	Thickness at 5 mins, Brix at fail	1	2
FSE11	Freezing Drizzle	-10	13	Octagon Octaflo EF	10°B (B=27.0)	2 Plates (35°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE12	Freezing Drizzle	-10	13	Octagon Octaflo EF	10°B (B=27.0)	2 Plates (35°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE13	Light Freezing Rain	-10	25	Clariant MP III 2031 WARM	100	Plate (10°)	Thickness at 5 mins, Brix at fail	1	2
FSE14	Light Freezing Rain	-10	25	Clariant MP III 2031 WARM	100	2 Plates (35°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE15	Light Freezing Rain	-10	25	Clariant MP III 2031 WARM	100	2 Plates (35°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE16	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	75	Plate (10°)	Thickness at 5 mins, Brix at fail	1	2
FSE17	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	75	2 Plates (35°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE18	Light Freezing Rain	-10	25	Clariant Max Flight Sneg	75	2 Plates (35°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	2
FSE19	Freezing Fog	-14	5	LNT P250-2	75	Plate (10°)	Thickness at 5 mins, Brix at fail	1	1
FSE20	Freezing Fog	-14	5	LNT P250-2	75	2 Plates (20°) Slat	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1
FSE21	Freezing Fog	-14	5	LNT P250-2	75	2 Plates (20°) Flap	Extend after 5-10min; thick at 5 mins, Brix at fail	1.5	1

NOTE 1: 2 plates used. 1 on top of other at 10° to start (with overlap), then split into 10° and 20/35°

NOTE 2: Consider deicing with 1 litre standard mix Type I, holding for 1 minute, then applying Type IV

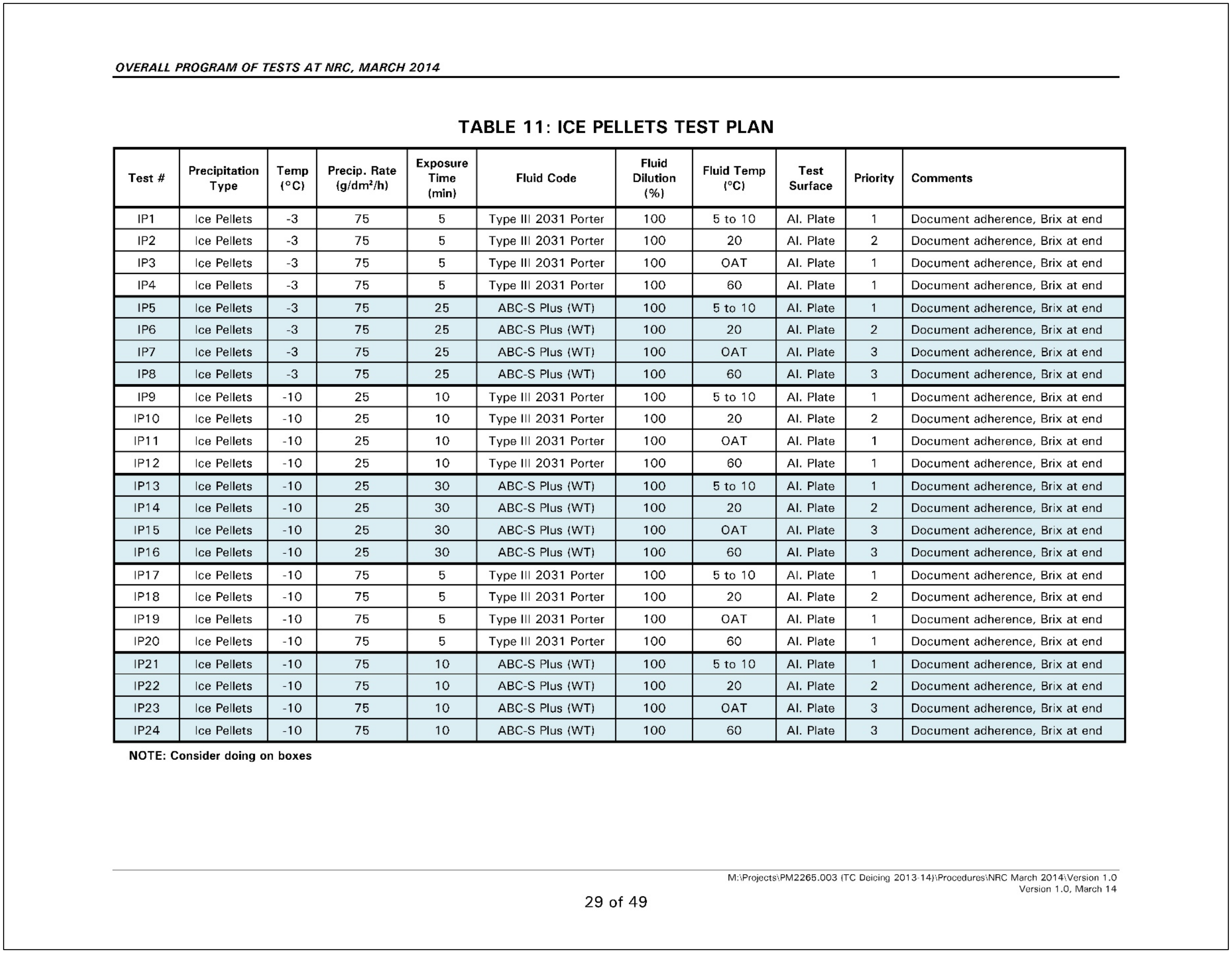


TABLE 11: ICE PELLETS TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Exposure Time (min)	Fluid Code	Fluid Dilution (%)	Fluid Temp (°C)	Test Surface	Priority	Comments
IP1	Ice Pellets	-3	75	5	Type III 2031 Porter	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP2	Ice Pellets	-3	75	5	Type III 2031 Porter	100	20	Al. Plate	2	Document adherence, Brix at end
IP3	Ice Pellets	-3	75	5	Type III 2031 Porter	100	OAT	Al. Plate	1	Document adherence, Brix at end
IP4	Ice Pellets	-3	75	5	Type III 2031 Porter	100	60	Al. Plate	1	Document adherence, Brix at end
IP5	Ice Pellets	-3	75	25	ABC-S Plus (WT)	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP6	Ice Pellets	-3	75	25	ABC-S Plus (WT)	100	20	Al. Plate	2	Document adherence, Brix at end
IP7	Ice Pellets	-3	75	25	ABC-S Plus (WT)	100	OAT	Al. Plate	3	Document adherence, Brix at end
IP8	Ice Pellets	-3	75	25	ABC-S Plus (WT)	100	60	Al. Plate	3	Document adherence, Brix at end
IP9	Ice Pellets	-10	25	10	Type III 2031 Porter	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP10	Ice Pellets	-10	25	10	Type III 2031 Porter	100	20	Al. Plate	2	Document adherence, Brix at end
IP11	Ice Pellets	-10	25	10	Type III 2031 Porter	100	OAT	Al. Plate	1	Document adherence, Brix at end
IP12	Ice Pellets	-10	25	10	Type III 2031 Porter	100	60	Al. Plate	1	Document adherence, Brix at end
IP13	Ice Pellets	-10	25	30	ABC-S Plus (WT)	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP14	Ice Pellets	-10	25	30	ABC-S Plus (WT)	100	20	Al. Plate	2	Document adherence, Brix at end
IP15	Ice Pellets	-10	25	30	ABC-S Plus (WT)	100	OAT	Al. Plate	3	Document adherence, Brix at end
IP16	Ice Pellets	-10	25	30	ABC-S Plus (WT)	100	60	Al. Plate	3	Document adherence, Brix at end
IP17	Ice Pellets	-10	75	5	Type III 2031 Porter	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP18	Ice Pellets	-10	75	5	Type III 2031 Porter	100	20	Al. Plate	2	Document adherence, Brix at end
IP19	Ice Pellets	-10	75	5	Type III 2031 Porter	100	OAT	Al. Plate	1	Document adherence, Brix at end
IP20	Ice Pellets	-10	75	5	Type III 2031 Porter	100	60	Al. Plate	1	Document adherence, Brix at end
IP21	Ice Pellets	-10	75	10	ABC-S Plus (WT)	100	5 to 10	Al. Plate	1	Document adherence, Brix at end
IP22	Ice Pellets	-10	75	10	ABC-S Plus (WT)	100	20	Al. Plate	2	Document adherence, Brix at end
IP23	Ice Pellets	-10	75	10	ABC-S Plus (WT)	100	OAT	Al. Plate	3	Document adherence, Brix at end
IP24	Ice Pellets	-10	75	10	ABC-S Plus (WT)	100	60	Al. Plate	3	Document adherence, Brix at end

NOTE: Consider doing on boxes

TABLE 12: WINDSHIELD WASHER FLUID TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm^2/h)	Fluid	Fluid Dilution (%)	Test Surface
WWF1	Freezing Fog	-3	2	Octagon Octaflo EF	10°B (B=21.25)	Al. Plate
WWF2	Freezing Fog	-3	2	WWF	undiluted	Al. Plate
WWF3	Freezing Fog	-3	2	Isopropyl Alcohol	99%	Al. Plate
WWF4	Freezing Fog	-10	5	Dow UCAR ADF (EG)	10°B (B=22.9)	Al. Plate
WWF5	Freezing Fog	-10	5	WWF	undiluted	Al. Plate
WWF6	Freezing Fog	-10	5	Isopropyl Alcohol	99%	Al. Plate
WWF7	Freezing Fog	-14	5	Octagon Octaflo EF	10°B (B=29.5)	Al. Plate
WWF8	Freezing Fog	-14	5	WWF	undiluted	Al. Plate
WWF9	Freezing Fog	-14	5	Isopropyl Alcohol	99%	Al. Plate
WWF10	Freezing Fog	-25	5	Dow UCAR ADF (EG)	10°B (B=30.5)	Al. Plate
WWF11	Freezing Fog	-25	5	WWF	undiluted	Al. Plate
WWF12	Freezing Fog	-25	5	Isopropyl Alcohol	99%	Al. Plate

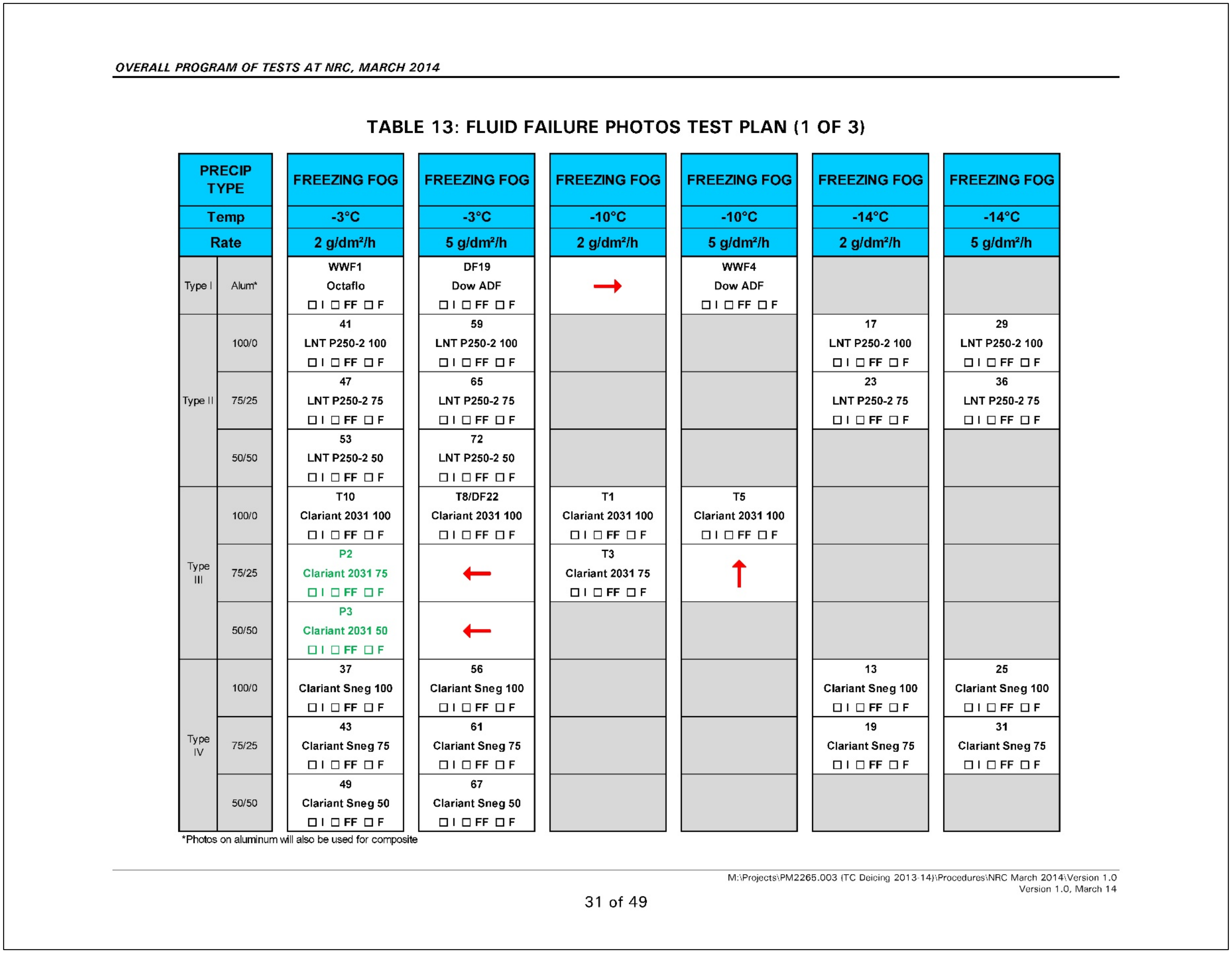


TABLE 13: FLUID FAILURE PHOTOS TEST PLAN (1 OF 3)

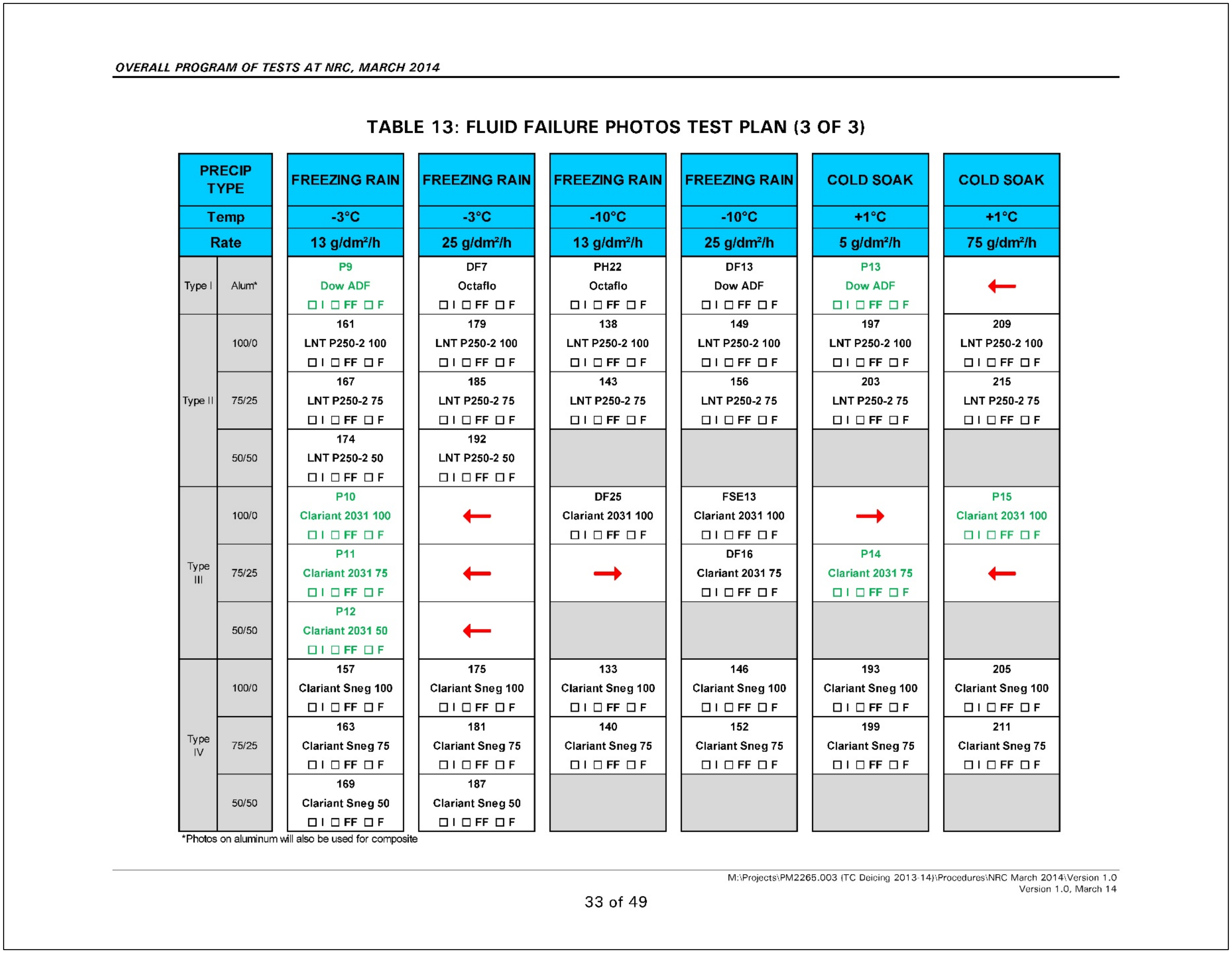
PRECIP TYPE		FREEZING FOG	FREEZING FOG	FREEZING FOG	FREEZING FOG	FREEZING FOG	FREEZING FOG
Temp		-3°C	-3°C	-10°C	-10°C	-14°C	-14°C
Rate		2 g/dm²/h	5 g/dm²/h	2 g/dm²/h	5 g/dm²/h	2 g/dm²/h	5 g/dm²/h
Type I	Alum*	WWF1 Octaflo ☐ I ☐ FF ☐ F	DF19 Dow ADF ☐ I ☐ FF ☐ F	→	WWF4 Dow ADF ☐ I ☐ FF ☐ F		
Type II	100/0	41 LNT P250-2 100 ☐ I ☐ FF ☐ F	59 LNT P250-2 100 ☐ I ☐ FF ☐ F			17 LNT P250-2 100 ☐ I ☐ FF ☐ F	29 LNT P250-2 100 ☐ I ☐ FF ☐ F
	75/25	47 LNT P250-2 75 ☐ I ☐ FF ☐ F	65 LNT P250-2 75 ☐ I ☐ FF ☐ F			23 LNT P250-2 75 ☐ I ☐ FF ☐ F	36 LNT P250-2 75 ☐ I ☐ FF ☐ F
	50/50	53 LNT P250-2 50 ☐ I ☐ FF ☐ F	72 LNT P250-2 50 ☐ I ☐ FF ☐ F				
Type III	100/0	T10 Clariant 2031 100 ☐ I ☐ FF ☐ F	T8/DF22 Clariant 2031 100 ☐ I ☐ FF ☐ F	T1 Clariant 2031 100 ☐ I ☐ FF ☐ F	T5 Clariant 2031 100 ☐ I ☐ FF ☐ F		
	75/25	P2 Clariant 2031 75 ☐ I ☐ FF ☐ F	←	T3 Clariant 2031 75 ☐ I ☐ FF ☐ F	↑		
	50/50	P3 Clariant 2031 50 ☐ I ☐ FF ☐ F	←				
Type IV	100/0	37 Clariant Sneg 100 ☐ I ☐ FF ☐ F	56 Clariant Sneg 100 ☐ I ☐ FF ☐ F			13 Clariant Sneg 100 ☐ I ☐ FF ☐ F	25 Clariant Sneg 100 ☐ I ☐ FF ☐ F
	75/25	43 Clariant Sneg 75 ☐ I ☐ FF ☐ F	61 Clariant Sneg 75 ☐ I ☐ FF ☐ F			19 Clariant Sneg 75 ☐ I ☐ FF ☐ F	31 Clariant Sneg 75 ☐ I ☐ FF ☐ F
	50/50	49 Clariant Sneg 50 ☐ I ☐ FF ☐ F	67 Clariant Sneg 50 ☐ I ☐ FF ☐ F				

*Photos on aluminum will also be used for composite

TABLE 13: FLUID FAILURE PHOTOS TEST PLAN (2 OF 3)

PRECIP TYPE		FREEZING FOG	FREEZING FOG	FREEZING DRIZZLE	FREEZING DRIZZLE	FREEZING DRIZZLE	FREEZING DRIZZLE
Temp		-25°C	-25°C	-3°C	-3°C	-10°C	-10°C
Rate		2 $g/dm^2/h$	5 $g/dm^2/h$	5 $g/dm^2/h$	13 $g/dm^2/h$	5 $g/dm^2/h$	13 $g/dm^2/h$
Type I	Alum*	→	WWF10 Dow ADF ☐ I ☐ FF ☐ F	→	PH10/FM2 Dow ADF ☐ I ☐ FF ☐ F	DF1 Octaflo ☐ I ☐ FF ☐ F	FSE10 Octaflo ☐ I ☐ FF ☐ F
Type II	100/0	5 LNT P250-2 100 ☐ I ☐ FF ☐ F	11 LNT P250-2 100 ☐ I ☐ FF ☐ F	101 LNT P250-2 100 ☐ I ☐ FF ☐ F	119 LNT P250-2 100 ☐ I ☐ FF ☐ F	77 LNT P250-2 100 ☐ I ☐ FF ☐ F	89 LNT P250-2 100 ☐ I ☐ FF ☐ F
	75/25			107 LNT P250-2 75 ☐ I ☐ FF ☐ F	125 LNT P250-2 75 ☐ I ☐ FF ☐ F	83 LNT P250-2 75 ☐ I ☐ FF ☐ F	95 LNT P250-2 75 ☐ I ☐ FF ☐ F
	50/50			113 LNT P250-2 50 ☐ I ☐ FF ☐ F	131 LNT P250-2 50 ☐ I ☐ FF ☐ F	n/a	n/a
Type III	100/0	→	P1 Clariant 2031 100 ☐ I ☐ FF ☐ F	P4 Clariant 2031 100 ☐ I ☐ FF ☐ F	←	→	P7 Clariant 2031 100 ☐ I ☐ FF ☐ F
	75/25			→	P6 Clariant 2031 75 ☐ I ☐ FF ☐ F	→	P8 Clariant 2031 75 ☐ I ☐ FF ☐ F
	50/50			P5 Clariant 2031 50 ☐ I ☐ FF ☐ F	←	n/a	n/a
Type IV	100/0	1 Clariant Sneg 100 ☐ I ☐ FF ☐ F	7 Clariant Sneg 100 ☐ I ☐ FF ☐ F	97 Clariant Sneg 100 ☐ I ☐ FF ☐ F	115 Clariant Sneg 100 ☐ I ☐ FF ☐ F	73 Clariant Sneg 100 ☐ I ☐ FF ☐ F	86 Clariant Sneg 100 ☐ I ☐ FF ☐ F
	75/25			103 Clariant Sneg 75 ☐ I ☐ FF ☐ F	121 Clariant Sneg 75 ☐ I ☐ FF ☐ F	79 Clariant Sneg 75 ☐ I ☐ FF ☐ F	91 Clariant Sneg 75 ☐ I ☐ FF ☐ F
	50/50			110 Clariant Sneg 50 ☐ I ☐ FF ☐ F	128 Clariant Sneg 50 ☐ I ☐ FF ☐ F	n/a	n/a

*Photos on aluminum will also be used for composite



OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

TABLE 13: FLUID FAILURE PHOTOS TEST PLAN (3 OF 3)

PRECIP TYPE		FREEZING RAIN	FREEZING RAIN	FREEZING RAIN	FREEZING RAIN	COLD SOAK	COLD SOAK
Temp		-3°C	-3°C	-10°C	-10°C	+1°C	+1°C
Rate		13 g/dm²/h	25 g/dm²/h	13 g/dm²/h	25 g/dm²/h	5 g/dm²/h	75 g/dm²/h
Type I	Alum*	P9 Dow ADF ☐ I ☐ FF ☐ F	DF7 Octaflo ☐ I ☐ FF ☐ F	PH22 Octaflo ☐ I ☐ FF ☐ F	DF13 Dow ADF ☐ I ☐ FF ☐ F	P13 Dow ADF ☐ I ☐ FF ☐ F	←
Type II	100/0	161 LNT P250-2 100 ☐ I ☐ FF ☐ F	179 LNT P250-2 100 ☐ I ☐ FF ☐ F	138 LNT P250-2 100 ☐ I ☐ FF ☐ F	149 LNT P250-2 100 ☐ I ☐ FF ☐ F	197 LNT P250-2 100 ☐ I ☐ FF ☐ F	209 LNT P250-2 100 ☐ I ☐ FF ☐ F
	75/25	167 LNT P250-2 75 ☐ I ☐ FF ☐ F	185 LNT P250-2 75 ☐ I ☐ FF ☐ F	143 LNT P250-2 75 ☐ I ☐ FF ☐ F	156 LNT P250-2 75 ☐ I ☐ FF ☐ F	203 LNT P250-2 75 ☐ I ☐ FF ☐ F	215 LNT P250-2 75 ☐ I ☐ FF ☐ F
	50/50	174 LNT P250-2 50 ☐ I ☐ FF ☐ F	192 LNT P250-2 50 ☐ I ☐ FF ☐ F				
Type III	100/0	P10 Clariant 2031 100 ☐ I ☐ FF ☐ F	←	DF25 Clariant 2031 100 ☐ I ☐ FF ☐ F	FSE13 Clariant 2031 100 ☐ I ☐ FF ☐ F	→	P15 Clariant 2031 100 ☐ I ☐ FF ☐ F
	75/25	P11 Clariant 2031 75 ☐ I ☐ FF ☐ F	←	→	DF16 Clariant 2031 75 ☐ I ☐ FF ☐ F	P14 Clariant 2031 75 ☐ I ☐ FF ☐ F	←
	50/50	P12 Clariant 2031 50 ☐ I ☐ FF ☐ F	←				
Type IV	100/0	157 Clariant Sneg 100 ☐ I ☐ FF ☐ F	175 Clariant Sneg 100 ☐ I ☐ FF ☐ F	133 Clariant Sneg 100 ☐ I ☐ FF ☐ F	146 Clariant Sneg 100 ☐ I ☐ FF ☐ F	193 Clariant Sneg 100 ☐ I ☐ FF ☐ F	205 Clariant Sneg 100 ☐ I ☐ FF ☐ F
	75/25	163 Clariant Sneg 75 ☐ I ☐ FF ☐ F	181 Clariant Sneg 75 ☐ I ☐ FF ☐ F	140 Clariant Sneg 75 ☐ I ☐ FF ☐ F	152 Clariant Sneg 75 ☐ I ☐ FF ☐ F	199 Clariant Sneg 75 ☐ I ☐ FF ☐ F	211 Clariant Sneg 75 ☐ I ☐ FF ☐ F
	50/50	169 Clariant Sneg 50 ☐ I ☐ FF ☐ F	187 Clariant Sneg 50 ☐ I ☐ FF ☐ F				

*Photos on aluminum will also be used for composite

TABLE 14: LIST OF FLUIDS

Fluid	Batch #	Fluid Temp	Fluid Dil or Brix (FFP)	Litres Required per Project													Total Litres	Pour Bottles	Notes
				ET	TH	TIII	5-MIN	PH-ET	PH-TH	PH-AD	PH-HW	DF	FSE	IP	WWF	P			
Type II, IV (HOT)																			
LNT P250-2	C3/01/01	OAT	100	32	2	-	-	-	-	-	-	-	-	-	-	-	**34**	**8* + 2~**	**3 jugs****
LNT P250-2	C3/01/01	OAT	75	28	2	-	-	-	-	-	-	-	4	-	-	-	**34**	**8* + 2~**	**2 jugs****
LNT P250-2	C3/01/01	OAT	50	12	2	-	-	-	-	-	-	3	-	-	-	-	**17**	**8* + 2~**	**1 jug****
Newave FCY 9311	201311002LS	OAT	100	32	2	-	-	-	-	-	-	-	-	-	-	-	**34**	**8* + 2~**	**3 jugs****
Newave FCY 9311	201311002LS	OAT	75	28	2	-	-	-	-	-	-	3	-	-	-	-	**33**	**8* + 2~**	**2 jugs****
Newave FCY 9311	201311002LS	OAT	50	12	2	-	-	-	-	-	-	-	4	-	-	-	**18**	**8* + 2~**	**1 jug****
Clariant Max Flight Sneg	TV 534	OAT	100	32	2	-	-	-	-	-	-	-	4	-	-	-	**38**	**8* + 2~**	**3 jugs****
Clariant Max Flight Sneg	TV 534	OAT	75	28	2	-	-	-	-	-	-	-	4	-	-	-	**34**	**8* + 2~**	**2 jugs****
Clariant Max Flight Sneg	TV 534	OAT	50	12	2	-	-	-	4	-	-	-	4	-	-	-	**22**	**8* + 2~**	**1 jug****
Type II, III, IV (R&D)																			
Clariant Safewing 2031 LV	USHA035838	20°C	100	-	-	9	-	-	-	-	-	-	-	-	-	5	**14**	**2**	**consolidate in 1 jug**
Clariant Safewing 2031 LV	USHA035838	20°C	75	-	-	2	-	-	-	-	-	-	-	-	-	5	**7**	**2**	**consolidate in 1 jug**
Clariant Safewing 2031 LV	USHA035838	20°C	50	-	-	-	-	-	-	-	-	-	-	-	-	3	**3**	**2**	**1 jug**
Clariant Safewing 2031 PORTER	Porter	20°C	100	-	-	-	-	-	-	-	-	6	4	12	-	-	**22**	**4**	**2 jugs**
Clariant Safewing 2031 PORTER	Porter	20°C	75	-	-	-	-	-	-	-	-	3	-	-	-	-	**3**	**3**	**no jug, dilute B = 27.00**
ABAX Ecowing 26	L12 321	OAT	75	-	-	-	-	3	-	-	-	-	-	-	-	-	**3**	**3**	**no jug**
Clariant Safewing Flight	DEG4145318	OAT	75	-	-	-	-	3	-	-	-	3	-	-	-	-	**6**	**6**	**no jug**
Clariant Safewing Flight PLUS	TV513	OAT	50	-	-	-	-	3	-	-	-	-	-	-	-	-	**3**	**3**	**no jug**
Clariant Safewing Launch Plus	TV 523	OAT	75	-	-	-	-	3	-	-	-	-	-	-	-	-	**3**	**3**	**no jug**
Dow EG106	IJ0201GKDR	OAT	100	-	-	-	-	3	-	-	-	-	-	-	-	-	**3**	**3**	**no jug**
Kilfrost ABC-S Plus (WT)	WT-12.13	OAT	100	-	-	-	-	-	-	-	-	-	-	12	-	-	**12**	**2**	**1 jug**
Type I																			
Octagon Octaflo EF	WL 102009	20°C	21.25 (-13°C)	-	-	-	-	3	-	-	-	3	-	-	1	-	**7**	**3**	**1 jug conc. + 5L aquapak**
Octagon Octaflo EF	WL 102009	20°C	27.0 (-20°C)	-	-	-	-	3	-	-	2	3	4	-	-	-	**12**	**3**	**10L aquapak**
Octagon Octaflo EF	WL 102009	20°C	29.5 (-24°C)	-	-	-	-	-	-	-	-	-	-	-	1	-	**1**	**1**	-
Dow UCAR ADF (EG)	aeromag 2014	20°C	17.6 (-13°C)	-	-	-	-	6	4	-	-	3	-	-	-	2	**15**	**4**	**1 jug conc. + 12L aquapak**
Dow UCAR ADF (EG)	aeromag 2014	20°C	22.9 (-20°C)	-	-	-	-	-	-	-	-	3	-	-	1	-	**4**	**4**	-
Dow UCAR ADF (EG)	aeromag 2014	20°C	30.5 (-35°C)	-	-	-	-	-	4	-	-	-	-	-	1	-	**5**	**5**	-
All Fluids				**216**	**18**	**11**	**0**	**27**	**12**	**0**	**2**	**30**	**28**	**24**	**4**	**15**	**387**		

Notes
* pour bottles already exist at site, pack them
**2 pour bottles should be placed in a freezer set @ -5°C for fluid to be ready for the first test condition, 5 pour bottles are required for the LNT P-250-2 50/50
~ 2 pour bottles should be placed at the site for natural snow testing

🟧 Warm Storage Fluid
🟦 Cold Storage Fluid

TABLE 15: TYPE I DILUTION TABLES

Octagon Octaflo EF (PG)					
FFP (°C)	**Test Temp (10°B)**	**% Fluid**	**Brix**	**Glycol for 4 L**	**Water for 4 L**
-13	-3	32.0	21.25	1.3	2.7
-20	-10	43.0	27.0	1.7	2.3
-24	-14	47.0	29.50	1.9	2.1
-35	-25	56.0	34.50	2.2	1.8

Dow UCAR ADF (EG)					
FFP (°C)	**Test Temp (10°B)**	**% Fluid**	**Brix**	**Glycol for 4 L**	**Water for 4 L**
-13	-3	27.4	17.6	1.1	2.9
-20	-10	36.3	22.9	1.5	2.5
-35	-25	50.3	30.5	2.0	2.0

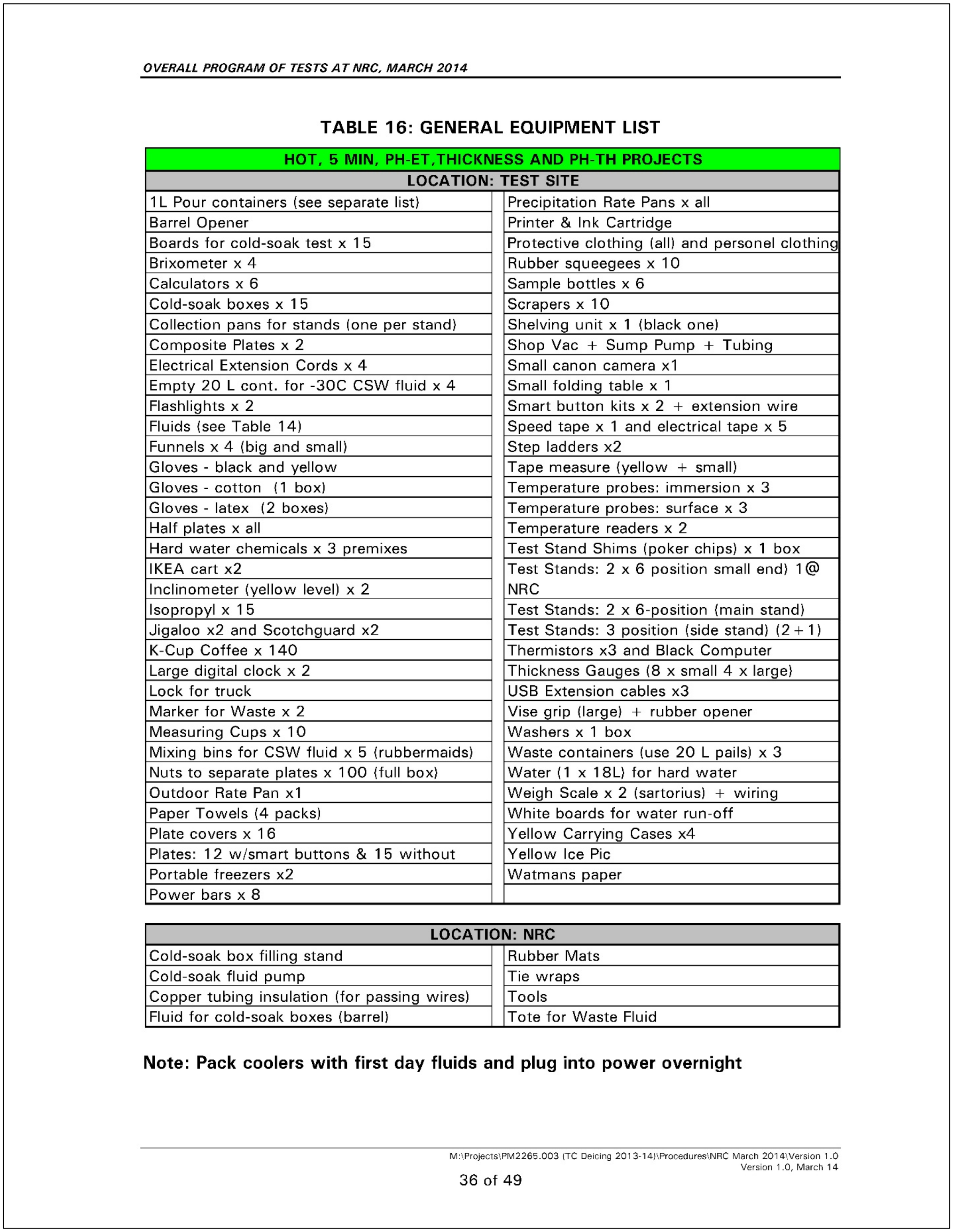


TABLE 16: GENERAL EQUIPMENT LIST

HOT, 5 MIN, PH-ET,THICKNESS AND PH-TH PROJECTS

LOCATION: TEST SITE

- 1L Pour containers (see separate list)
- Barrel Opener
- Boards for cold-soak test x 15
- Brixometer x 4
- Calculators x 6
- Cold-soak boxes x 15
- Collection pans for stands (one per stand)
- Composite Plates x 2
- Electrical Extension Cords x 4
- Empty 20 L cont. for -30C CSW fluid x 4
- Flashlights x 2
- Fluids (see Table 14)
- Funnels x 4 (big and small)
- Gloves - black and yellow
- Gloves - cotton (1 box)
- Gloves - latex (2 boxes)
- Half plates x all
- Hard water chemicals x 3 premixes
- IKEA cart x2
- Inclinometer (yellow level) x 2
- Isopropyl x 15
- Jigaloo x2 and Scotchguard x2
- K-Cup Coffee x 140
- Large digital clock x 2
- Lock for truck
- Marker for Waste x 2
- Measuring Cups x 10
- Mixing bins for CSW fluid x 5 (rubbermaids)
- Nuts to separate plates x 100 (full box)
- Outdoor Rate Pan x1
- Paper Towels (4 packs)
- Plate covers x 16
- Plates: 12 w/smart buttons & 15 without
- Portable freezers x2
- Power bars x 8

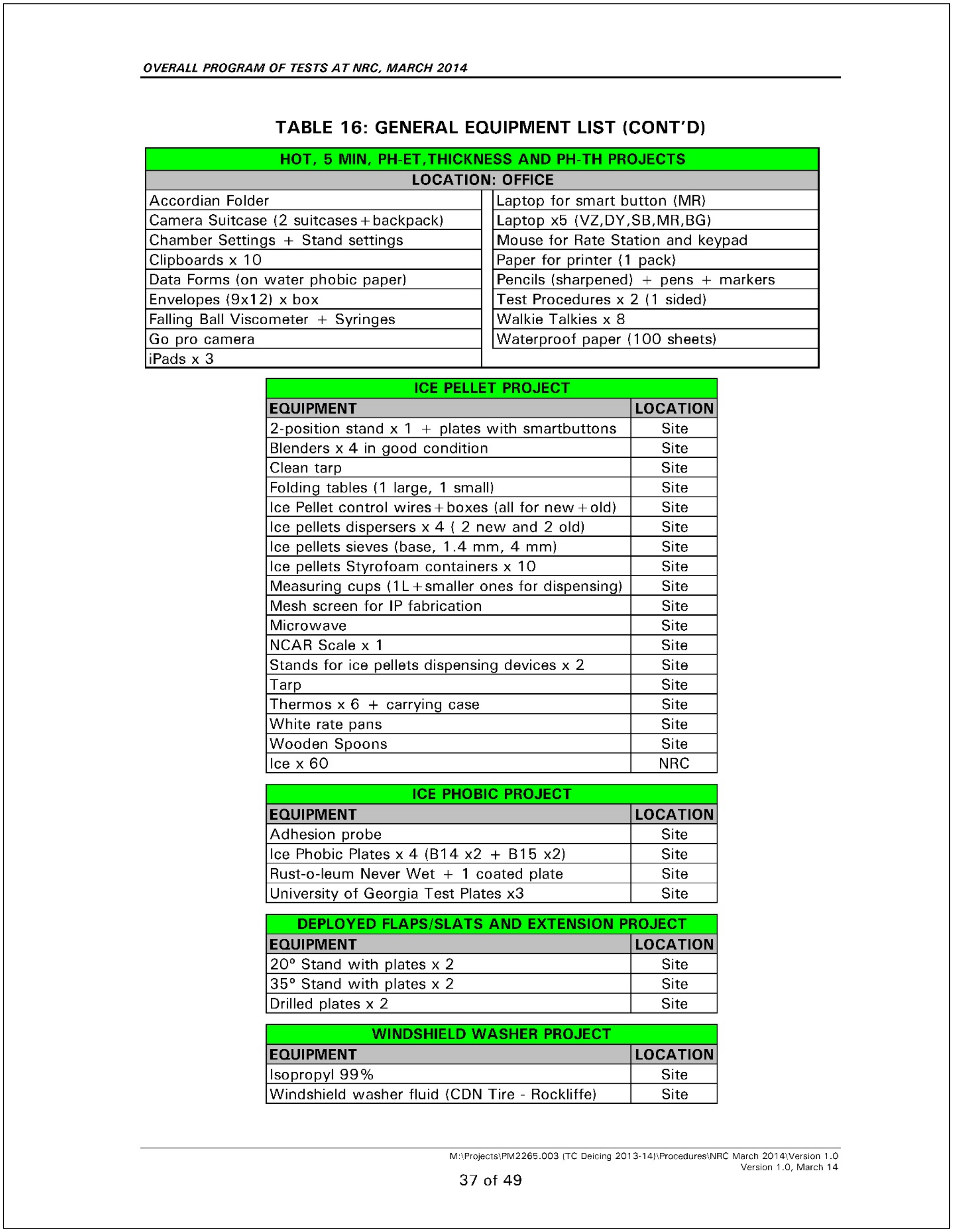
- Precipitation Rate Pans x all
- Printer & Ink Cartridge
- Protective clothing (all) and personel clothing
- Rubber squeegees x 10
- Sample bottles x 6
- Scrapers x 10
- Shelving unit x 1 (black one)
- Shop Vac + Sump Pump + Tubing
- Small canon camera x1
- Small folding table x 1
- Smart button kits x 2 + extension wire
- Speed tape x 1 and electrical tape x 5
- Step ladders x2
- Tape measure (yellow + small)
- Temperature probes: immersion x 3
- Temperature probes: surface x 3
- Temperature readers x 2
- Test Stand Shims (poker chips) x 1 box
- Test Stands: 2 x 6 position small end) 1@ NRC
- Test Stands: 2 x 6-position (main stand)
- Test Stands: 3 position (side stand) (2+1)
- Thermistors x3 and Black Computer
- Thickness Gauges (8 x small 4 x large)
- USB Extension cables x3
- Vise grip (large) + rubber opener
- Washers x 1 box
- Waste containers (use 20 L pails) x 3
- Water (1 x 18L) for hard water
- Weigh Scale x 2 (sartorius) + wiring
- White boards for water run-off
- Yellow Carrying Cases x4
- Yellow Ice Pic
- Watmans paper

LOCATION: NRC

- Cold-soak box filling stand
- Cold-soak fluid pump
- Copper tubing insulation (for passing wires)
- Fluid for cold-soak boxes (barrel)

- Rubber Mats
- Tie wraps
- Tools
- Tote for Waste Fluid

Note: Pack coolers with first day fluids and plug into power overnight



OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

TABLE 16: GENERAL EQUIPMENT LIST (CONT'D)

HOT, 5 MIN, PH-ET,THICKNESS AND PH-TH PROJECTS	
LOCATION: OFFICE	
Accordian Folder	Laptop for smart button (MR)
Camera Suitcase (2 suitcases+backpack)	Laptop x5 (VZ,DY,SB,MR,BG)
Chamber Settings + Stand settings	Mouse for Rate Station and keypad
Clipboards x 10	Paper for printer (1 pack)
Data Forms (on water phobic paper)	Pencils (sharpened) + pens + markers
Envelopes (9x12) x box	Test Procedures x 2 (1 sided)
Falling Ball Viscometer + Syringes	Walkie Talkies x 8
Go pro camera	Waterproof paper (100 sheets)
iPads x 3	

ICE PELLET PROJECT	
EQUIPMENT	**LOCATION**
2-position stand x 1 + plates with smartbuttons	Site
Blenders x 4 in good condition	Site
Clean tarp	Site
Folding tables (1 large, 1 small)	Site
Ice Pellet control wires+boxes (all for new+old)	Site
Ice pellets dispersers x 4 (2 new and 2 old)	Site
Ice pellets sieves (base, 1.4 mm, 4 mm)	Site
Ice pellets Styrofoam containers x 10	Site
Measuring cups (1L+smaller ones for dispensing)	Site
Mesh screen for IP fabrication	Site
Microwave	Site
NCAR Scale x 1	Site
Stands for ice pellets dispensing devices x 2	Site
Tarp	Site
Thermos x 6 + carrying case	Site
White rate pans	Site
Wooden Spoons	Site
Ice x 60	NRC

ICE PHOBIC PROJECT	
EQUIPMENT	**LOCATION**
Adhesion probe	Site
Ice Phobic Plates x 4 (B14 x2 + B15 x2)	Site
Rust-o-leum Never Wet + 1 coated plate	Site
University of Georgia Test Plates x3	Site

DEPLOYED FLAPS/SLATS AND EXTENSION PROJECT	
EQUIPMENT	**LOCATION**
20° Stand with plates x 2	Site
35° Stand with plates x 2	Site
Drilled plates x 2	Site

WINDSHIELD WASHER PROJECT	
EQUIPMENT	**LOCATION**
Isopropyl 99%	Site
Windshield washer fluid (CDN Tire - Rockliffe)	Site

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

37 of 49

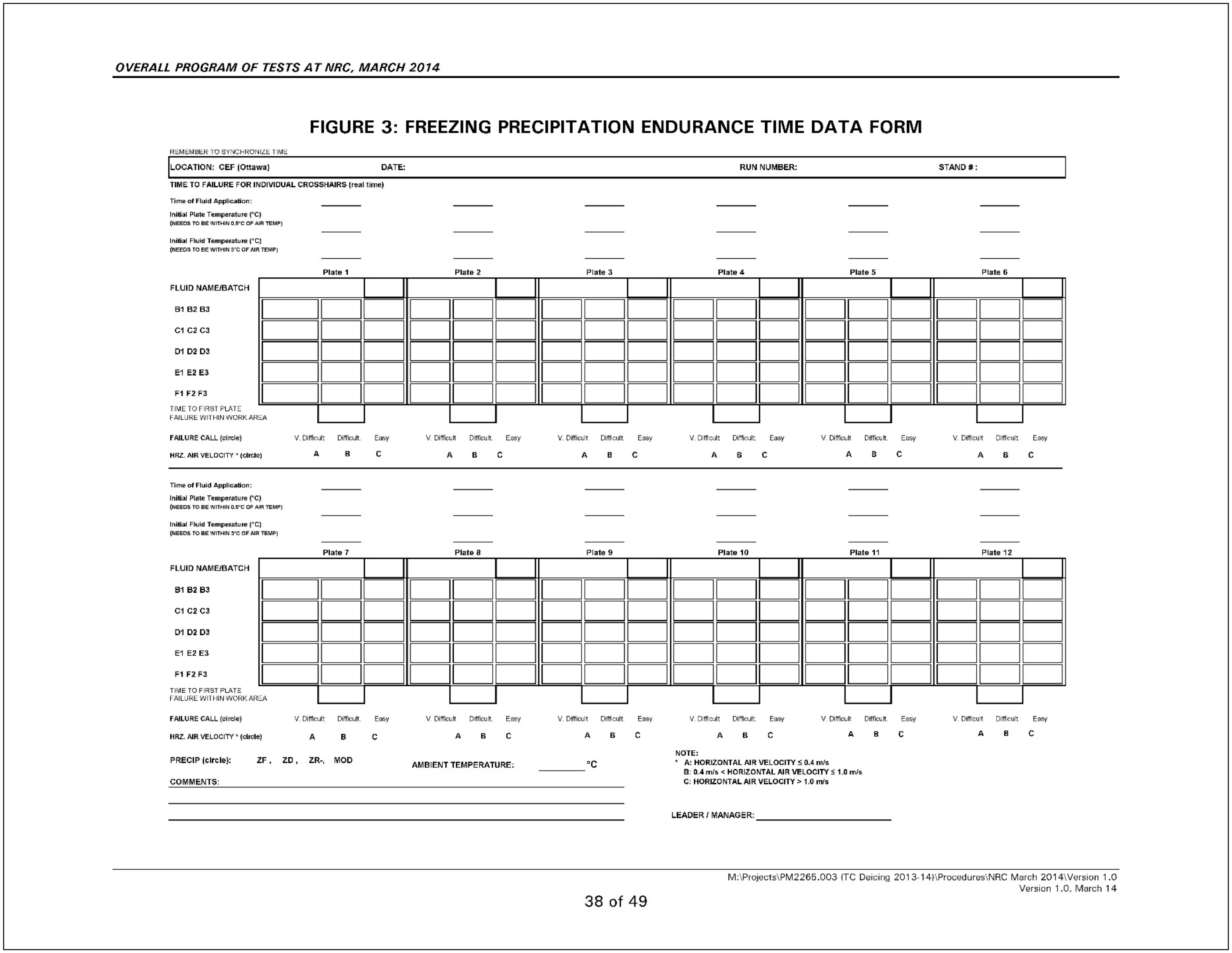


FIGURE 3: FREEZING PRECIPITATION ENDURANCE TIME DATA FORM

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
Initial Plate Temperature (°C) **(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)**						
Initial Fluid Temperature (°C) **(NEEDS TO BE WITHIN 3°C OF AIR TEMP)**						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) **(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)**						
Initial Fluid Temperature (°C) **(NEEDS TO BE WITHIN 3°C OF AIR TEMP)**						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

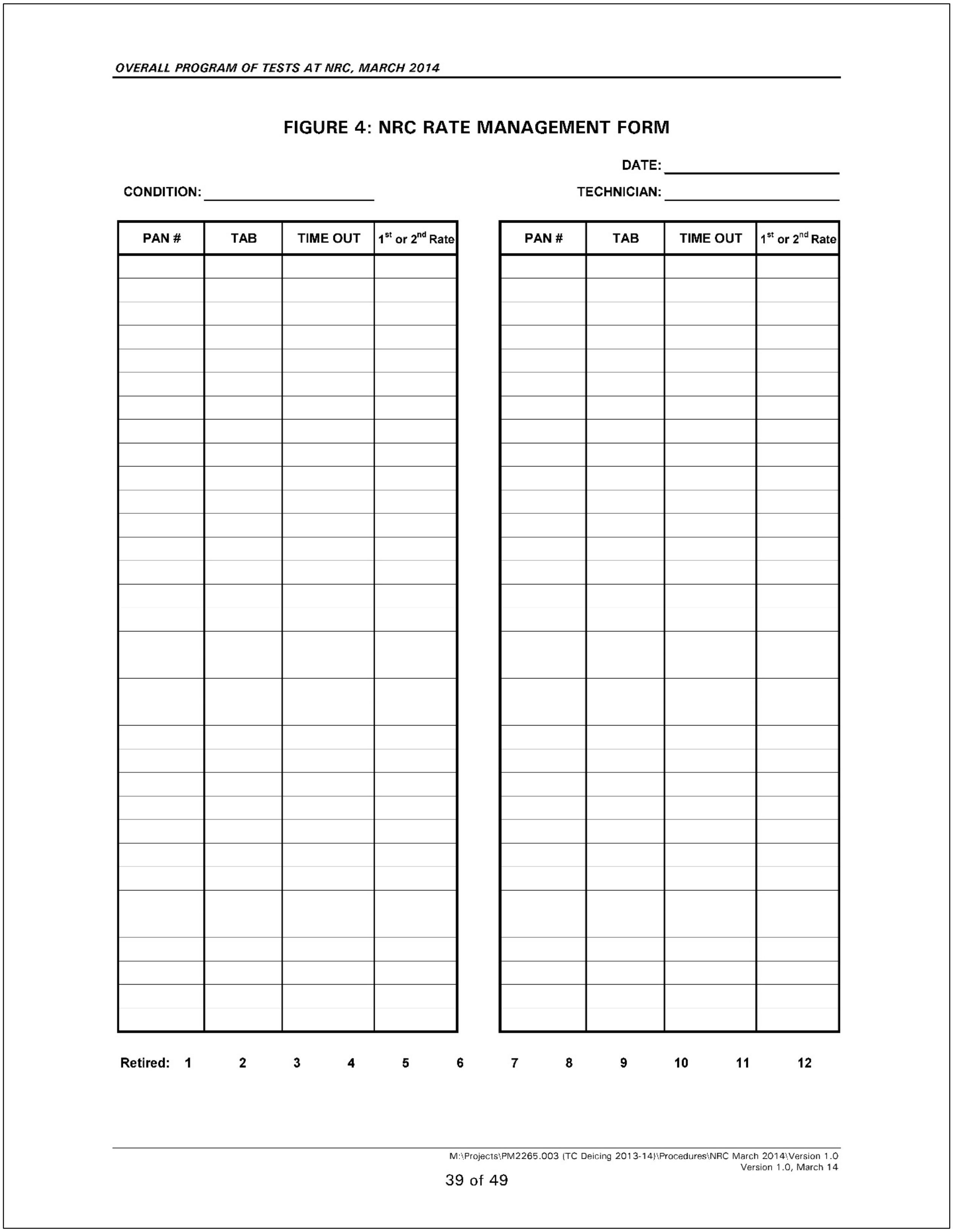
PRECIP (circle): ZF , ZD , ZR-, MOD

AMBIENT TEMPERATURE: ________ °C

COMMENTS:

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

LEADER / MANAGER: ____________________



OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

FIGURE 4: NRC RATE MANAGEMENT FORM

DATE: ____________________

CONDITION: ____________________

TECHNICIAN: ____________________

PAN #	TAB	TIME OUT	1st or 2nd Rate

PAN #	TAB	TIME OUT	1st or 2nd Rate

Retired: 1 2 3 4 5 6 7 8 9 10 11 12

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

39 of 49

FIGURE 5: NRC CONTINUOUS RATE FORM

Condition	Date	Plate Position	Average Continuous Rate	Comments
ZF, -25, 2				
ZF, -25, 5				
ZF, -14, 2				
ZF, -14, 5				
ZF, -10, 2				
ZF, -10, 5				
ZF, -3, 2				
ZF, -3, 5				
ZD, -3, 5				
ZD, -3, 13				
ZD, -10, 5				
ZD, -10, 13				
ZR, -3, 13				
ZR, -3, 25				
ZR, -10, 13				
ZR, -10, 25				
CS, 1, 5				
CS, 1, 75				

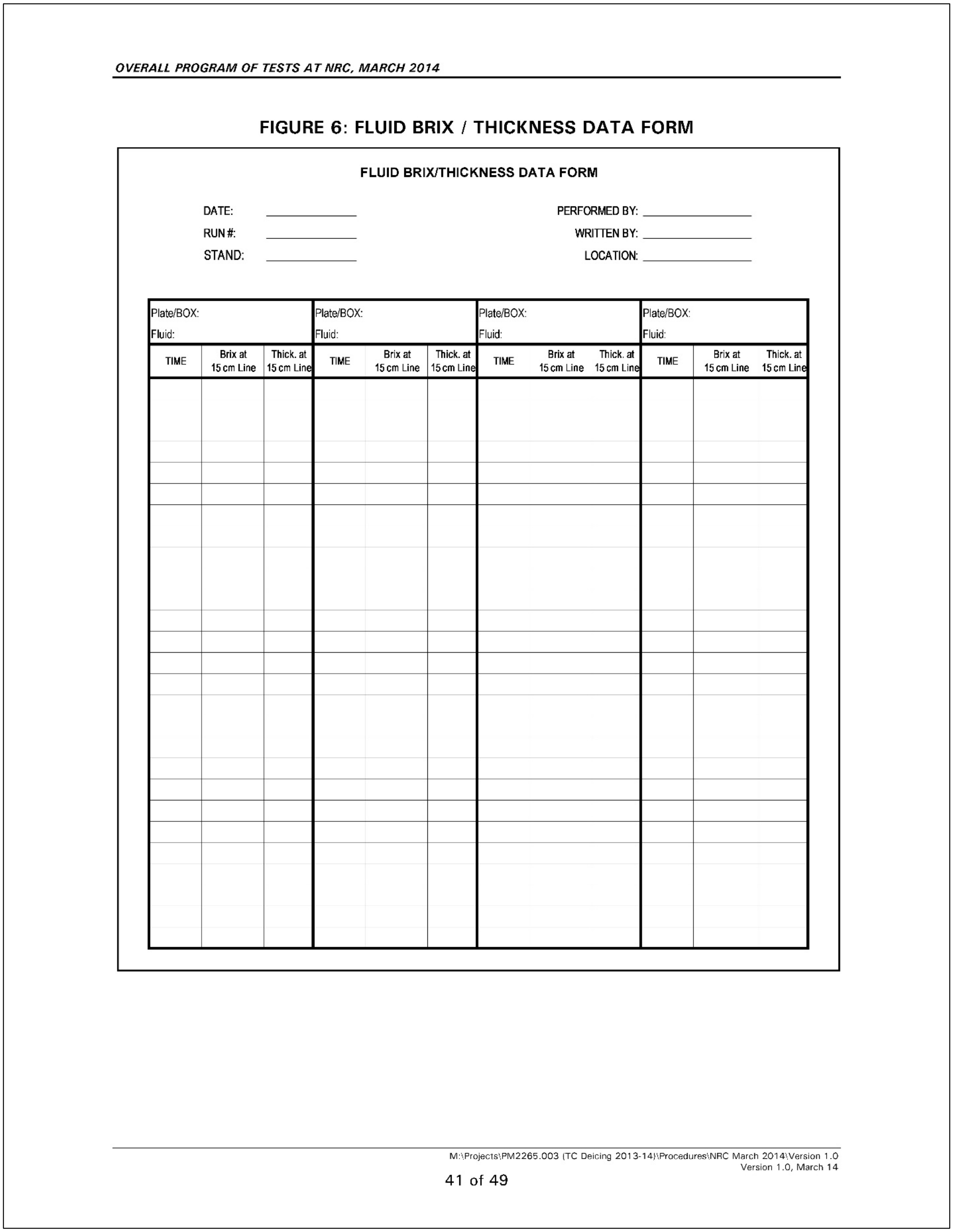


FIGURE 6: FLUID BRIX / THICKNESS DATA FORM

FLUID BRIX/THICKNESS DATA FORM

DATE: ______________ PERFORMED BY: ________________

RUN #: ______________ WRITTEN BY: ________________

STAND: ______________ LOCATION: ________________

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

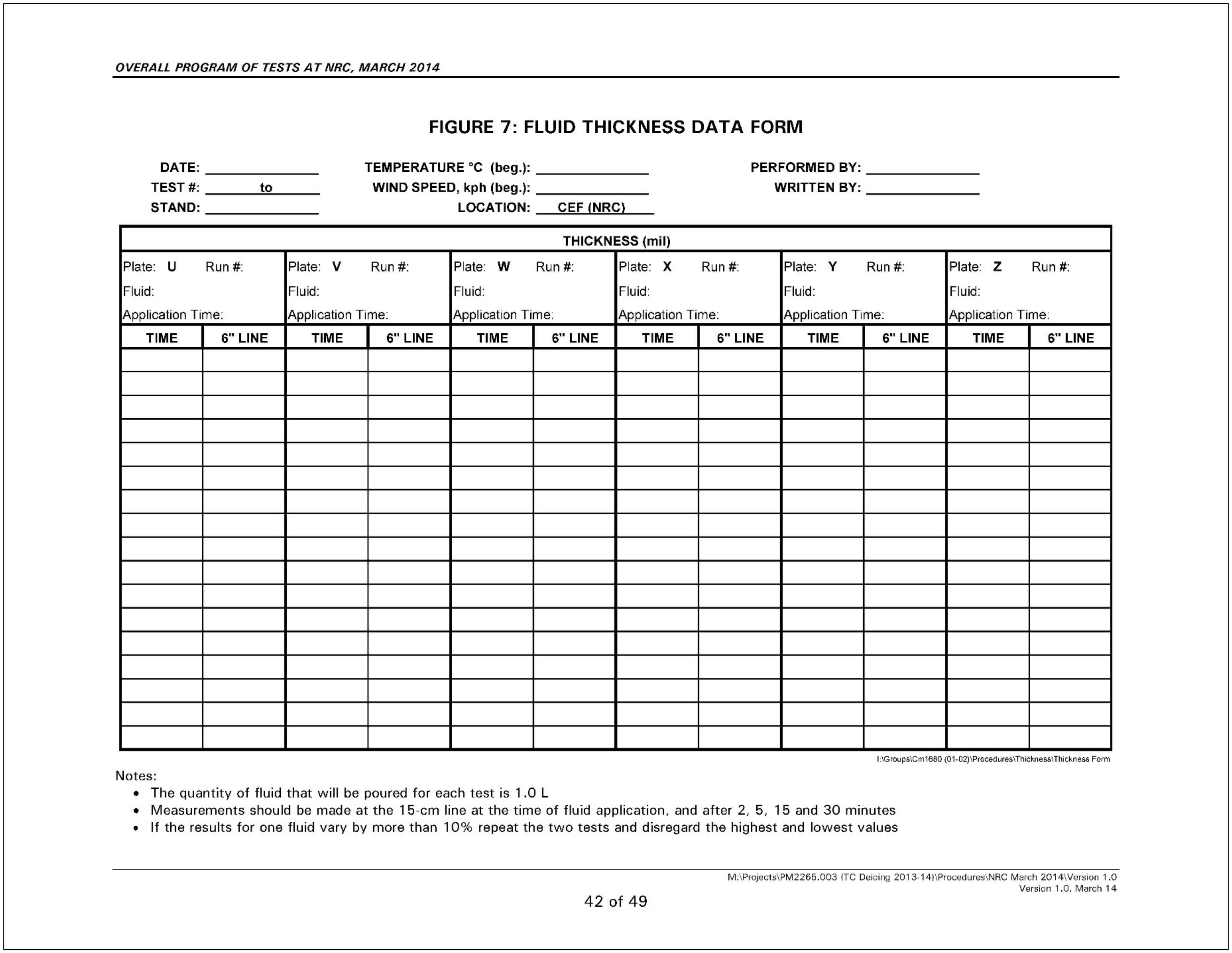


FIGURE 7: FLUID THICKNESS DATA FORM

DATE: ______________
TEST #: _______ to _______
STAND: ______________

TEMPERATURE °C (beg.): ______________
WIND SPEED, kph (beg.): ______________
LOCATION: CEF (NRC)

PERFORMED BY: ______________
WRITTEN BY: ______________

THICKNESS (mil)											
Plate: **U** Run #: Fluid: Application Time:		Plate: **V** Run #: Fluid: Application Time:		Plate: **W** Run #: Fluid: Application Time:		Plate: **X** Run #: Fluid: Application Time:		Plate: **Y** Run #: Fluid: Application Time:		Plate: **Z** Run #: Fluid: Application Time:	
TIME	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**

I:\Groups\Cm1680 (01-02)\Procedures\Thickness\Thickness Form

Notes:

- The quantity of fluid that will be poured for each test is 1.0 L
- Measurements should be made at the 15-cm line at the time of fluid application, and after 2, 5, 15 and 30 minutes
- If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values

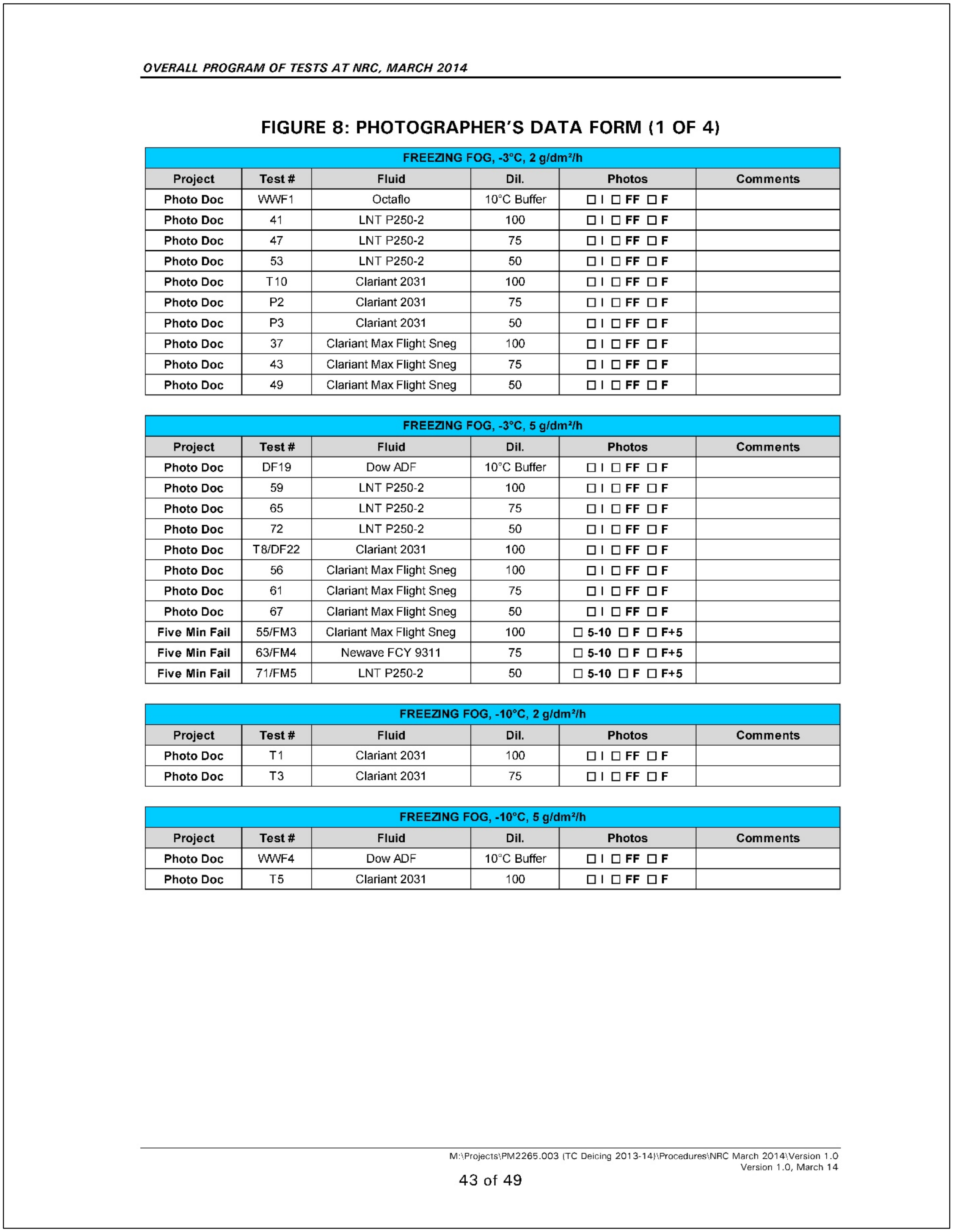


FIGURE 8: PHOTOGRAPHER'S DATA FORM (1 OF 4)

FREEZING FOG, -3°C, 2 g/dm²/h

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	WWF1	Octaflo	10°C Buffer	☐ I ☐ FF ☐ F	
Photo Doc	41	LNT P250-2	100	☐ I ☐ FF ☐ F	
Photo Doc	47	LNT P250-2	75	☐ I ☐ FF ☐ F	
Photo Doc	53	LNT P250-2	50	☐ I ☐ FF ☐ F	
Photo Doc	T10	Clariant 2031	100	☐ I ☐ FF ☐ F	
Photo Doc	P2	Clariant 2031	75	☐ I ☐ FF ☐ F	
Photo Doc	P3	Clariant 2031	50	☐ I ☐ FF ☐ F	
Photo Doc	37	Clariant Max Flight Sneg	100	☐ I ☐ FF ☐ F	
Photo Doc	43	Clariant Max Flight Sneg	75	☐ I ☐ FF ☐ F	
Photo Doc	49	Clariant Max Flight Sneg	50	☐ I ☐ FF ☐ F	

FREEZING FOG, -3°C, 5 g/dm²/h

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	DF19	Dow ADF	10°C Buffer	☐ I ☐ FF ☐ F	
Photo Doc	59	LNT P250-2	100	☐ I ☐ FF ☐ F	
Photo Doc	65	LNT P250-2	75	☐ I ☐ FF ☐ F	
Photo Doc	72	LNT P250-2	50	☐ I ☐ FF ☐ F	
Photo Doc	T8/DF22	Clariant 2031	100	☐ I ☐ FF ☐ F	
Photo Doc	56	Clariant Max Flight Sneg	100	☐ I ☐ FF ☐ F	
Photo Doc	61	Clariant Max Flight Sneg	75	☐ I ☐ FF ☐ F	
Photo Doc	67	Clariant Max Flight Sneg	50	☐ I ☐ FF ☐ F	
Five Min Fail	55/FM3	Clariant Max Flight Sneg	100	☐ 5-10 ☐ F ☐ F+5	
Five Min Fail	63/FM4	Newave FCY 9311	75	☐ 5-10 ☐ F ☐ F+5	
Five Min Fail	71/FM5	LNT P250-2	50	☐ 5-10 ☐ F ☐ F+5	

FREEZING FOG, -10°C, 2 g/dm²/h

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	T1	Clariant 2031	100	☐ I ☐ FF ☐ F	
Photo Doc	T3	Clariant 2031	75	☐ I ☐ FF ☐ F	

FREEZING FOG, -10°C, 5 g/dm²/h

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	WWF4	Dow ADF	10°C Buffer	☐ I ☐ FF ☐ F	
Photo Doc	T5	Clariant 2031	100	☐ I ☐ FF ☐ F	

FIGURE 8: PHOTOGRAPHER'S DATA FORM (2 OF 4)

FREEZING FOG, -14°C, 2 g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	17	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	23	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	13	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	19	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

FREEZING FOG, -14°C, 5 g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	29	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	36	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	25	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	31	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

FREEZING FOG, -25°C, 2 g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	5	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	1	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	

FREEZING FOG, -25°C, 5 g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	WWF10	Dow ADF	10°C Buffer	☐ I ☐ **FF** ☐ **F**	
Photo Doc	11	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P1	Clariant 2031	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	7	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	

COLD SOAK, +1°C, 5 g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	P13	Dow ADF	10°C Buffer	☐ I ☐ **FF** ☐ **F**	
Photo Doc	197	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	203	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P14	Clariant 2031	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	193	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	199	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

COLD SOAK, +1°C, g/dm^2/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	209	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	215	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P15	Clariant 2031	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	205	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	211	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

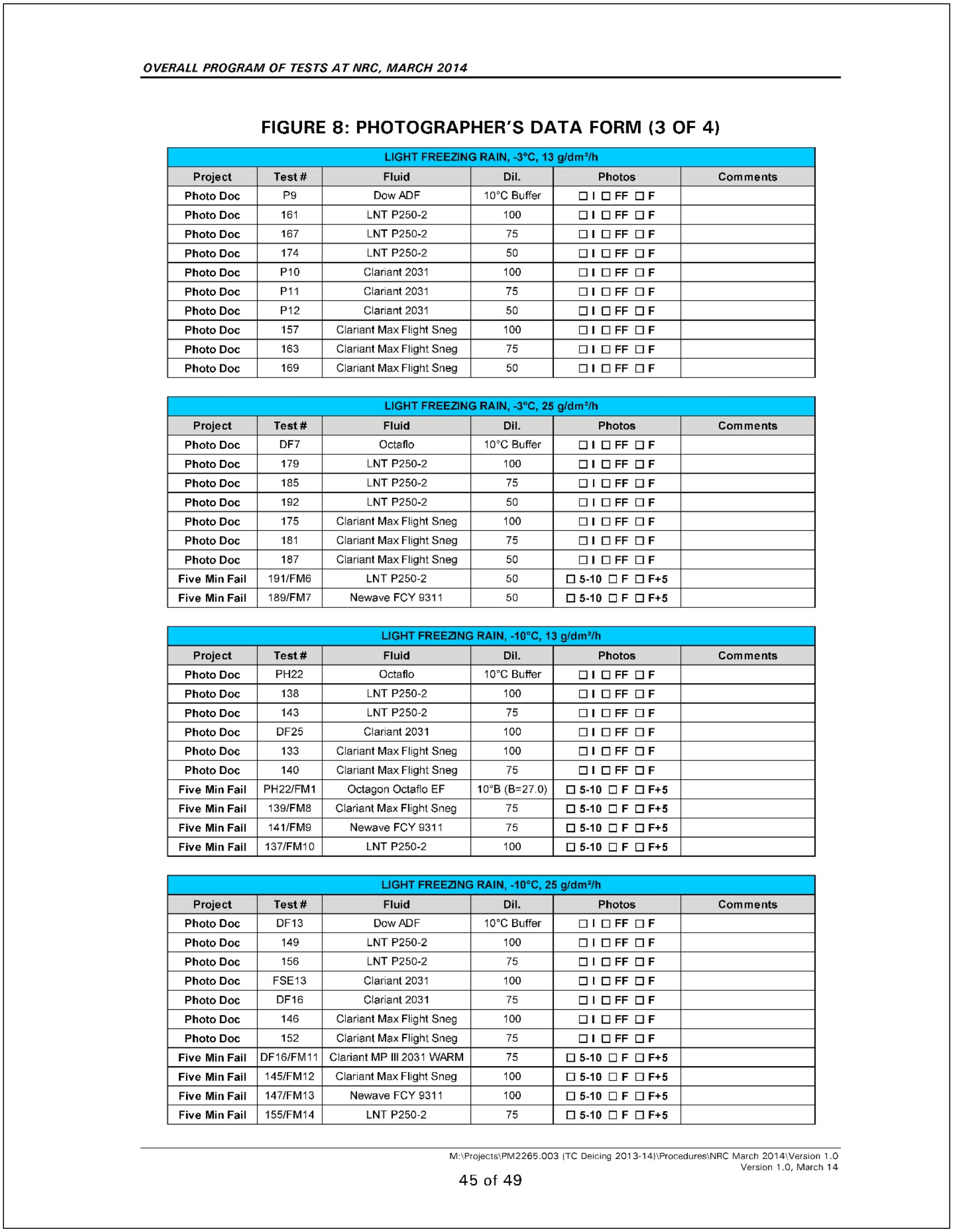


FIGURE 8: PHOTOGRAPHER'S DATA FORM (3 OF 4)

LIGHT FREEZING RAIN, -3°C, 13 $g/dm^2/h$

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	P9	Dow ADF	10°C Buffer	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	161	LNT P250-2	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	167	LNT P250-2	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	174	LNT P250-2	50	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	P10	Clariant 2031	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	P11	Clariant 2031	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	P12	Clariant 2031	50	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	157	Clariant Max Flight Sneg	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	163	Clariant Max Flight Sneg	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	169	Clariant Max Flight Sneg	50	☐ **I** ☐ **FF** ☐ **F**	

LIGHT FREEZING RAIN, -3°C, 25 $g/dm^2/h$

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	DF7	Octaflo	10°C Buffer	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	179	LNT P250-2	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	185	LNT P250-2	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	192	LNT P250-2	50	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	175	Clariant Max Flight Sneg	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	181	Clariant Max Flight Sneg	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	187	Clariant Max Flight Sneg	50	☐ **I** ☐ **FF** ☐ **F**	
Five Min Fail	191/FM6	LNT P250-2	50	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	189/FM7	Newave FCY 9311	50	☐ **5-10** ☐ **F** ☐ **F+5**	

LIGHT FREEZING RAIN, -10°C, 13 $g/dm^2/h$

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	PH22	Octaflo	10°C Buffer	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	138	LNT P250-2	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	143	LNT P250-2	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	DF25	Clariant 2031	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	133	Clariant Max Flight Sneg	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	140	Clariant Max Flight Sneg	75	☐ **I** ☐ **FF** ☐ **F**	
Five Min Fail	PH22/FM1	Octagon Octaflo EF	10°B (B=27.0)	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	139/FM8	Clariant Max Flight Sneg	75	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	141/FM9	Newave FCY 9311	75	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	137/FM10	LNT P250-2	100	☐ **5-10** ☐ **F** ☐ **F+5**	

LIGHT FREEZING RAIN, -10°C, 25 $g/dm^2/h$

Project	Test #	Fluid	Dil.	Photos	Comments
Photo Doc	DF13	Dow ADF	10°C Buffer	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	149	LNT P250-2	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	156	LNT P250-2	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	FSE13	Clariant 2031	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	DF16	Clariant 2031	75	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	146	Clariant Max Flight Sneg	100	☐ **I** ☐ **FF** ☐ **F**	
Photo Doc	152	Clariant Max Flight Sneg	75	☐ **I** ☐ **FF** ☐ **F**	
Five Min Fail	DF16/FM11	Clariant MP III 2031 WARM	75	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	145/FM12	Clariant Max Flight Sneg	100	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	147/FM13	Newave FCY 9311	100	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	155/FM14	LNT P250-2	75	☐ **5-10** ☐ **F** ☐ **F+5**	

FIGURE 8: PHOTOGRAPHER'S DATA FORM (4 OF 4)

FREEZING DRIZZLE, -3°C, 5 g/dm²/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	101	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	107	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	113	LNT P250-2	50	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P4	Clariant 2031	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P5	Clariant 2031	50	☐ I ☐ **FF** ☐ **F**	
Photo Doc	97	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	103	Clariant Max Flight Sneg	50	☐ I ☐ **FF** ☐ **F**	
Photo Doc	110	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Five Min Fail	109/FM15	Clariant Max Flight Sneg	50	☐ **5-10** ☐ **F** ☐ **F+5**	
Five Min Fail	111/FM16	Newave FCY 9311	50	☐ **5-10** ☐ **F** ☐ **F+5**	

FREEZING DRIZZLE, -3°C, 13 g/dm²/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	PH10/FM2	Dow ADF	10°C Buffer	☐ I ☐ **FF** ☐ **F**	
Photo Doc	119	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	125	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	131	LNT P250-2	50	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P6	Clariant 2031	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	115	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	121	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	128	Clariant Max Flight Sneg	50	☐ I ☐ **FF** ☐ **F**	
Five Min Fail	PH10/FM2	Dow UCAR ADF (EG)	10°B (B=17.6)	☐ **5-10** ☐ **F** ☐ **F+5**	

FREEZING DRIZZLE, -10°C, 5 g/dm²/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	DF1	Octaflo	10°C Buffer	☐ I ☐ **FF** ☐ **F**	
Photo Doc	77	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	83	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	73	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	79	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

FREEZING DRIZZLE, -10°C, 13 g/dm²/h					
Project	**Test #**	**Fluid**	**Dil.**	**Photos**	**Comments**
Photo Doc	FSE10	Octaflo	10°C Buffer	☐ I ☐ **FF** ☐ **F**	
Photo Doc	89	LNT P250-2	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	95	LNT P250-2	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P7	Clariant 2031	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	P8	Clariant 2031	75	☐ I ☐ **FF** ☐ **F**	
Photo Doc	86	Clariant Max Flight Sneg	100	☐ I ☐ **FF** ☐ **F**	
Photo Doc	91	Clariant Max Flight Sneg	75	☐ I ☐ **FF** ☐ **F**	

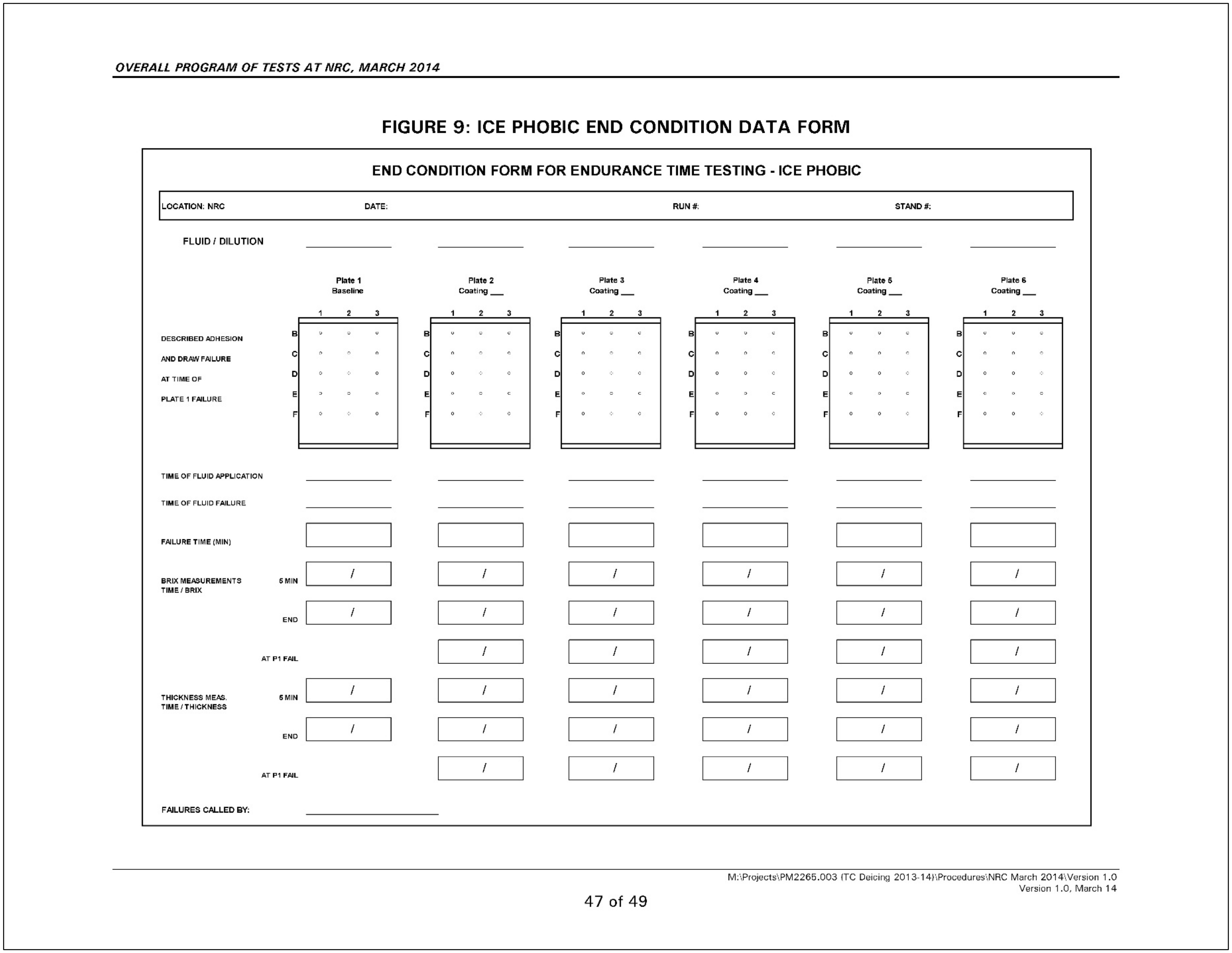


FIGURE 9: ICE PHOBIC END CONDITION DATA FORM

END CONDITION FORM FOR ENDURANCE TIME TESTING - ICE PHOBIC

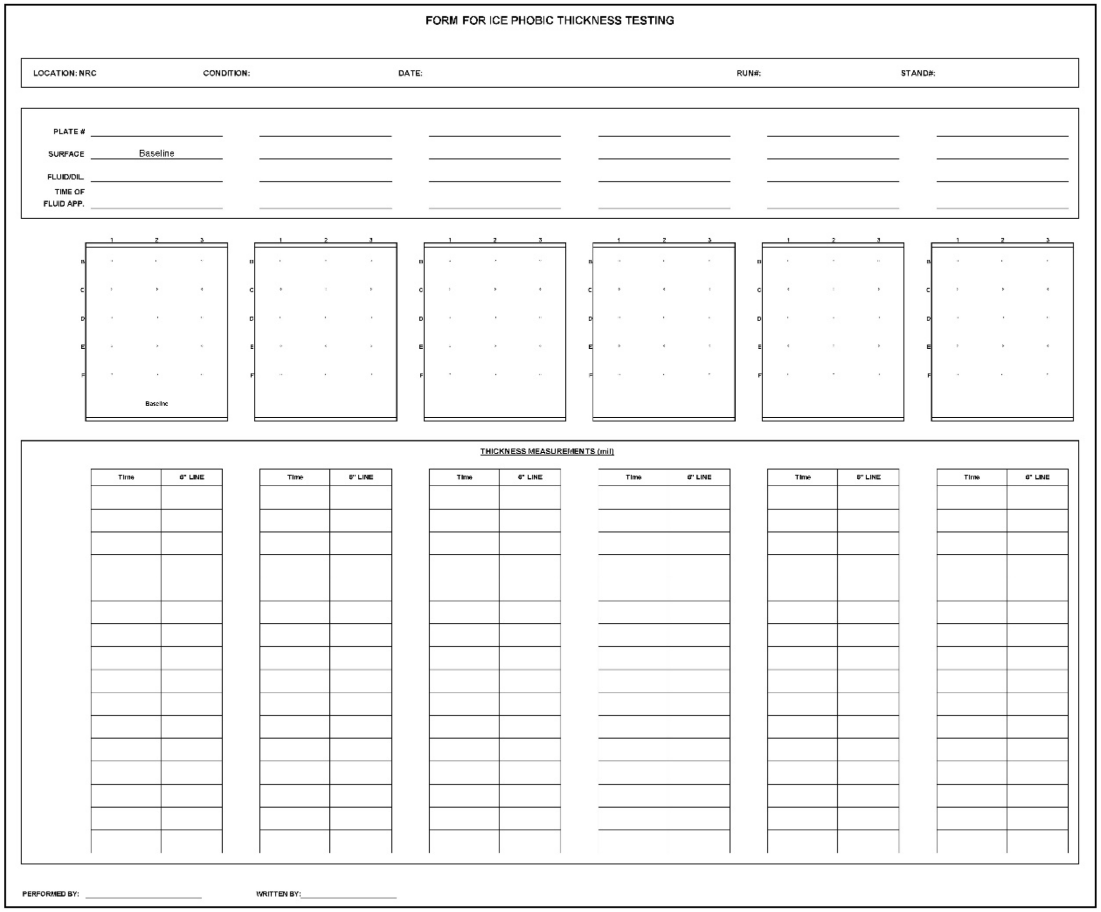
LOCATION: NRC DATE: RUN #: STAND #:

FLUID / DILUTION		________	________	________	________	________	________
		Plate 1 Baseline	Plate 2 Coating ___	Plate 3 Coating ___	Plate 4 Coating ___	Plate 5 Coating ___	Plate 6 Coating ___
DESCRIBED ADHESION AND DRAW FAILURE AT TIME OF PLATE 1 FAILURE		1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○	1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○	1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○	1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○	1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○	1 2 3 B ○ ○ ○ C ○ ○ ○ D ○ ○ ○ E ○ ○ ○ F ○ ○ ○
TIME OF FLUID APPLICATION		________	________	________	________	________	________
TIME OF FLUID FAILURE		________	________	________	________	________	________
FAILURE TIME (MIN)							
BRIX MEASUREMENTS TIME / BRIX	5 MIN	/	/	/	/	/	/
	END	/	/	/	/	/	/
	AT P1 FAIL		/	/	/	/	/
THICKNESS MEAS. TIME / THICKNESS	5 MIN	/	/	/	/	/	/
	END	/	/	/	/	/	/
	AT P1 FAIL		/	/	/	/	/

FAILURES CALLED BY: ________________

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

FIGURE 10: ICE PHOBIC THICKNESS DATA FORM



FORM FOR ICE PHOBIC THICKNESS TESTING

LOCATION: NRC   CONDITION: DATE: RUN#:   STAND#:

PLATE #						
SURFACE	Baseline					
FLUID/DIL.						
TIME OF FLUID APP.						

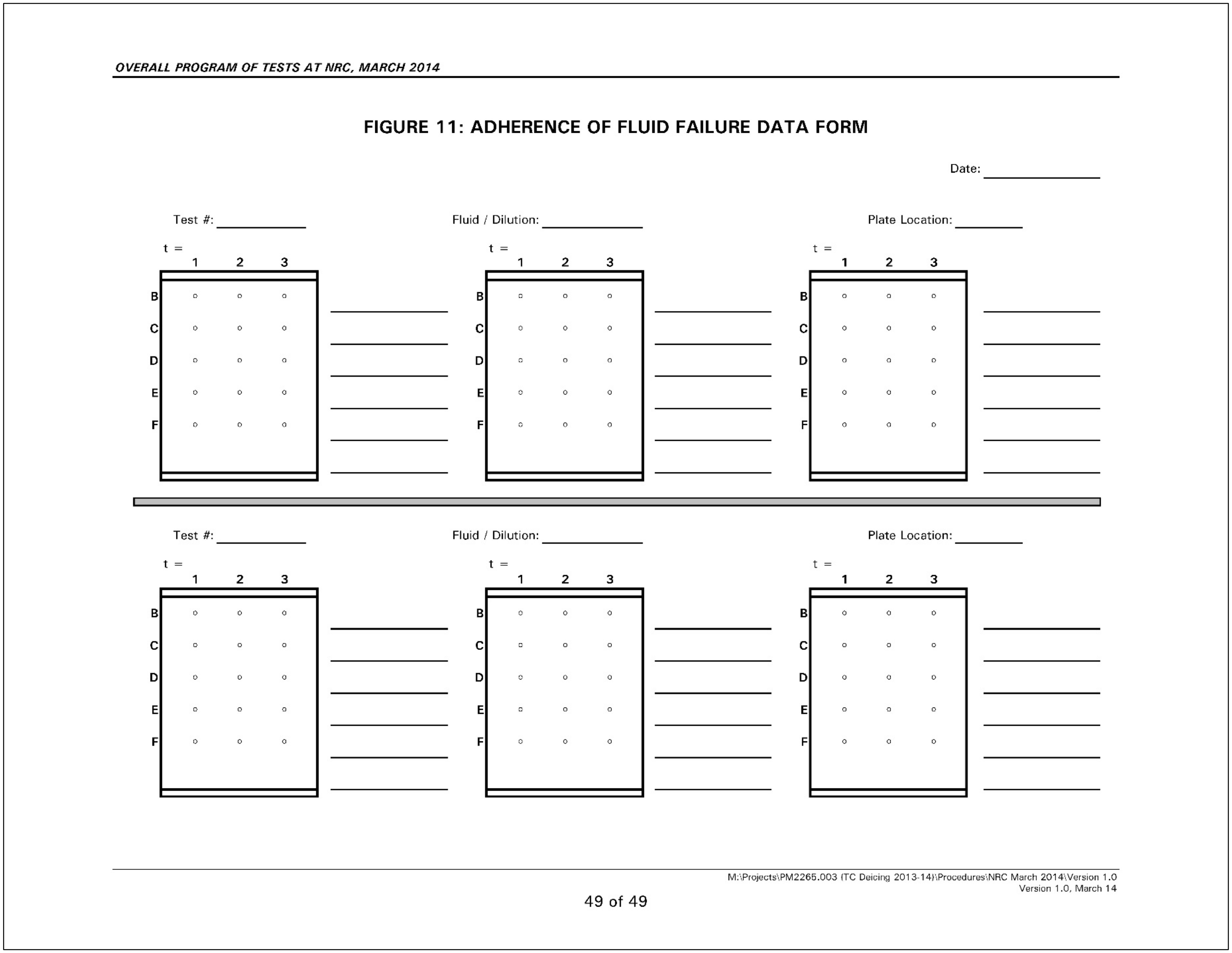
THICKNESS MEASUREMENTS (mil)

Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE

PERFORMED BY: ____________________   WRITTEN BY: ____________________

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

48 of 49



OVERALL PROGRAM OF TESTS AT NRC, MARCH 2014

FIGURE 11: ADHERENCE OF FLUID FAILURE DATA FORM

Date: ____________

Test #: ____________ Fluid / Dilution: ____________ Plate Location: ____________

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

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

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

Test #: ____________ Fluid / Dilution: ____________ Plate Location: ____________

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

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

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

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Procedures\NRC March 2014\Version 1.0
Version 1.0, March 14

49 of 49

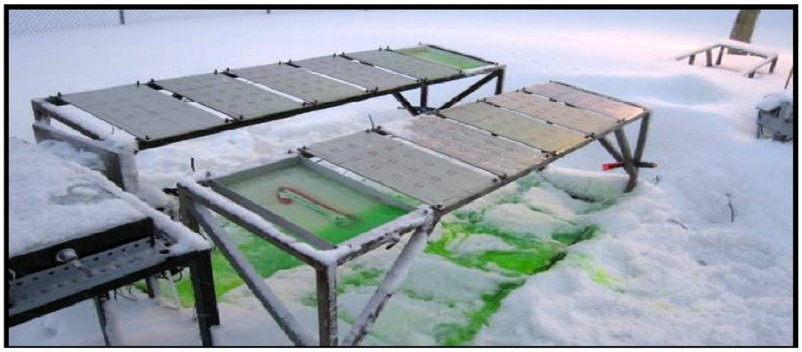
This page intentionally left blank.

APPENDIX C

FLUID MANUFACTURER REPORT: BALTIC GROUND SERVICES DEFROSOL ADF (TYPE I)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Baltic Ground Services Defrosol ADF (Type I)



Prepared for

Baltic Ground Services

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 2.0
Report No. BGS-D 2013-14

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Baltic Ground Services Defrosol ADF (Type I)

Prepared for

Baltic Ground Services

Prepared by:

Stephanie Bendickson
Project Analyst

Nov. 24, 2014
Date

Reviewed by:

John D'Avirro, Eng.
Program Manager

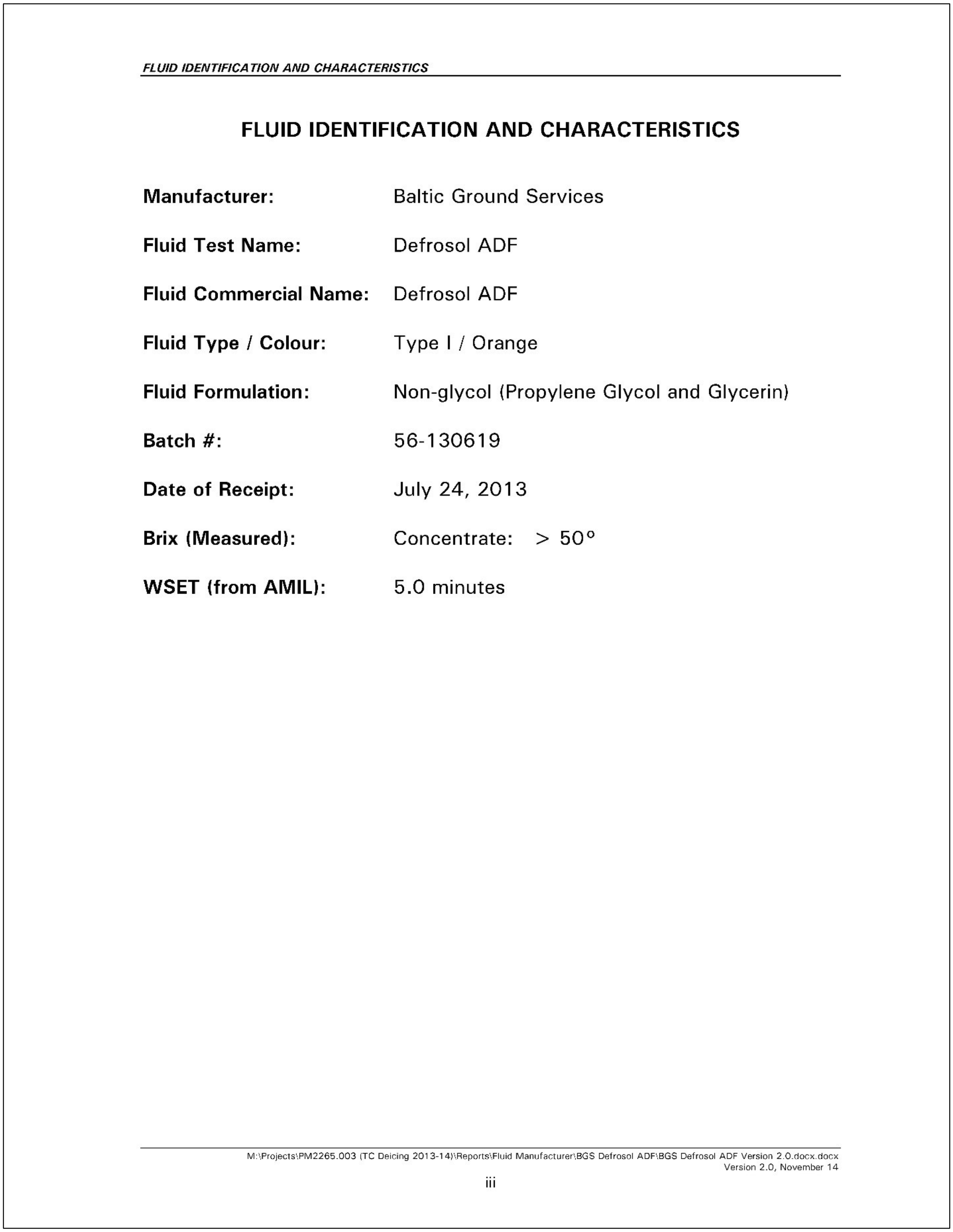
Nov. 24, 2014
Date

Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 2.0
Report No. BGS-D 2013-14

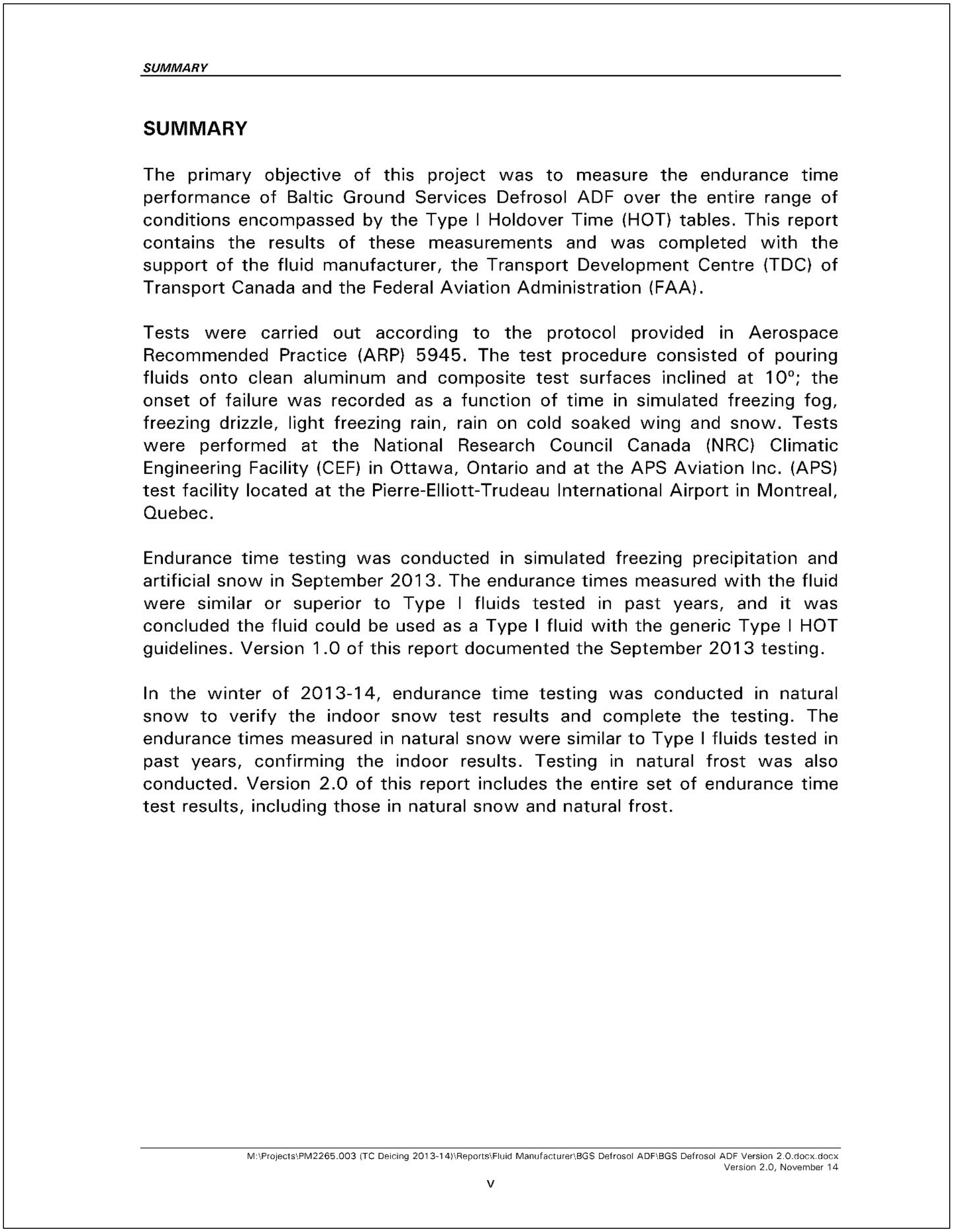
ii



FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Baltic Ground Services
Fluid Test Name:	Defrosol ADF
Fluid Commercial Name:	Defrosol ADF
Fluid Type / Colour:	Type I / Orange
Fluid Formulation:	Non-glycol (Propylene Glycol and Glycerin)
Batch #:	56-130619
Date of Receipt:	July 24, 2013
Brix (Measured):	Concentrate: > 50°
WSET (from AMIL):	5.0 minutes

This page intentionally left blank.



SUMMARY

The primary objective of this project was to measure the endurance time performance of Baltic Ground Services Defrosol ADF over the entire range of conditions encompassed by the Type I Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5945. The test procedure consisted of pouring fluids onto clean aluminum and composite test surfaces inclined at 10°; the onset of failure was recorded as a function of time in simulated freezing fog, freezing drizzle, light freezing rain, rain on cold soaked wing and snow. Tests were performed at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa, Ontario and at the APS Aviation Inc. (APS) test facility located at the Pierre-Elliott-Trudeau International Airport in Montreal, Quebec.

Endurance time testing was conducted in simulated freezing precipitation and artificial snow in September 2013. The endurance times measured with the fluid were similar or superior to Type I fluids tested in past years, and it was concluded the fluid could be used as a Type I fluid with the generic Type I HOT guidelines. Version 1.0 of this report documented the September 2013 testing.

In the winter of 2013-14, endurance time testing was conducted in natural snow to verify the indoor snow test results and complete the testing. The endurance times measured in natural snow were similar to Type I fluids tested in past years, confirming the indoor results. Testing in natural frost was also conducted. Version 2.0 of this report includes the entire set of endurance time test results, including those in natural snow and natural frost.

This page intentionally left blank.

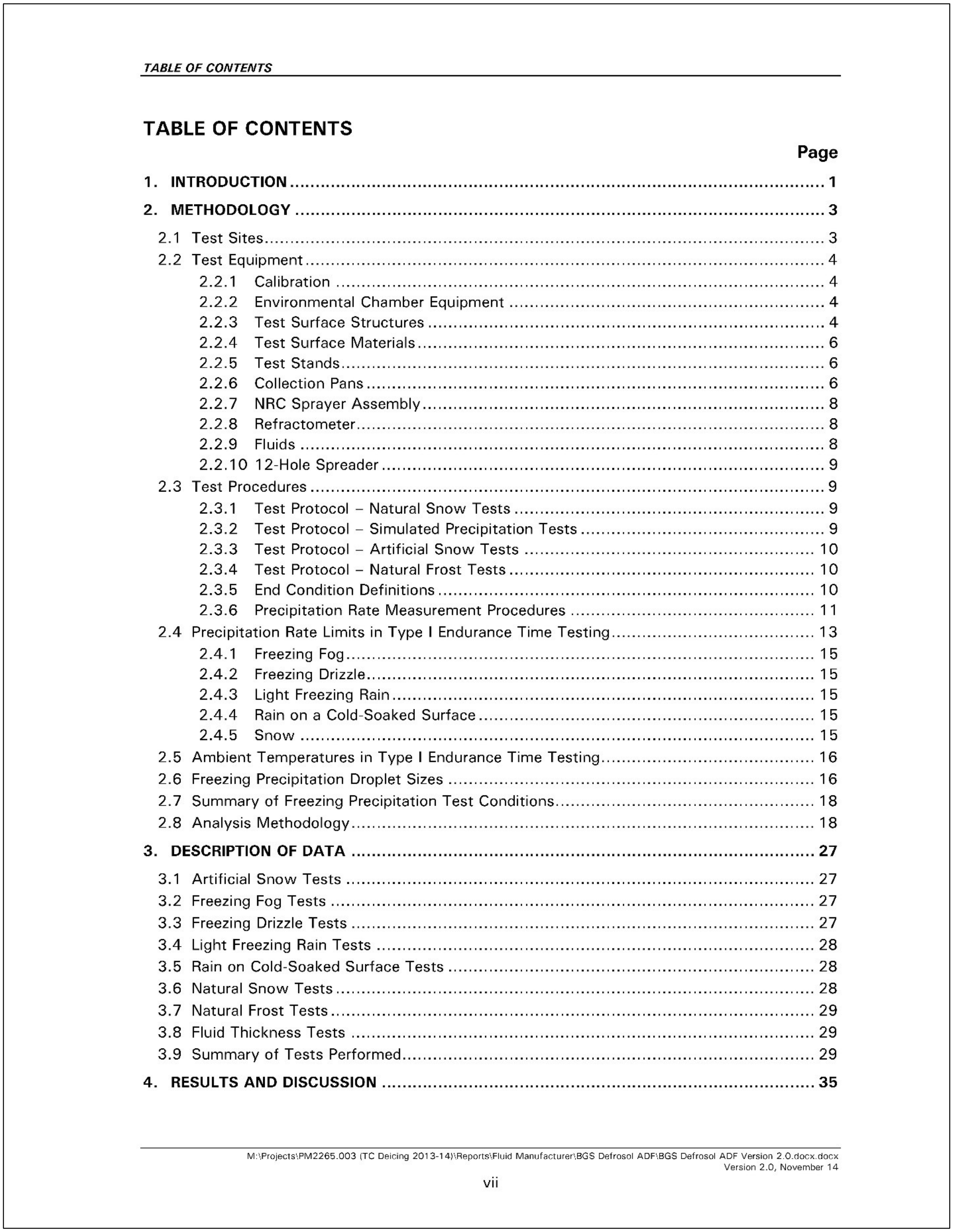


TABLE OF CONTENTS

Page

1. INTRODUCTION 1

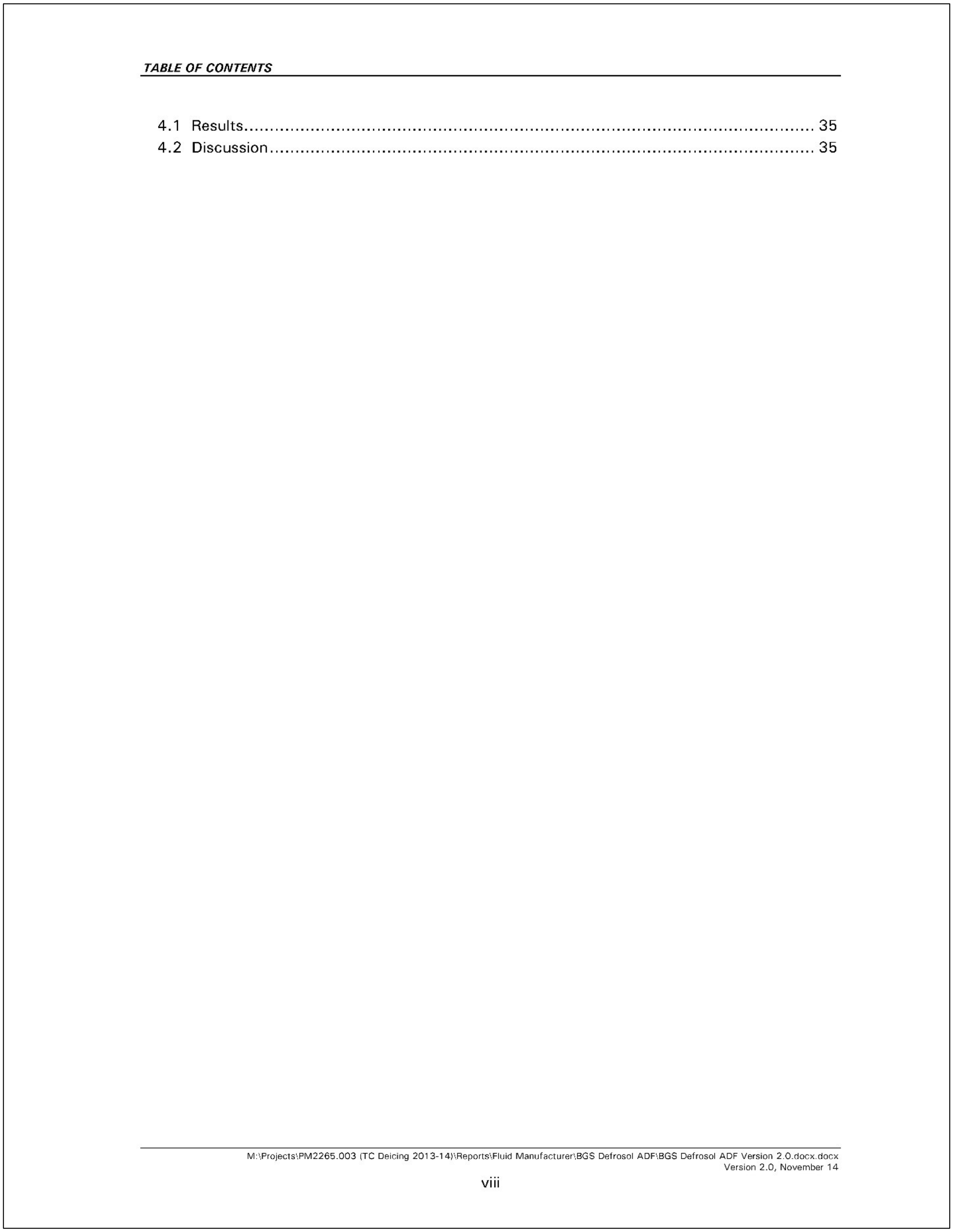
2. METHODOLOGY 3

- 2.1 Test Sites 3
- 2.2 Test Equipment 4
  - 2.2.1 Calibration 4
  - 2.2.2 Environmental Chamber Equipment 4
  - 2.2.3 Test Surface Structures 4
  - 2.2.4 Test Surface Materials 6
  - 2.2.5 Test Stands 6
  - 2.2.6 Collection Pans 6
  - 2.2.7 NRC Sprayer Assembly 8
  - 2.2.8 Refractometer 8
  - 2.2.9 Fluids 8
  - 2.2.10 12-Hole Spreader 9
- 2.3 Test Procedures 9
  - 2.3.1 Test Protocol – Natural Snow Tests 9
  - 2.3.2 Test Protocol – Simulated Precipitation Tests 9
  - 2.3.3 Test Protocol – Artificial Snow Tests 10
  - 2.3.4 Test Protocol – Natural Frost Tests 10
  - 2.3.5 End Condition Definitions 10
  - 2.3.6 Precipitation Rate Measurement Procedures 11
- 2.4 Precipitation Rate Limits in Type I Endurance Time Testing 13
  - 2.4.1 Freezing Fog 15
  - 2.4.2 Freezing Drizzle 15
  - 2.4.3 Light Freezing Rain 15
  - 2.4.4 Rain on a Cold-Soaked Surface 15
  - 2.4.5 Snow 15
- 2.5 Ambient Temperatures in Type I Endurance Time Testing 16
- 2.6 Freezing Precipitation Droplet Sizes 16
- 2.7 Summary of Freezing Precipitation Test Conditions 18
- 2.8 Analysis Methodology 18

3. DESCRIPTION OF DATA 27

- 3.1 Artificial Snow Tests 27
- 3.2 Freezing Fog Tests 27
- 3.3 Freezing Drizzle Tests 27
- 3.4 Light Freezing Rain Tests 28
- 3.5 Rain on Cold-Soaked Surface Tests 28
- 3.6 Natural Snow Tests 28
- 3.7 Natural Frost Tests 29
- 3.8 Fluid Thickness Tests 29
- 3.9 Summary of Tests Performed 29

4. RESULTS AND DISCUSSION 35



4.1 Results.. 35
4.2 Discussion.. 35

LIST OF FIGURES

Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 3
Figure 2.2: Standard Test Plate Schematic.. 5
Figure 2.3: Cold Soak Box Schematic.. 5
Figure 2.4: Test Stand Setup Schematic.. 7
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 13
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing................................. 14
Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface 36
Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface 36
Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface.. 37
Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface 37
Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface 38
Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface 38
Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface.. 39
Figure 4.8: Freezing Fog, Below -10°C, Composite Surface 39
Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface 40
Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface 40
Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface.................................... 41
Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface 41
Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface 42
Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface 42
Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface 43
Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface 43
Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface 44
Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface 44
Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface 45
Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface 45
Figure 4.21: Natural Snow, Aluminum Surface 46
Figure 4.22: Natural Snow, Composite Surface 46
Figure 4.23: Artificial Snow, -3°C and Above, Aluminum Surface 47

LIST OF TABLES

Page

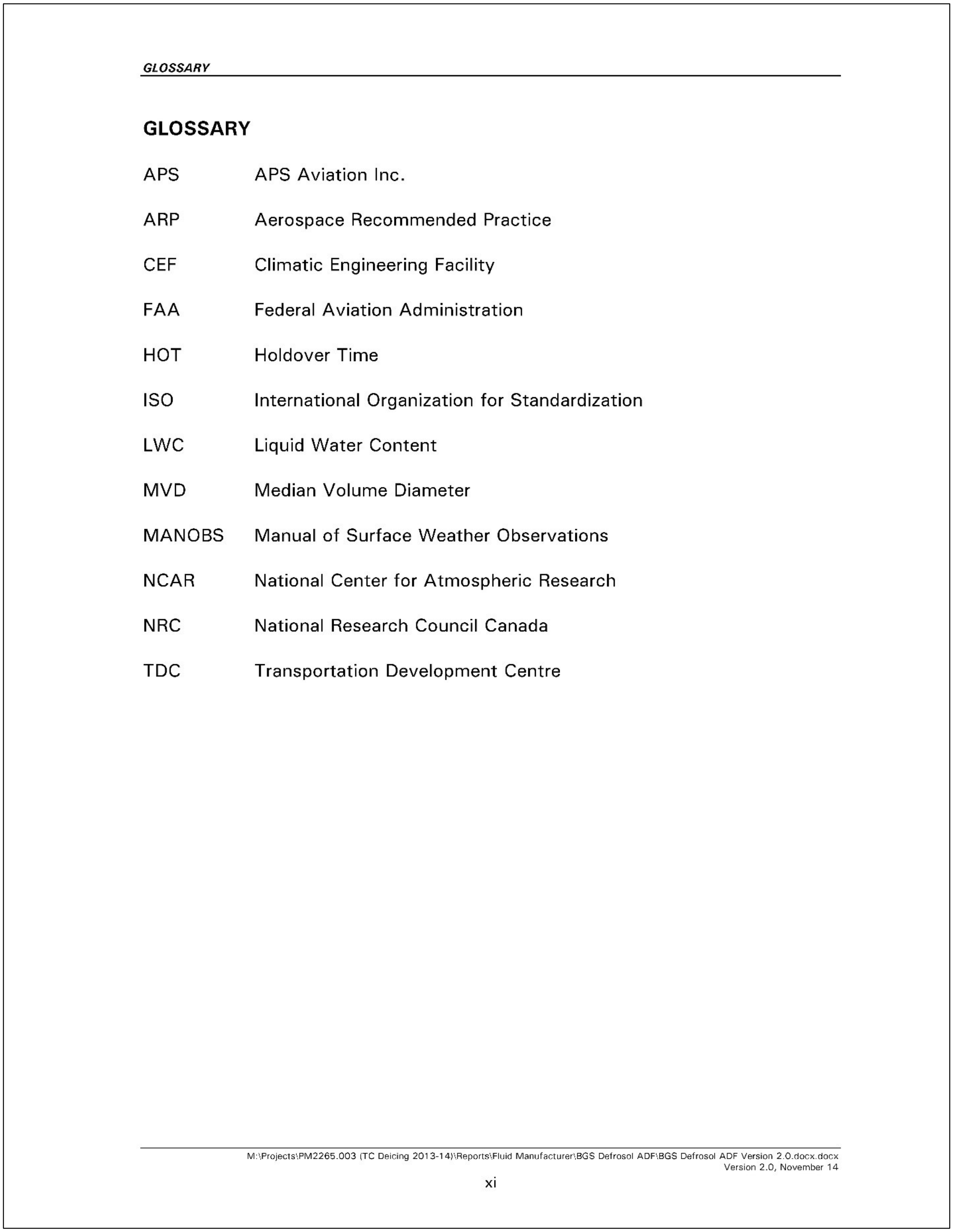
Table 2.1: BGS Defrosol ADF Dilution Table... 8
Table 2.2: Definition of Weather Phenomenon.. 14
Table 2.3: Theoretical and Experimental MVDs... 17
Table 2.4: Summary of Freezing Precipitation Test Conditions (Type I Fluids)........................ 18
Table 3.1: Summary of Tests Performed (Freezing Precipitation)... 30
Table 3.2: Summary of Tests Performed (Snow)... 33
Table 3.3: Summary of Tests Performed (Frost).. 34

LIST OF PHOTOS

Page

Photo 2.1: APS Test Site - View from Test Pad.. 19
Photo 2.2: APS Test Site - View from Trailer 19
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 20
Photo 2.4: Inside View of NRC Climatic Engineering Facility... 20
Photo 2.5: Test Plates Mounted on Stand.. 21
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 21

Photo 2.7: Frost Plate with Insulated Backing 22
Photo 2.8: Collection Pans Used Indoors at the NRC 22
Photo 2.9: Sprayer Assembly 23
Photo 2.10: Sprayer Assembly in Use 23
Photo 2.11: Sprayer Nozzle 24
Photo 2.12: Hand Held Brixometer 24
Photo 2.13: Twelve Hole Spreader Used for Fluid Application 25
Photo 2.14: Standard Plate Setup for Type I Testing with Artificial Snowmaker 25



GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TDC	Transportation Development Centre

This page intentionally left blank.

1. INTRODUCTION

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of de/anti-icing fluid holdover time (HOT) tables. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

Testing has shown that Type II and Type IV fluid endurance time performance varies considerably by fluid. As a result, endurance time testing is carried out with all Type II and Type IV fluids and fluid-specific HOT tables are developed for each Type II/IV fluid based on the results of the testing.

In contrast, a significant body of previous research and testing has indicated the endurance time performance of all Type I fluids formulated with glycol is similar. As a result, all Type I fluids are used with the Type I generic holdover times (no fluid-specific holdover times are provided) and regulators no longer require endurance time testing be conducted with Type I fluids formulated with propylene glycol, ethylene glycol or diethylene glycol. However, they do require the endurance time performance of fluids formulated with other glycol bases or with non-glycol bases be measured. This is to ensure the endurance time performance of these fluids is similar to the performance of the Type I fluids that were used to generate the current Type I generic holdover times.

This report provides a detailed account of the endurance time testing APS Aviation Inc. (APS) carried out with **Baltic Ground Services (BGS) Defrosol ADF**, a new Type I fluid formulated with a non-glycol base. It describes the test methodology used, endurance time data collected, and conclusions derived from the results.

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada and the Federal Aviation Administration (FAA).

This page intentionally left blank.

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5945 provides the procedure and requirements for endurance time testing with Type I fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5945, and some aspects which are not included in ARP5945. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type I endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type I endurance time data.

2.1 Test Sites

Natural and artificial snow and natural frost testing is performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport. The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

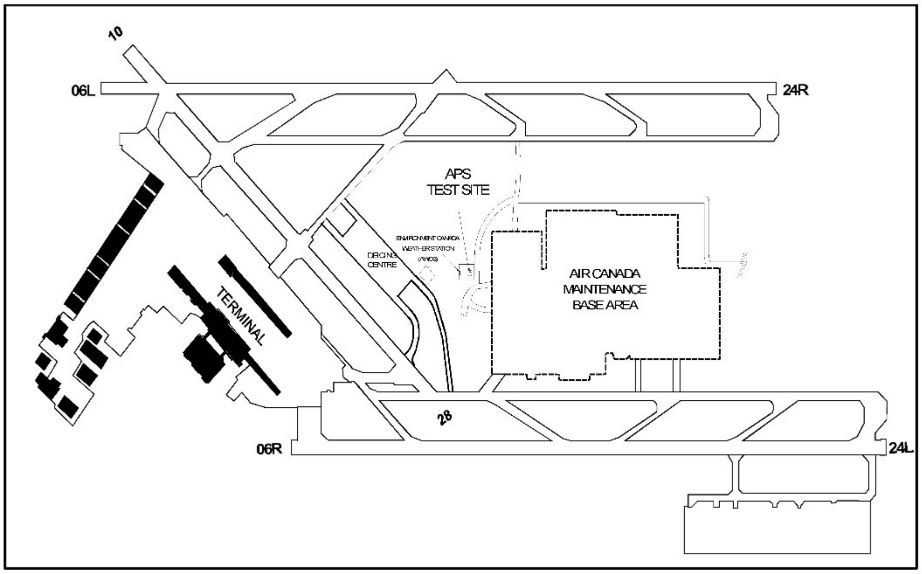


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

Tests under conditions of simulated freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing are conducted indoors at the National Research Council (NRC) Climatic Engineering Facility (CEF), where precipitation is artificially produced. Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing.

2.2 Test Equipment

The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

2.2.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

2.2.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5945.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1″), 15 cm (6″) and 30 cm (12″) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 2.3.3) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing and in natural snow testing with Type I fluids. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests and a leading edge thermal equivalent box when used empty for testing Type I fluids in natural snow conditions.

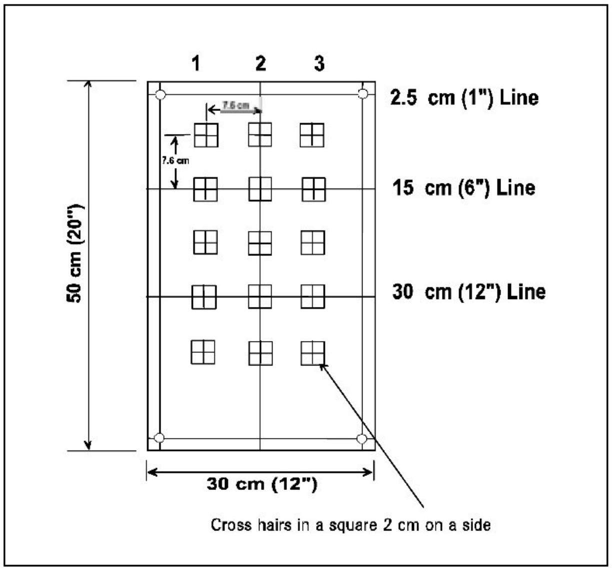


Figure 2.2: Standard Test Plate Schematic

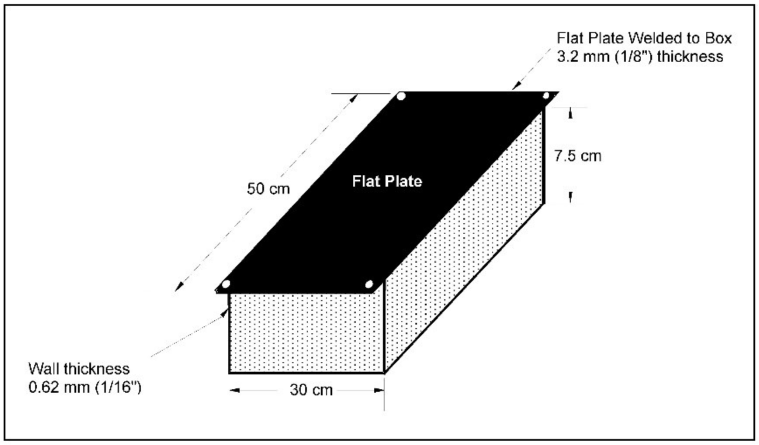


Figure 2.3: Cold Soak Box Schematic

In natural frost, tests are conducted on frosticator plates. The frosticator plates are constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 2.7 shows a white-painted aluminum frosticator plate.

2.2.4 Test Surface Materials

Research has shown endurance times of Type I fluids can be shorter on composite surfaces than on aluminum surfaces. For many years all test surfaces used in endurance time testing were constructed of aluminum. However, since Transport Canada and the FAA implemented new holdover times for composite surfaces in the winter of 2010-11, all Type I fluids evaluated for endurance time performance are tested on both aluminum and composite surfaces. The details of the test surface materials are as follows:

- Aluminum: Alclad 2024 T3 aluminum, 0.32 cm thick; and
- Composite: Carbon fibre cross weave fabric, 0.32 cm thick.

Previous research has shown this composite material produces endurance time results representative of many composite aircraft materials.

2.2.5 Test Stands

Figure 2.4 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

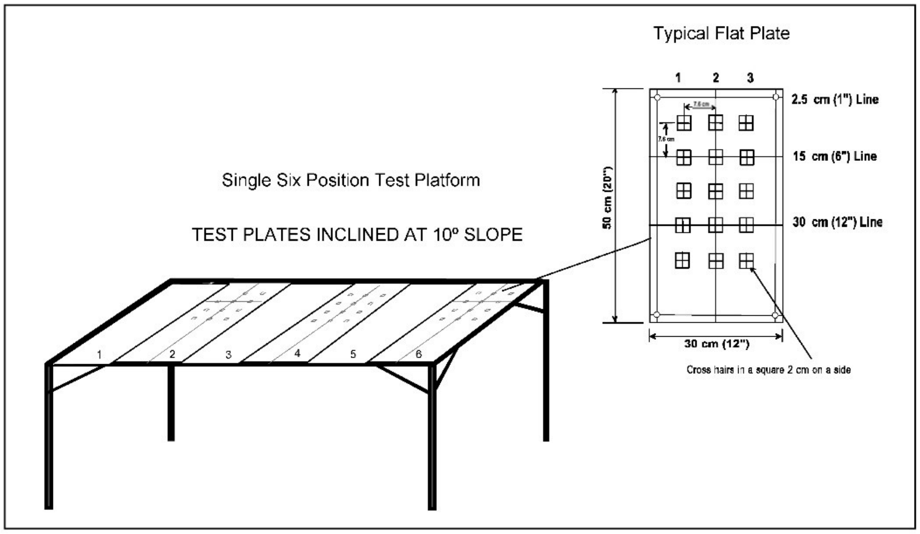


Figure 2.4: Test Stand Setup Schematic

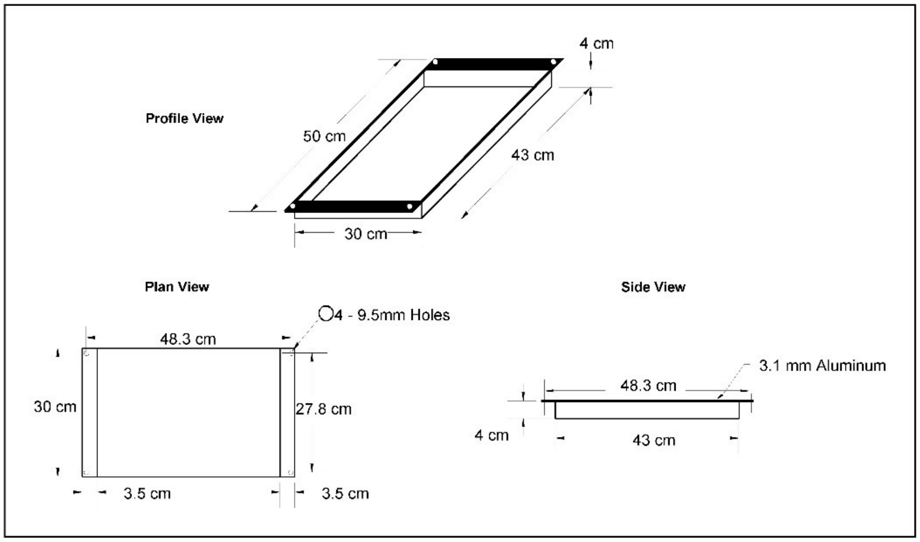


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.11.

2.2.8 Refractometer

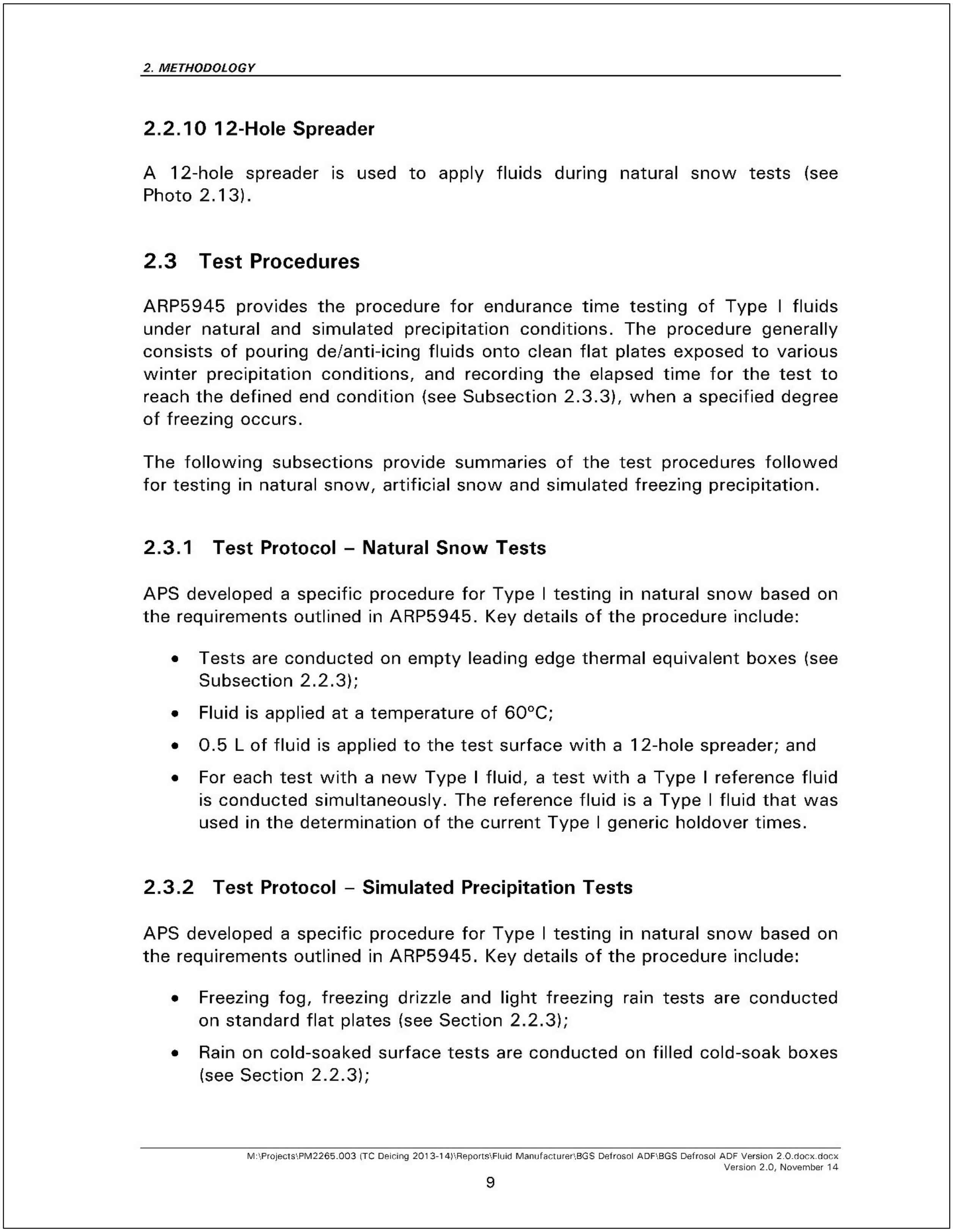
Freeze points were measured using a hand-held Misco refractometer with a Brix scale (see Photo 2.12)

2.2.9 Fluids

Testing was carried out using fluid diluted to a freeze point 10°C below the ambient temperature. Information provided by the manufacturer was used to develop the dilution table shown in Table 2.1, which was used to mix the fluid to the appropriate freeze point for each test.

Table 2.1: BGS Defrosol ADF Dilution Table

Test Temp. (°C)	**FFP** (°C)	**Fluid** %	**Brix** (°)	**Fluid for 4 L**	**Water for 4 L**
+1	-9	27.6	19.0	1.10	2.90
-3	-13	35.7	24.0	1.43	2.57
-6	-16	40.7	27.5	1.63	2.37
-10	-20	46.3	31.25	1.85	2.15
-25	-35	60.4	41.0	2.42	1.58



2.2.10 12-Hole Spreader

A 12-hole spreader is used to apply fluids during natural snow tests (see Photo 2.13).

2.3 Test Procedures

ARP5945 provides the procedure for endurance time testing of Type I fluids under natural and simulated precipitation conditions. The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 2.3.3), when a specified degree of freezing occurs.

The following subsections provide summaries of the test procedures followed for testing in natural snow, artificial snow and simulated freezing precipitation.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type I testing in natural snow based on the requirements outlined in ARP5945. Key details of the procedure include:

- Tests are conducted on empty leading edge thermal equivalent boxes (see Subsection 2.2.3);
- Fluid is applied at a temperature of 60°C;
- 0.5 L of fluid is applied to the test surface with a 12-hole spreader; and
- For each test with a new Type I fluid, a test with a Type I reference fluid is conducted simultaneously. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.3.2 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type I testing in natural snow based on the requirements outlined in ARP5945. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soaked surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);

- Fluid is applied at a temperature of 20°C; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Artificial Snow Tests

APS developed a specific procedure for Type I testing in artificial snow based on the requirements outlined in ARP5485 (ARP5945 does not currently include a procedure for artificial snow testing). Key details of the procedure include:

- Tests are conducted on a standard test plate with insulated tray (see Photo 2.14);
- Fluid is applied at a temperature of 60°C;
- 0.5 L of fluid is applied to the test surface with a 12-hole spreader; and
- For each test with a new Type I fluid, a test with a Type I reference fluid is also conducted. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.3.4 Test Protocol – Natural Frost Tests

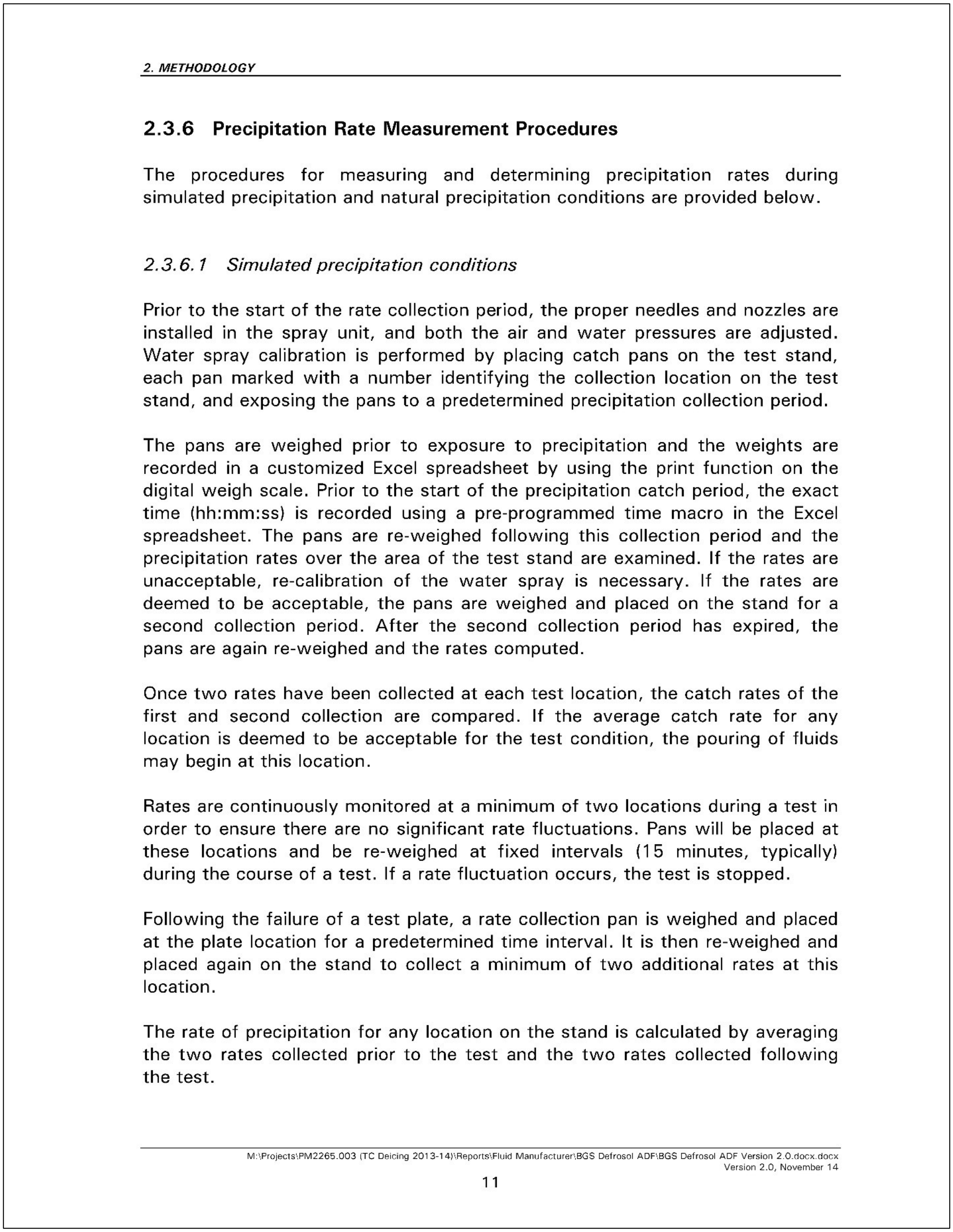
APS developed a specific procedure for Type I testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 2.2.3);
- Fluid is applied at 20°C; and
- 0.5 L of fluid is hand-poured on the test surface.

2.3.5 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

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



2.3.6 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.6.1 Simulated precipitation conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

2.3.6.2 Natural precipitation conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any HOT test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 206 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \text{ x } t_1 + R_2 \text{ x } t_2 + R_3 \text{ x } t_3)}{t_1 + t_2 + t_3}$$

In the example shown in Figure 2.6, the rate is calculated as follows:

$$\frac{(25 \text{ x } 10 + 22 \text{ x } 8 + 34 \text{ x } 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

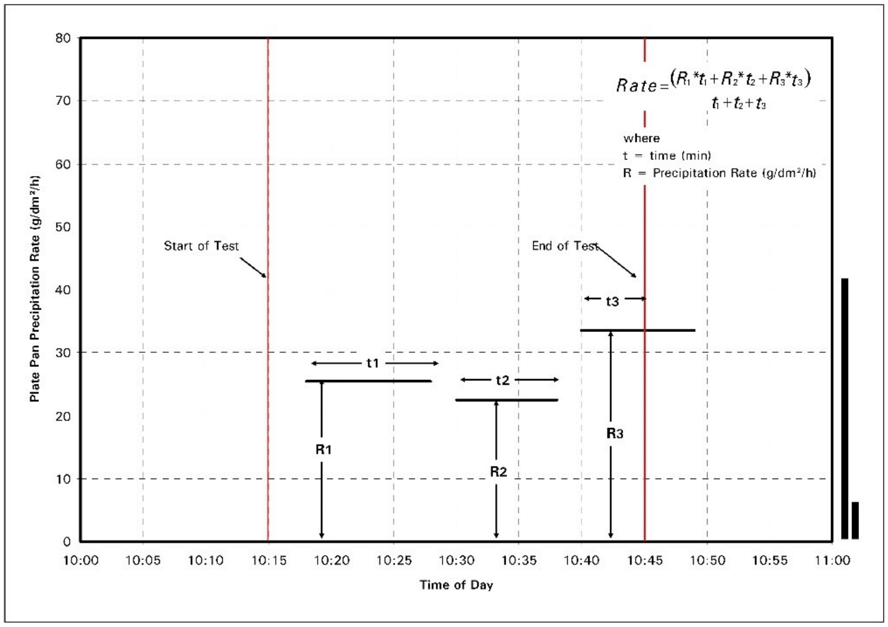


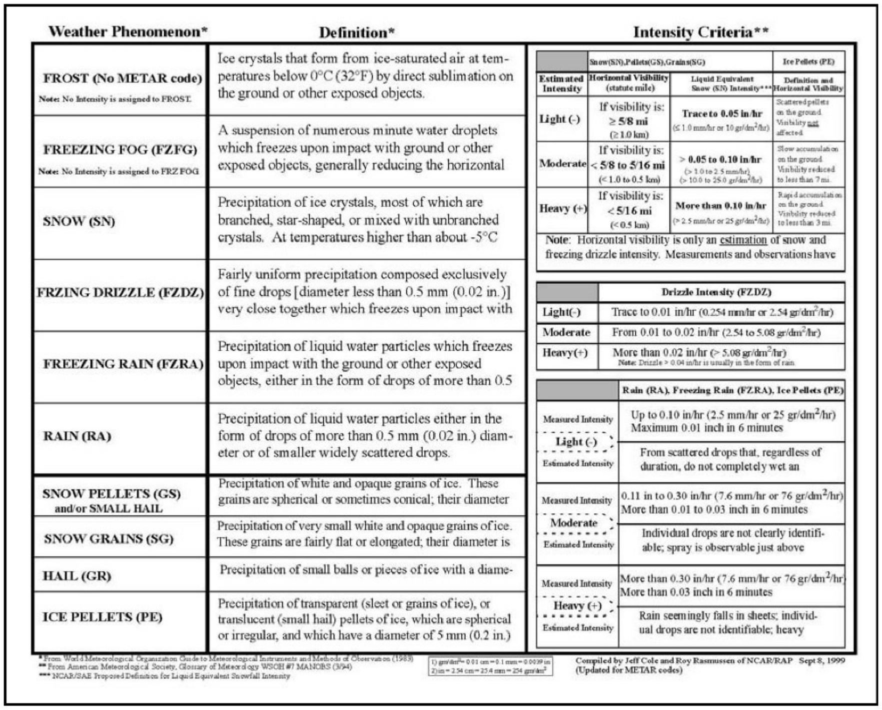
Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type I Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.2 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS) (3/94).*

The precipitation rate limits established for Type I endurance time testing are provided in ARP5945 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type I endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 2.2.

Table 2.2: Definition of Weather Phenomenon



Weather Phenomenon*	Definition*
FROST (No METAR code) Note: No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) Note: No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	Horizontal Visibility (statute mile)	Liquid Equivalent Snow (SN) Intensity***	Definition and Horizontal Visibility
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	Trace to 0.05 in/hr (≤ 1.0 mm/hr or 10 gr/dm²/hr)	Scattered pellets on the ground. Visibility not affected.
Moderate	If visibility is: < 5/8 to 5/16 mi (< 1.0 to 0.5 km)	> 0.05 to 0.10 in/hr (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: < 5/16 mi (< 0.5 km)	More than 0.10 in/hr (> 2.5 mm/hr or 25 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.
Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have			

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) Note: Drizzle > 0.04 in/hr is usually in the form of rain

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm²/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gm/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999
(Updated for METAR codes)

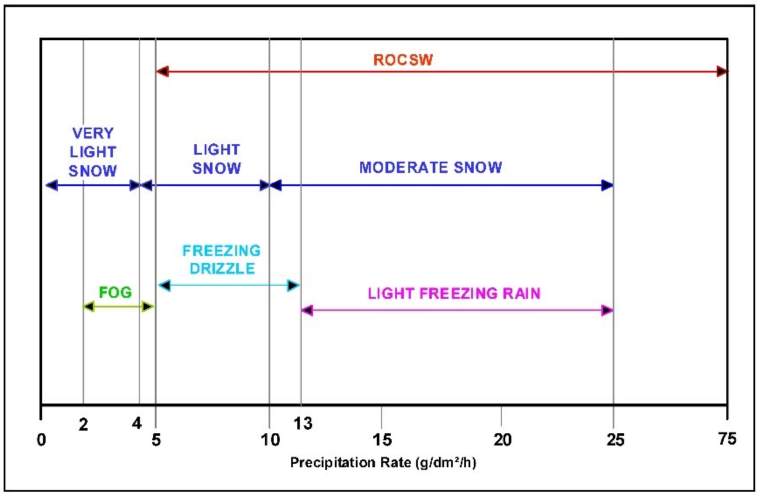
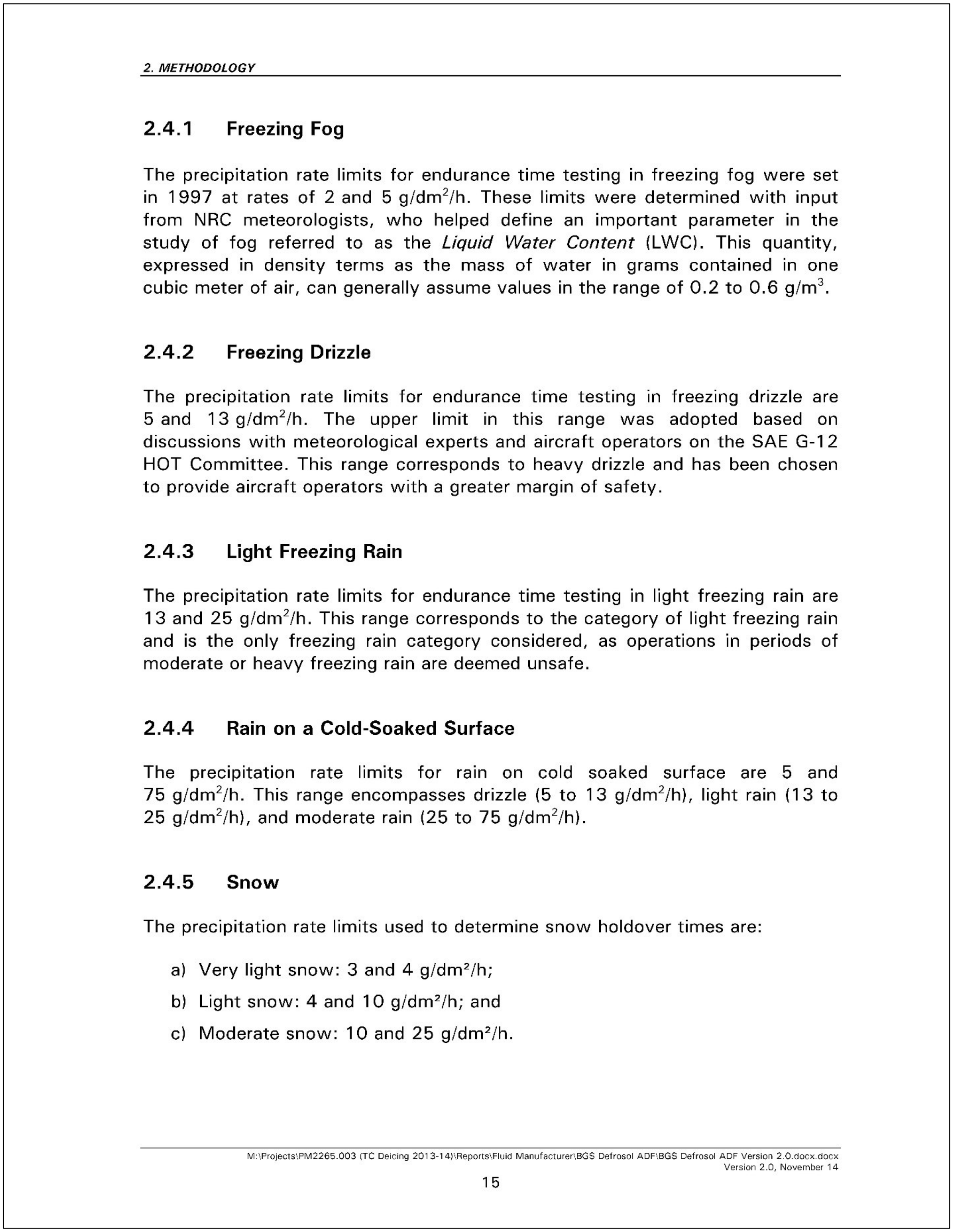


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing



2.4.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

2.4.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.

2.4.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.4.4 Rain on a Cold-Soaked Surface

The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

2.4.5 Snow

The precipitation rate limits used to determine snow holdover times are:

a) Very light snow: 3 and 4 g/dm^2/h;

b) Light snow: 4 and 10 g/dm^2/h; and

c) Moderate snow: 10 and 25 g/dm^2/h.

2.5 Ambient Temperatures in Type I Endurance Time Testing

The Type I generic holdover time tables provide holdover times for four temperature ranges:

- -3°C and above
- Below -3 to -6°C
- Below -6 to -10°C
- Below -10°C

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation and artificial snow testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -6°C, -10°C and -25°C
- Freezing Drizzle: -3°C, -6°C and -10°C
- Light Freezing Rain: -6°C and -10°C (see note below)
- Rain on Cold Soaked Surface: +1°C

Note: Testing is not carried out with Type I fluids in light freezing rain at -3°C as the latent heat of freezing in calm test conditions produces artificially long endurance times.

2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

$$\text{MVD} = (\text{precipitation rate}/10)^{0.23},$$ where MVD is in mm and rate of precipitation is in $g/dm^2/h$

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below:

a) *For the outdoor test:*

Location:	Montreal P.E.T. Airport
Precipitation:	Natural Light Freezing Rain
Precipitation Rate:	20 g/dm²/h
Calibrated MVD:	1.0 mm

b) *For the indoor test:*

Location:	National Research Council
Precipitation:	Simulated Light Freezing Rain
Precipitation Rate:	25 g/dm²/h
Calibrated MVD:	1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation. As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm²/h): 30 μm
- Freezing Fog, low precipitation rate (2 g/dm²/h): 30 μm

- Freezing Drizzle, high precipitation rate (13 g/dm²/h): 350 μm
- Freezing Drizzle, low precipitation rate (5 g/dm²/h): 250 μm

- Light Freezing Rain, high precipitation rate (25 g/dm²/h): 1,000 μm
- Light Freezing Rain, low precipitation rate (13 g/dm²/h): 1,000 μm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm²/h): 250 μm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm²/h): 1,400 μm

Table 2.3: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm²/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type I fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 20 weather conditions listed in Table 2.4.

2.8 Analysis Methodology

The endurance time performance of Type I fluids is evaluated by comparing the data collected to the performance of historical Type I fluids (i.e. the Type I fluids the generic Type I holdover times are based on). In order for the endurance time performance of a new Type I fluid to be considered acceptable, the endurance time results need to be similar or superior to the historical fluid data.

Table 2.4: Summary of Freezing Precipitation Test Conditions (Type I Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-6°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-10°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-25°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
Freezing Drizzle	-3°C	5 g/dm²/h (250 µm)
		13 g/dm²/h (350 µm)
	-6°C	5 g/dm²/h (250 µm)
		13 g/dm²/h (350 µm)
	-10°C	5 g/dm²/h (250 µm)
		13 g/dm²/h (350 µm)
Light Freezing Rain	-6°C	13 g/dm²/h (1,000 µm)
		25 g/dm²/h (1,000 µm)
	-10°C	13 g/dm²/h (1,000 µm)
		25 g/dm²/h (1,000 µm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm²/h (250 µm)
		75 g/dm²/h (1,400 µm)

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility

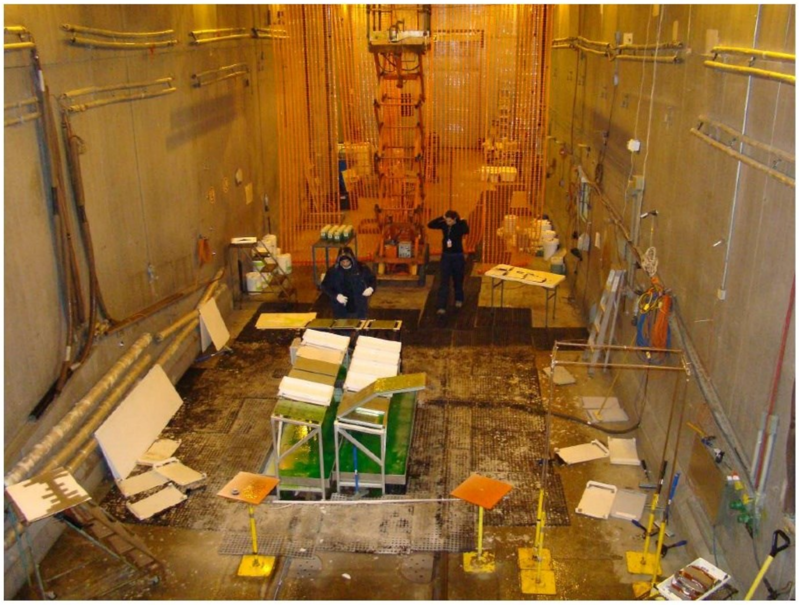


Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

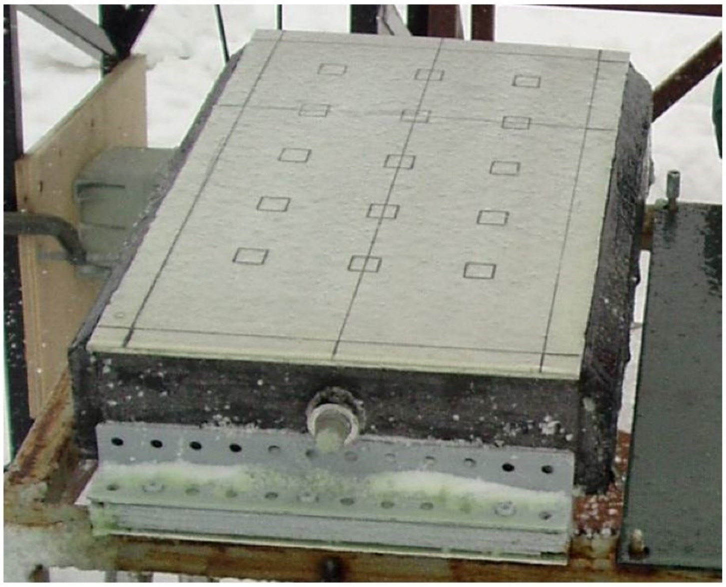


Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

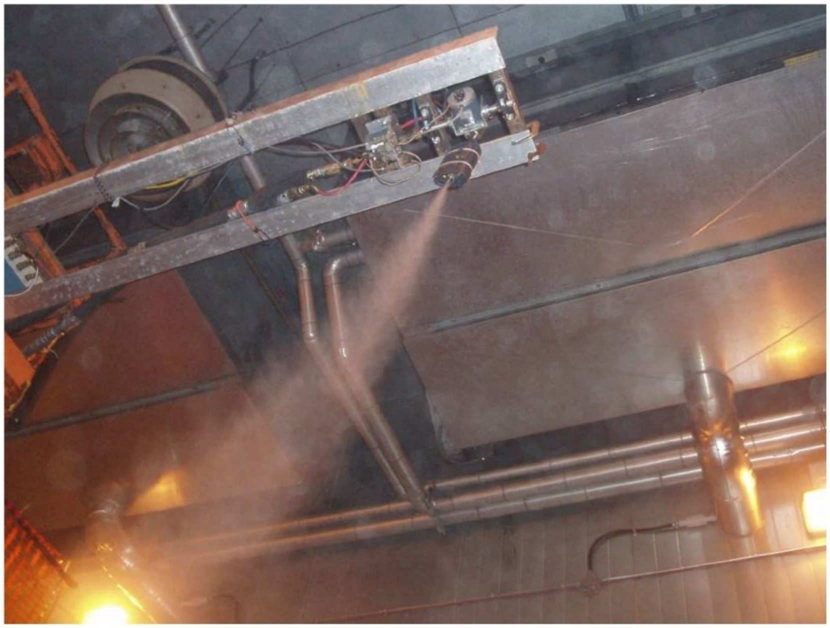


Photo 2.11: Sprayer Nozzle

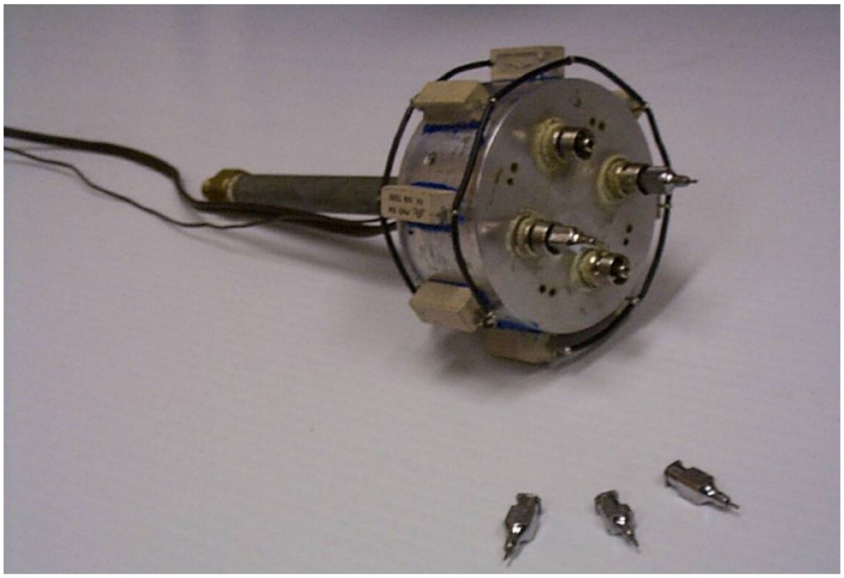


Photo 2.12: Hand Held Brixometer

Photo 2.13: Twelve Hole Spreader Used for Fluid Application

Photo 2.14: Standard Plate Setup for Type I Testing with Artificial Snowmaker

This page intentionally left blank.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the quantity of tests performed by precipitation type, test surface, and test temperature. A list of the tests conducted is provided in Section 3.9.

3.1 Artificial Snow Tests

Three tests were conducted with an artificial snowmaker at the APS test site in September 2013. For comparison purposes, the tests were repeated with a baseline historic Type I fluid.

Test Surface	-3°C	-6°C	-10°C	-25°C
Aluminum	3	0	0	0

3.2 Freezing Fog Tests

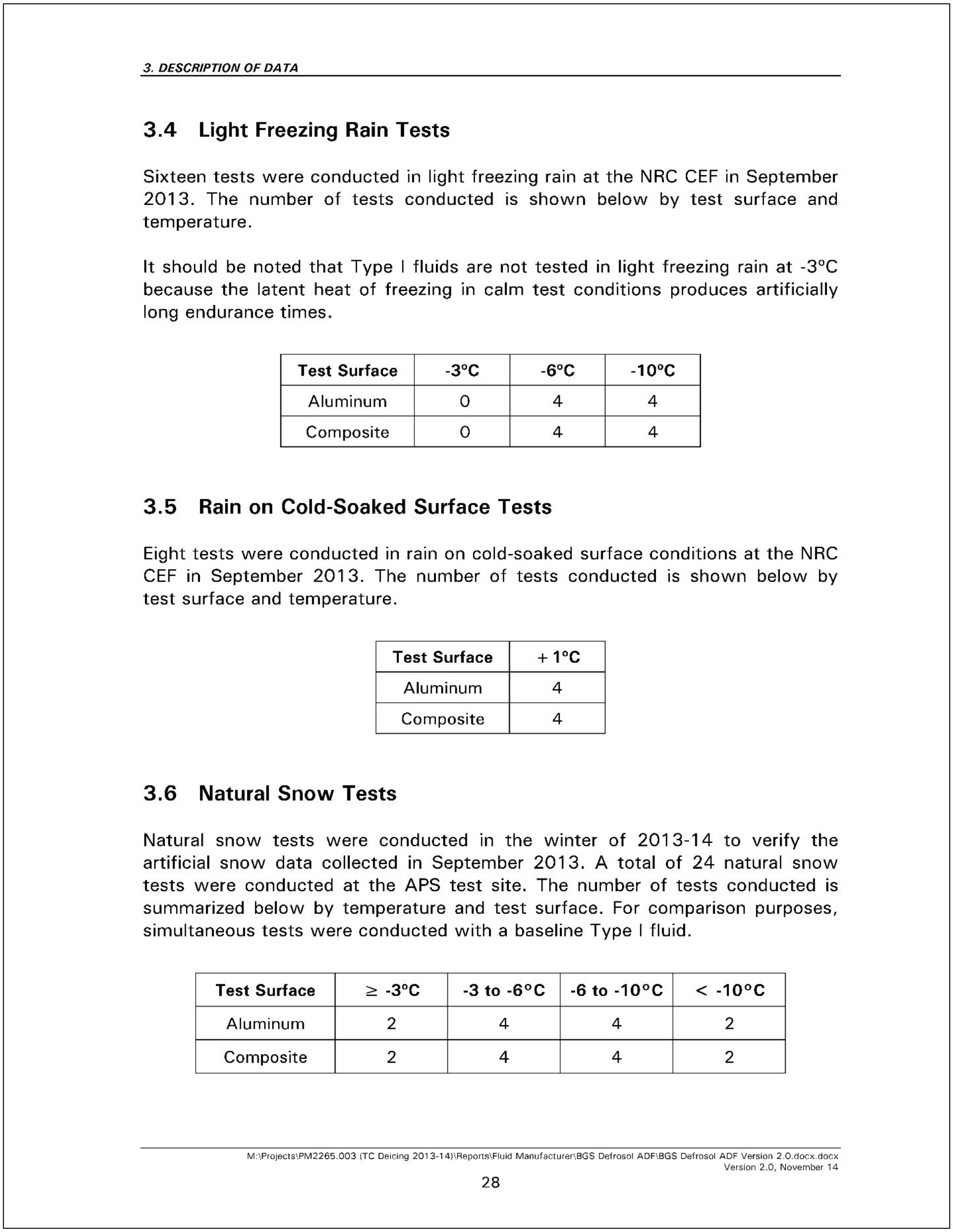
Thirty-two tests were conducted in freezing fog at the NRC CEF in September 2013. The number of tests conducted is shown below by test surface and temperature.

Test Surface	-3°C	-6°C	-10°C	-25°C
Aluminum	4	4	4	4
Composite	4	4	4	4

3.3 Freezing Drizzle Tests

Twenty-four tests were conducted in freezing drizzle at the NRC CEF in September 2013. The number of tests conducted is shown below by test surface and temperature.

Test Surface	-3°C	-6°C	-10°C
Aluminum	4	4	4
Composite	4	4	4



3.4 Light Freezing Rain Tests

Sixteen tests were conducted in light freezing rain at the NRC CEF in September 2013. The number of tests conducted is shown below by test surface and temperature.

It should be noted that Type I fluids are not tested in light freezing rain at -3°C because the latent heat of freezing in calm test conditions produces artificially long endurance times.

Test Surface	-3°C	-6°C	-10°C
Aluminum	0	4	4
Composite	0	4	4

3.5 Rain on Cold-Soaked Surface Tests

Eight tests were conducted in rain on cold-soaked surface conditions at the NRC CEF in September 2013. The number of tests conducted is shown below by test surface and temperature.

Test Surface	+ 1°C
Aluminum	4
Composite	4

3.6 Natural Snow Tests

Natural snow tests were conducted in the winter of 2013-14 to verify the artificial snow data collected in September 2013. A total of 24 natural snow tests were conducted at the APS test site. The number of tests conducted is summarized below by temperature and test surface. For comparison purposes, simultaneous tests were conducted with a baseline Type I fluid.

Test Surface	≥ -3°C	-3 to -6°C	-6 to -10°C	< -10°C
Aluminum	2	4	4	2
Composite	2	4	4	2

3.7 Natural Frost Tests

Eight tests were conducted in natural frost at the APS test site in the winter of 2013-14. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Test Surface	**≥-1°C**	**<-1 to -3°C**	**<-3 to -10°C**	**<-10°C**
Aluminum	0	0	0	4
Composite	0	0	0	4

3.8 Fluid Thickness Tests

Fluid thickness tests were conducted at the NRC CEF in September 2013. The purpose of these tests was to measure the film thickness profile of BGS Defrosol ADF under dry conditions. Two tests were performed at an ambient temperature of -3°C. The measurements are displayed below.

For each test, one litre of fluid was poured onto a flat plate mounted at 10° to the horizontal. Film thickness measurements were taken at the 15-cm (6") line at pre-selected time intervals over a 30-minute interval. The thickness after 30 minutes was 0.1 mm.

Measurement	**Time after Application (mins)**	**Thickness (mm)**	
		Run 1	**Run 2**
1	5	0.1	0.1
2	30	0.1	0.1

3.9 Summary of Tests Performed

Details of the tests performed are provided in Tables 3.1 (freezing precipitation), Table 3.2 (snow), and Table 3.3 (frost).

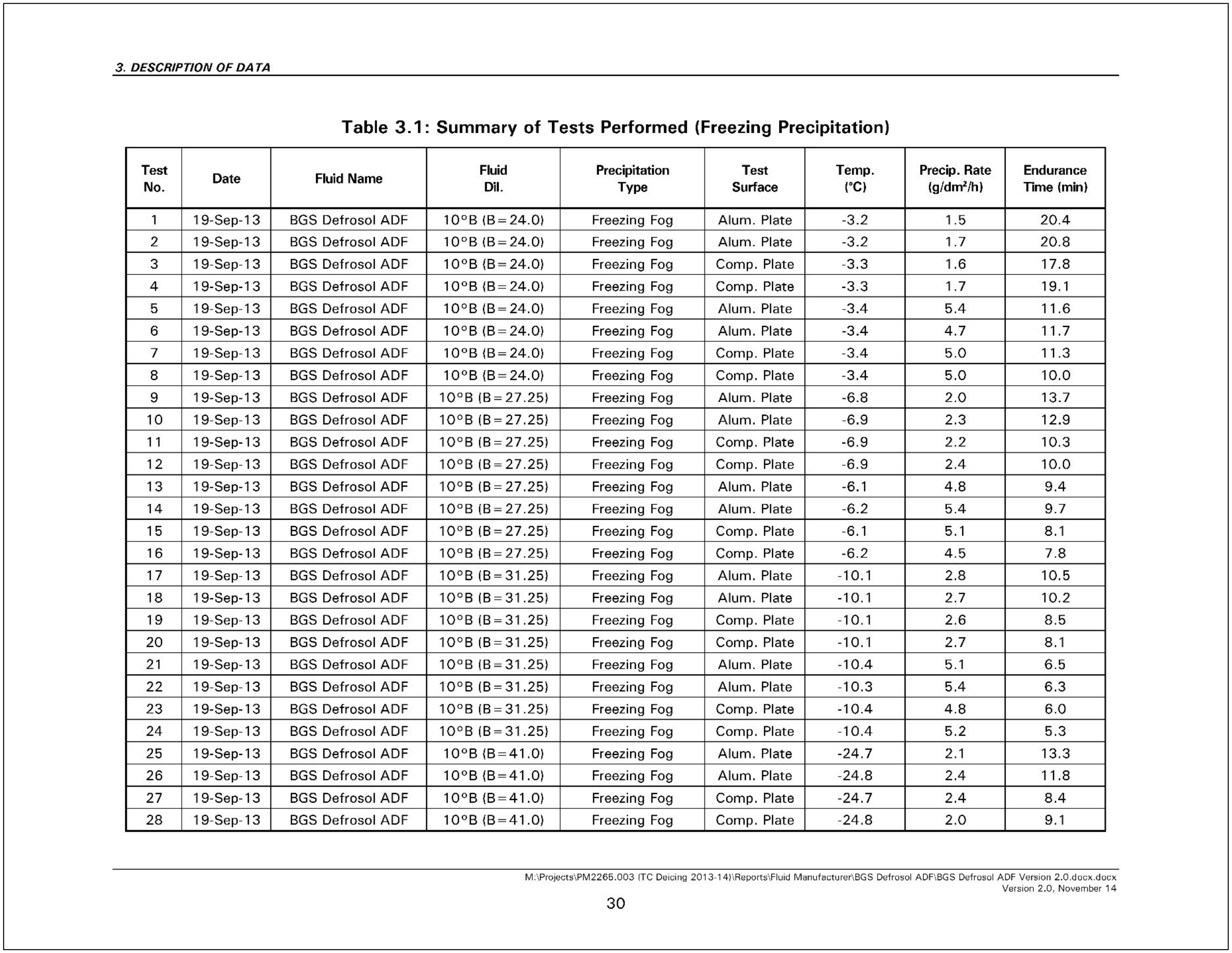


Table 3.1: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
1	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Alum. Plate	-3.2	1.5	20.4
2	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Alum. Plate	-3.2	1.7	20.8
3	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.3	1.6	17.8
4	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.3	1.7	19.1
5	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Alum. Plate	-3.4	5.4	11.6
6	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Alum. Plate	-3.4	4.7	11.7
7	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.4	5.0	11.3
8	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.4	5.0	10.0
9	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Alum. Plate	-6.8	2.0	13.7
10	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Alum. Plate	-6.9	2.3	12.9
11	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.9	2.2	10.3
12	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.9	2.4	10.0
13	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Alum. Plate	-6.1	4.8	9.4
14	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Alum. Plate	-6.2	5.4	9.7
15	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.1	5.1	8.1
16	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.2	4.5	7.8
17	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Alum. Plate	-10.1	2.8	10.5
18	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Alum. Plate	-10.1	2.7	10.2
19	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.1	2.6	8.5
20	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.1	2.7	8.1
21	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Alum. Plate	-10.4	5.1	6.5
22	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Alum. Plate	-10.3	5.4	6.3
23	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.4	4.8	6.0
24	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.4	5.2	5.3
25	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Alum. Plate	-24.7	2.1	13.3
26	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Alum. Plate	-24.8	2.4	11.8
27	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.7	2.4	8.4
28	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.8	2.0	9.1

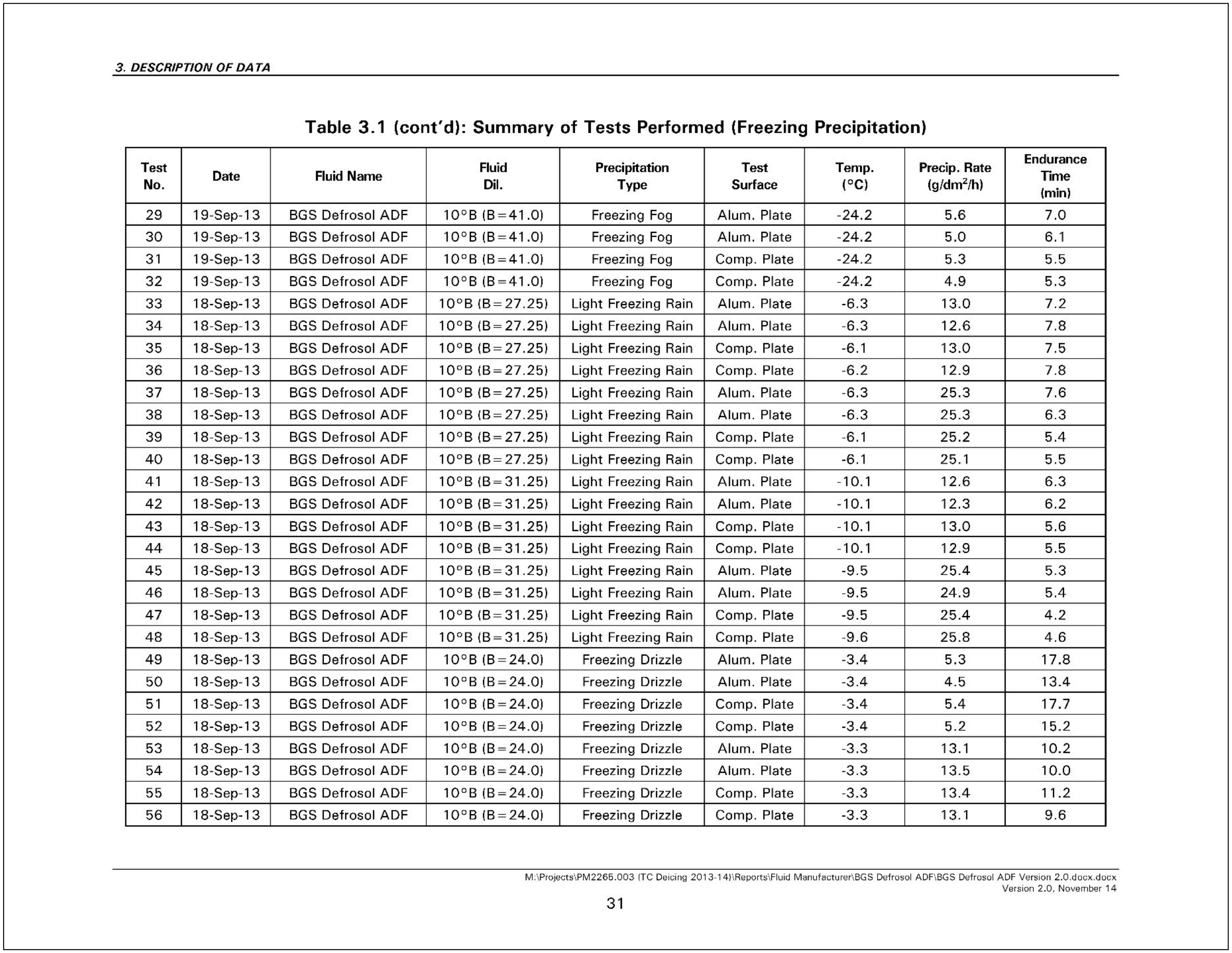


Table 3.1 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
29	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Alum. Plate	-24.2	5.6	7.0
30	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Alum. Plate	-24.2	5.0	6.1
31	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.2	5.3	5.5
32	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.2	4.9	5.3
33	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Alum. Plate	-6.3	13.0	7.2
34	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Alum. Plate	-6.3	12.6	7.8
35	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	13.0	7.5
36	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.2	12.9	7.8
37	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Alum. Plate	-6.3	25.3	7.6
38	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Alum. Plate	-6.3	25.3	6.3
39	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	25.2	5.4
40	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	25.1	5.5
41	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Alum. Plate	-10.1	12.6	6.3
42	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Alum. Plate	-10.1	12.3	6.2
43	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-10.1	13.0	5.6
44	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-10.1	12.9	5.5
45	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Alum. Plate	-9.5	25.4	5.3
46	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Alum. Plate	-9.5	24.9	5.4
47	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-9.5	25.4	4.2
48	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-9.6	25.8	4.6
49	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Alum. Plate	-3.4	5.3	17.8
50	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Alum. Plate	-3.4	4.5	13.4
51	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.4	5.4	17.7
52	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.4	5.2	15.2
53	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Alum. Plate	-3.3	13.1	10.2
54	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Alum. Plate	-3.3	13.5	10.0
55	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.3	13.4	11.2
56	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.3	13.1	9.6

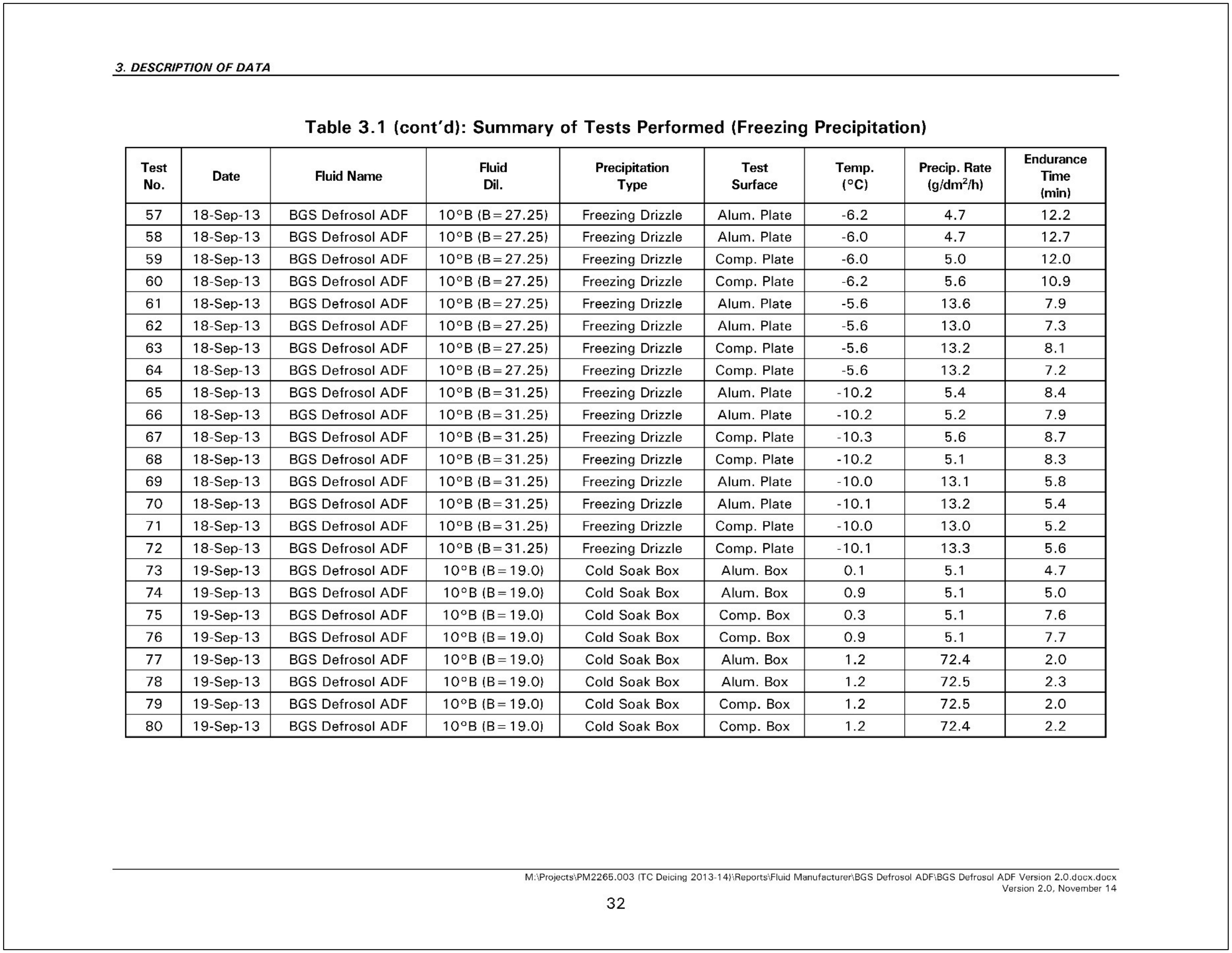


Table 3.1 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
57	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Alum. Plate	-6.2	4.7	12.2
58	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Alum. Plate	-6.0	4.7	12.7
59	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-6.0	5.0	12.0
60	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-6.2	5.6	10.9
61	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Alum. Plate	-5.6	13.6	7.9
62	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Alum. Plate	-5.6	13.0	7.3
63	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-5.6	13.2	8.1
64	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-5.6	13.2	7.2
65	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Alum. Plate	-10.2	5.4	8.4
66	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Alum. Plate	-10.2	5.2	7.9
67	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.3	5.6	8.7
68	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.2	5.1	8.3
69	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Alum. Plate	-10.0	13.1	5.8
70	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Alum. Plate	-10.1	13.2	5.4
71	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.0	13.0	5.2
72	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.1	13.3	5.6
73	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Alum. Box	0.1	5.1	4.7
74	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Alum. Box	0.9	5.1	5.0
75	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	0.3	5.1	7.6
76	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	0.9	5.1	7.7
77	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Alum. Box	1.2	72.4	2.0
78	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Alum. Box	1.2	72.5	2.3
79	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	1.2	72.5	2.0
80	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	1.2	72.4	2.2

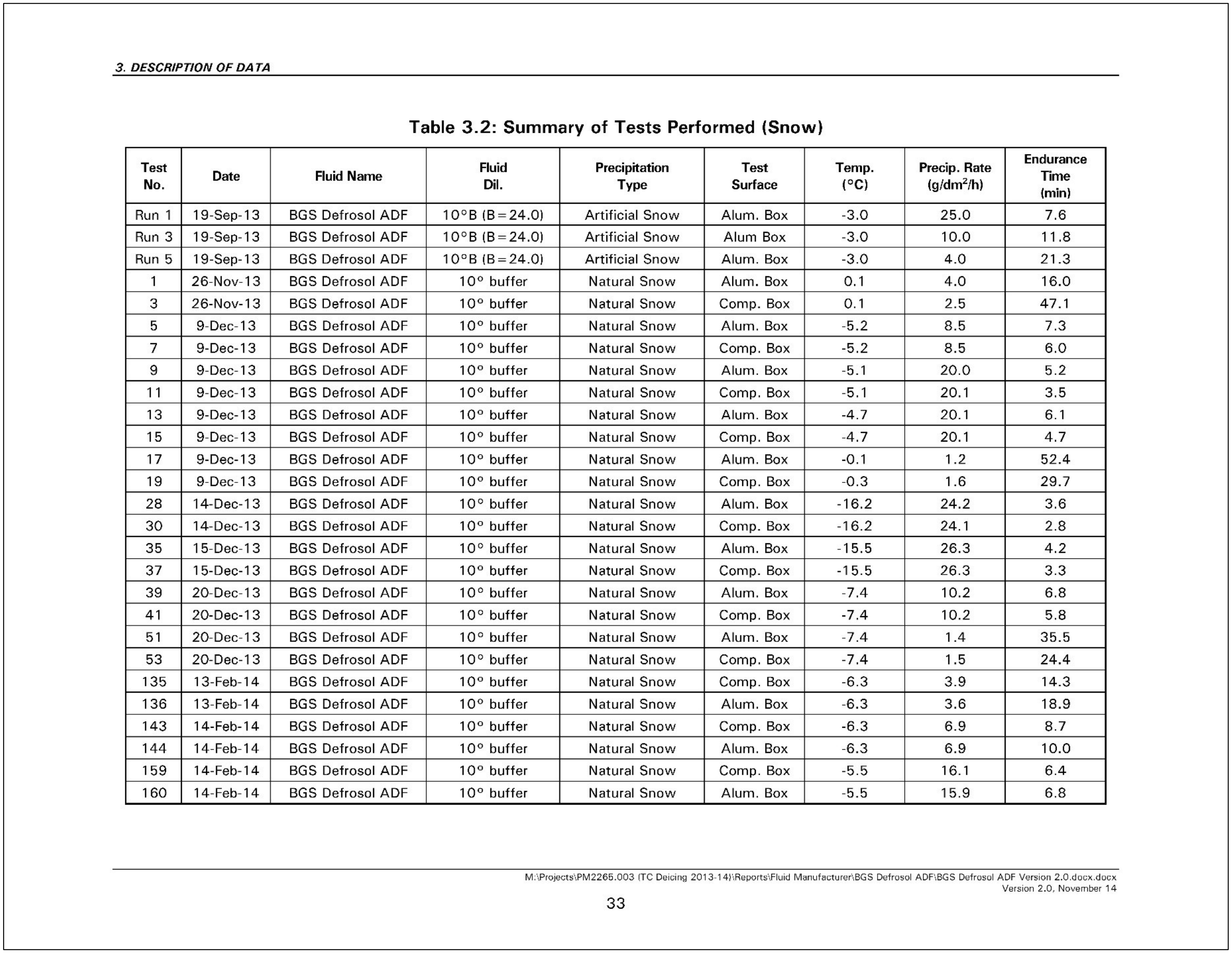


Table 3.2: Summary of Tests Performed (Snow)

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
Run 1	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Artificial Snow	Alum. Box	-3.0	25.0	7.6
Run 3	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Artificial Snow	Alum Box	-3.0	10.0	11.8
Run 5	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Artificial Snow	Alum. Box	-3.0	4.0	21.3
1	26-Nov-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	0.1	4.0	16.0
3	26-Nov-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	0.1	2.5	47.1
5	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-5.2	8.5	7.3
7	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-5.2	8.5	6.0
9	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-5.1	20.0	5.2
11	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-5.1	20.1	3.5
13	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-4.7	20.1	6.1
15	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-4.7	20.1	4.7
17	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-0.1	1.2	52.4
19	9-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-0.3	1.6	29.7
28	14-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-16.2	24.2	3.6
30	14-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-16.2	24.1	2.8
35	15-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-15.5	26.3	4.2
37	15-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-15.5	26.3	3.3
39	20-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-7.4	10.2	6.8
41	20-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-7.4	10.2	5.8
51	20-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-7.4	1.4	35.5
53	20-Dec-13	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-7.4	1.5	24.4
135	13-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-6.3	3.9	14.3
136	13-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-6.3	3.6	18.9
143	14-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-6.3	6.9	8.7
144	14-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-6.3	6.9	10.0
159	14-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Comp. Box	-5.5	16.1	6.4
160	14-Feb-14	BGS Defrosol ADF	10° buffer	Natural Snow	Alum. Box	-5.5	15.9	6.8

Table 3.3: Summary of Tests Performed (Frost)

Test No.	Date	Fluid Name	Fluid Dilution	Precipitation Type	Test Surface	Temp (°C)	Average Rate (g/dm²/h)	Wind Speed (km/h)	Average RH (%)	Endurance Time (min)	Final Brix (°)	Comments
8	11-Feb-14	BGS Defrosol ADF	10° buffer	Natural Frost	Alum.	-16.4	0.06	7	59.5	175	33.75	Failed
9	11-Feb-14	BGS Defrosol ADF	10° buffer	Natural Frost	Comp.	-16.3	0.06	9.3	58.6	98	n/a	Failed
10	11-Feb-14	BGS Defrosol ADF	10° buffer	Natural Frost	Alum.	-15.2	0.05	1.25	71.25	182	n/a	Failed
11	11-Feb-14	BGS Defrosol ADF	10° buffer	Natural Frost	Comp.	-14.8	0.06	1.6	70.3	121	n/a	Failed
16	5-Mar-14	BGS Defrosol ADF	10° buffer	Natural Frost	Alum.	-13.7	0.06	4	73	107	28.25	Failed
17	5-Mar-14	BGS Defrosol ADF	10° buffer	Natural Frost	Comp.	-13.4	0.06	4	73	67	31.75	Failed
20	5-Mar-14	BGS Defrosol ADF	10° buffer	Natural Frost	Alum.	-16.0	0.04	9	61.2	167	36.50	DNF
21	5-Mar-14	BGS Defrosol ADF	10° buffer	Natural Frost	Comp.	-16.0	0.04	9	61.2	167	35.00	DNF

4. RESULTS AND DISCUSSION

The endurance time test results of BGS Defrosol ADF are presented in this section. To assess the performance of the fluid, the endurance time results are compared to historic Type I fluid endurance times.

4.1 Results

Figures 4.1 to 4.20 show the results of testing in simulated freezing precipitation. There is one chart for each freezing precipitation cell in the Type I generic holdover time tables, with the exception of the "-3°C and above" light freezing rain cells (see note in Subsection 2.5). Each chart contains the BGS Defrosol ADF endurance times (represented with solid diamonds), the endurance times of other Type I fluids (represented with hollow diamonds) and the current Type I generic holdover times (represented by solid squares).

Figures 4.21 to 4.22 show the results of testing in natural snow. The BGS Defrosol ADF endurance times are represented with solid shapes and the endurance times of other Type I fluids are represented with hollow shapes.

Figure 4.23 shows the results of testing in artificial snow. There is one chart showing the results collected at a temperature of -3°C. For each precipitation rate under which tests were conducted, there is a bar showing the endurance time of BGS Defrosol ADF and a bar showing the endurance time of the historic Type I fluid tested.

The natural frost data was presented in Table 3.3. All tests, including those where fluid failure did not occur (due to active frost ending before fluid failure could occur), surpassed the Type I holdover times.

4.2 Discussion

The data collected shows the endurance times of BGS Defrosol ADF are similar or superior to the endurance times of Type I fluids tested in past years and to the current Type I generic holdover times. These results indicate this non-glycol based fluid performs similar to glycol based Type I fluids from an endurance time perspective and therefore can be used with the generic Type I HOT guidelines.

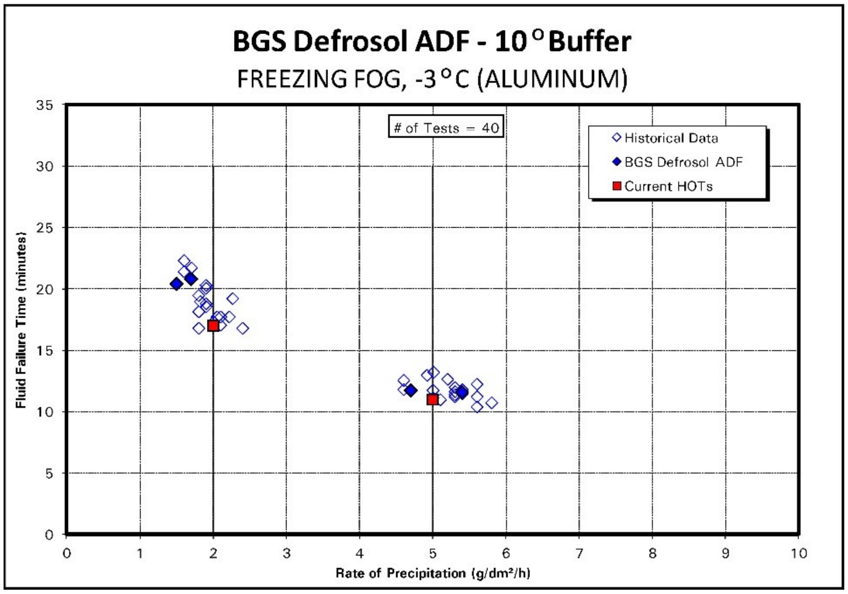


Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface

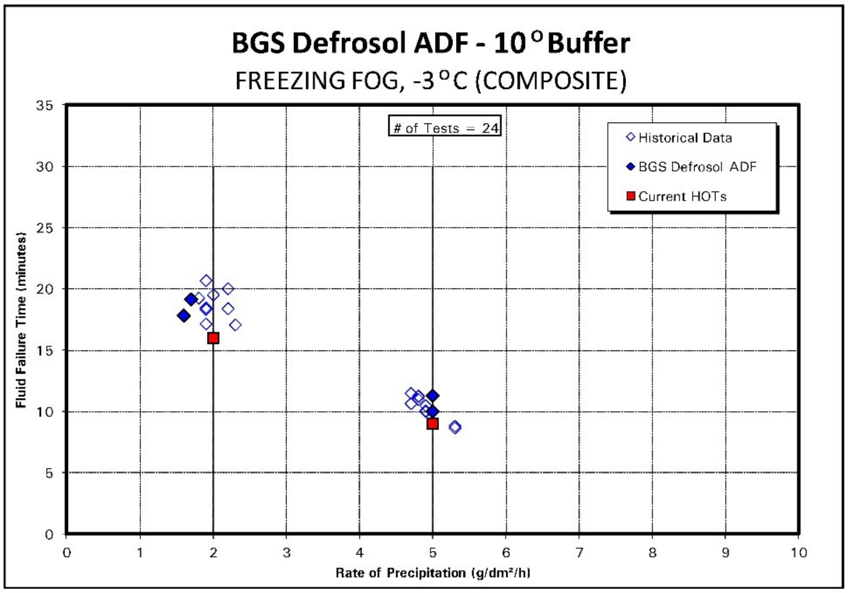


Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface

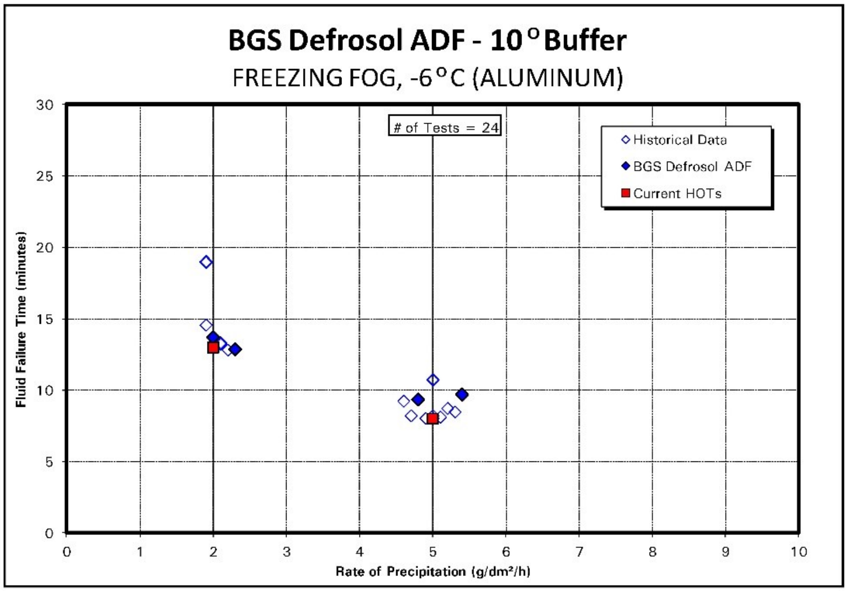


Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface

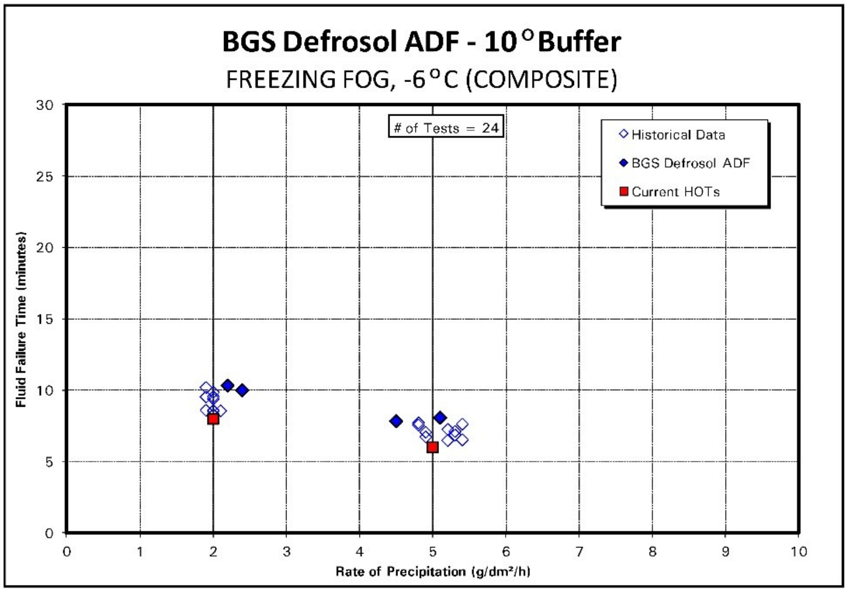


Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface

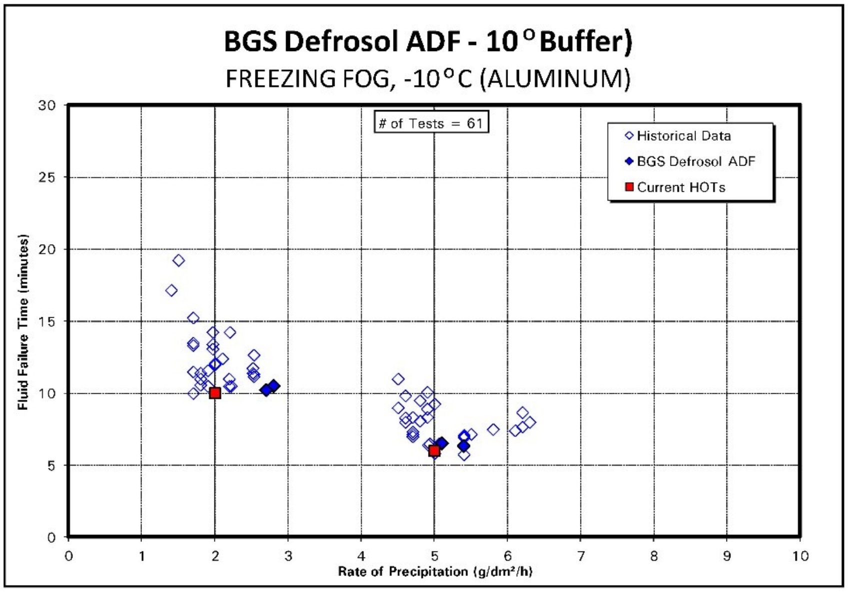


Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface

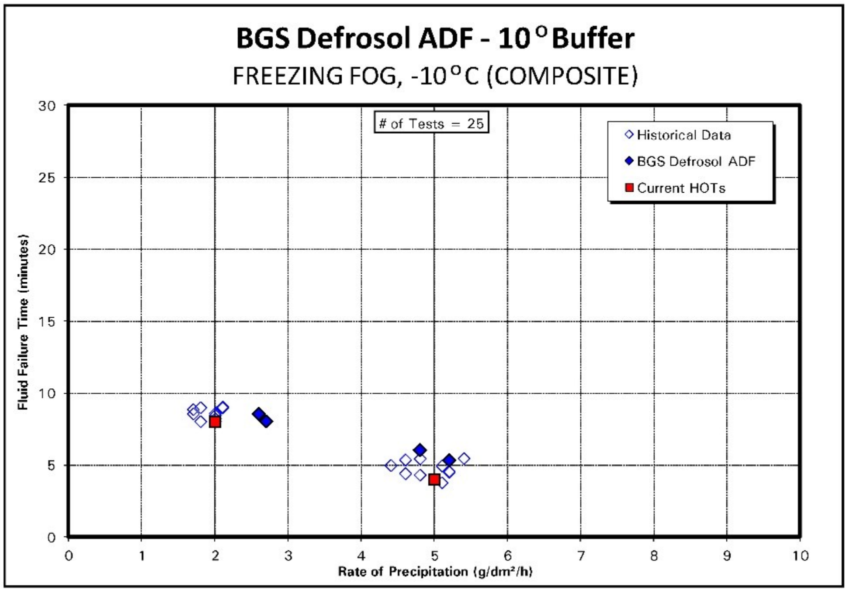


Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface

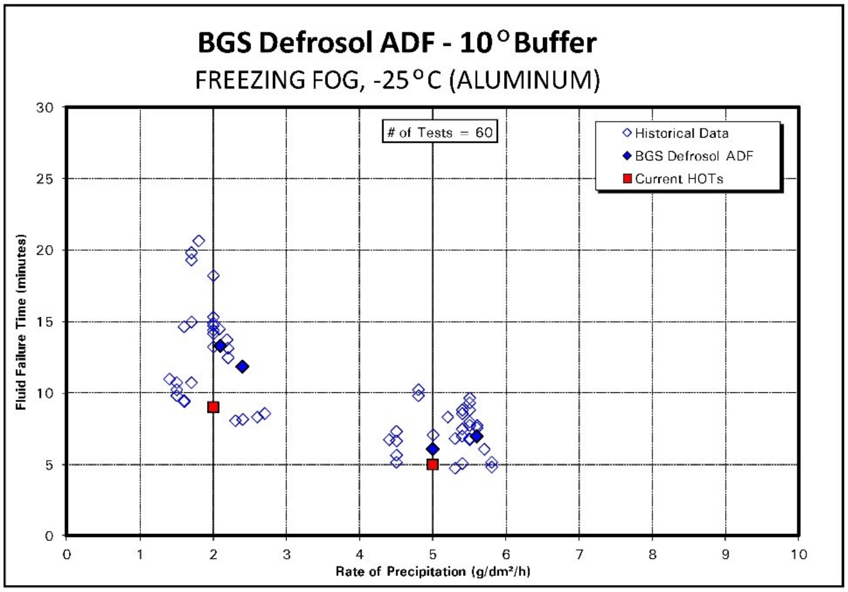


Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface

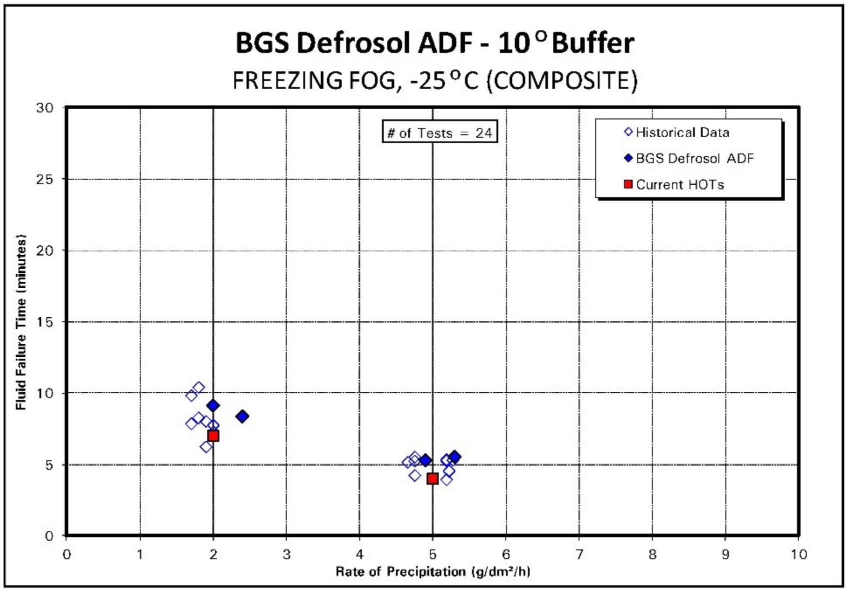


Figure 4.8: Freezing Fog, Below -10°C, Composite Surface

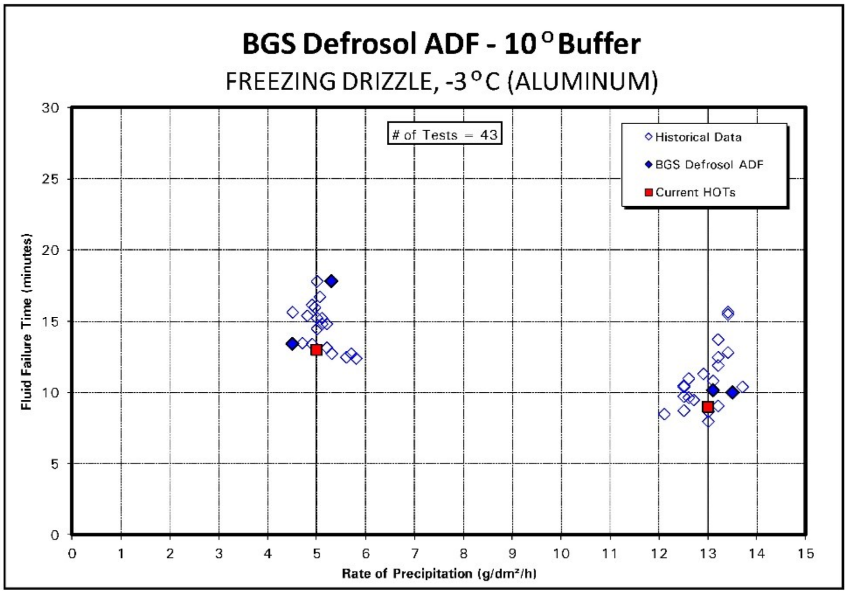


Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface

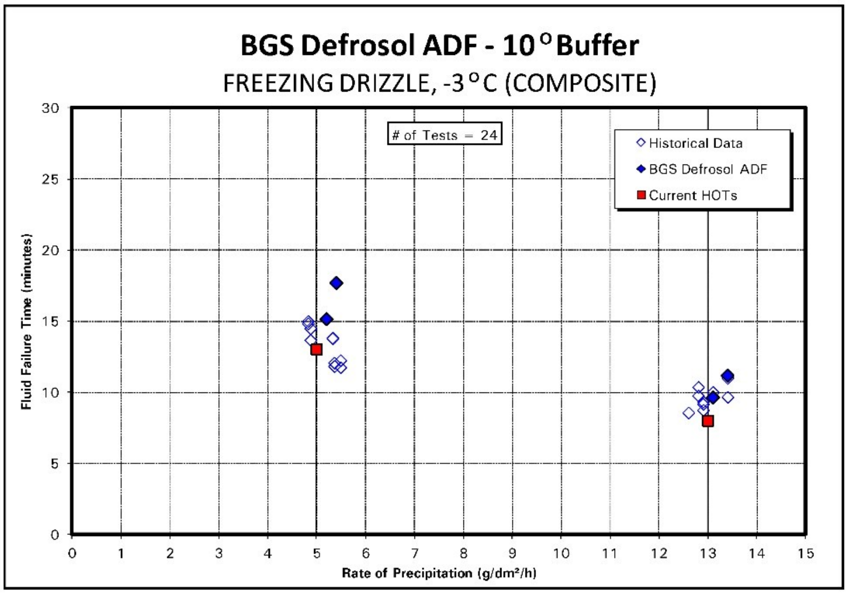


Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface

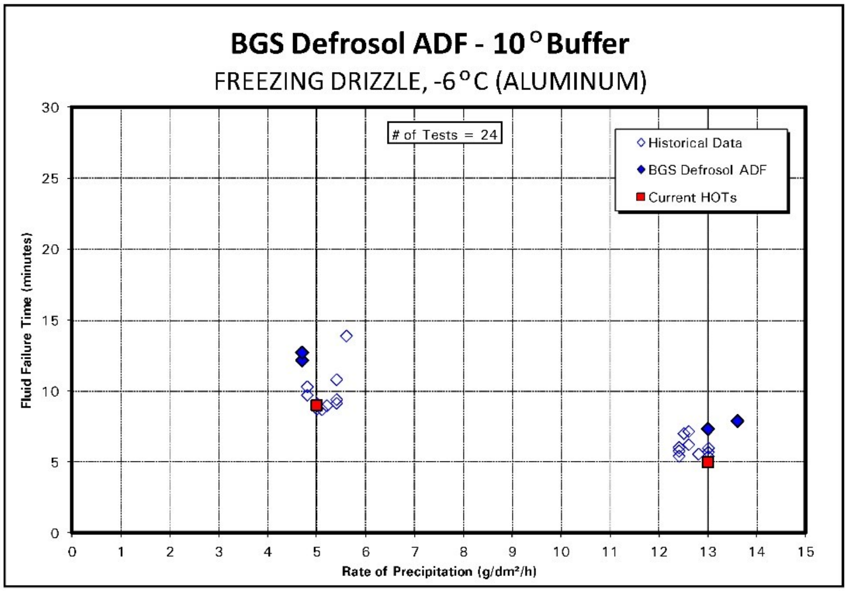


Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface

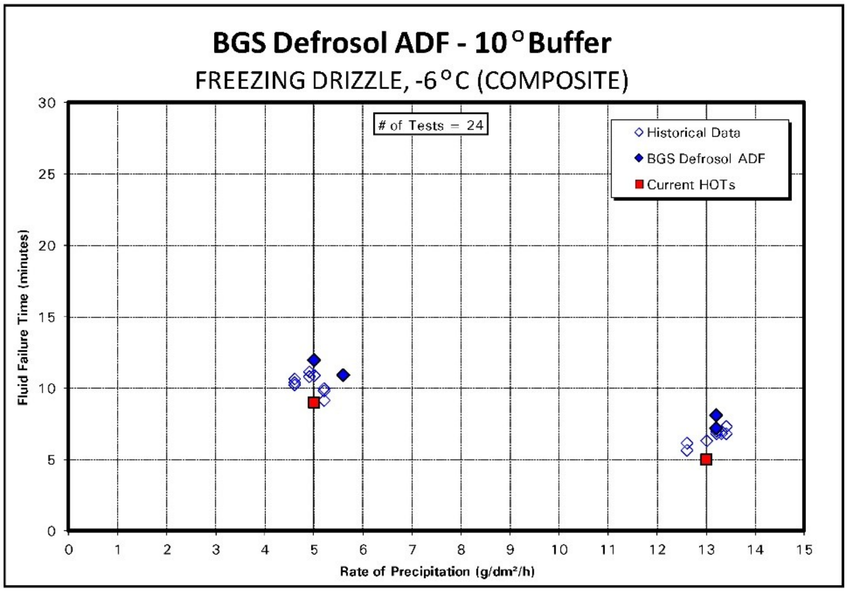


Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface

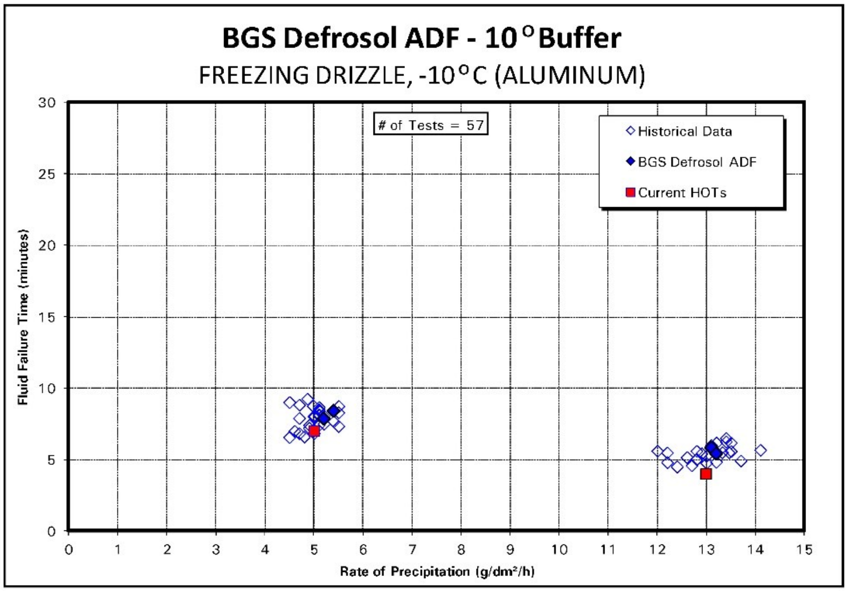


Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface

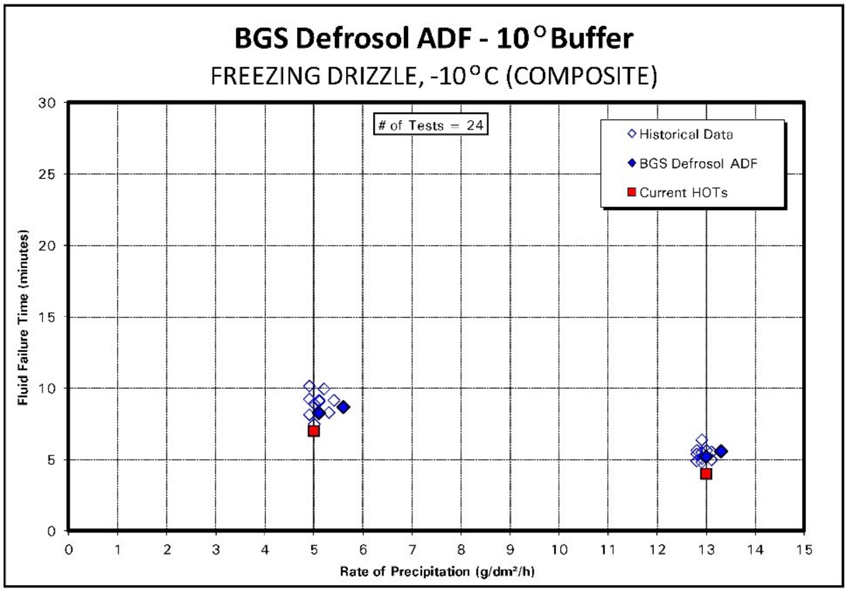


Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface

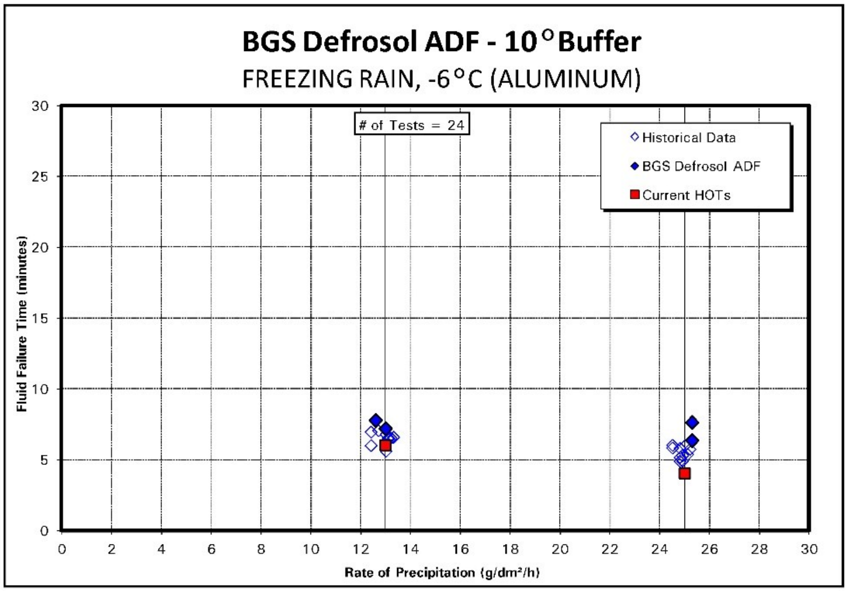


Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface

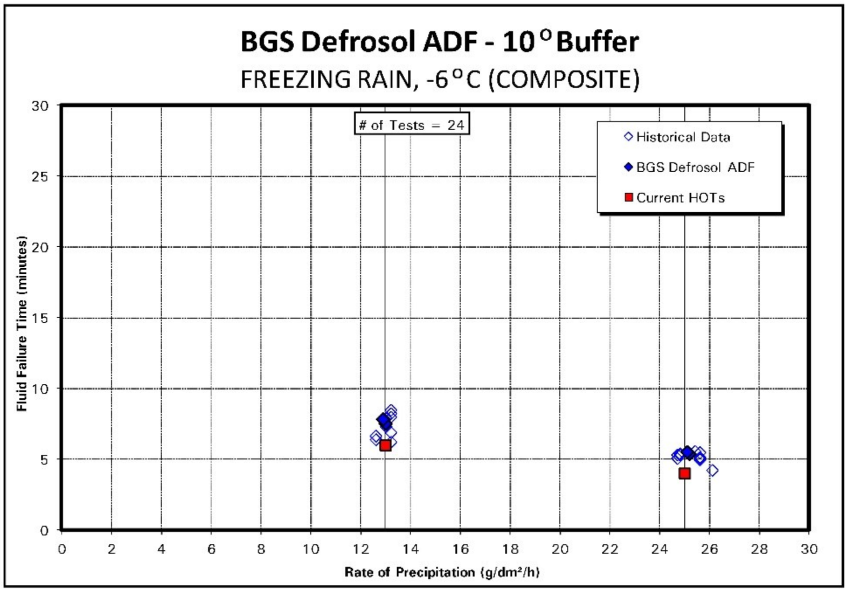


Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface

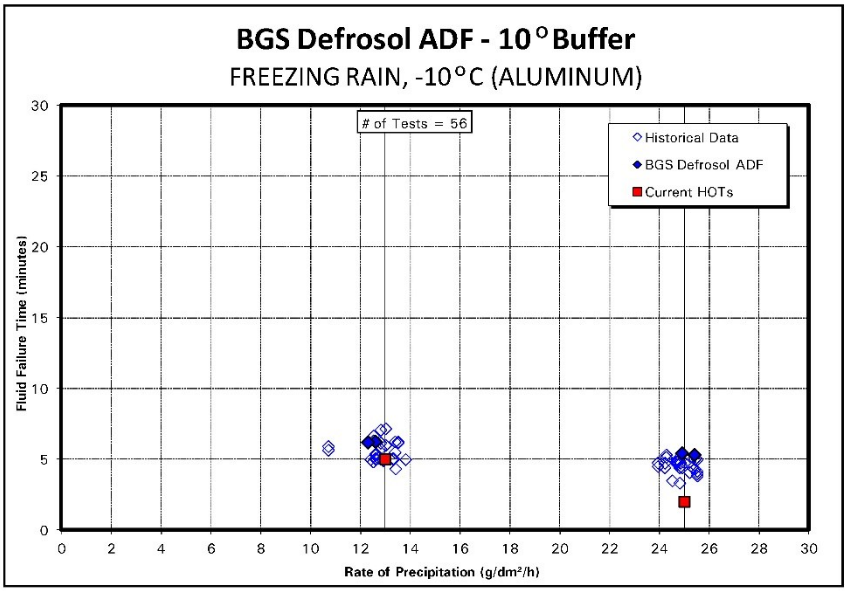


Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface

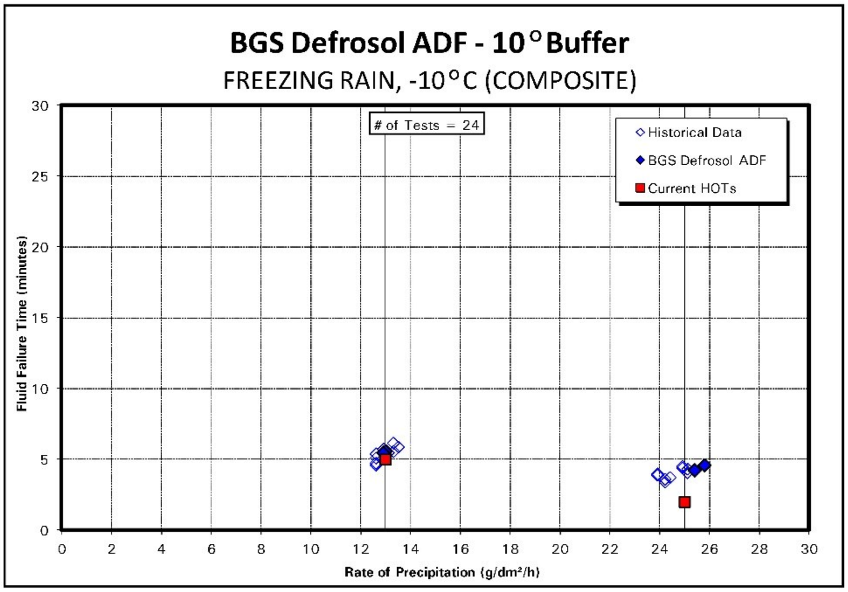


Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface

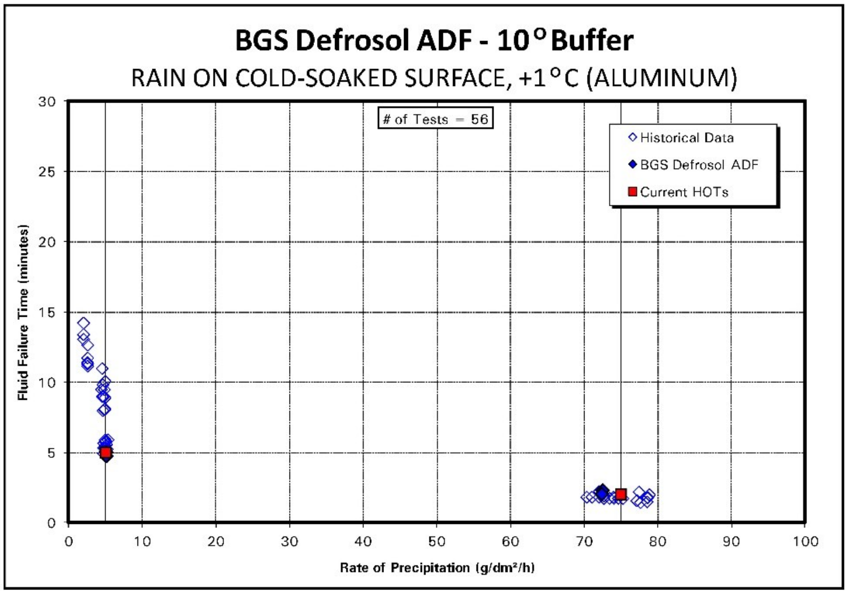


Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface

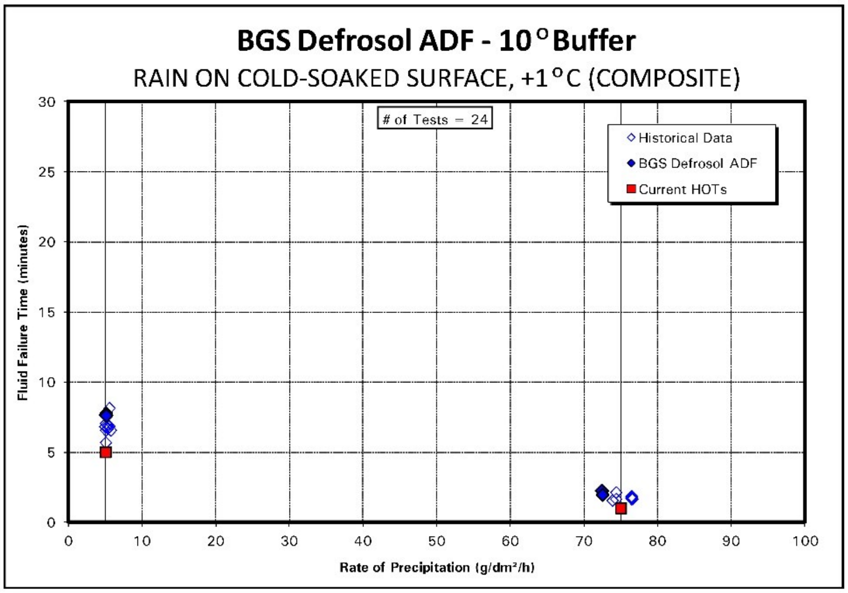


Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface

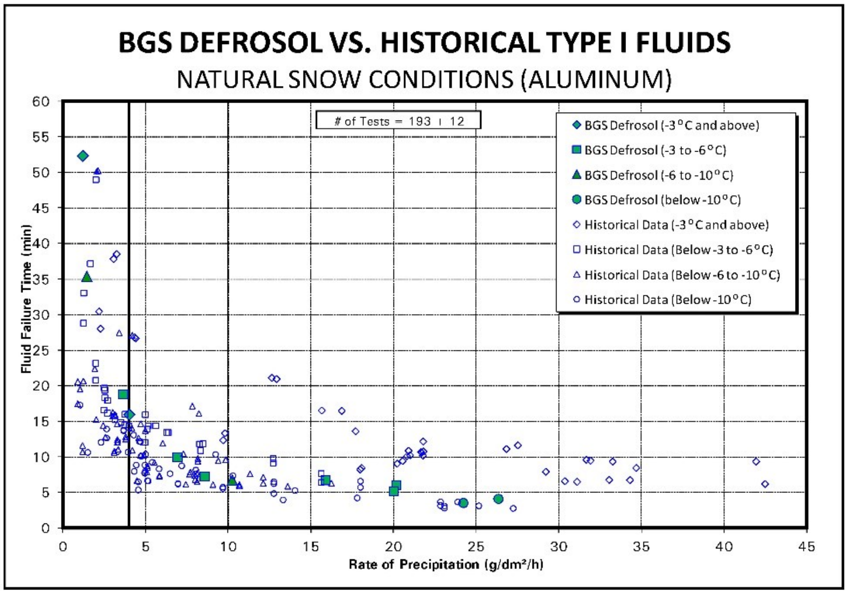


Figure 4.21: Natural Snow, Aluminum Surface

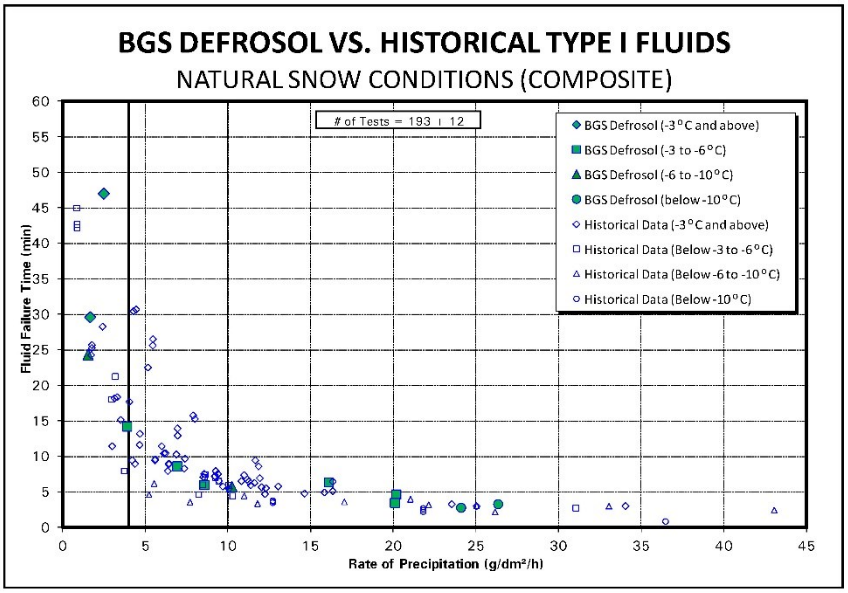


Figure 4.22: Natural Snow, Composite Surface

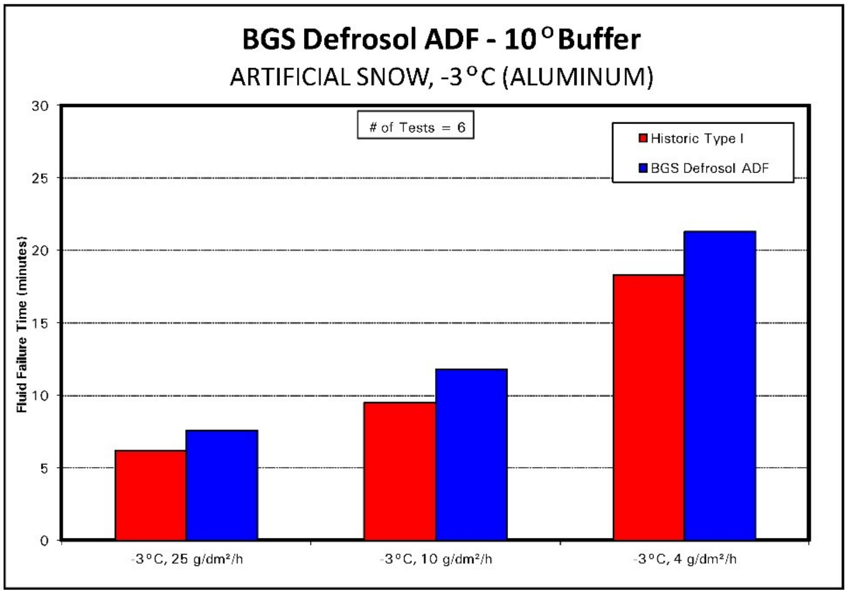


Figure 4.23: Artificial Snow, -3°C and Above, Aluminum Surface

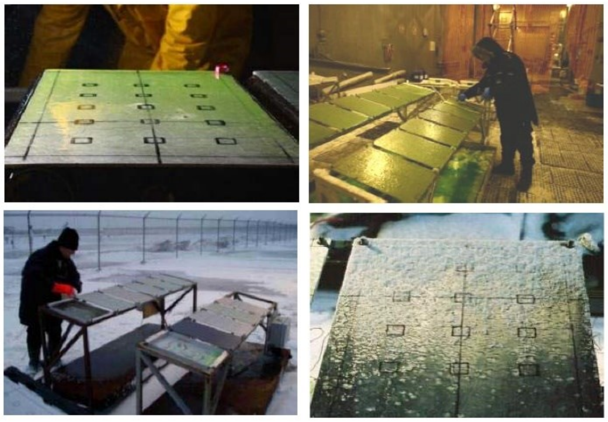
This page intentionally left blank.

APPENDIX D

FLUID MANUFACTURER REPORT:
LNT SOLUTIONS P250 (TYPE II)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

LNT Solutions P250 (Type II)



Prepared for

LNT Solutions

by

APS
Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. L-250 2013-14

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

LNT Solutions P250 (Type II)

Prepared for

LNT Solutions

Prepared by: Nov. 28, 2014

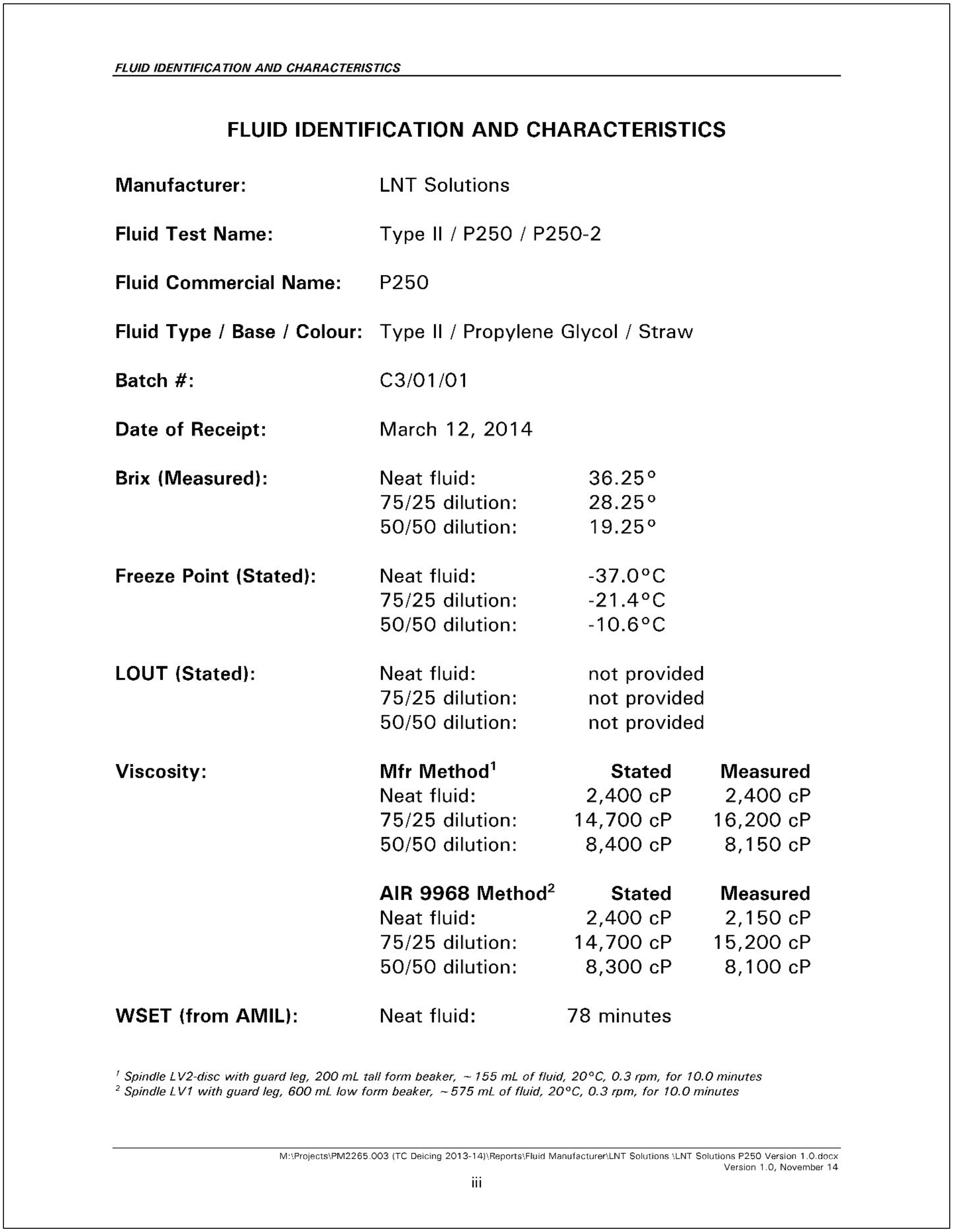
Stephanie Bendickson, Project Analyst — Date

Reviewed by: Nov. 28, 2014

John D'Avirro, Eng., Program Manager — Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. L-250 2013-14



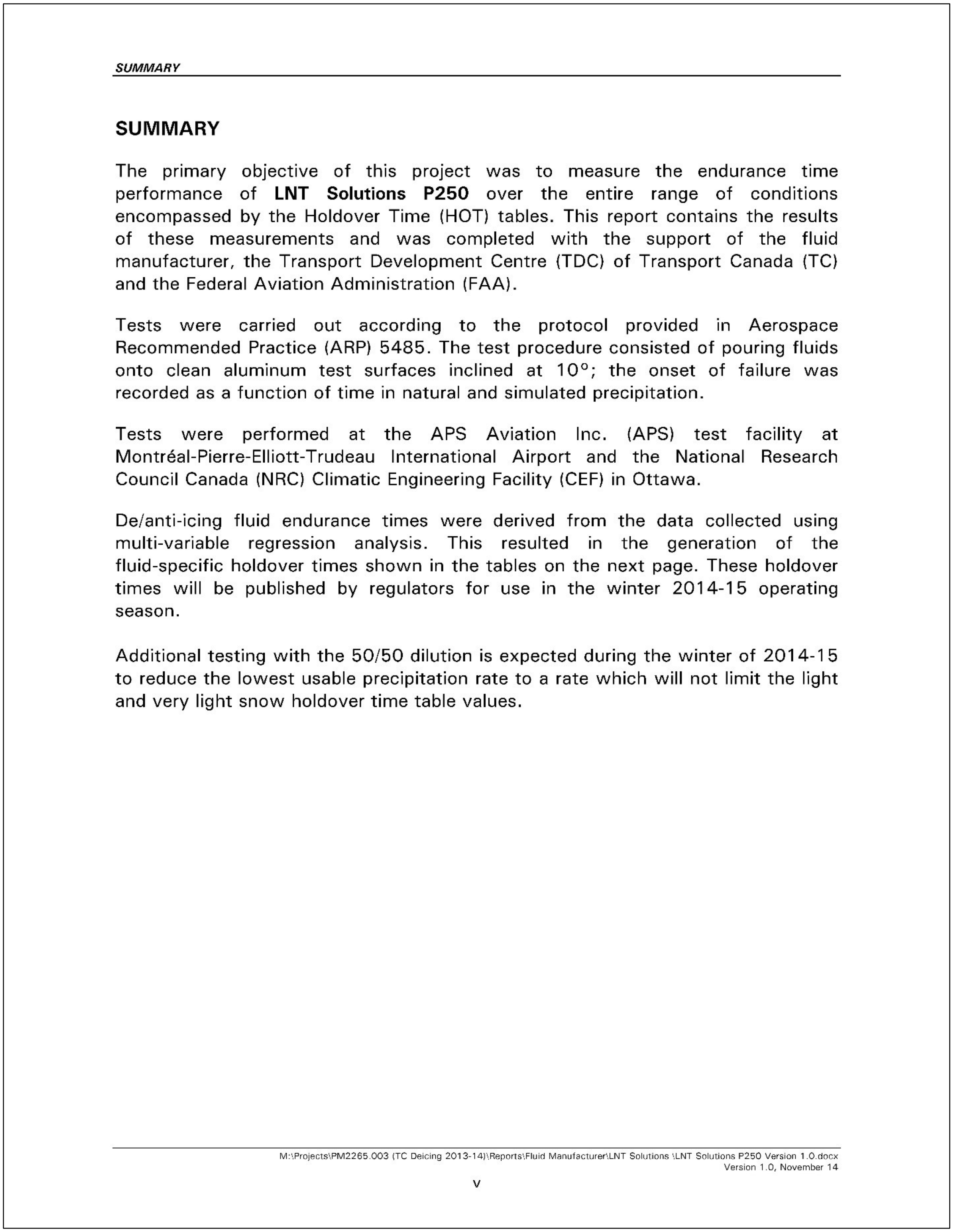
FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	LNT Solutions		
Fluid Test Name:	Type II / P250 / P250-2		
Fluid Commercial Name:	P250		
Fluid Type / Base / Colour:	Type II / Propylene Glycol / Straw		
Batch #:	C3/01/01		
Date of Receipt:	March 12, 2014		
Brix (Measured):	Neat fluid:	36.25°	
	75/25 dilution:	28.25°	
	50/50 dilution:	19.25°	
Freeze Point (Stated):	Neat fluid:	-37.0°C	
	75/25 dilution:	-21.4°C	
	50/50 dilution:	-10.6°C	
LOUT (Stated):	Neat fluid:	not provided	
	75/25 dilution:	not provided	
	50/50 dilution:	not provided	
Viscosity:	**Mfr Method**[1]	**Stated**	**Measured**
	Neat fluid:	2,400 cP	2,400 cP
	75/25 dilution:	14,700 cP	16,200 cP
	50/50 dilution:	8,400 cP	8,150 cP
	AIR 9968 Method[2]	**Stated**	**Measured**
	Neat fluid:	2,400 cP	2,150 cP
	75/25 dilution:	14,700 cP	15,200 cP
	50/50 dilution:	8,300 cP	8,100 cP
WSET (from AMIL):	Neat fluid:	78 minutes	

[1] *Spindle LV2-disc with guard leg, 200 mL tall form beaker, ~155 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*

[2] *Spindle LV1 with guard leg, 600 mL low form beaker, ~575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*

This page intentionally left blank.



SUMMARY

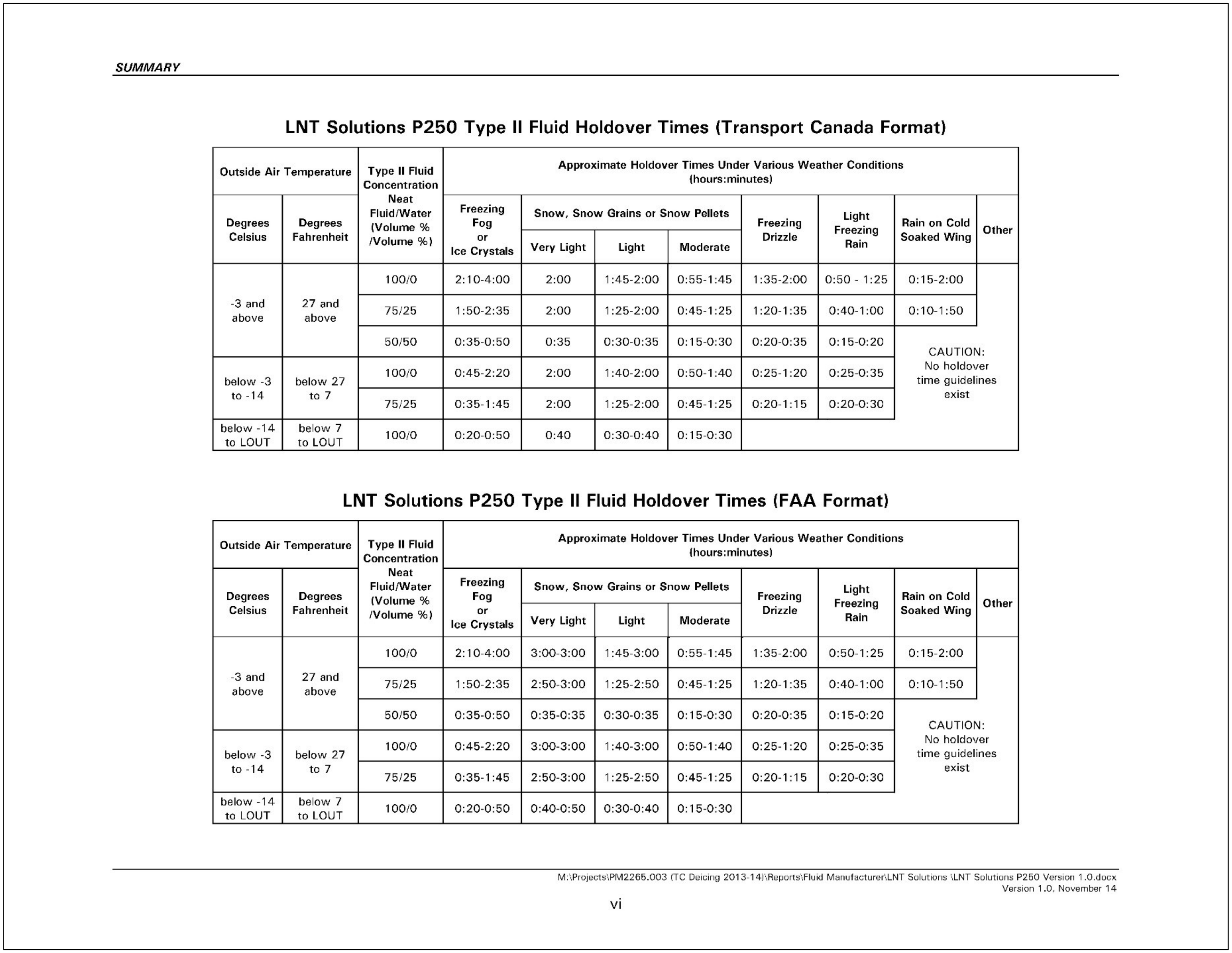
The primary objective of this project was to measure the endurance time performance of **LNT Solutions P250** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown in the tables on the next page. These holdover times will be published by regulators for use in the winter 2014-15 operating season.

Additional testing with the 50/50 dilution is expected during the winter of 2014-15 to reduce the lowest usable precipitation rate to a rate which will not limit the light and very light snow holdover time table values.



LNT Solutions P250 Type II Fluid Holdover Times (Transport Canada Format)

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

LNT Solutions P250 Type II Fluid Holdover Times (FAA Format)

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

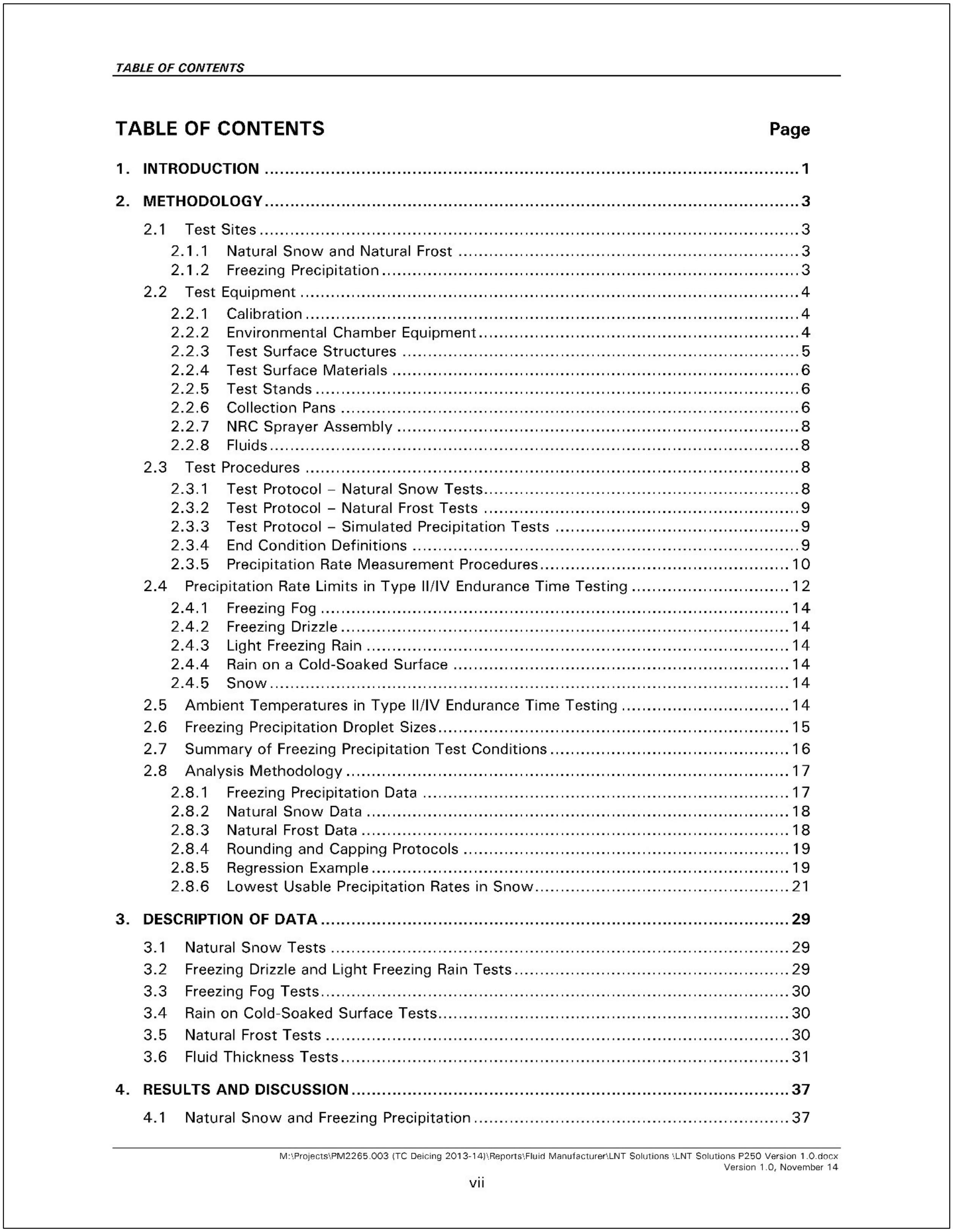


TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHODOLOGY 3
   - 2.1 Test Sites 3
     - 2.1.1 Natural Snow and Natural Frost 3
     - 2.1.2 Freezing Precipitation 3
   - 2.2 Test Equipment 4
     - 2.2.1 Calibration 4
     - 2.2.2 Environmental Chamber Equipment 4
     - 2.2.3 Test Surface Structures 5
     - 2.2.4 Test Surface Materials 6
     - 2.2.5 Test Stands 6
     - 2.2.6 Collection Pans 6
     - 2.2.7 NRC Sprayer Assembly 8
     - 2.2.8 Fluids 8
   - 2.3 Test Procedures 8
     - 2.3.1 Test Protocol – Natural Snow Tests 8
     - 2.3.2 Test Protocol – Natural Frost Tests 9
     - 2.3.3 Test Protocol – Simulated Precipitation Tests 9
     - 2.3.4 End Condition Definitions 9
     - 2.3.5 Precipitation Rate Measurement Procedures 10
   - 2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 12
     - 2.4.1 Freezing Fog 14
     - 2.4.2 Freezing Drizzle 14
     - 2.4.3 Light Freezing Rain 14
     - 2.4.4 Rain on a Cold-Soaked Surface 14
     - 2.4.5 Snow 14
   - 2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 14
   - 2.6 Freezing Precipitation Droplet Sizes 15
   - 2.7 Summary of Freezing Precipitation Test Conditions 16
   - 2.8 Analysis Methodology 17
     - 2.8.1 Freezing Precipitation Data 17
     - 2.8.2 Natural Snow Data 18
     - 2.8.3 Natural Frost Data 18
     - 2.8.4 Rounding and Capping Protocols 19
     - 2.8.5 Regression Example 19
     - 2.8.6 Lowest Usable Precipitation Rates in Snow 21

3. DESCRIPTION OF DATA 29
   - 3.1 Natural Snow Tests 29
   - 3.2 Freezing Drizzle and Light Freezing Rain Tests 29
   - 3.3 Freezing Fog Tests 30
   - 3.4 Rain on Cold-Soaked Surface Tests 30
   - 3.5 Natural Frost Tests 30
   - 3.6 Fluid Thickness Tests 31

4. RESULTS AND DISCUSSION 37
   - 4.1 Natural Snow and Freezing Precipitation 37

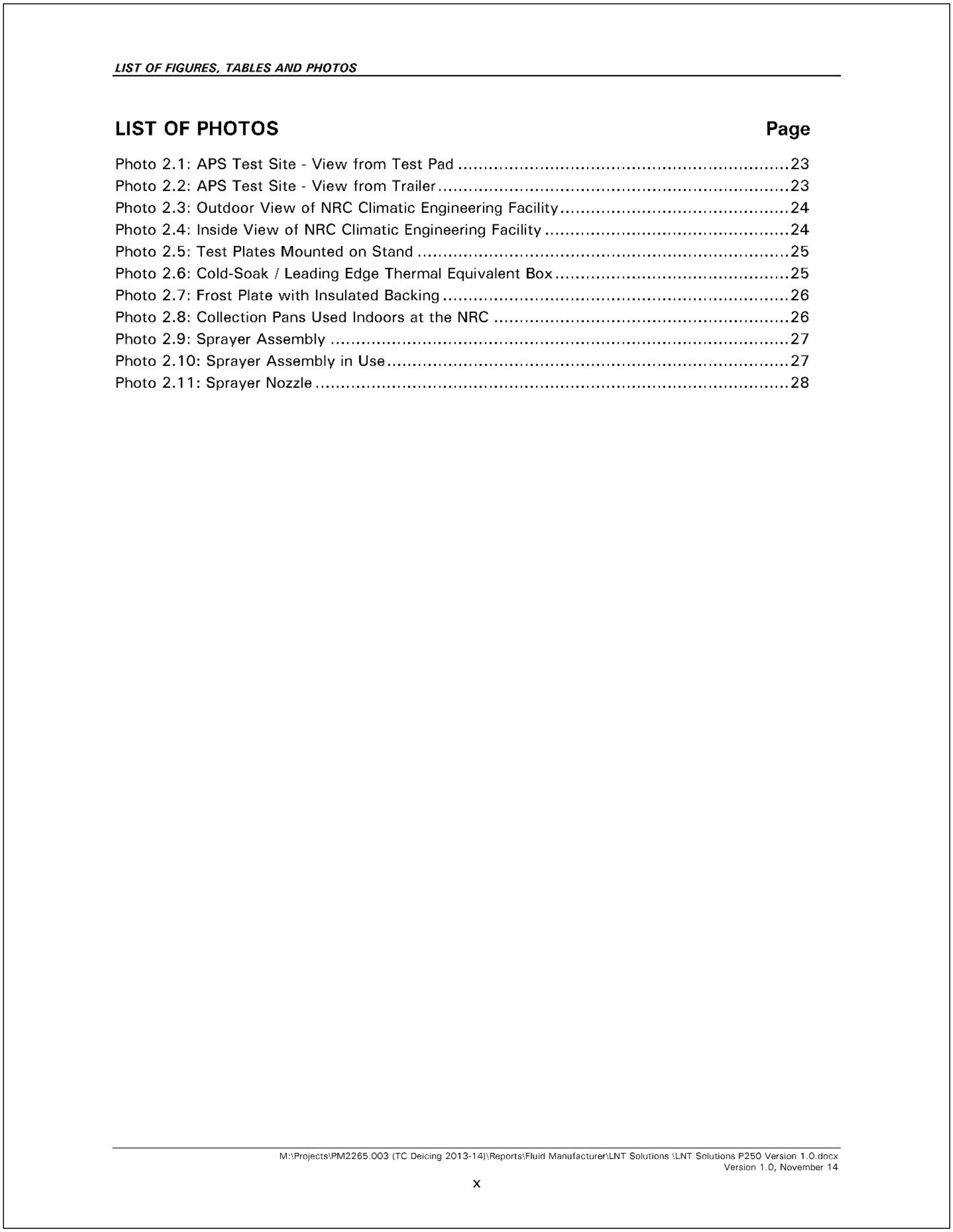
4.2 Natural Frost 37
4.3 Holdover Time Table 37
  4.3.1 Holdover Times in Snow, Below -14°C to LOUT 37
  4.3.2 Holdover Times in Frost 38
  4.3.3 Fluid Viscosity 38
4.4 Lowest Usable Precipitation Rates in Snow 38
4.5 Discussion 39

LIST OF FIGURES Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 6
Figure 2.4: Test Stand Setup Schematic 7
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 12
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 13
Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 20
Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain...................20
Figure 3.1: Fluid Thickness Profiles of LNT Solutions P250 31
Figure 3.2: Final Fluid Thickness of LNT Solutions P250 31
Figure 4.1: Type II Neat – Natural Snow 40
Figure 4.2: Type II 75/25 – Natural Snow 40
Figure 4.3: Type II 50/50 – Natural Snow 41
Figure 4.4: Type II Neat – Freezing Drizzle 41
Figure 4.5: Type II 75/25 – Freezing Drizzle 42
Figure 4.6: Type II 50/50 – Freezing Drizzle 42
Figure 4.7: Type II Neat – Light Freezing Rain...43
Figure 4.8: Type II 75/25 – Light Freezing Rain...43
Figure 4.9: Type II 50/50 – Light Freezing Rain...44
Figure 4.10: Type II Neat – Freezing Fog..44
Figure 4.11: Type II 75/25 – Freezing Fog..45
Figure 4.12: Type II 50/50 – Freezing Fog..45
Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface..46
Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface 46

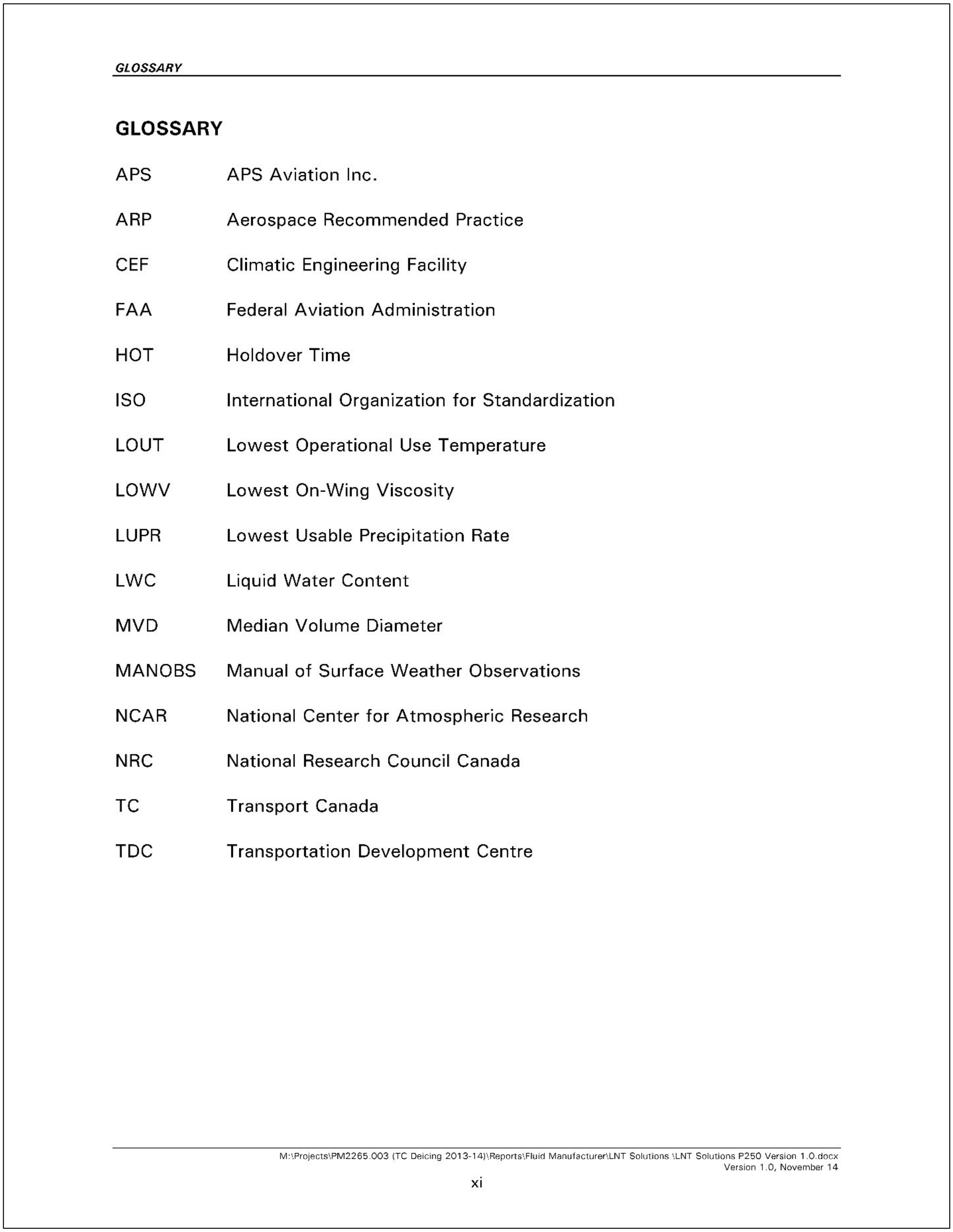
LIST OF TABLES Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 15
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 17
Table 2.4: LUPR Factor Scoring System...22
Table 3.1: Summary of Tests Performed (Snow) 32
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 34
Table 3.3: Summary of Tests Performed (Natural Frost)...36
Table 4.1: Regression Equation Coefficients for LNT Solutions P250 47
Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions P250 (Transport Canada Format) 48
Table 4.3: Fluid Specific Holdover Time Guidelines – LNT Solutions P250 (FAA Format).........49
Table 4.4: LUPR Statistics – LNT Solutions P250..50



LIST OF PHOTOS Page

Photo 2.1: APS Test Site - View from Test Pad 23
Photo 2.2: APS Test Site - View from Trailer 23
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 24
Photo 2.4: Inside View of NRC Climatic Engineering Facility 24
Photo 2.5: Test Plates Mounted on Stand 25
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 25
Photo 2.7: Frost Plate with Insulated Backing 26
Photo 2.8: Collection Pans Used Indoors at the NRC 26
Photo 2.9: Sprayer Assembly 27
Photo 2.10: Sprayer Assembly in Use 27
Photo 2.11: Sprayer Nozzle 28



GLOSSARY

GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Reports\Fluid Manufacturer\LNT Solutions \LNT Solutions P250 Version 1.0.docx
Version 1.0, November 14

xi

This page intentionally left blank.

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **LNT Solutions P250**, a new Type II fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

This page intentionally left blank.

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type II/IV endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type II/IV endurance time data.

2.1 Test Sites

2.1.1 Natural Snow and Natural Frost

Natural snow and natural frost testing is typically performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport.

The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

In winter 2013-14, additional natural snow testing was conducted in Val d'Or, Quebec and Ottawa, Ontario.

2.1.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC Climatic Engineering Facility (CEF), where precipitation was artificially produced.

Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

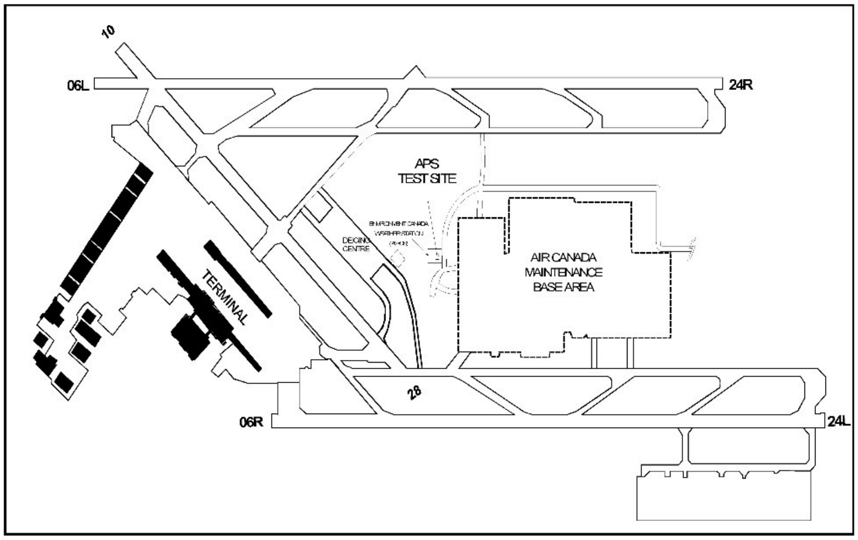


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

2.2 Test Equipment

The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

2.2.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

2.2.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5485.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1″), 15 cm (6″) and 30 cm (12″) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 2.3.4) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests.

In natural frost, tests are conducted on frosticator plates, which are the current standard test surface used in frost holdover time testing. The frosticator plates were constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 2.7 shows a white-painted aluminum frosticator plate.

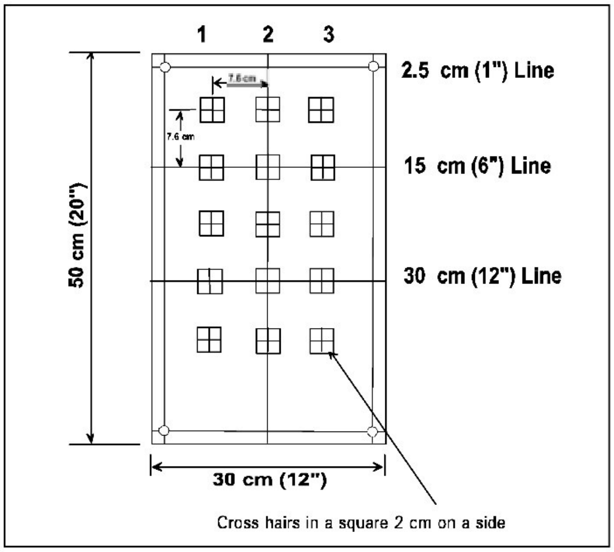


Figure 2.2: Standard Test Plate Schematic

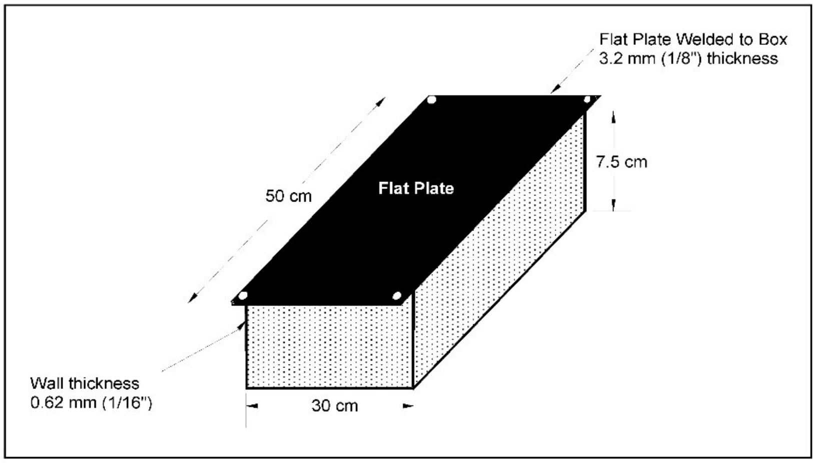


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Testing of Type II, III and IV fluids is carried out exclusively on aluminum surfaces. The aluminum used is 0.32 cm thick Alclad 2024 T3 aluminum.

2.2.5 Test Stands

Figure 2.4 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

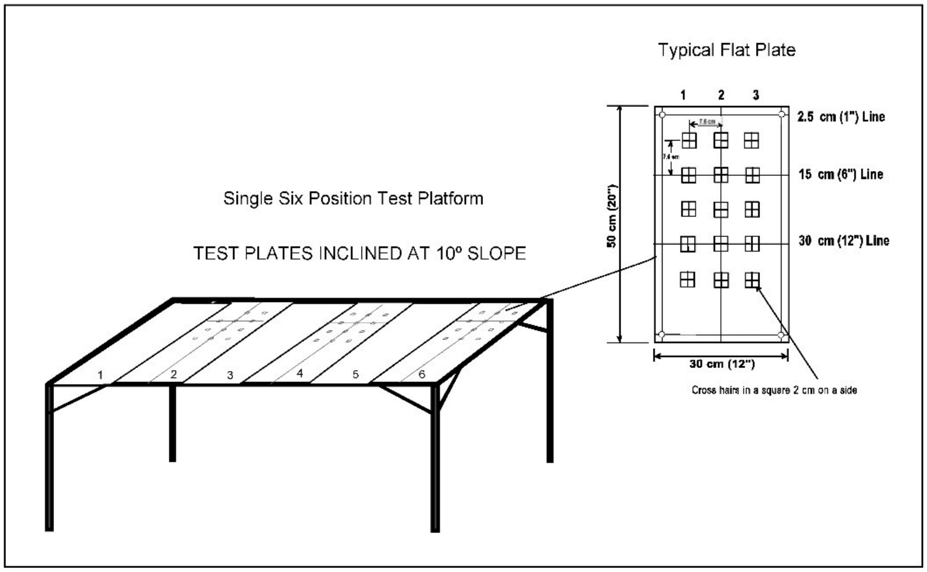


Figure 2.4: Test Stand Setup Schematic

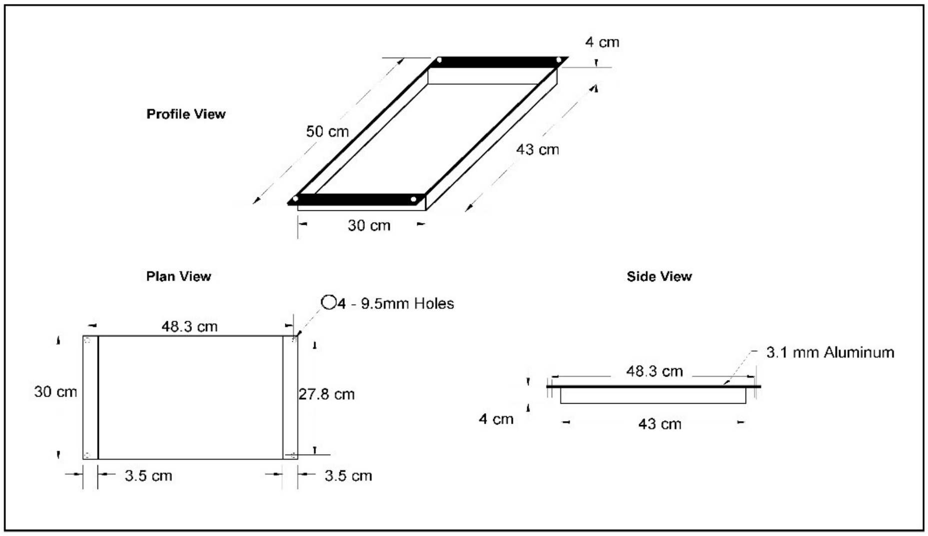


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.11.

2.2.8 Fluids

Testing was carried out with LNT Solutions P250 in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

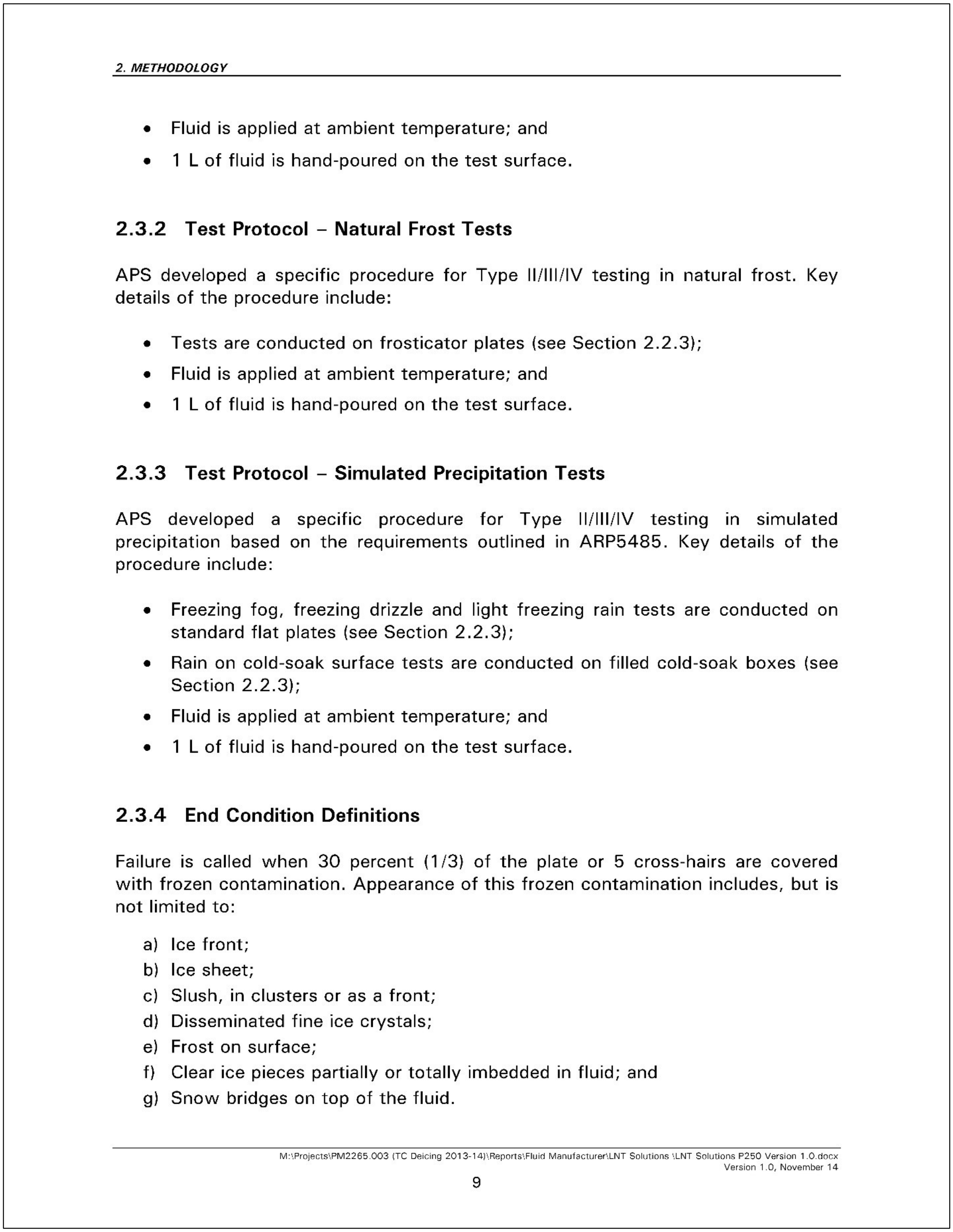
ARP5485 provides the procedure for endurance time testing of Type II, III and IV fluids under natural and simulated precipitation conditions.

The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 2.3.4), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, natural frost and simulated freezing precipitation testing.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type II, III and IV fluid testing in natural snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted are conducted on standard flat plates (see Section 2.2.3);



- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – Natural Frost Tests

APS developed a specific procedure for Type II/III/IV testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type II/III/IV testing in simulated precipitation based on the requirements outlined in ARP5485. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

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

2.3.5 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

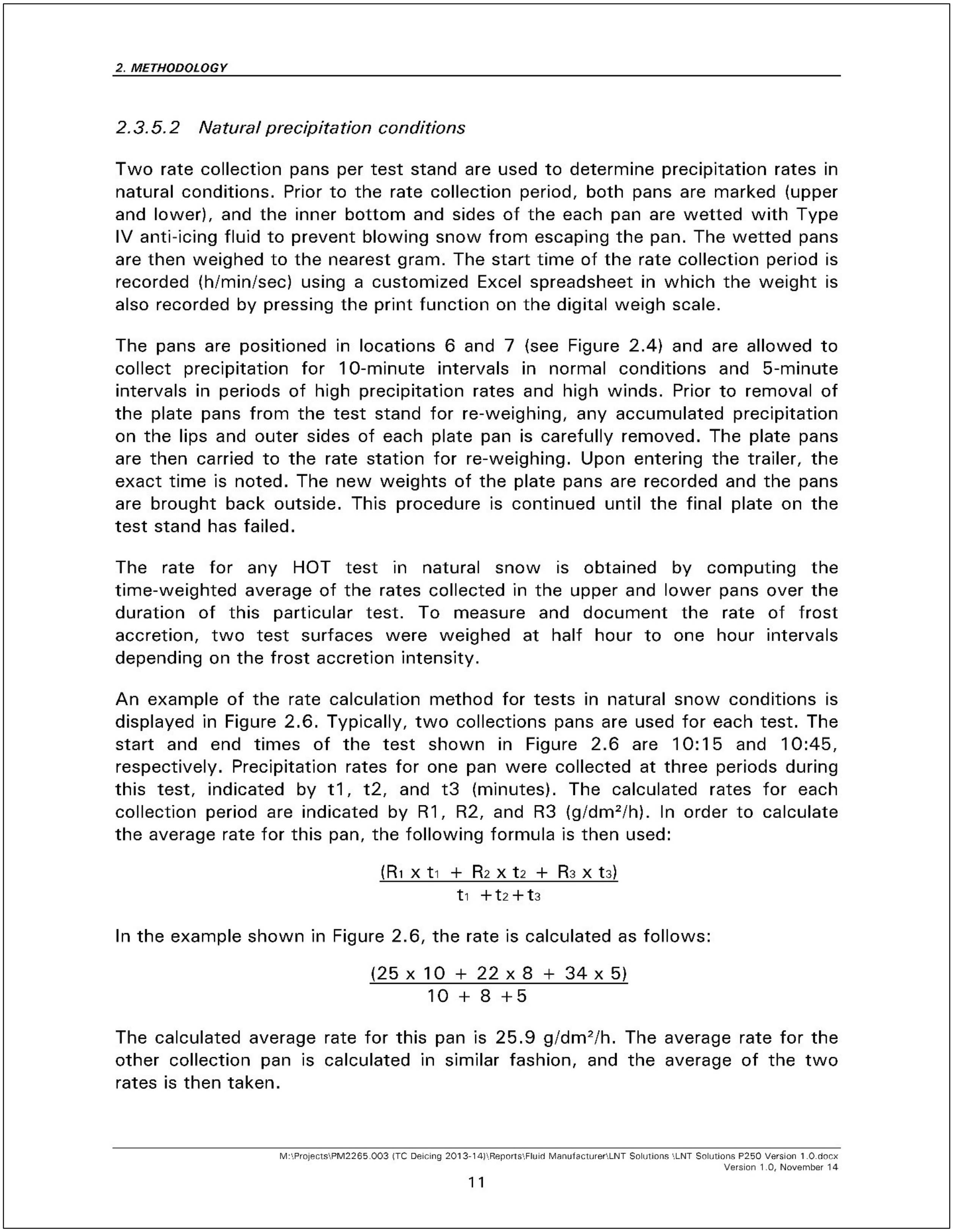
2.3.5.1 Simulated precipitation conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.
The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, then the pouring of fluids may begin at this location.
Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.



2.3.5.2 Natural precipitation conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any HOT test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 2.6 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \times t_1 + R_2 \times t_2 + R_3 \times t_3)}{t_1 + t_2 + t_3}$$

In the example shown in Figure 2.6, the rate is calculated as follows:

$$\frac{(25 \times 10 + 22 \times 8 + 34 \times 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

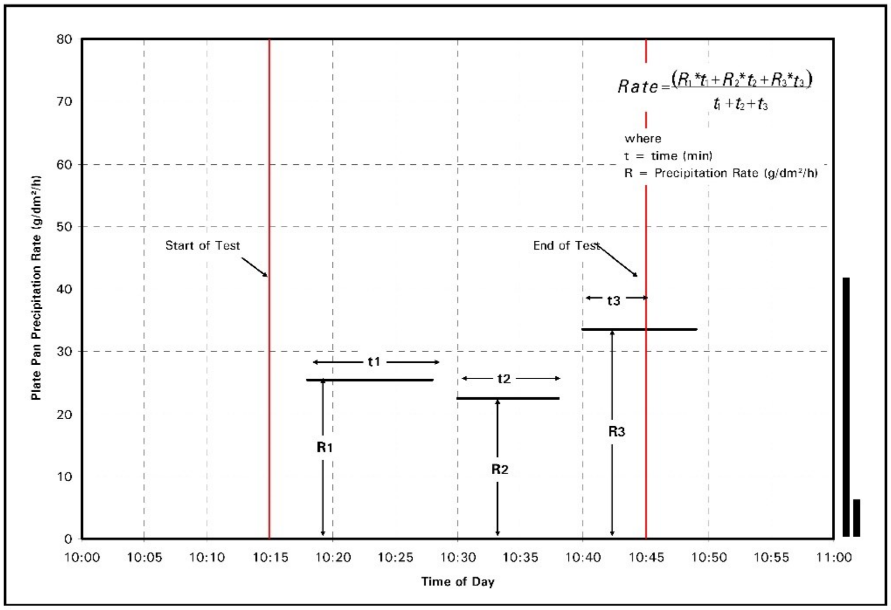


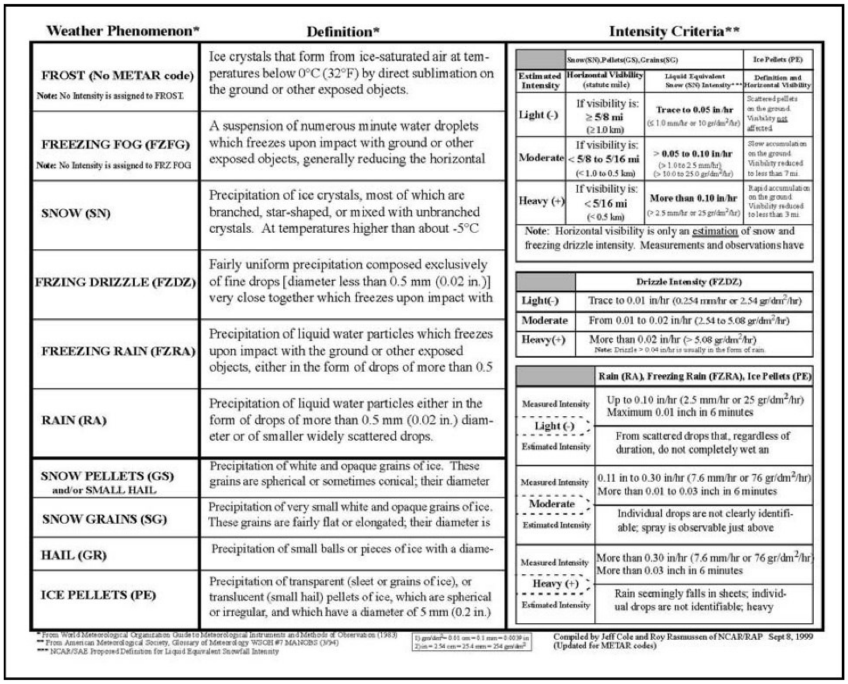
Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS*) (3/94).

The precipitation rate limits established for Type II/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/IV endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 2.1.

Table 2.1: Definition of Weather Phenomenon



Weather Phenomenon*	Definition*
FROST (No METAR code) **Note:** No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) **Note:** No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (SN) Intensity*** **	**Definition and Horizontal Visibility**
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm/hr or 10 gr/dm²/hr)	Scattered pellets on the ground. Visibility <u>not</u> affected
Moderate	If visibility is: < 5/8 to 5/16 mi (< 1.0 to 0.5 km)	**> 0.05 to 0.10 in/hr** (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: < 5/16 mi (< 0.5 km)	**More than 0.10 in/hr** (> 2.5 mm/hr or 25 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.

Note: Horizontal visibility is only an <u>estimation</u> of snow and freezing drizzle intensity. Measurements and observations have

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) **Note:** Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm²/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gm/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999
(Updated for METAR codes)

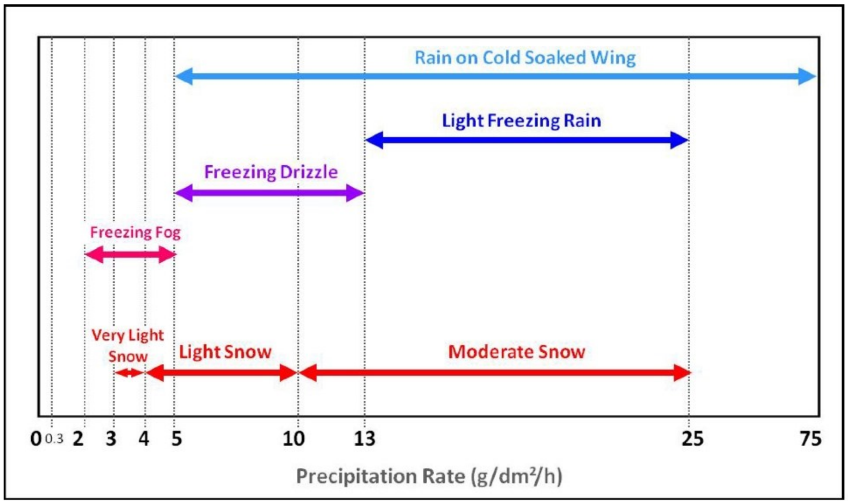


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

2.4.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.

2.4.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.4.4 Rain on a Cold-Soaked Surface

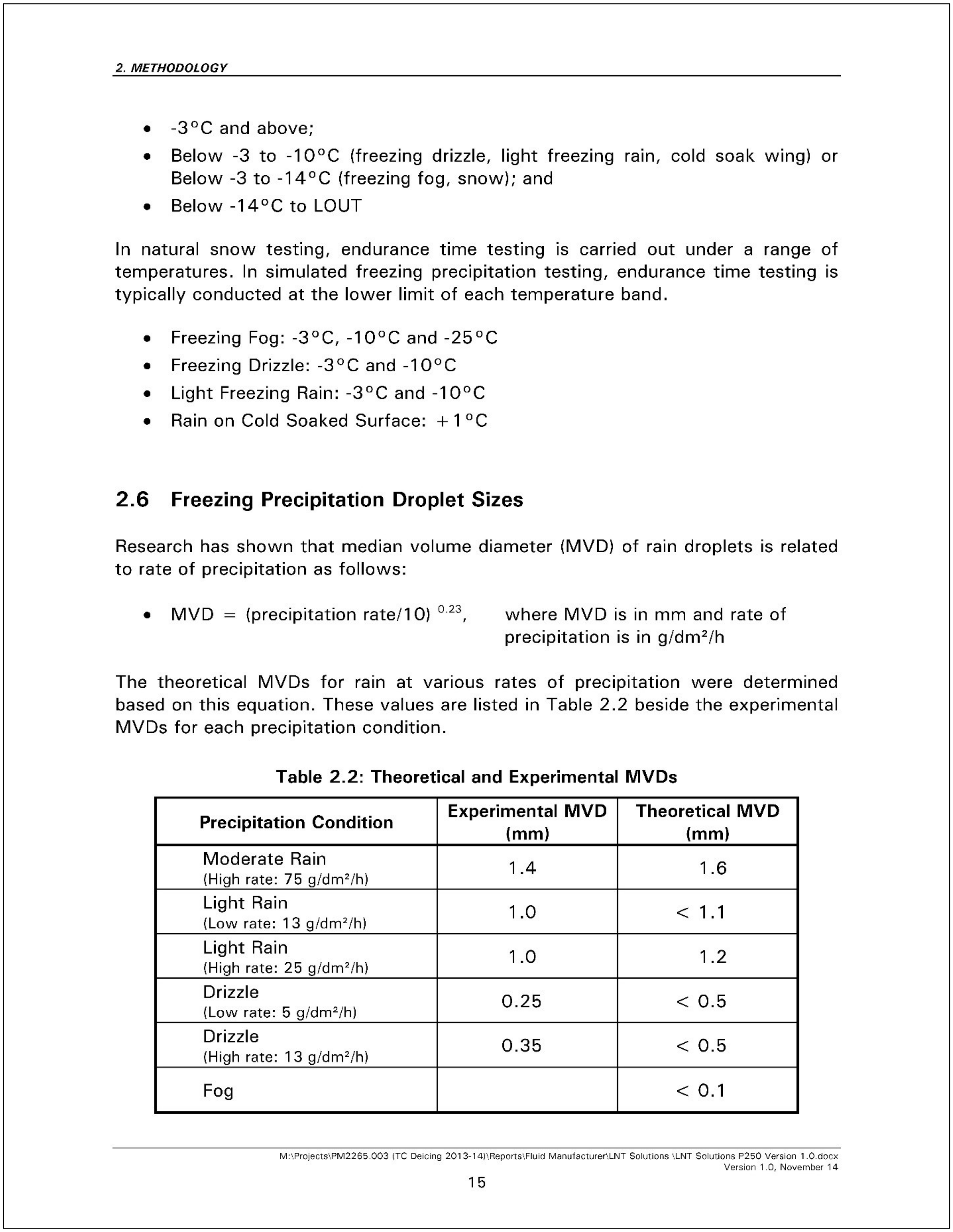
The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 g/dm^2/h. These rate limits encompass very light, light and moderate snow.

2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:



- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -25°C
- Freezing Drizzle: -3°C and -10°C
- Light Freezing Rain: -3°C and -10°C
- Rain on Cold Soaked Surface: +1°C

2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

- $\text{MVD} = (\text{precipitation rate}/10)^{0.23}$, where MVD is in mm and rate of precipitation is in g/dm²/h

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm²/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below:

a) *For the outdoor test:*
Location: Montreal P.E.T. Airport
Precipitation: Natural Light Freezing Rain
Precipitation Rate: 20 g/dm²/h
Calibrated MVD: 1.0 mm

b) *For the indoor test:*
Location: National Research Council
Precipitation: Simulated Light Freezing Rain
Precipitation Rate: 25 g/dm²/h
Calibrated MVD: 1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation.
As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm²/h): 30 µm
- Freezing Fog, low precipitation rate (2 g/dm²/h): 30 µm

- Freezing Drizzle, high precipitation rate (13 g/dm²/h): 350 µm
- Freezing Drizzle, low precipitation rate (5 g/dm²/h): 250 µm

- Light Freezing Rain, high precipitation rate (25 g/dm²/h): 1,000 µm
- Light Freezing Rain, low precipitation rate (13 g/dm²/h): 1,000 µm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm²/h): 250 µm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm²/h): 1,400 µm

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/IV fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 16 weather conditions listed in Table 2.3.

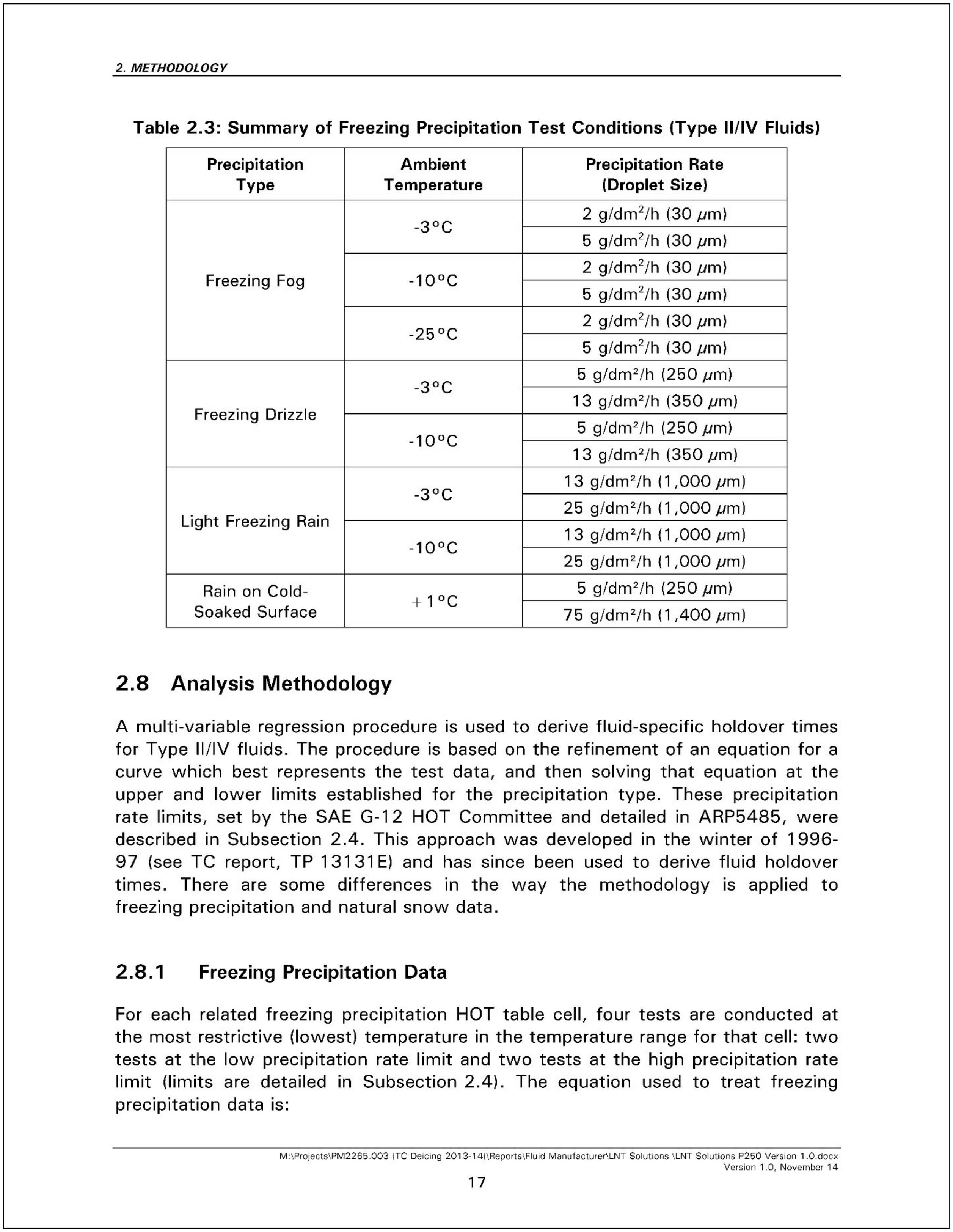


Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-10°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-25°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
Freezing Drizzle	-3°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
	-10°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
Light Freezing Rain	-3°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
	-10°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm^2/h (250 μm)
		75 g/dm^2/h (1,400 μm)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/IV fluids. The procedure is based on the refinement of an equation for a curve which best represents the test data, and then solving that equation at the upper and lower limits established for the precipitation type. These precipitation rate limits, set by the SAE G-12 HOT Committee and detailed in ARP5485, were described in Subsection 2.4. This approach was developed in the winter of 1996-97 (see TC report, TP 13131E) and has since been used to derive fluid holdover times. There are some differences in the way the methodology is applied to freezing precipitation and natural snow data.

2.8.1 Freezing Precipitation Data

For each related freezing precipitation HOT table cell, four tests are conducted at the most restrictive (lowest) temperature in the temperature range for that cell: two tests at the low precipitation rate limit and two tests at the high precipitation rate limit (limits are detailed in Subsection 2.4). The equation used to treat freezing precipitation data is:

- $t = 10^{I}R^{a}$, where

  t = Time (minutes)
  R = Rate of precipitation ($g/dm^2/h$)
  I, a = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.2 Natural Snow Data

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural snow tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather data under all temperatures and precipitation rates encompassed by the HOT tables.

The general form of the regression equation is modified for natural snow to incorporate the variable of temperature and also to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C. The equation used to treat natural snow data is:

- $t = 10^{I} R^{a} (2\text{-}T)^{b}$, where

  t = Time (minutes)
  R = Rate of precipitation ($g/dm^2/h$)
  I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.3 Natural Frost Data

Regression analysis is not used in the determination of frost holdover times. The current Type II/III/IV generic frost holdover times were determined based on several years of testing using all fluids which were commercially available at the time. A "minimum values" analysis methodology was used to determine appropriate holdover times from the test data.

The purpose of natural frost testing with new fluids is to verify the fluids can be used with the generic frost holdover times. The analysis methodology is to compare the frost test data collected with the new fluid to the current generic holdover times. If the test data provides holdover times equal to or greater than the generic holdover times then the generic holdover times have been validated for the new fluid.

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural frost tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather several data points with each fluid/dilution.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: Holdover times are rounded to the nearest whole "5" minute, i.e. 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 to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: All holdover time values are capped at maximum values. The caps differ by precipitation type, and in the case of snow, by regulator. The caps are as follows:
    - Freezing Fog holdover time values are capped at 4 hours;
    - Freezing Drizzle, Light Freezing Rain, Rain on Cold Soaked Wing holdover times are capped at 2 hours; and
    - Snow holdover times are capped at 2 hours by Transport Canada and 3 hours by FAA.

2.8.5 Regression Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.8. The plots contain data for one Neat Type IV fluid, in one temperature range (-10°C), in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.9. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The HOT range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

The holdover times for this fluid at -10°C are 20 minutes at 13 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the HOT range for this particular fluid in the light freezing rain, neat fluid, below -3 to -10°C cell. This illustrates the general approach used in the determination of a fluid HOT range for any given cell in the HOT table.

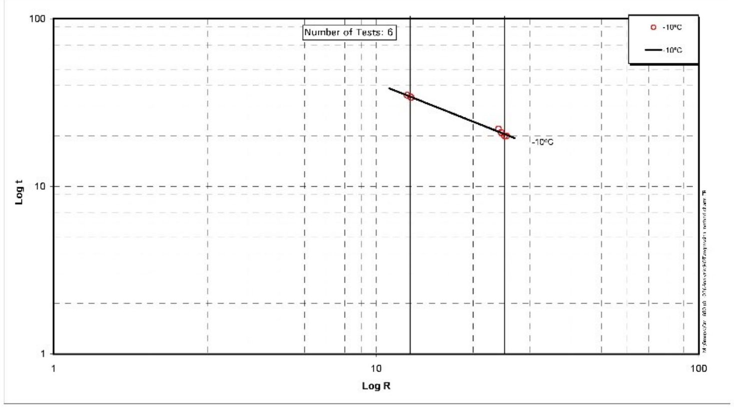


Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

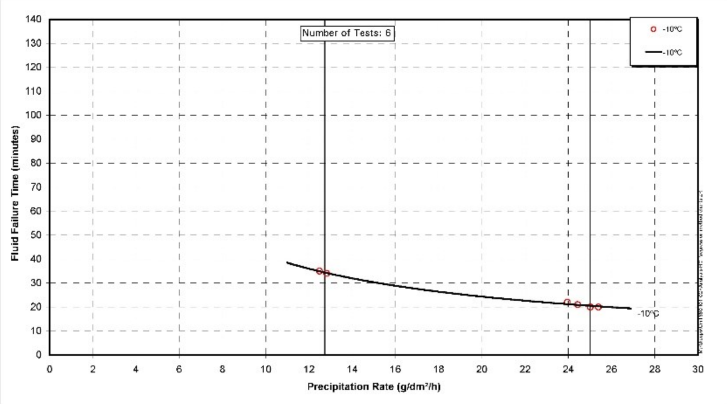
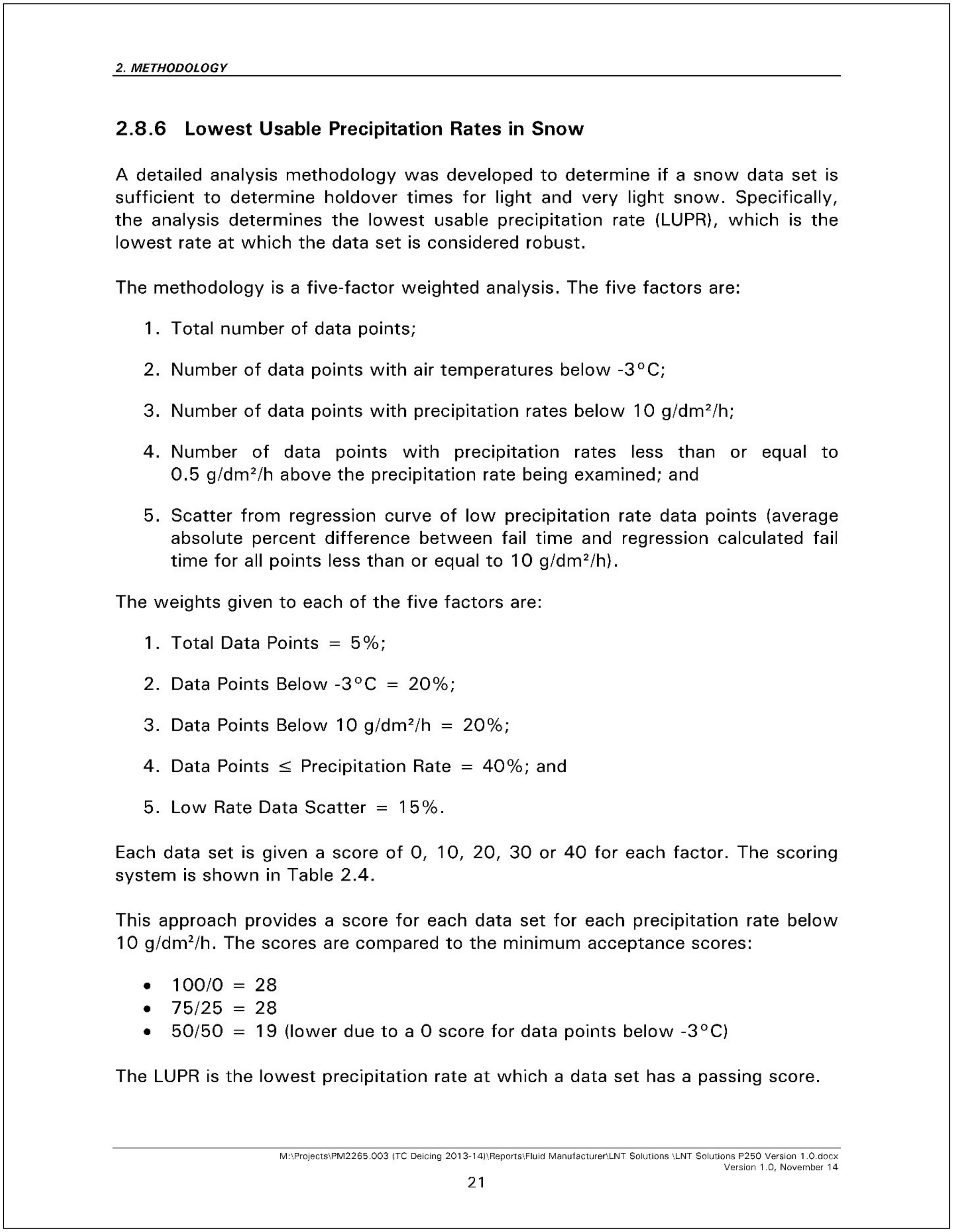


Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain



2.8.6 Lowest Usable Precipitation Rates in Snow

A detailed analysis methodology was developed to determine if a snow data set is sufficient to determine holdover times for light and very light snow. Specifically, the analysis determines the lowest usable precipitation rate (LUPR), which is the lowest rate at which the data set is considered robust.

The methodology is a five-factor weighted analysis. The five factors are:

1. Total number of data points;
2. Number of data points with air temperatures below -3°C;
3. Number of data points with precipitation rates below 10 g/dm²/h;
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined; and
5. Scatter from regression curve of low precipitation rate data points (average absolute percent difference between fail time and regression calculated fail time for all points less than or equal to 10 g/dm²/h).

The weights given to each of the five factors are:

1. Total Data Points = 5%;
2. Data Points Below -3°C = 20%;
3. Data Points Below 10 g/dm²/h = 20%;
4. Data Points ≤ Precipitation Rate = 40%; and
5. Low Rate Data Scatter = 15%.

Each data set is given a score of 0, 10, 20, 30 or 40 for each factor. The scoring system is shown in Table 2.4.

This approach provides a score for each data set for each precipitation rate below 10 g/dm²/h. The scores are compared to the minimum acceptance scores:

- 100/0 = 28
- 75/25 = 28
- 50/50 = 19 (lower due to a 0 score for data points below -3°C)

The LUPR is the lowest precipitation rate at which a data set has a passing score.

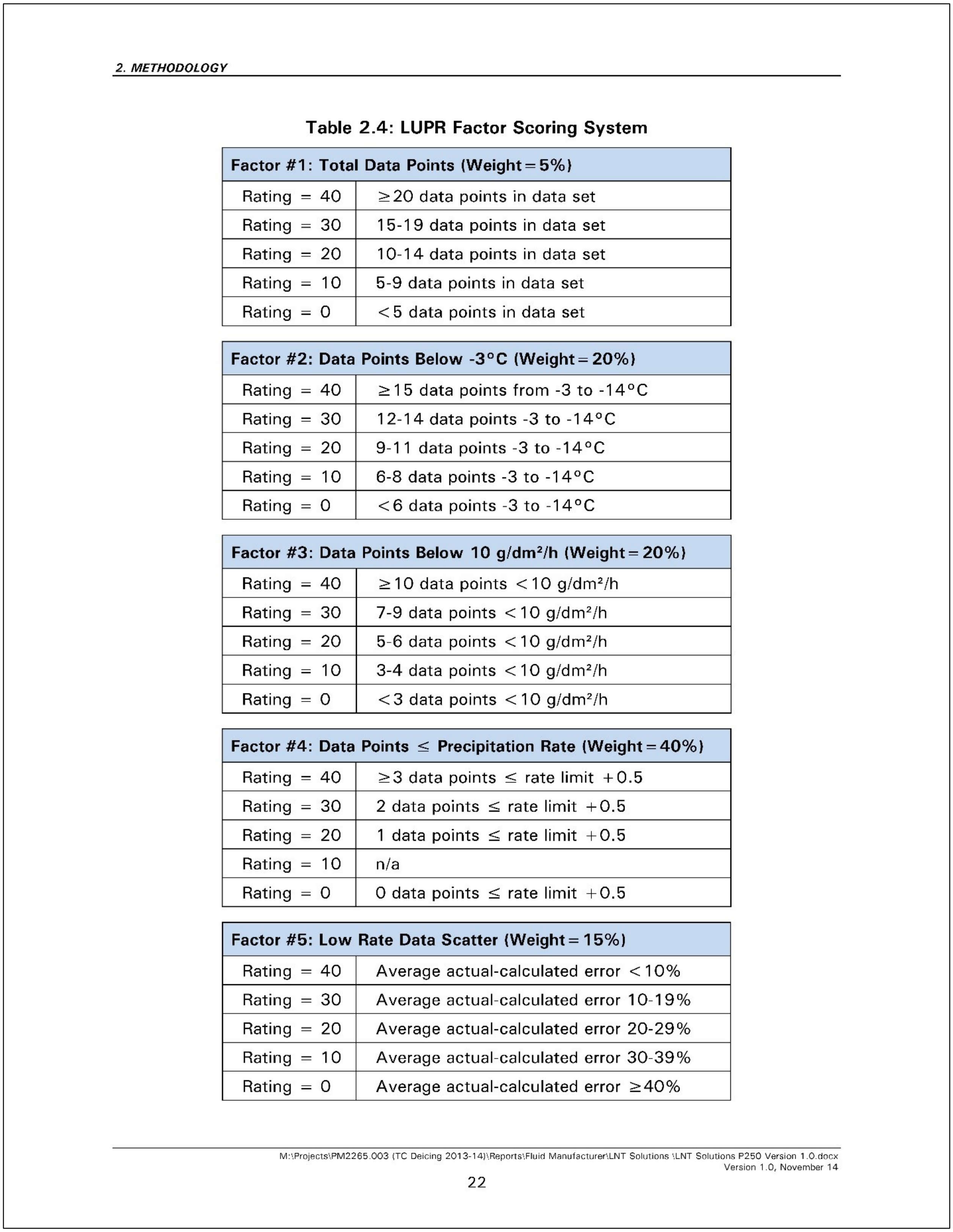


Table 2.4: LUPR Factor Scoring System

Factor #1: Total Data Points (Weight = 5%)	
Rating = 40	≥20 data points in data set
Rating = 30	15-19 data points in data set
Rating = 20	10-14 data points in data set
Rating = 10	5-9 data points in data set
Rating = 0	<5 data points in data set

Factor #2: Data Points Below -3°C (Weight = 20%)	
Rating = 40	≥15 data points from -3 to -14°C
Rating = 30	12-14 data points -3 to -14°C
Rating = 20	9-11 data points -3 to -14°C
Rating = 10	6-8 data points -3 to -14°C
Rating = 0	<6 data points -3 to -14°C

Factor #3: Data Points Below 10 g/dm²/h (Weight = 20%)	
Rating = 40	≥10 data points <10 g/dm²/h
Rating = 30	7-9 data points <10 g/dm²/h
Rating = 20	5-6 data points <10 g/dm²/h
Rating = 10	3-4 data points <10 g/dm²/h
Rating = 0	<3 data points <10 g/dm²/h

Factor #4: Data Points ≤ Precipitation Rate (Weight = 40%)	
Rating = 40	≥3 data points ≤ rate limit +0.5
Rating = 30	2 data points ≤ rate limit +0.5
Rating = 20	1 data points ≤ rate limit +0.5
Rating = 10	n/a
Rating = 0	0 data points ≤ rate limit +0.5

Factor #5: Low Rate Data Scatter (Weight = 15%)	
Rating = 40	Average actual-calculated error <10%
Rating = 30	Average actual-calculated error 10-19%
Rating = 20	Average actual-calculated error 20-29%
Rating = 10	Average actual-calculated error 30-39%
Rating = 0	Average actual-calculated error ≥40%

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility

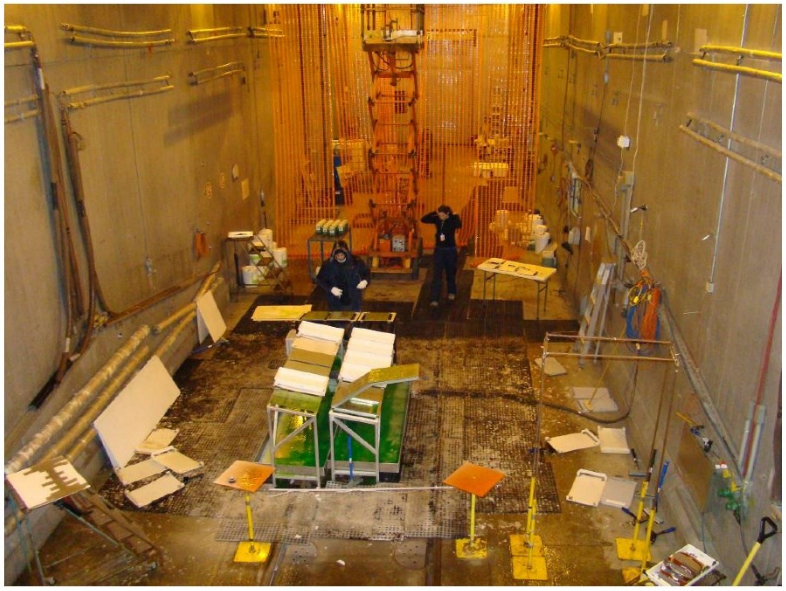


Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

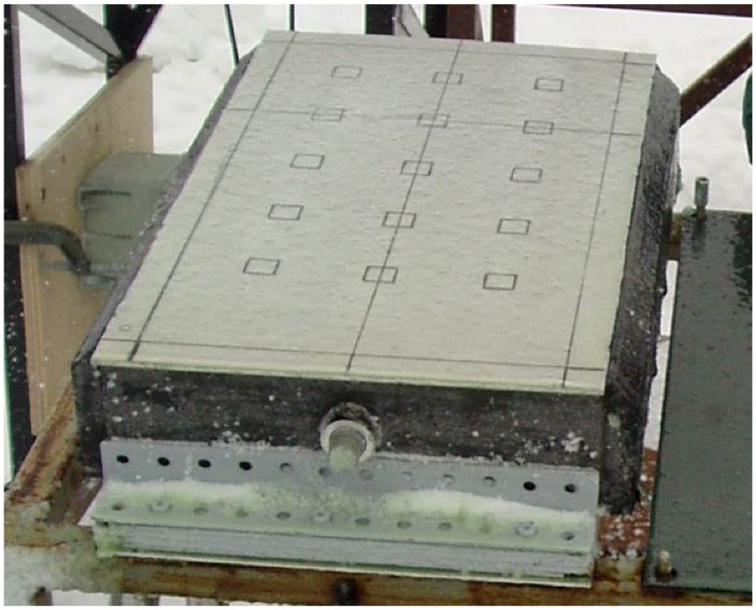


Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

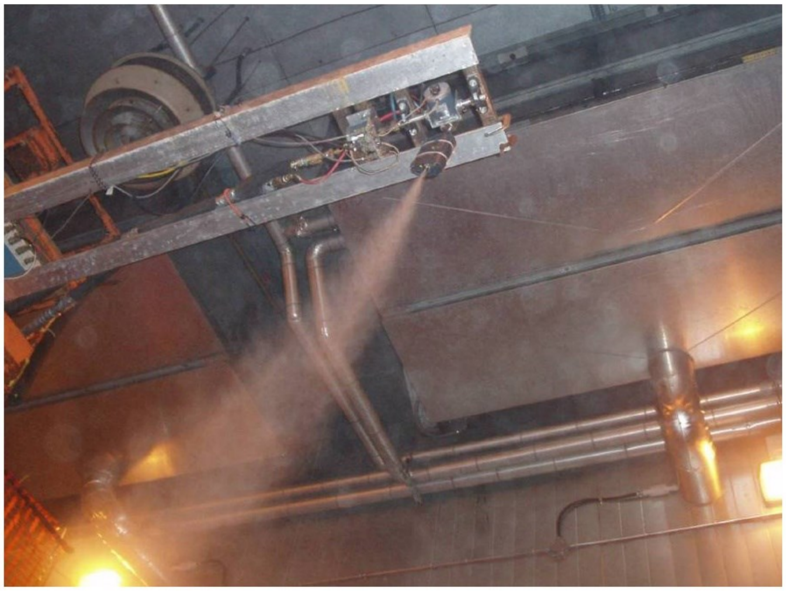
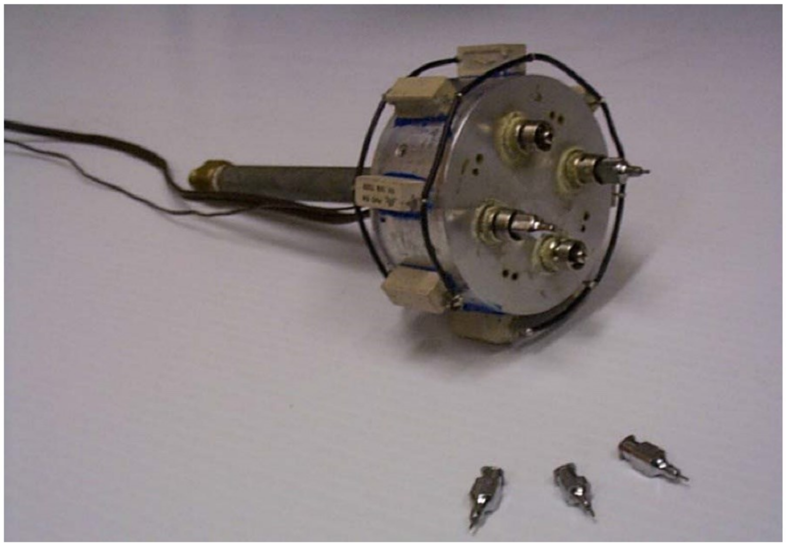
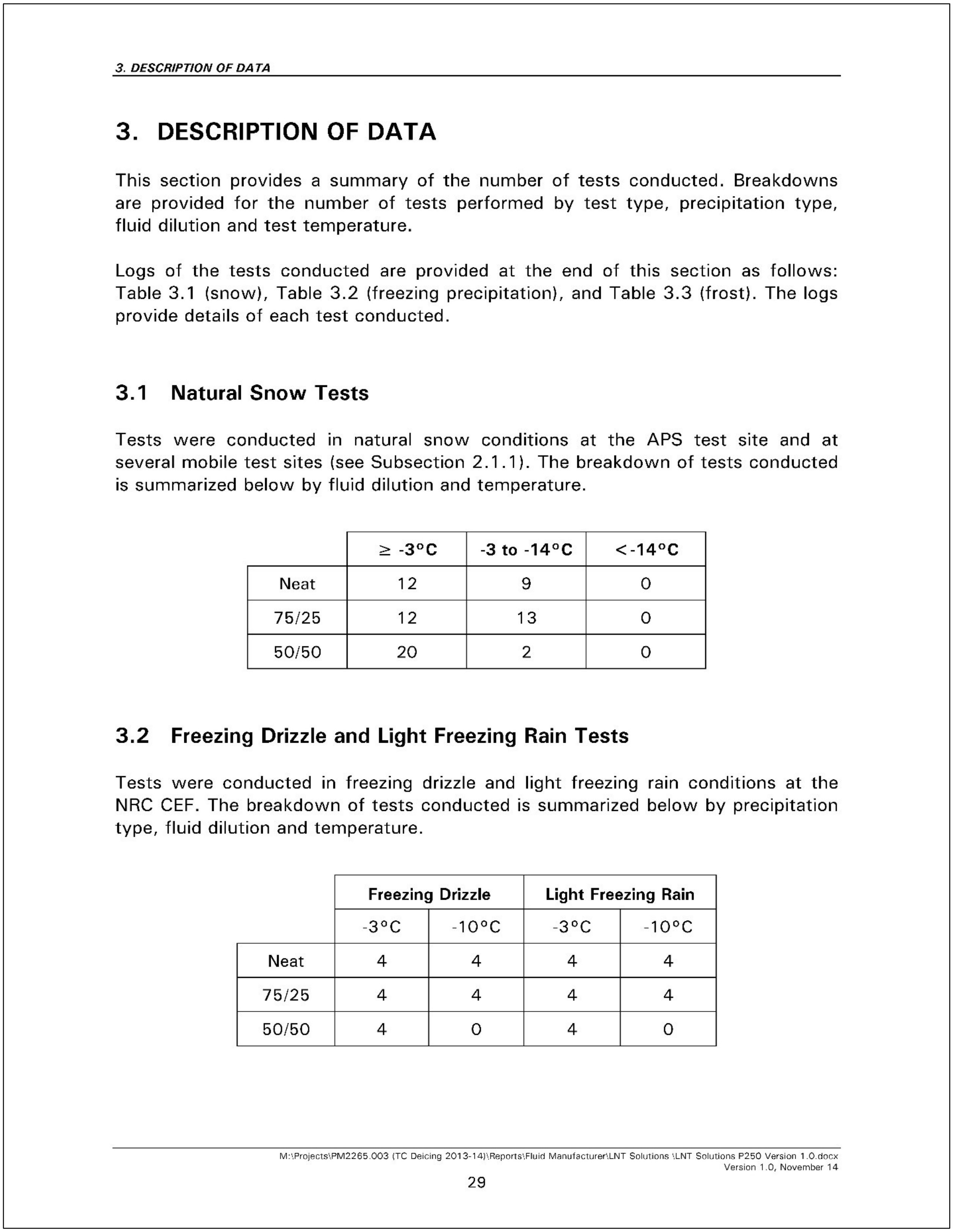


Photo 2.11: Sprayer Nozzle





3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

Logs of the tests conducted are provided at the end of this section as follows: Table 3.1 (snow), Table 3.2 (freezing precipitation), and Table 3.3 (frost). The logs provide details of each test conducted.

3.1 Natural Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.1.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥ -3°C	**-3 to -14°C**	**<-14°C**
Neat	12	9	0
75/25	12	13	0
50/50	20	2	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		**Light Freezing Rain**	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4
75/25	4	4	4	4
50/50	4	0	4	0

3.3 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	-14°C	-25°C
Neat	4	4	4
75/25	4	4	0
50/50	4	0	0

3.4 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	4
50/50	0

3.5 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	2	0	0
75/25	0	2	0	0
50/50	0	2	0	0

3.6 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

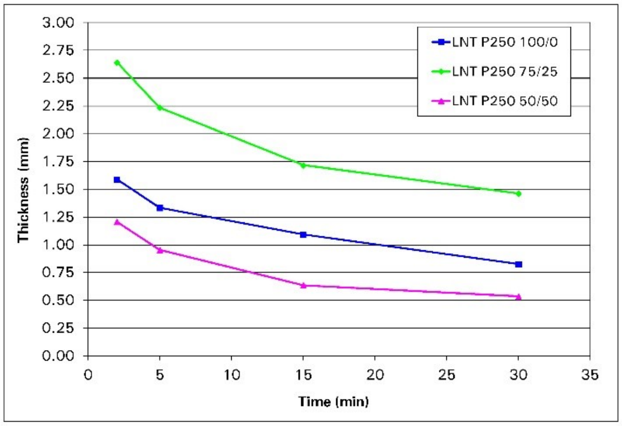


Figure 3.1: Fluid Thickness Profiles of LNT Solutions P250

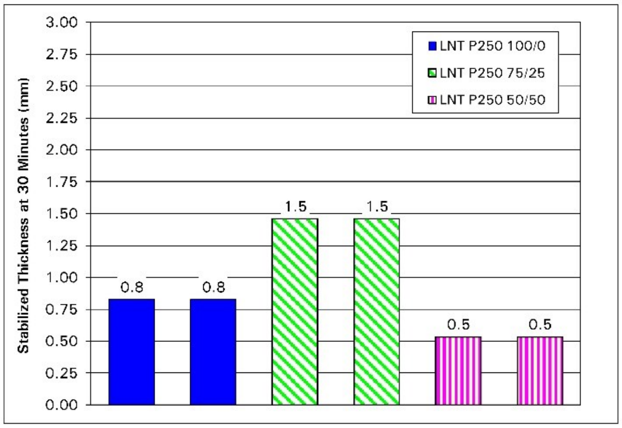


Figure 3.2: Final Fluid Thickness of LNT Solutions P250

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
187	12-Mar-14	Natural Snow	LNT Solutions P250	75%	-10.8	14.2	77.2
197	12-Mar-14	Natural Snow	LNT Solutions P250	75%	-10.9	26.5	48.0
198	12-Mar-14	Natural Snow	LNT Solutions P250	100%	-12.1	13.9	68.1
199	12-Mar-14	Natural Snow	LNT Solutions P250	75%	-12.1	14.1	56.6
202	19-Mar-14	Natural Snow	LNT Solutions P250	50%	0.8	29.9	7.7
205	19-Mar-14	Natural Snow	LNT Solutions P250	100%	0.8	25.1	64.9
209	19-Mar-14	Natural Snow	LNT Solutions P250	50%	0.8	35.2	4.9
212	19-Mar-14	Natural Snow	LNT Solutions P250	50%	0.8	19.5	24.2
215	19-Mar-14	Natural Snow	LNT Solutions P250	50%	0.8	24.0	11.9
216	19-Mar-14	Natural Snow	LNT Solutions P250	75%	0.8	21.0	51.5
218	19-Mar-14	Natural Snow	LNT Solutions P250	100%	1.2	4.3	181.0
220	19-Mar-14	Natural Snow	LNT Solutions P250	50%	1.2	1.8	144.2
222	19-Mar-14	Natural Snow	LNT Solutions P250	75%	1.2	4.0	174.5
223	19-Mar-14	Natural Snow	LNT Solutions P250	100%	0.9	10.1	140.7
224	19-Mar-14	Natural Snow	LNT Solutions P250	75%	0.9	14.5	73.9
225	19-Mar-14	Natural Snow	LNT Solutions P250	50%	0.7	13.3	21.8
227	20-Mar-14	Natural Snow	LNT Solutions P250	50%	0.7	15.7	17.9
229	20-Mar-14	Natural Snow	LNT Solutions P250	50%	1.0	6.7	73.5
230	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.4	34.2	15.1
231	22-Mar-14	Natural Snow	LNT Solutions P250	100%	-3.4	43.8	40.5
232	22-Mar-14	Natural Snow	LNT Solutions P250	75%	-3.5	47.3	29.5
233	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.5	44.8	13.6
237	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.0	40.6	12.8
238	22-Mar-14	Natural Snow	LNT Solutions P250	75%	-3.2	23.3	72.7
239	22-Mar-14	Natural Snow	LNT Solutions P250	100%	-3.2	18.8	107.9
245	22-Mar-14	Natural Snow	LNT Solutions P250	100%	-3.3	25.5	53.5
246	22-Mar-14	Natural Snow	LNT Solutions P250	75%	-3.3	30.6	27.1
247	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.4	20.0	7.6
254	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.4	16.4	17.7
255	22-Mar-14	Natural Snow	LNT Solutions P250	75%	-3.4	23.7	58.1
256	22-Mar-14	Natural Snow	LNT Solutions P250	100%	-3.4	26.0	65.2
260	22-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.2	20.7	19.5
263	27-Mar-14	Natural Snow	LNT Solutions P250	100%	-9.2	3.3	232.7
264	27-Mar-14	Natural Snow	LNT Solutions P250	75%	-11.3	4.3	151.6
265	27-Mar-14	Natural Snow	LNT Solutions P250	100%	-9.2	3.0	240.6
266	27-Mar-14	Natural Snow	LNT Solutions P250	75%	-9.2	3.0	239.8

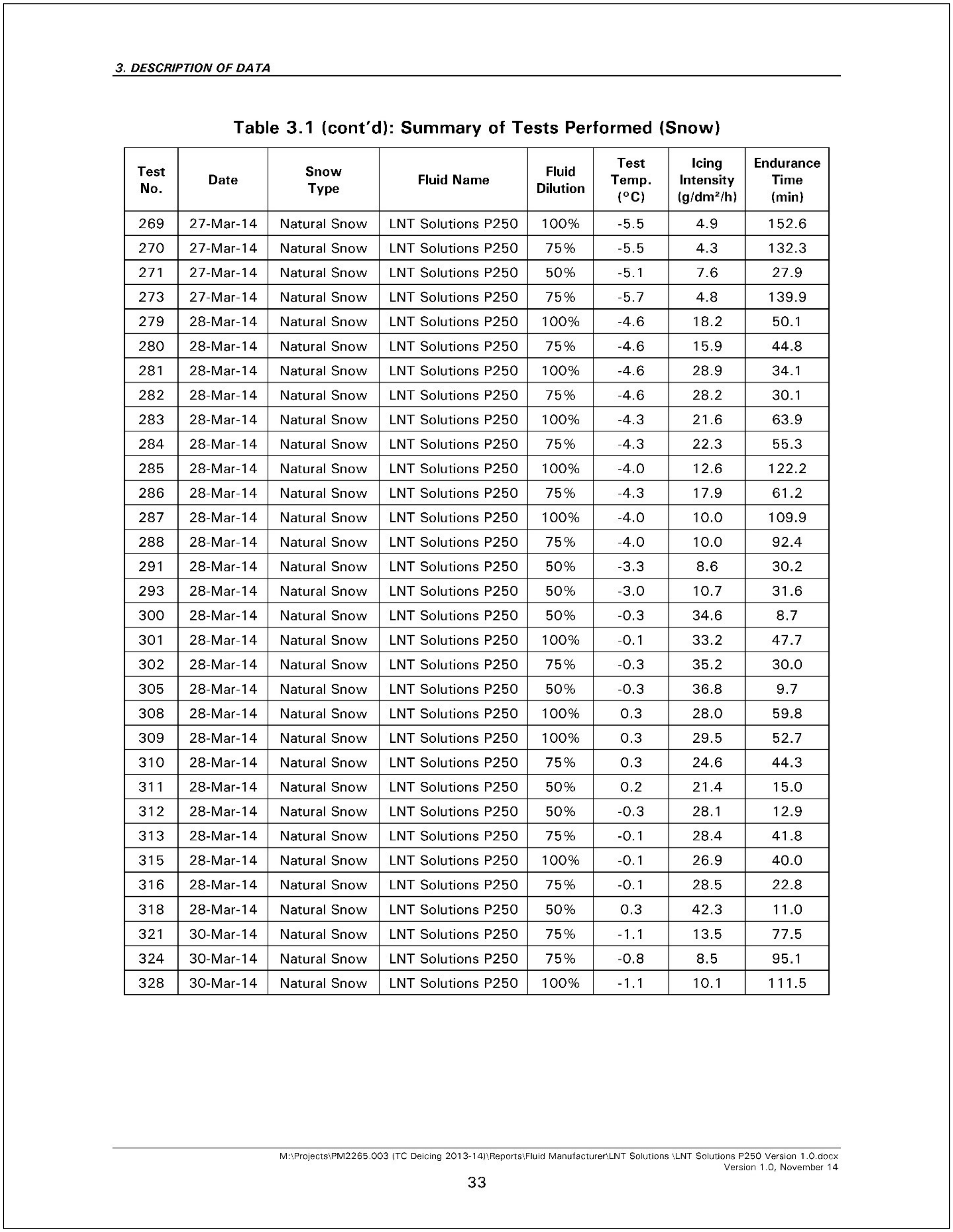


Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
269	27-Mar-14	Natural Snow	LNT Solutions P250	100%	-5.5	4.9	152.6
270	27-Mar-14	Natural Snow	LNT Solutions P250	75%	-5.5	4.3	132.3
271	27-Mar-14	Natural Snow	LNT Solutions P250	50%	-5.1	7.6	27.9
273	27-Mar-14	Natural Snow	LNT Solutions P250	75%	-5.7	4.8	139.9
279	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-4.6	18.2	50.1
280	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-4.6	15.9	44.8
281	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-4.6	28.9	34.1
282	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-4.6	28.2	30.1
283	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-4.3	21.6	63.9
284	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-4.3	22.3	55.3
285	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-4.0	12.6	122.2
286	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-4.3	17.9	61.2
287	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-4.0	10.0	109.9
288	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-4.0	10.0	92.4
291	28-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.3	8.6	30.2
293	28-Mar-14	Natural Snow	LNT Solutions P250	50%	-3.0	10.7	31.6
300	28-Mar-14	Natural Snow	LNT Solutions P250	50%	-0.3	34.6	8.7
301	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-0.1	33.2	47.7
302	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-0.3	35.2	30.0
305	28-Mar-14	Natural Snow	LNT Solutions P250	50%	-0.3	36.8	9.7
308	28-Mar-14	Natural Snow	LNT Solutions P250	100%	0.3	28.0	59.8
309	28-Mar-14	Natural Snow	LNT Solutions P250	100%	0.3	29.5	52.7
310	28-Mar-14	Natural Snow	LNT Solutions P250	75%	0.3	24.6	44.3
311	28-Mar-14	Natural Snow	LNT Solutions P250	50%	0.2	21.4	15.0
312	28-Mar-14	Natural Snow	LNT Solutions P250	50%	-0.3	28.1	12.9
313	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-0.1	28.4	41.8
315	28-Mar-14	Natural Snow	LNT Solutions P250	100%	-0.1	26.9	40.0
316	28-Mar-14	Natural Snow	LNT Solutions P250	75%	-0.1	28.5	22.8
318	28-Mar-14	Natural Snow	LNT Solutions P250	50%	0.3	42.3	11.0
321	30-Mar-14	Natural Snow	LNT Solutions P250	75%	-1.1	13.5	77.5
324	30-Mar-14	Natural Snow	LNT Solutions P250	75%	-0.8	8.5	95.1
328	30-Mar-14	Natural Snow	LNT Solutions P250	100%	-1.1	10.1	111.5

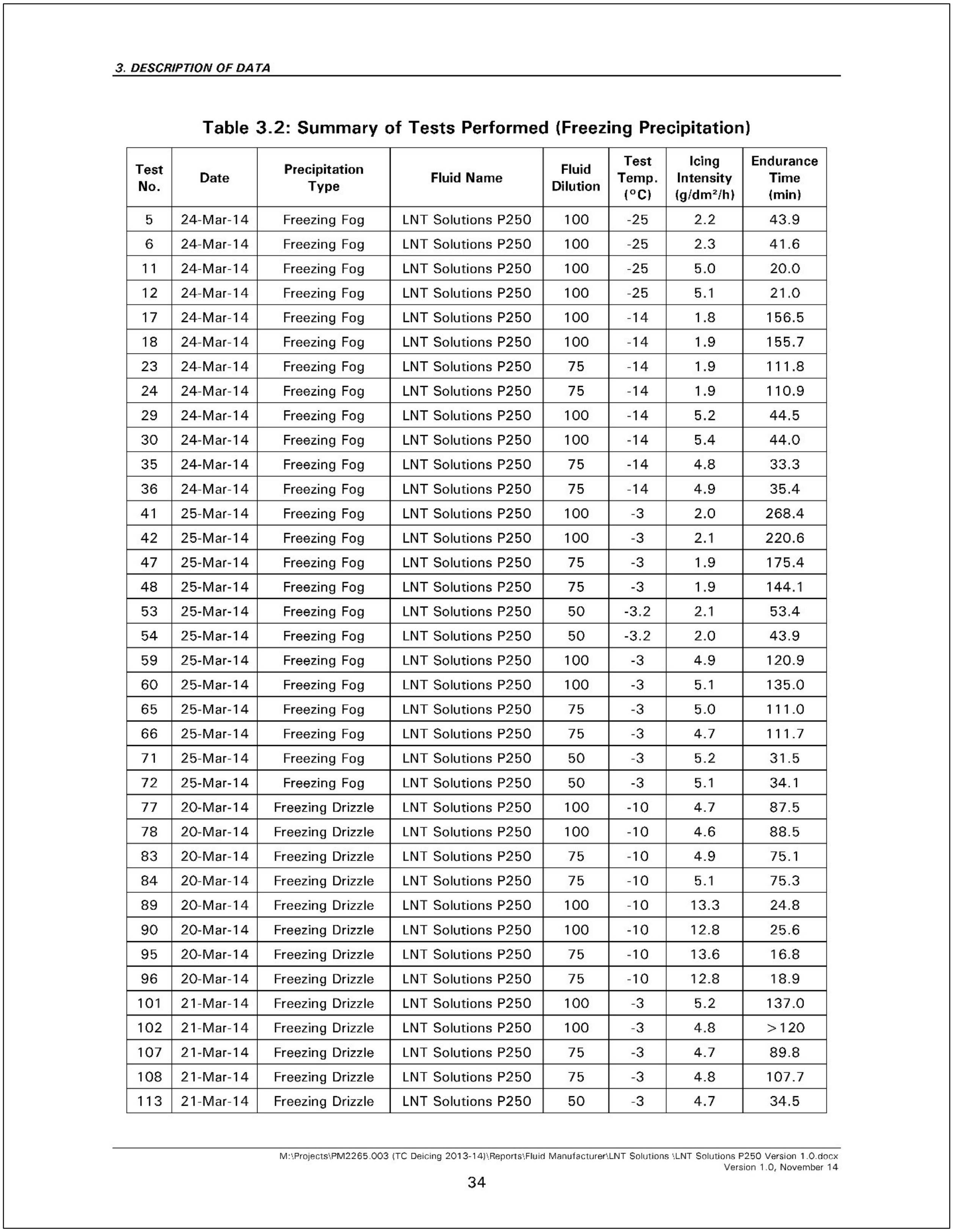


Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
5	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-25	2.2	43.9
6	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-25	2.3	41.6
11	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-25	5.0	20.0
12	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-25	5.1	21.0
17	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-14	1.8	156.5
18	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-14	1.9	155.7
23	24-Mar-14	Freezing Fog	LNT Solutions P250	75	-14	1.9	111.8
24	24-Mar-14	Freezing Fog	LNT Solutions P250	75	-14	1.9	110.9
29	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-14	5.2	44.5
30	24-Mar-14	Freezing Fog	LNT Solutions P250	100	-14	5.4	44.0
35	24-Mar-14	Freezing Fog	LNT Solutions P250	75	-14	4.8	33.3
36	24-Mar-14	Freezing Fog	LNT Solutions P250	75	-14	4.9	35.4
41	25-Mar-14	Freezing Fog	LNT Solutions P250	100	-3	2.0	268.4
42	25-Mar-14	Freezing Fog	LNT Solutions P250	100	-3	2.1	220.6
47	25-Mar-14	Freezing Fog	LNT Solutions P250	75	-3	1.9	175.4
48	25-Mar-14	Freezing Fog	LNT Solutions P250	75	-3	1.9	144.1
53	25-Mar-14	Freezing Fog	LNT Solutions P250	50	-3.2	2.1	53.4
54	25-Mar-14	Freezing Fog	LNT Solutions P250	50	-3.2	2.0	43.9
59	25-Mar-14	Freezing Fog	LNT Solutions P250	100	-3	4.9	120.9
60	25-Mar-14	Freezing Fog	LNT Solutions P250	100	-3	5.1	135.0
65	25-Mar-14	Freezing Fog	LNT Solutions P250	75	-3	5.0	111.0
66	25-Mar-14	Freezing Fog	LNT Solutions P250	75	-3	4.7	111.7
71	25-Mar-14	Freezing Fog	LNT Solutions P250	50	-3	5.2	31.5
72	25-Mar-14	Freezing Fog	LNT Solutions P250	50	-3	5.1	34.1
77	20-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-10	4.7	87.5
78	20-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-10	4.6	88.5
83	20-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-10	4.9	75.1
84	20-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-10	5.1	75.3
89	20-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-10	13.3	24.8
90	20-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-10	12.8	25.6
95	20-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-10	13.6	16.8
96	20-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-10	12.8	18.9
101	21-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-3	5.2	137.0
102	21-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-3	4.8	>120
107	21-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-3	4.7	89.8
108	21-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-3	4.8	107.7
113	21-Mar-14	Freezing Drizzle	LNT Solutions P250	50	-3	4.7	34.5

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
114	21-Mar-14	Freezing Drizzle	LNT Solutions P250	50	-3	4.6	33.8
119	19-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-3	13.7	91.5
120	19-Mar-14	Freezing Drizzle	LNT Solutions P250	100	-3	13.2	96.7
125	19-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-3	13.2	88.4
126	19-Mar-14	Freezing Drizzle	LNT Solutions P250	75	-3	13.5	72.6
131	19-Mar-14	Freezing Drizzle	LNT Solutions P250	50	-3	13.0	18.9
132	19-Mar-14	Freezing Drizzle	LNT Solutions P250	50	-3	13.5	18.3
137	20-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-10	13.3	35.6
138	20-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-10	13.5	36.4
143	20-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-10	12.6	29.5
144	20-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-10	12.9	30.3
149	20-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-10	24.8	22.3
150	20-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-10	25.7	23.5
155	20-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-10	24.8	16.4
156	20-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-10	24.6	19.6
161	19-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-3	12.8	90.8
162	19-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-3	12.7	85.4
167	19-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-3	12.8	56.7
168	19-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-3	12.6	68.7
173	19-Mar-14	Light Freezing Rain	LNT Solutions P250	50	-3	12.8	22.0
174	19-Mar-14	Light Freezing Rain	LNT Solutions P250	50	-3	12.8	18.6
179	21-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-3	25.0	48.0
180	21-Mar-14	Light Freezing Rain	LNT Solutions P250	100	-3	25.3	49.6
185	21-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-3	24.4	37.8
186	21-Mar-14	Light Freezing Rain	LNT Solutions P250	75	-3	24.7	44.7
191	21-Mar-14	Light Freezing Rain	LNT Solutions P250	50	-3	24.7	12.7
192	21-Mar-14	Light Freezing Rain	LNT Solutions P250	50	-3	25.3	12.8
197	26-Mar-14	Cold Soak Box	LNT Solutions P250	100	1.0	5.3	111.7
198	26-Mar-14	Cold Soak Box	LNT Solutions P250	100	1.0	5.2	120.0
203	26-Mar-14	Cold Soak Box	LNT Solutions P250	75	1.0	5.4	112.0
204	26-Mar-14	Cold Soak Box	LNT Solutions P250	75	1.1	5.4	93.5
209	26-Mar-14	Cold Soak Box	LNT Solutions P250	100	0.7	75.6	15.9
210	26-Mar-14	Cold Soak Box	LNT Solutions P250	100	1.3	74.7	18.2
215	26-Mar-14	Cold Soak Box	LNT Solutions P250	75	1.1	75.2	12.6
216	26-Mar-14	Cold Soak Box	LNT Solutions P250	75	1.1	73.2	12.1

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
25	16-Apr-14	Natural Frost	LNT Solutions P250	100%	694	0.03	-2.9	4	75	Did Not Fail
26	16-Apr-14	Natural Frost	LNT Solutions P250	75%	563	0.03	-3.2	3	78	Did Not Fail
27	16-Apr-14	Natural Frost	LNT Solutions P250	50%	456	0.03	-3.5	3	81	Did Not Fail
36	17-Apr-14	Natural Frost	LNT Solutions P250	100%	659	0.09	-2.1	8	64	Did Not Fail
37	17-Apr-14	Natural Frost	LNT Solutions P250	75%	381	0.11	-2.7	8	69	Did Not Fail
38	17-Apr-14	Natural Frost	LNT Solutions P250	50%	380	0.11	-2.7	8	69	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The results of the data analyses are presented in this section.

4.1 Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the data collected in natural snow and simulated freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface). These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type II HOT guidelines.

Multi-variable regression analysis was performed on these data sets as described in Subsection 2.8. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type II fluid-specific HOT tables. Two exceptions are:

- the coldest temperature band snow cells (see Subsection 4.3.1); and
- light and very light snow holdover times (see Subsection 4.4).

4.2 Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the generic holdover times. All completed ("failed") tests surpassed the generic holdover times, as did all tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates the generic frost holdover times have been substantiated for LNT Solutions P250.

4.3 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for LNT Solutions P250. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.3.1 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, the existing propylene Type II/IV fluids were given generic values in the "Below -14 to LOUT" snow cell. It was also decided that all new Type II/IV fluids would be given generic values. Accordingly, LNT Solutions P250 has been given generic values in the "Below -14°C to LOUT" snow cells.

4.3.2 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT table. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the LNT Solutions P250 fluid-specific HOT table.

4.3.3 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.4 Lowest Usable Precipitation Rates in Snow

The LUPRs for LNT Solutions P250 were determined by analysing the natural snow data sets using the analysis methodology described in Subsection 2.8.6. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for LNT Solutions P250 are:

- 100/0 = 3 g/dm²/h;
- 75/25 = 3 g/dm²/h; and
- 50/50 = 8 g/dm²/h.

As the 50/50 LUPR is higher than the very light snow precipitation rate limits (3, 4 g/dm²/h) and the light snow lower precipitation rate limit (4 g/dm²/h), the light and very light snow holdover times were reduced. The 50/50 LUPR of 8 g/dm²/h was used to determine holdover times for these holdover time values.

4.5 Discussion

As LNT Solutions intends to commercialize P250, TC and FAA will publish its fluid-specific HOT table in their 2014-15 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the LUPR data will be published in the related TC and FAA Regression Information documents.

Additional data will be collected with the 50/50 fluid in winter 2014-15 in an attempt to reduce the LUPR to 3 g/dm²/h or lower. When this is accomplished, the 50/50 snow holdover times will be increased accordingly.

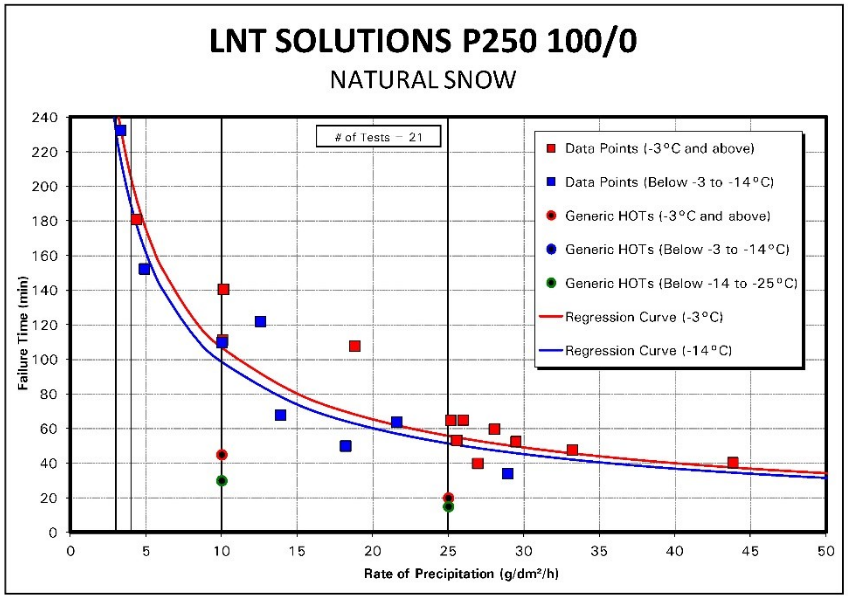


Figure 4.1: Type II Neat – Natural Snow

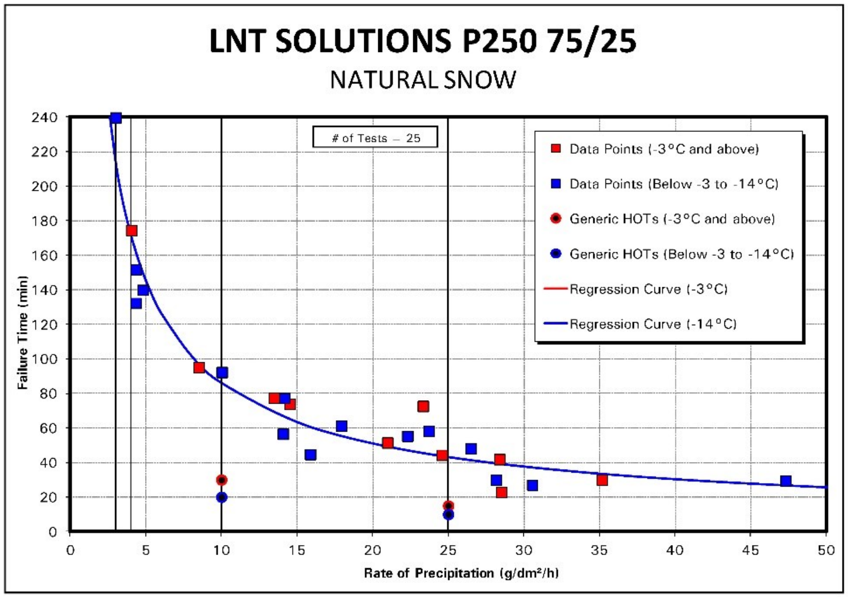


Figure 4.2: Type II 75/25 – Natural Snow

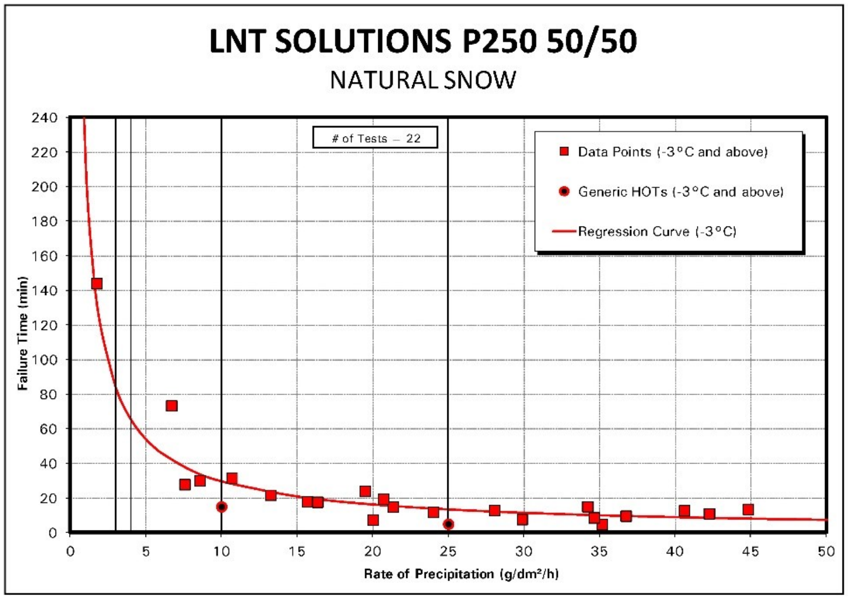


Figure 4.3: Type II 50/50 – Natural Snow

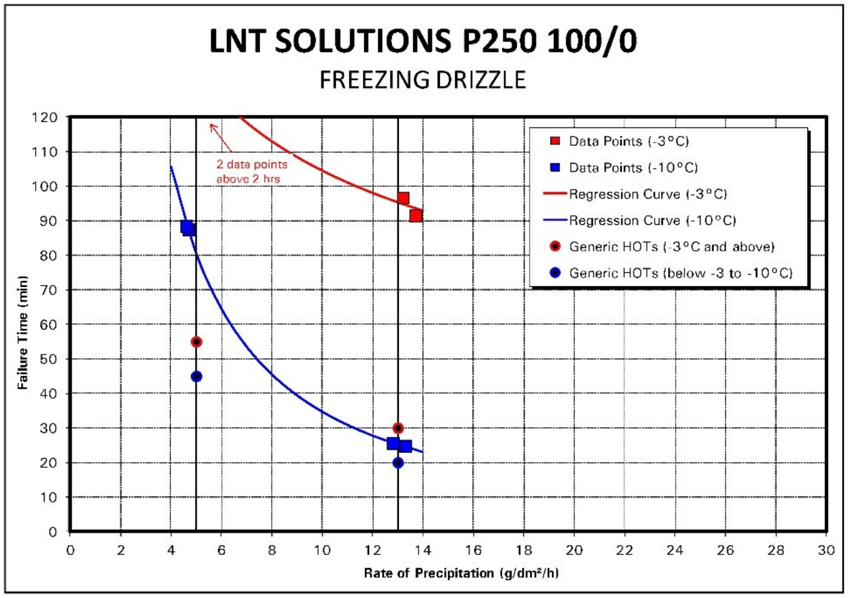


Figure 4.4: Type II Neat – Freezing Drizzle

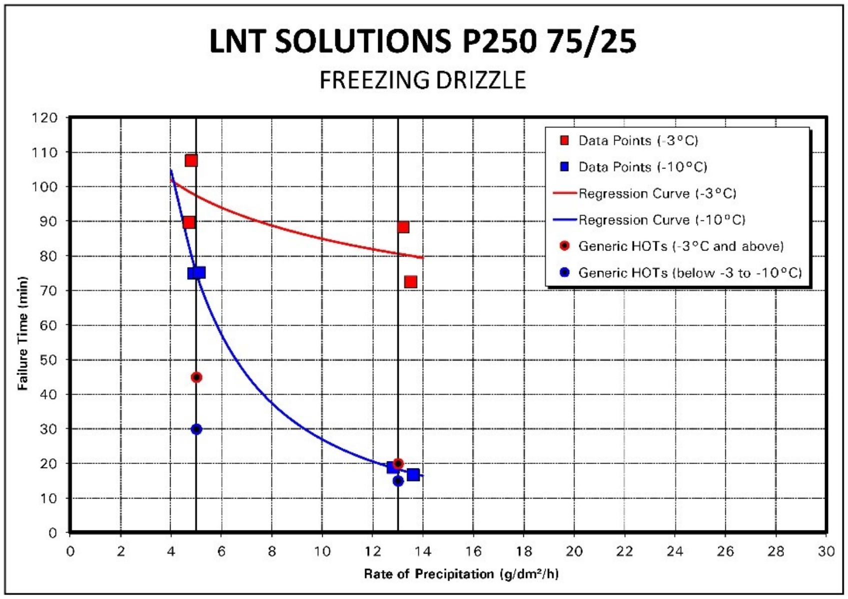


Figure 4.5: Type II 75/25 – Freezing Drizzle

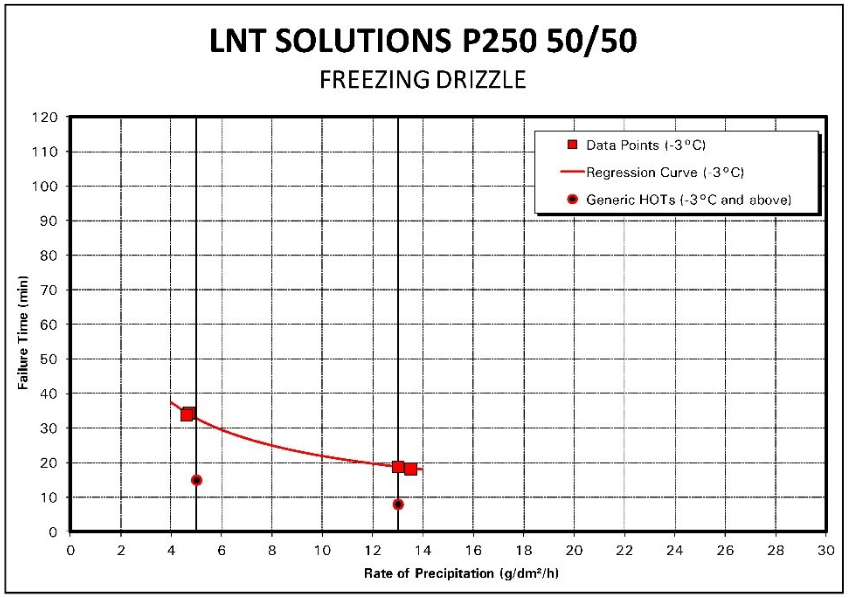


Figure 4.6: Type II 50/50 – Freezing Drizzle

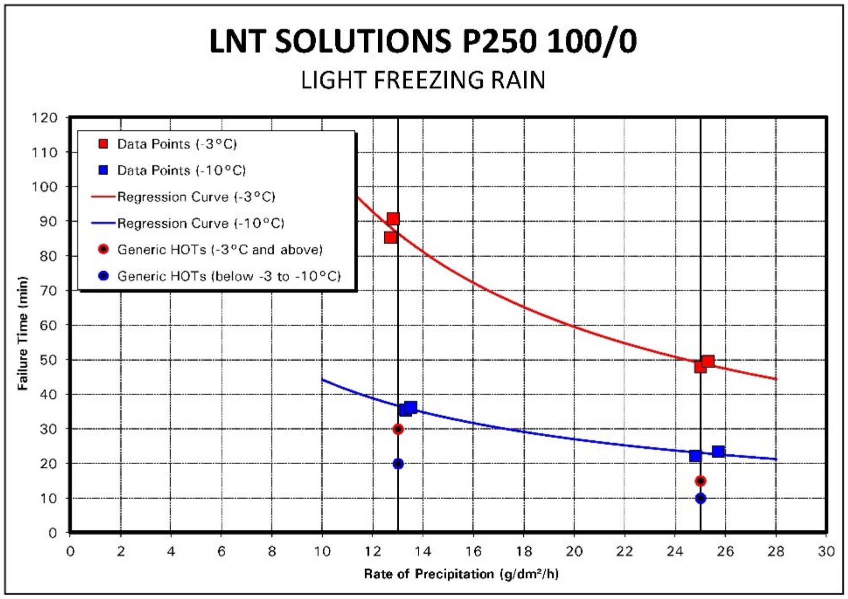


Figure 4.7: Type II Neat – Light Freezing Rain

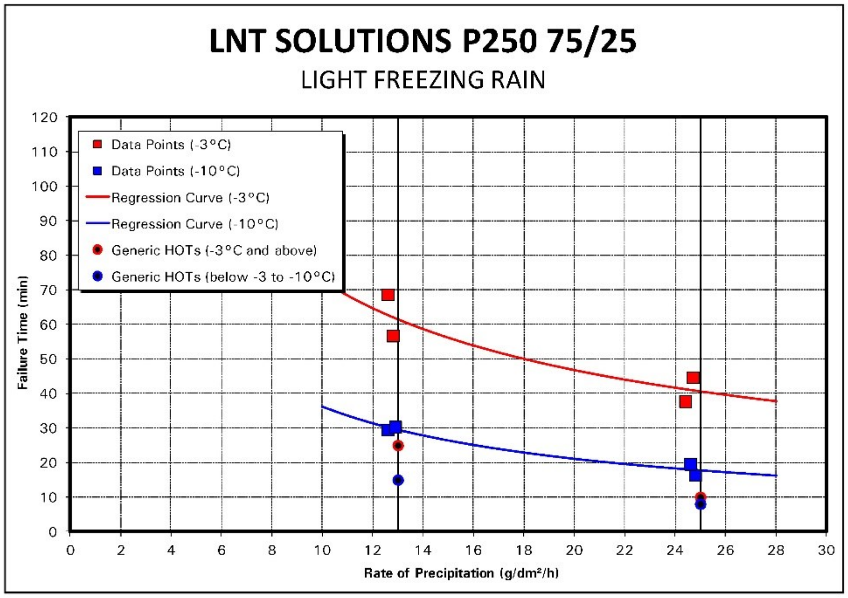


Figure 4.8: Type II 75/25 – Light Freezing Rain

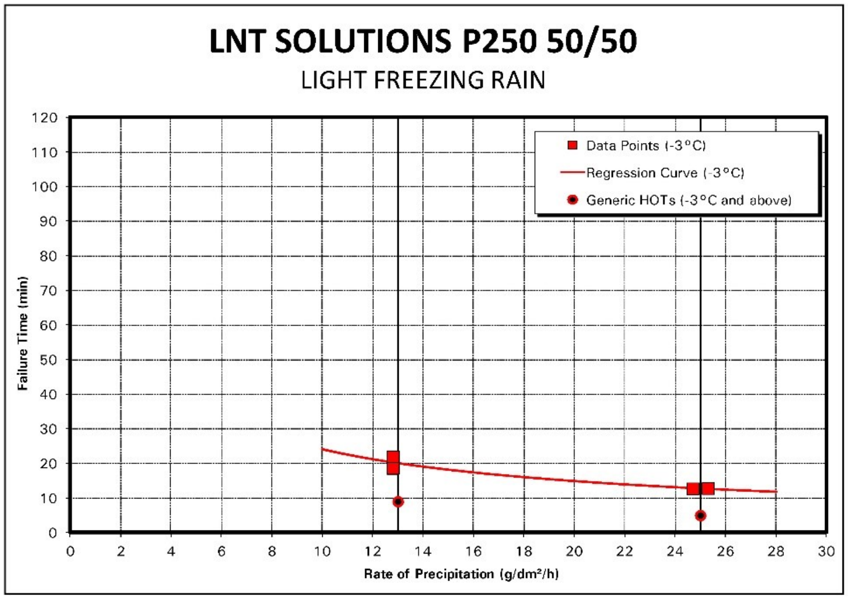


Figure 4.9: Type II 50/50 – Light Freezing Rain

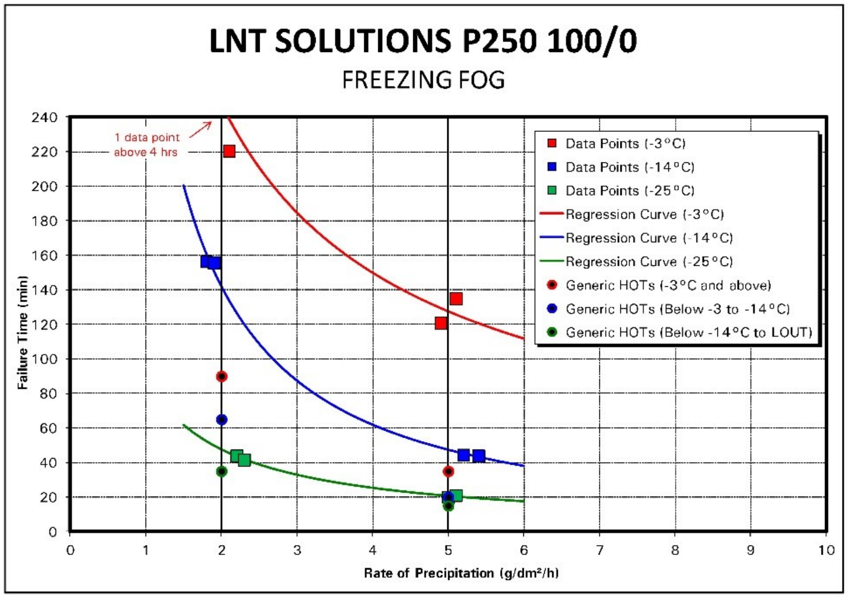


Figure 4.10: Type II Neat – Freezing Fog

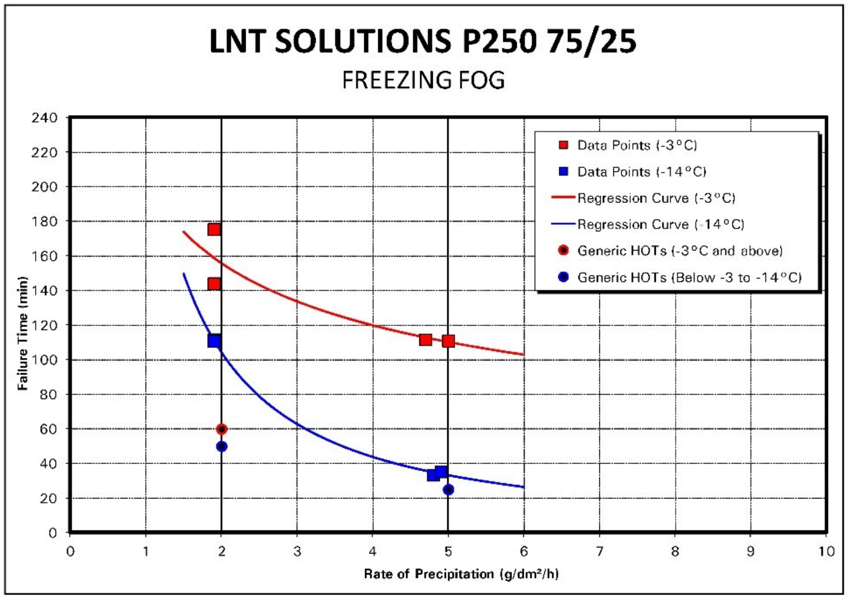


Figure 4.11: Type II 75/25 – Freezing Fog

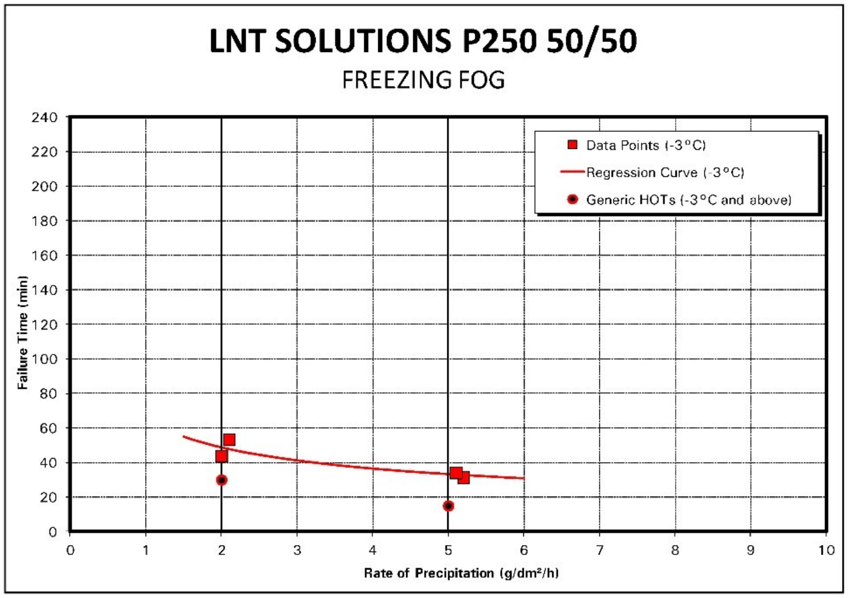


Figure 4.12: Type II 50/50 – Freezing Fog

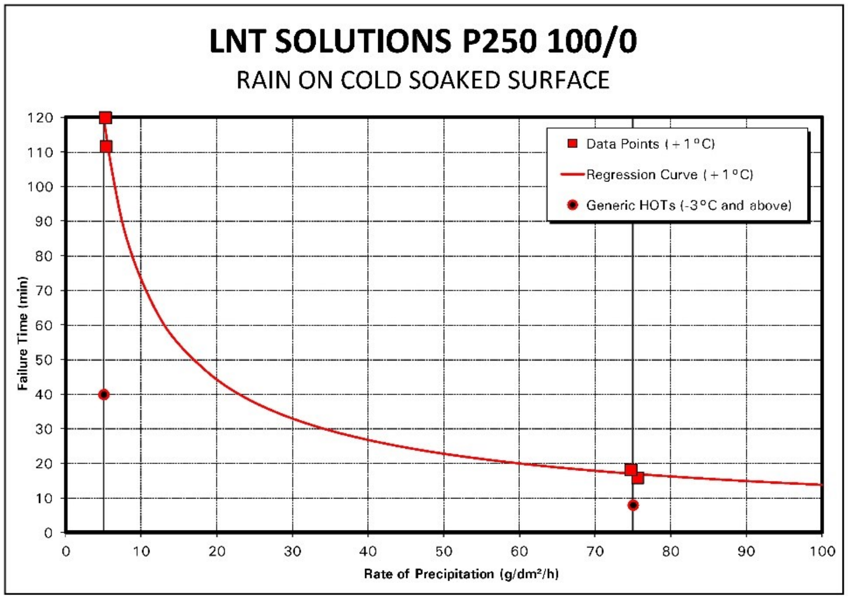


Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface

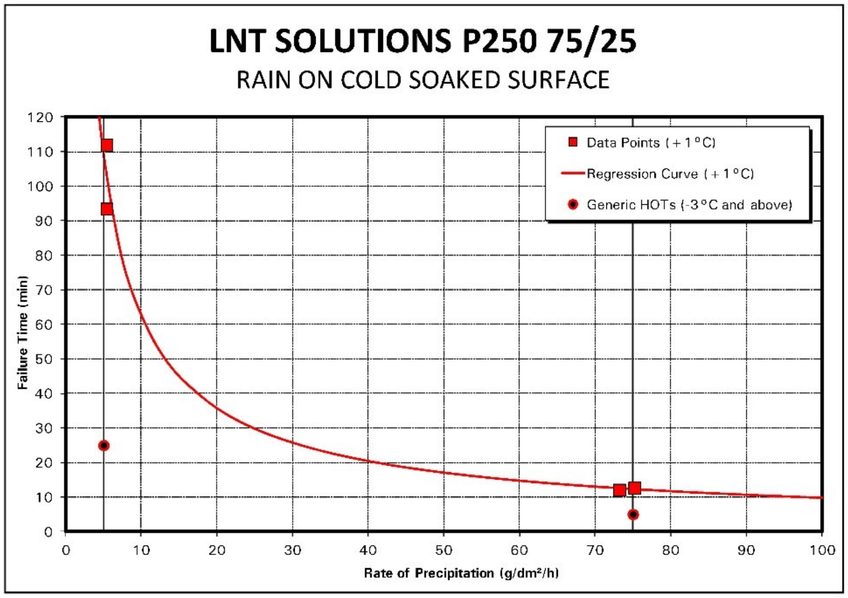


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for LNT Solutions P250

Natural Snow Conditions

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
LNT Solutions P250	Neat	88%	2.7865	-0.7100	-0.0686	21
LNT Solutions P250	75%	88%	2.6894	-0.7555	0.0000	25
LNT Solutions P250	50%	79%	2.3361	-0.8636	0.0000	22

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

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	-3°C	95%	2.6120	-0.7237	4
LNT Solutions P250	75/25	-3°C	87%	2.3071	-0.3797	4
LNT Solutions P250	50/50	-3°C	85%	1.8141	-0.4176	4
LNT Solutions P250	Neat	-14°C	100%	2.5125	-1.1965	4
LNT Solutions P250	75/25	-14°C	100%	2.3960	-1.2541	4
LNT Solutions P250	Neat	-25°C	100%	1.9517	-0.9112	4

General Equation $t = 10^I R^A$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	-3°C	97%	2.3698	-0.3507	4
LNT Solutions P250	75/25	-3°C	54%	2.1265	-0.1979	4
LNT Solutions P250	50/50	-3°C	100%	1.9204	-0.5800	4
LNT Solutions P250	Neat	-10°C	100%	2.7526	-1.2111	4
LNT Solutions P250	75/25	-10°C	100%	2.9133	-1.4840	4

General Equation $t = 10^I R^A$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	-3°C	99%	2.9042	-0.8680	4
LNT Solutions P250	75/25	-3°C	85%	2.4972	-0.6358	4
LNT Solutions P250	50/50	-3°C	94%	2.0671	-0.6870	4
LNT Solutions P250	Neat	-10°C	98%	2.3546	-0.7092	4
LNT Solutions P250	75/25	-10°C	94%	2.3372	-0.7789	4

General Equation $t = 10^I R^A$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	+1°C	100%	2.5822	-0.7200	4
LNT Solutions P250	75/25	+1°C	100%	2.6004	-0.8062	4

General Equation $t = 10^I R^A$

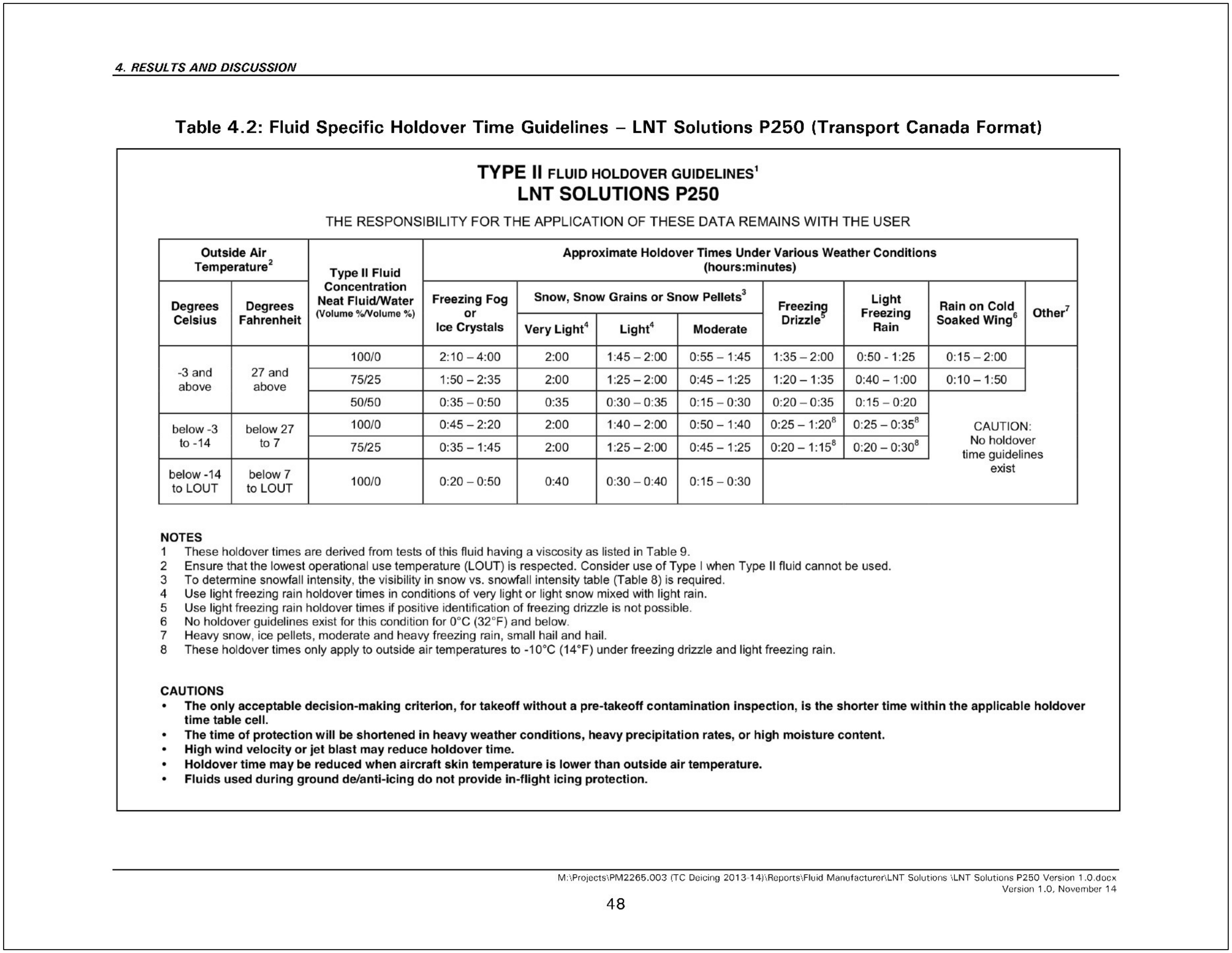


Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions P250 (Transport Canada Format)

TYPE II FLUID HOLDOVER GUIDELINES[1]
LNT SOLUTIONS P250

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:10 – 4:00	2:00	1:45 – 2:00	0:55 – 1:45	1:35 – 2:00	0:50 - 1:25	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:50 – 2:35	2:00	1:25 – 2:00	0:45 – 1:25	1:20 – 1:35	0:40 – 1:00	0:10 – 1:50	
		50/50	0:35 – 0:50	0:35	0:30 – 0:35	0:15 – 0:30	0:20 – 0:35	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:20	2:00	1:40 – 2:00	0:50 – 1:40	0:25 – 1:20[8]	0:25 – 0:35[8]		
		75/25	0:35 – 1:45	2:00	1:25 – 2:00	0:45 – 1:25	0:20 – 1:15[8]	0:20 – 0:30[8]		
below -14 to LOUT	below 7 to LOUT	100/0	0:20 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

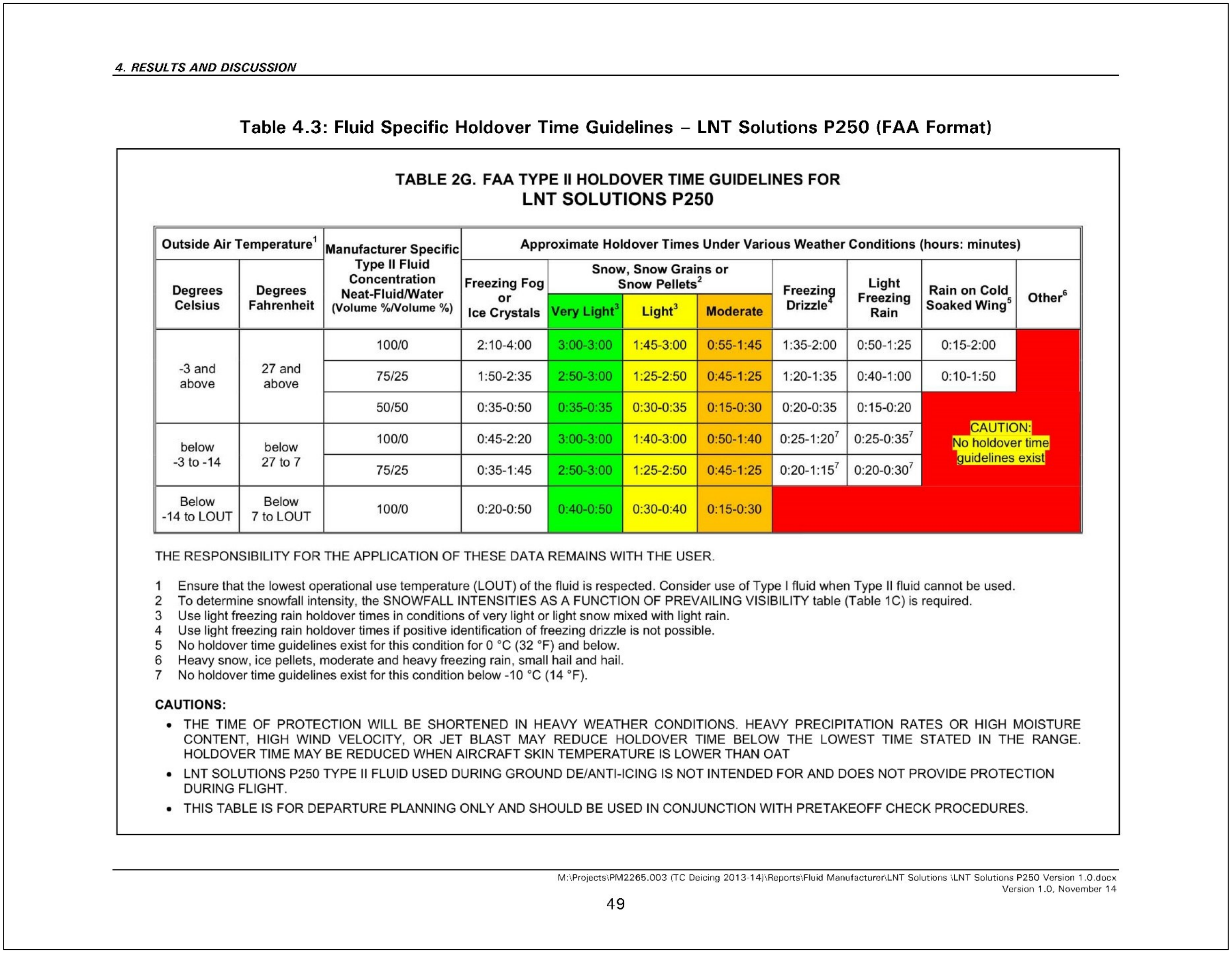


Table 4.3: Fluid Specific Holdover Time Guidelines – LNT Solutions P250 (FAA Format)

TABLE 2G. FAA TYPE II HOLDOVER TIME GUIDELINES FOR
LNT SOLUTIONS P250

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

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- LNT SOLUTIONS P250 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Table 4.4: LUPR Statistics – LNT Solutions P250

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	21	40	25	40	22	40
Data Points -3 to -14°C	13	30	16	40	n/a	0
Data Points <10.0	4	10	6	20	4	10
Data Points < =9.5	4	40	6	40	4	40
Data Points < =8.5	4	40	6	40	3	40
Data Points < =7.5	4	40	5	40	2	30
Data Points < =6.5	4	40	5	40	1	20
Data Points < =5.5	4	40	5	40	1	20
Data Points < =4.5	3	40	4	40	1	20
Data Points < =3.5	2	30	1	20	1	20
Data Points < =2.5	0	0	0	0	1	20
Scatter 0-10 g	9%	40	8%	40	30%	10

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	32	pass	36	pass	22	pass
8 g/dm²/h	32	pass	36	pass	22	pass
7 g/dm²/h	32	pass	36	pass	18	fail
6 g/dm²/h	32	pass	36	pass	14	fail
5 g/dm²/h	32	pass	36	pass	14	fail
4 g/dm²/h	32	pass	36	pass	14	fail
3 g/dm²/h	28	pass	28	pass	14	fail
2 g/dm²/h	16	fail	20	fail	14	fail

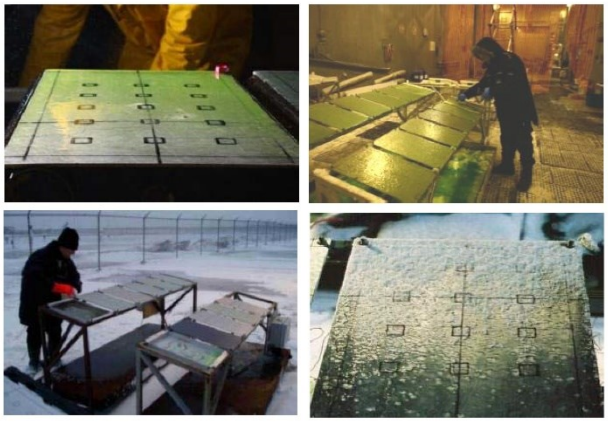
LUPR	100/0	75/25	50/50
	3 g/dm²/h	3 g/dm²/h	8 g/dm²/h

APPENDIX E

FLUID MANUFACTURER REPORT:
CLARIANT MAX FLIGHT SNEG (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Max Flight Sneg (Type IV)



Prepared for

Clariant GmbH

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. C-MFS 2013-14

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Max Flight Sneg (Type IV)

Prepared for

Clariant GmbH

Prepared by:

Nov. 28, 2014

Stephanie Bendickson
Project Analyst

Date

Reviewed by:

Nov. 28, 2014

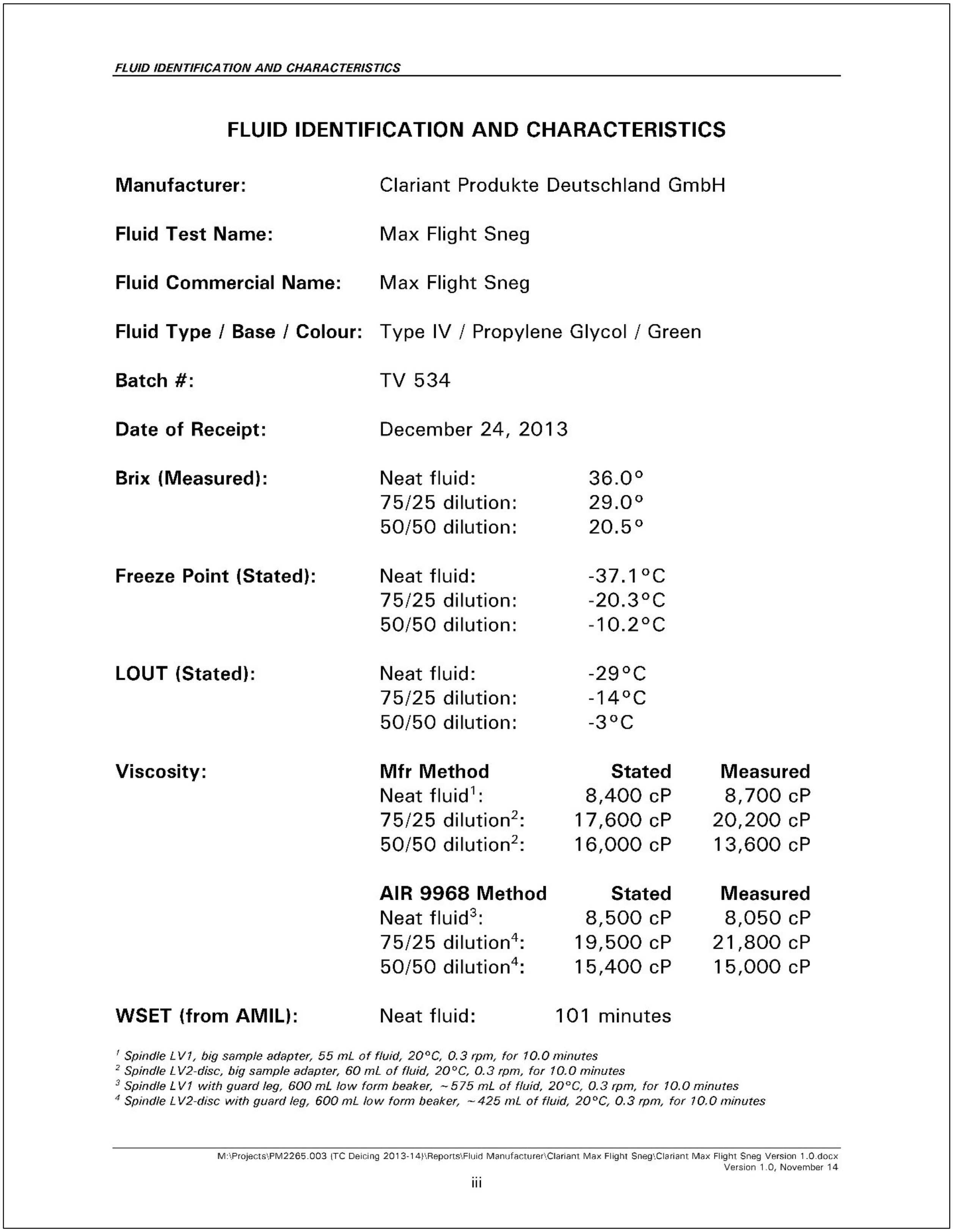
John D'Avirro, Eng.
Program Manager

Date

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. C-MFS 2013-14



FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer: Clariant Produkte Deutschland GmbH

Fluid Test Name: Max Flight Sneg

Fluid Commercial Name: Max Flight Sneg

Fluid Type / Base / Colour: Type IV / Propylene Glycol / Green

Batch #: TV 534

Date of Receipt: December 24, 2013

Brix (Measured):	Neat fluid:	36.0°
	75/25 dilution:	29.0°
	50/50 dilution:	20.5°

Freeze Point (Stated):	Neat fluid:	-37.1°C
	75/25 dilution:	-20.3°C
	50/50 dilution:	-10.2°C

LOUT (Stated):	Neat fluid:	-29°C
	75/25 dilution:	-14°C
	50/50 dilution:	-3°C

Viscosity:	**Mfr Method**	**Stated**	**Measured**
	Neat fluid[1]:	8,400 cP	8,700 cP
	75/25 dilution[2]:	17,600 cP	20,200 cP
	50/50 dilution[2]:	16,000 cP	13,600 cP
	AIR 9968 Method	**Stated**	**Measured**
	Neat fluid[3]:	8,500 cP	8,050 cP
	75/25 dilution[4]:	19,500 cP	21,800 cP
	50/50 dilution[4]:	15,400 cP	15,000 cP

WSET (from AMIL): Neat fluid: 101 minutes

[1] *Spindle LV1, big sample adapter, 55 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*
[2] *Spindle LV2-disc, big sample adapter, 60 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*
[3] *Spindle LV1 with guard leg, 600 mL low form beaker, ~575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*
[4] *Spindle LV2-disc with guard leg, 600 mL low form beaker, ~425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*

This page intentionally left blank.

SUMMARY

The primary objective of this project was to measure the endurance time performance of **Clariant Max Flight Sneg** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown in the tables on the next page. These holdover times will be published by regulators for use in the winter 2014-15 operating season.

Clariant Max Flight Sneg Type IV Fluid Holdover Times (Transport Canada Format)

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume % /Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
				Very Light	Light	Moderate				
-3 and above	27 and above	100/0	2:25-4:00	2:00	1:40-2:00	1:05-1:40	2:00-2:00	0:50-1:40	0:20-1:30	
		75/25	4:00-4:00	2:00	1:30-2:00	0:55-1:30	1:30-2:00	1:05-1:20	0:15-1:45	
		50/50	1:30-3:30	1:45	0:45-1:45	0:20-0:45	0:35-1:10	0:15-0:30	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-2:20	2:00	1:15-2:00	0:45-1:15	0:30-1:25	0:25-0:40		
		75/25	0:30-1:25	1:40	1:00-1:40	0:40-1:00	0:20-1:05	0:20-0:40		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:40	0:30-0:40	0:15-0:30				

Clariant Max Flight Sneg Type IV Fluid Holdover Times (FAA Format)

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume % /Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
				Very Light	Light	Moderate				
-3 and above	27 and above	100/0	2:25-4:00	2:45-3:00	1:40-2:45	1:05-1:40	2:00-2:00	0:50-1:40	0:20-1:30	
		75/25	4:00-4:00	2:25-2:50	1:30-2:25	0:55-1:30	1:30-2:00	1:05-1:20	0:15-1:45	
		50/50	1:30-3:30	1:45-2:20	0:45-1:45	0:20-0:45	0:35-1:10	0:15-0:30	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-2:20	2:00-2:20	1:15-2:00	0:45-1:15	0:30-1:25	0:25-0:40		
		75/25	0:30-1:25	1:40-2:00	1:00-1:40	0:40-1:00	0:20-1:05	0:20-0:40		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

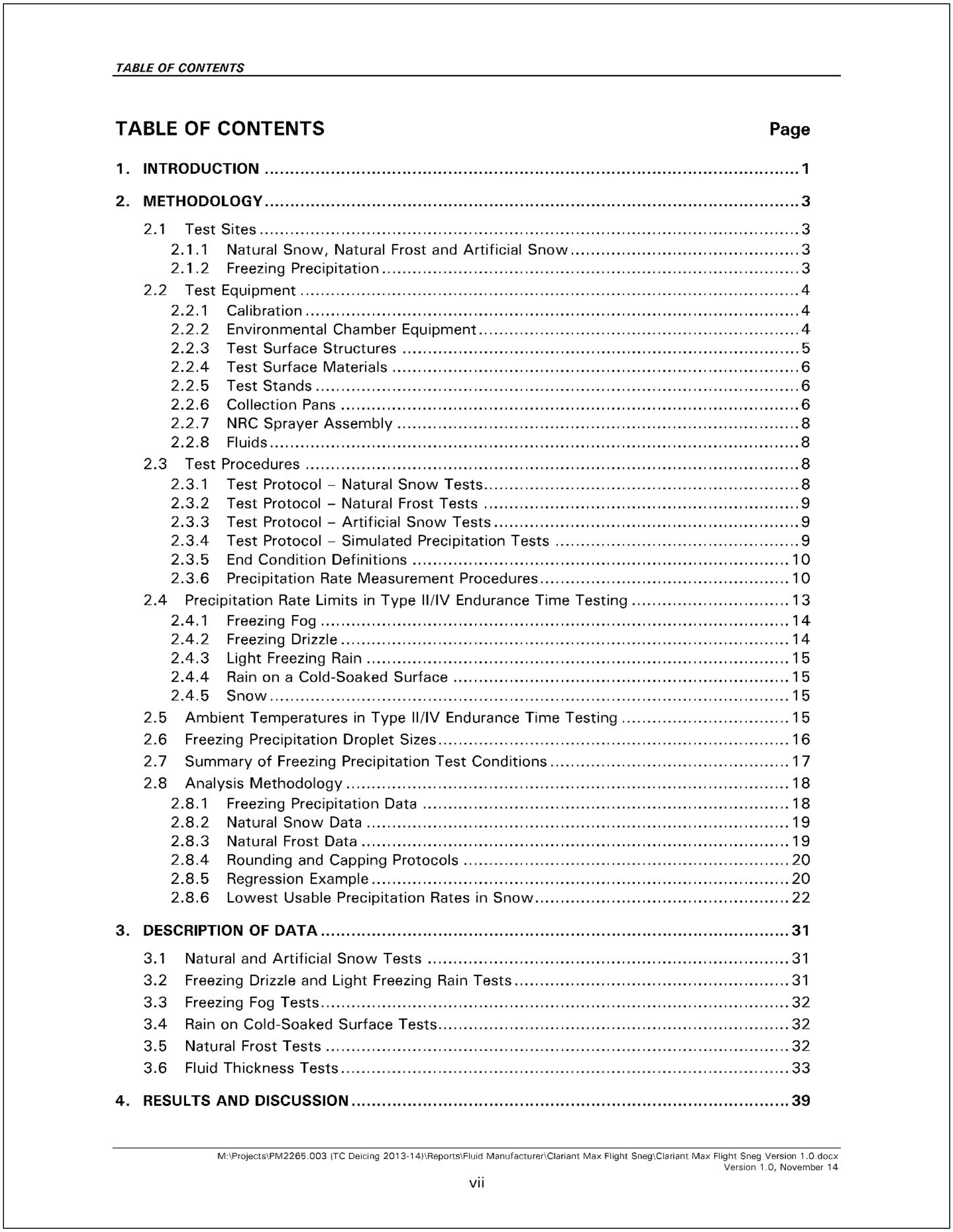


TABLE OF CONTENTS

Page

1. **INTRODUCTION 1**

2. **METHODOLOGY 3**

- 2.1 Test Sites 3
  - 2.1.1 Natural Snow, Natural Frost and Artificial Snow 3
  - 2.1.2 Freezing Precipitation 3
- 2.2 Test Equipment 4
  - 2.2.1 Calibration 4
  - 2.2.2 Environmental Chamber Equipment 4
  - 2.2.3 Test Surface Structures 5
  - 2.2.4 Test Surface Materials 6
  - 2.2.5 Test Stands 6
  - 2.2.6 Collection Pans 6
  - 2.2.7 NRC Sprayer Assembly 8
  - 2.2.8 Fluids 8
- 2.3 Test Procedures 8
  - 2.3.1 Test Protocol – Natural Snow Tests 8
  - 2.3.2 Test Protocol – Natural Frost Tests 9
  - 2.3.3 Test Protocol – Artificial Snow Tests 9
  - 2.3.4 Test Protocol – Simulated Precipitation Tests 9
  - 2.3.5 End Condition Definitions 10
  - 2.3.6 Precipitation Rate Measurement Procedures 10
- 2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 13
  - 2.4.1 Freezing Fog 14
  - 2.4.2 Freezing Drizzle 14
  - 2.4.3 Light Freezing Rain 15
  - 2.4.4 Rain on a Cold-Soaked Surface 15
  - 2.4.5 Snow 15
- 2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 15
- 2.6 Freezing Precipitation Droplet Sizes 16
- 2.7 Summary of Freezing Precipitation Test Conditions 17
- 2.8 Analysis Methodology 18
  - 2.8.1 Freezing Precipitation Data 18
  - 2.8.2 Natural Snow Data 19
  - 2.8.3 Natural Frost Data 19
  - 2.8.4 Rounding and Capping Protocols 20
  - 2.8.5 Regression Example 20
  - 2.8.6 Lowest Usable Precipitation Rates in Snow 22

3. **DESCRIPTION OF DATA 31**

- 3.1 Natural and Artificial Snow Tests 31
- 3.2 Freezing Drizzle and Light Freezing Rain Tests 31
- 3.3 Freezing Fog Tests 32
- 3.4 Rain on Cold-Soaked Surface Tests 32
- 3.5 Natural Frost Tests 32
- 3.6 Fluid Thickness Tests 33

4. **RESULTS AND DISCUSSION 39**

4.1 Natural Snow and Freezing Precipitation 39
4.2 Natural Frost 39
4.3 Holdover Time Table 39
  4.3.1 Holdover Times in Snow, Below -14°C to LOUT 39
  4.3.2 Holdover Times in Frost 40
  4.3.3 Fluid Viscosity 40
4.4 Lowest Usable Precipitation Rates in Snow 40
4.5 Discussion 40

LIST OF FIGURES Page

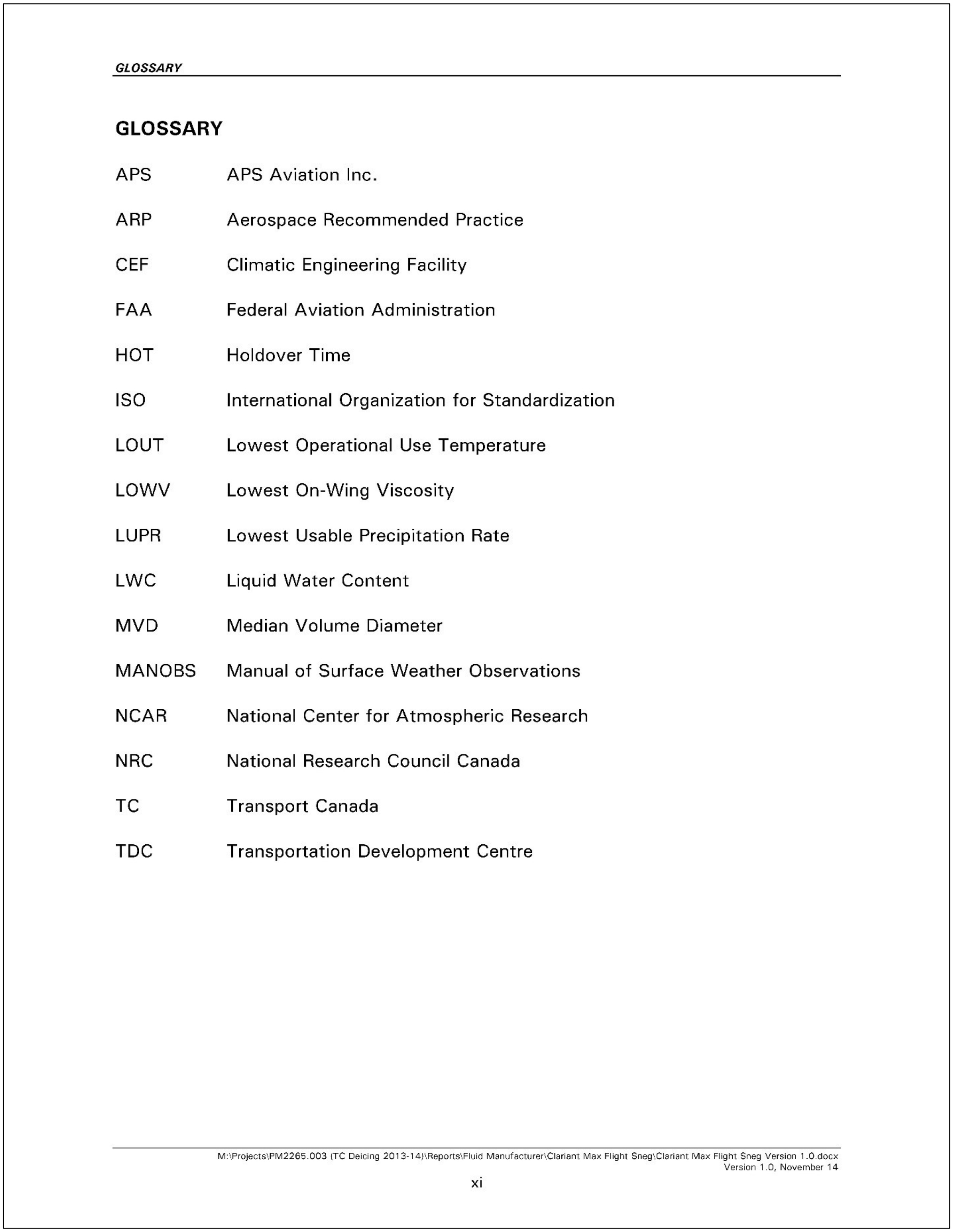
Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 6
Figure 2.4: Test Stand Setup Schematic 7
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 12
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 14
Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 21
Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain...................21
Figure 3.1: Fluid Thickness Profiles of Clariant Max Flight Sneg 33
Figure 3.2: Final Fluid Thickness of Clariant Max Flight Sneg 33
Figure 4.1: Type IV Neat – Natural Snow...41
Figure 4.2: Type IV 75/25 – Natural Snow...41
Figure 4.3: Type IV 50/50 – Natural Snow...42
Figure 4.4: Type IV Neat – Freezing Drizzle 42
Figure 4.5: Type IV 75/25 – Freezing Drizzle 43
Figure 4.6: Type IV 50/50 – Freezing Drizzle 43
Figure 4.7: Type IV Neat – Light Freezing Rain 44
Figure 4.8: Type IV 75/25 – Light Freezing Rain 44
Figure 4.9: Type IV 50/50 – Light Freezing Rain 45
Figure 4.10: Type IV Neat – Freezing Fog 45
Figure 4.11: Type IV 75/25 – Freezing Fog 46
Figure 4.12: Type IV 50/50 – Freezing Fog 46
Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface 47
Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface 47

LIST OF TABLES Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 16
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 18
Table 2.4: LUPR Factor Scoring System...23
Table 3.1: Summary of Tests Performed (Snow) 34
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 36
Table 3.3: Summary of Tests Performed (Natural Frost)...38
Table 4.1: Regression Equation Coefficients for Clariant Max Flight Sneg.............................48
Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Max Flight Sneg (Transport Canada Format) 49
Table 4.3: Fluid Specific Holdover Time Guidelines – Clariant Max Flight Sneg (FAA Format) ..50
Table 4.4: LUPR Statistics – Clariant Max Flight Sneg 51

LIST OF PHOTOS Page

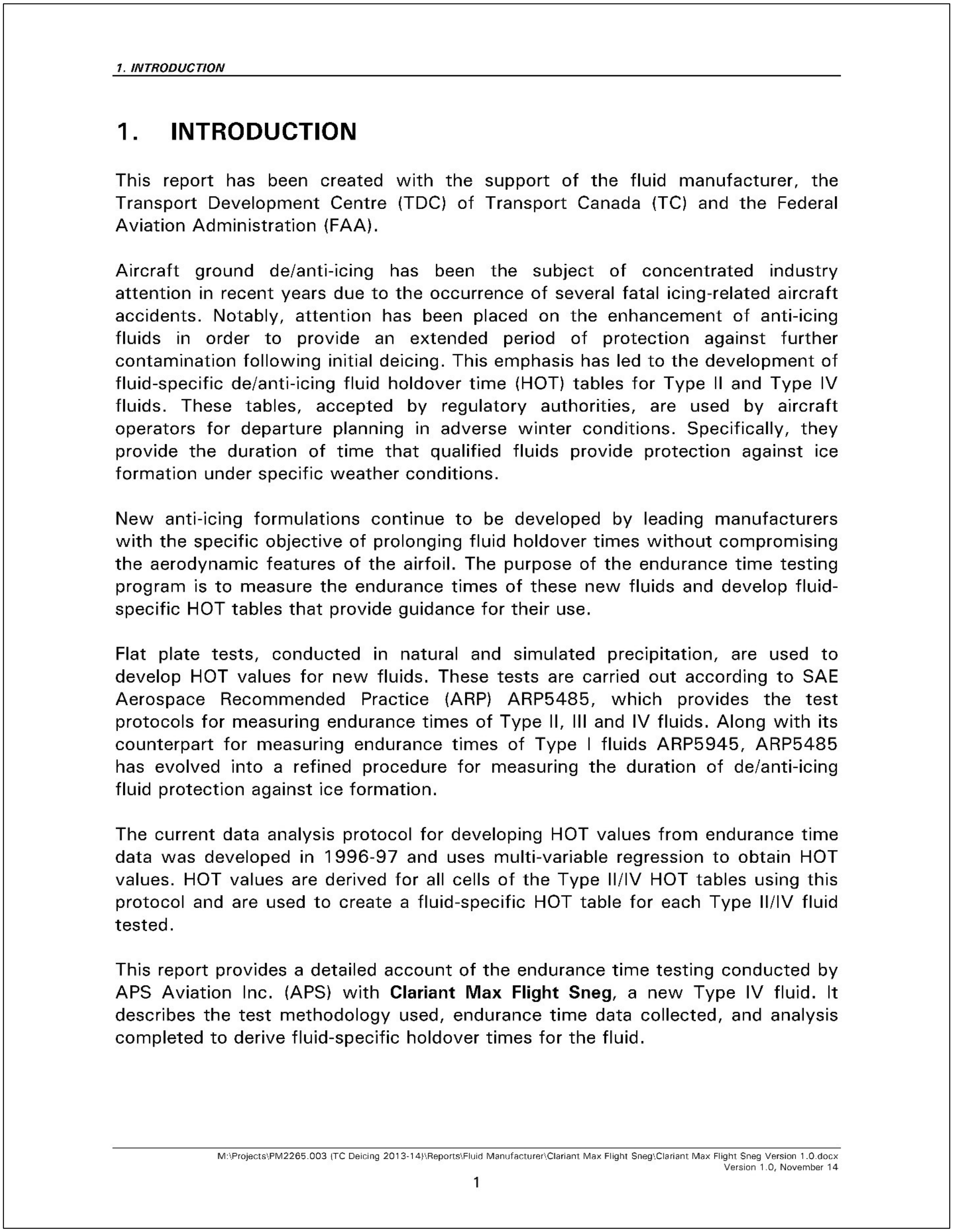
Photo 2.1: APS Test Site - View from Test Pad 24
Photo 2.2: APS Test Site - View from Trailer 24
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 25
Photo 2.4: Inside View of NRC Climatic Engineering Facility 25
Photo 2.5: Test Plates Mounted on Stand 26
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 26
Photo 2.7: Frost Plate with Insulated Backing 27
Photo 2.8: Collection Pans Used Indoors at the NRC 27
Photo 2.9: Sprayer Assembly 28
Photo 2.10: Sprayer Assembly in Use 28
Photo 2.11: Sprayer Nozzle 29
Photo 2.12: Standard Plate Setup for Testing with Artificial Snowmaker 29



GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

This page intentionally left blank.



1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Clariant Max Flight Sneg**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

This page intentionally left blank.

2

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type II/IV endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type II/IV endurance time data.

2.1 Test Sites

2.1.1 Natural Snow, Natural Frost and Artificial Snow

Natural snow, natural frost and artificial snow testing is typically performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport.

The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures; artificial snow testing is conducted inside this trailer. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

In winter 2013-14, additional natural snow testing was conducted in Ottawa, Ontario.

2.1.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC Climatic Engineering Facility (CEF), where precipitation was artificially produced.

Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

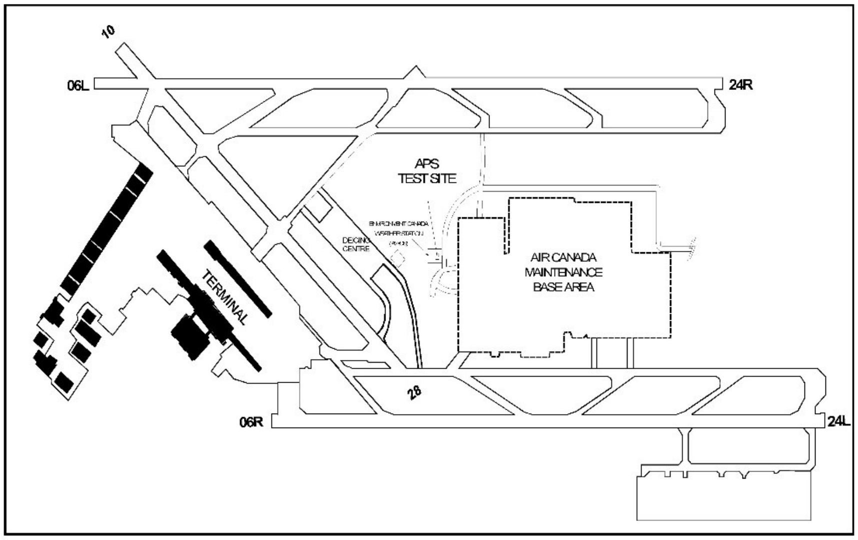


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

2.2 Test Equipment

The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

2.2.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

2.2.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5485.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1″), 15 cm (6″) and 30 cm (12″) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 2.3.5) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests.

In natural frost, tests are conducted on frosticator plates, which are the current standard test surface used in frost holdover time testing. The frosticator plates were constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 2.7 shows a white-painted aluminum frosticator plate.

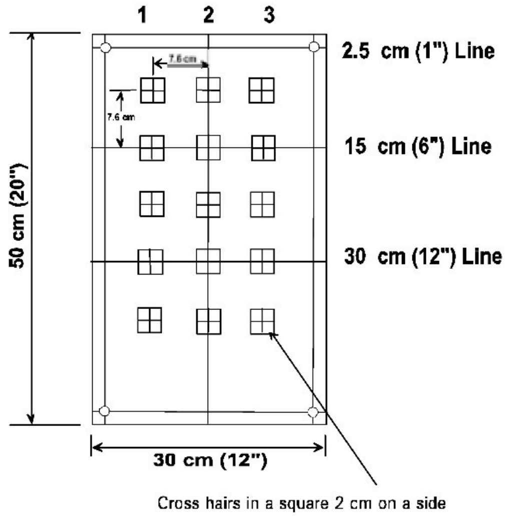


Figure 2.2: Standard Test Plate Schematic

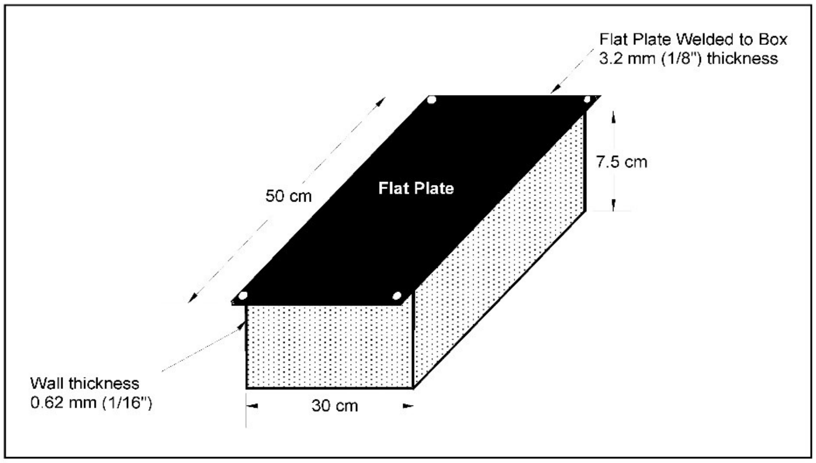


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Testing of Type II, III and IV fluids is carried out exclusively on aluminum surfaces. The aluminum used is 0.32 cm thick Alclad 2024 T3 aluminum.

2.2.5 Test Stands

Figure 2.4 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

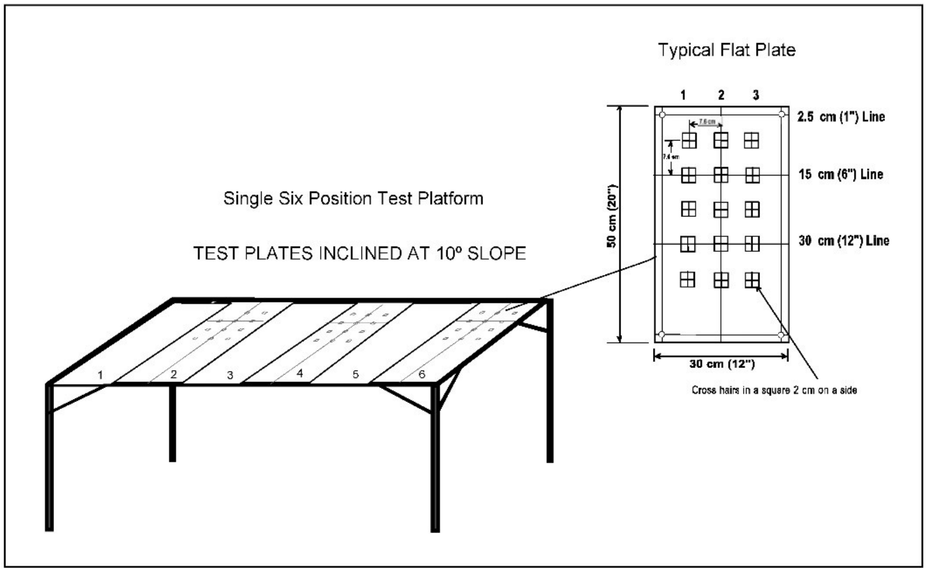


Figure 2.4: Test Stand Setup Schematic

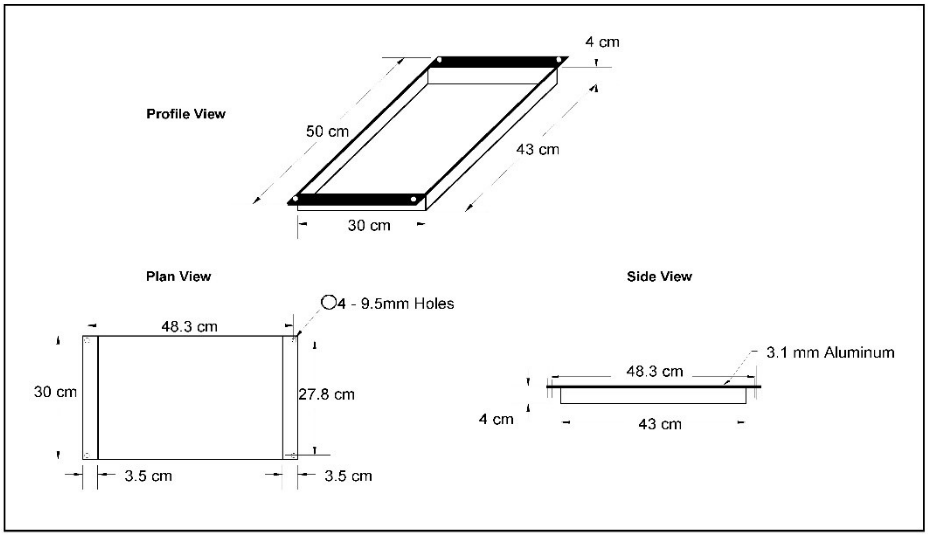


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.11.

2.2.8 Fluids

Testing was carried out with Clariant Max Flight Sneg in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

ARP5485 provides the procedure for endurance time testing of Type II, III and IV fluids under natural and simulated precipitation conditions.

The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 2.3.5), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, natural frost, artificial snow and simulated freezing precipitation testing.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type II, III and IV fluid testing in natural snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted are conducted on standard flat plates (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – Natural Frost Tests

APS developed a specific procedure for Type II/III/IV testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Artificial Snow Tests

APS developed a specific procedure for testing in artificial snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted on a standard plate (shown mounted on the snowmaker scale in Photo 2.12);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type II/III/IV testing in simulated precipitation based on the requirements outlined in ARP5485. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.5 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

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

2.3.6 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.6.1 Simulated precipitation conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.
The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, then the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

2.3.6.2 Natural precipitation conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any HOT test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 2.6 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \text{ x } t_1 \ + \ R_2 \text{ x } t_2 \ + \ R_3 \text{ x } t_3)}{t_1 \ + t_2 + t_3}$$

In the example shown in Figure 2.6, the rate is calculated as follows:

$$\frac{(25 \text{ x } 10 \ + \ 22 \text{ x } 8 \ + \ 34 \text{ x } 5)}{10 \ + \ 8 \ + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

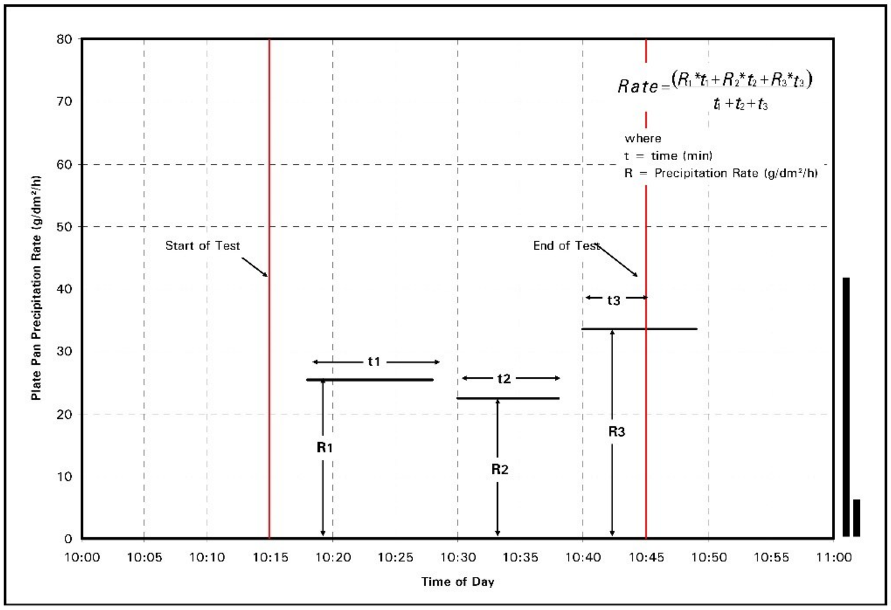
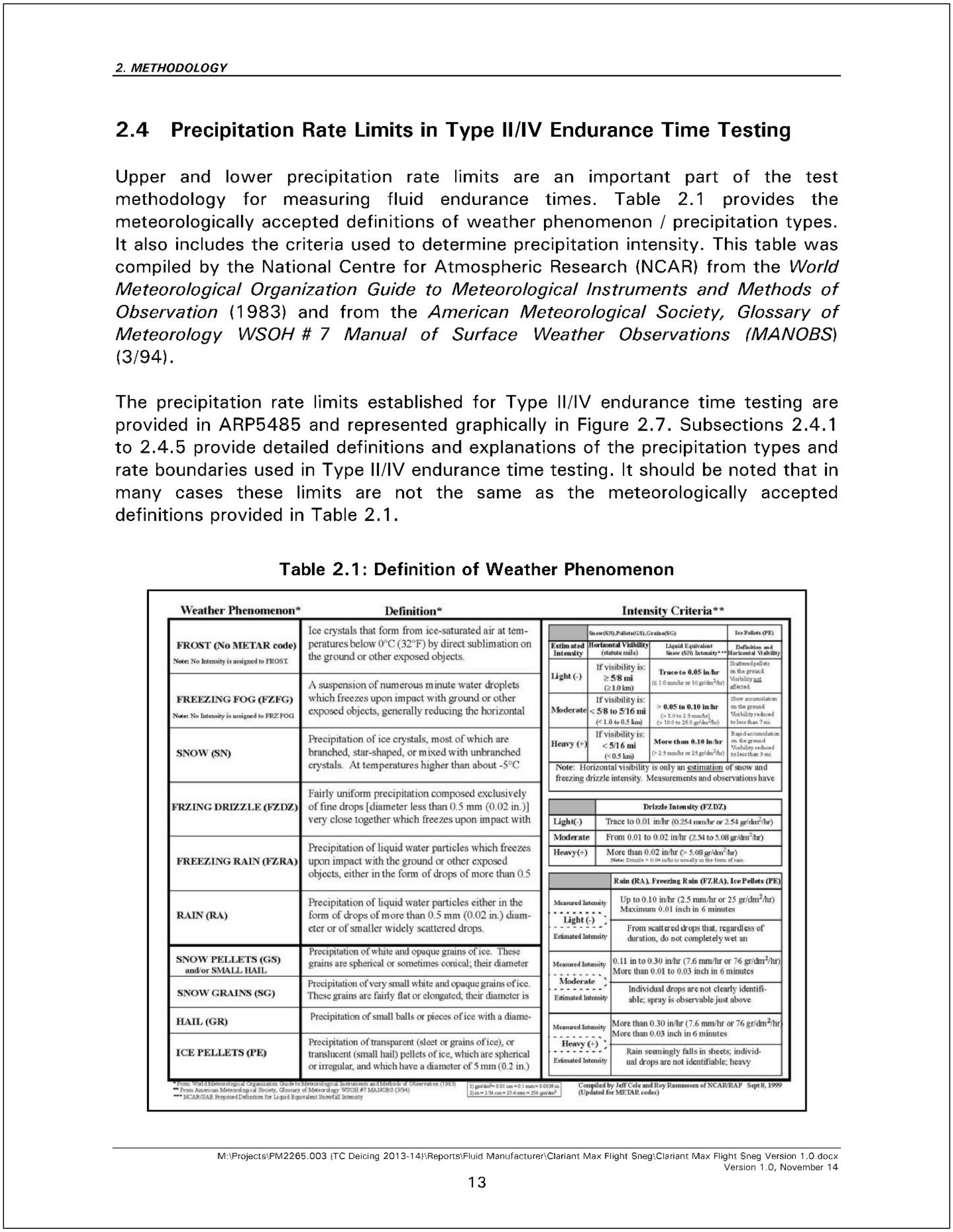


Figure 2.6: Calculation of Outdoor Precipitation Rate



2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS)* (3/94).

The precipitation rate limits established for Type II/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/IV endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 2.1.

Table 2.1: Definition of Weather Phenomenon

Weather Phenomenon*	Definition*
FROST (No METAR code) **Note:** No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) **Note:** No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (SN) Intensity*****	**Definition and Horizontal Visibility**
Light (-)	If visibility is: **≥ 5/8 mi** (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm/hr or 10 gr/dm^2/hr)	Scattered pellets on the ground. Visibility not affected
Moderate	If visibility is: **< 5/8 to 5/16 mi** (< 1.0 to 0.5 km)	**> 0.05 to 0.10 in/hr** (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm^2/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: **< 5/16 mi** (< 0.5 km)	**More than 0.10 in/hr** (> 2.5 mm/hr or 25 gr/dm^2/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.
Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have			

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm^2/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm^2/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm^2/hr) **Note:** Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm^2/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm^2/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm^2/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gm/dm^2 = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm^2

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999
(Updated for METAR codes)

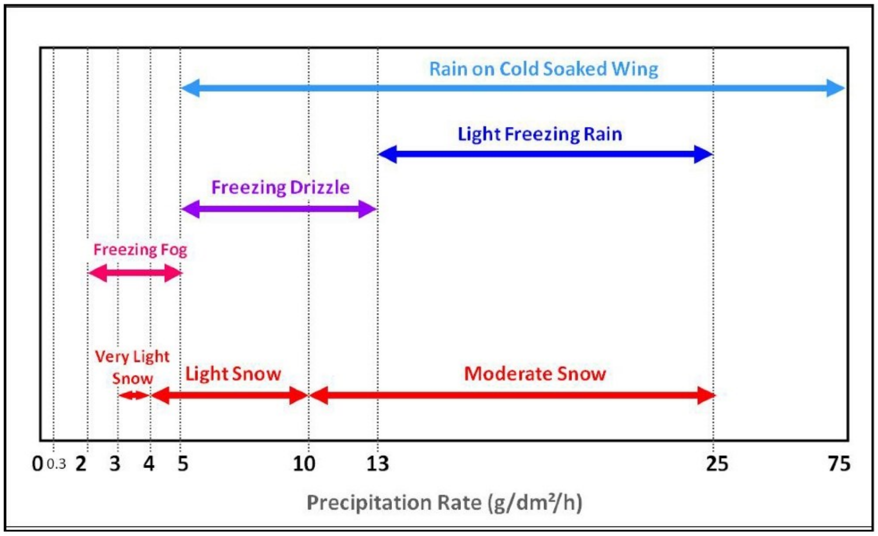


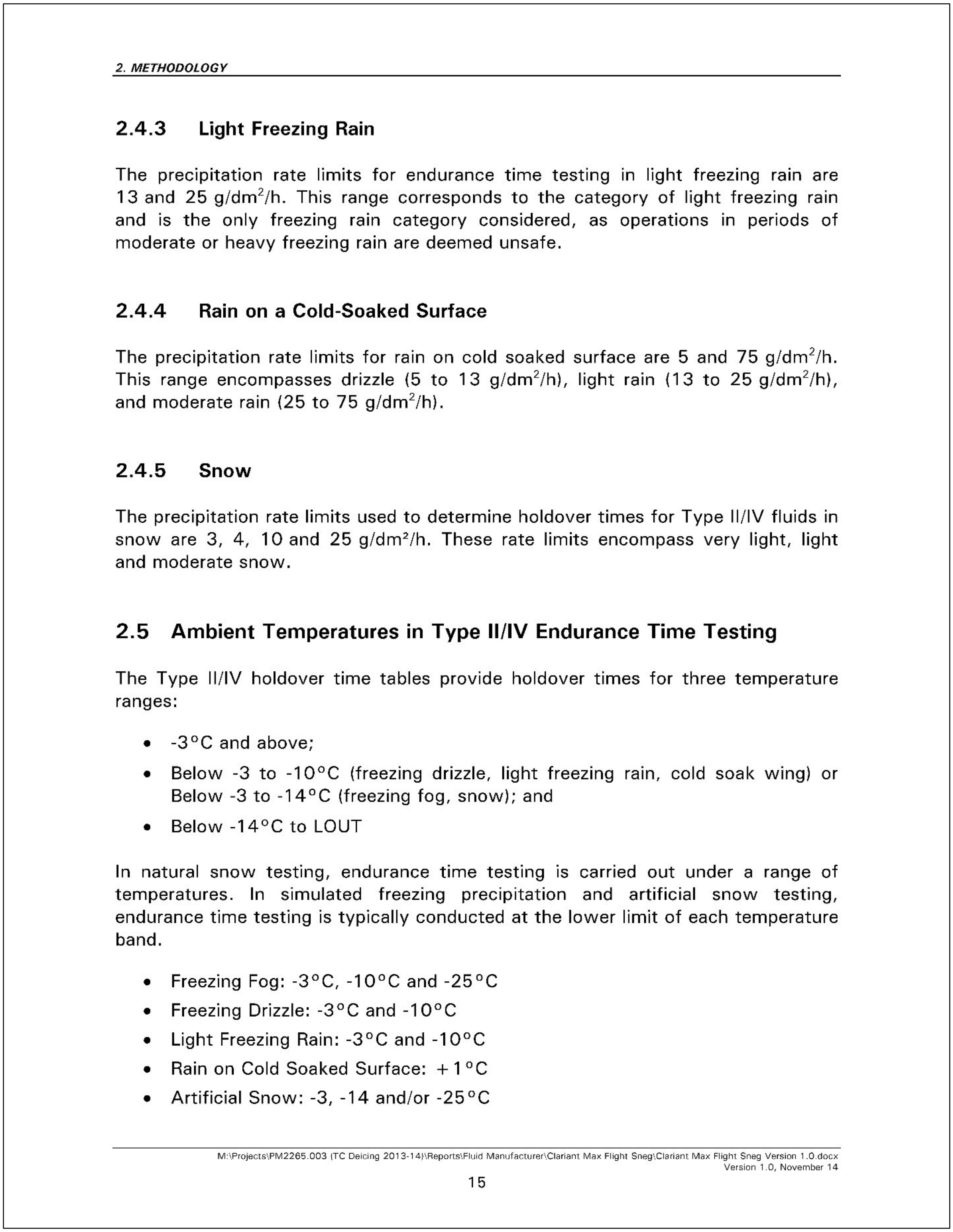
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

2.4.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.



2.4.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.4.4 Rain on a Cold-Soaked Surface

The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 g/dm^2/h. These rate limits encompass very light, light and moderate snow.

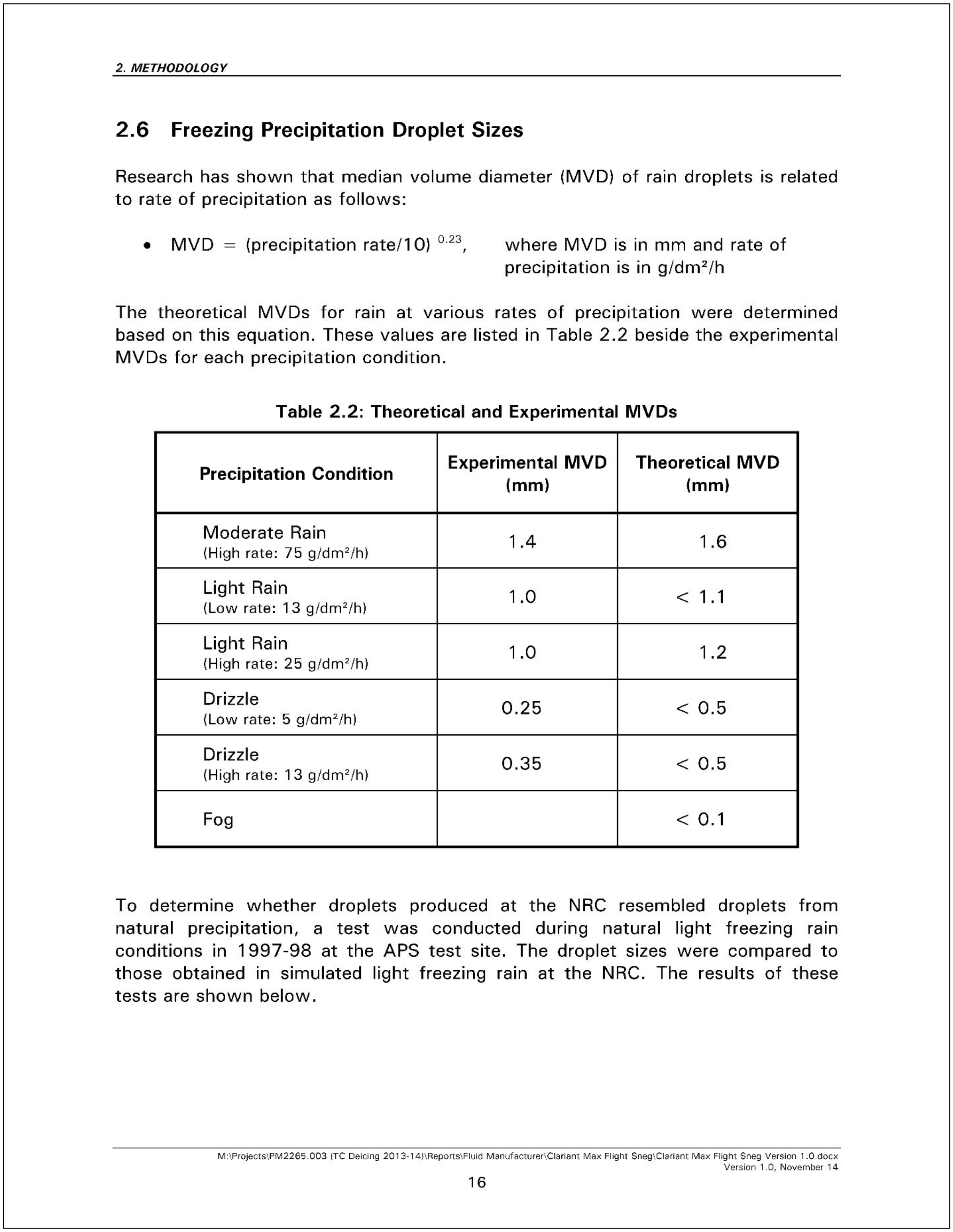
2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:

- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation and artificial snow testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -25°C
- Freezing Drizzle: -3°C and -10°C
- Light Freezing Rain: -3°C and -10°C
- Rain on Cold Soaked Surface: +1°C
- Artificial Snow: -3, -14 and/or -25°C



2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

- MVD = $(\text{precipitation rate}/10)^{0.23}$, where MVD is in mm and rate of precipitation is in g/dm²/h

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm²/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below.

a) *For the outdoor test:*

Location:	Montreal P.E.T. Airport
Precipitation:	Natural Light Freezing Rain
Precipitation Rate:	20 g/dm²/h
Calibrated MVD:	1.0 mm

b) *For the indoor test:*

Location:	National Research Council
Precipitation:	Simulated Light Freezing Rain
Precipitation Rate:	25 g/dm²/h
Calibrated MVD:	1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation.
As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm²/h): 30 μm
- Freezing Fog, low precipitation rate (2 g/dm²/h): 30 μm

- Freezing Drizzle, high precipitation rate (13 g/dm²/h): 350 μm
- Freezing Drizzle, low precipitation rate (5 g/dm²/h): 250 μm

- Light Freezing Rain, high precipitation rate (25 g/dm²/h): 1,000 μm
- Light Freezing Rain, low precipitation rate (13 g/dm²/h): 1,000 μm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm²/h): 250 μm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm²/h): 1,400 μm

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/IV fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 16 weather conditions listed in Table 2.3.

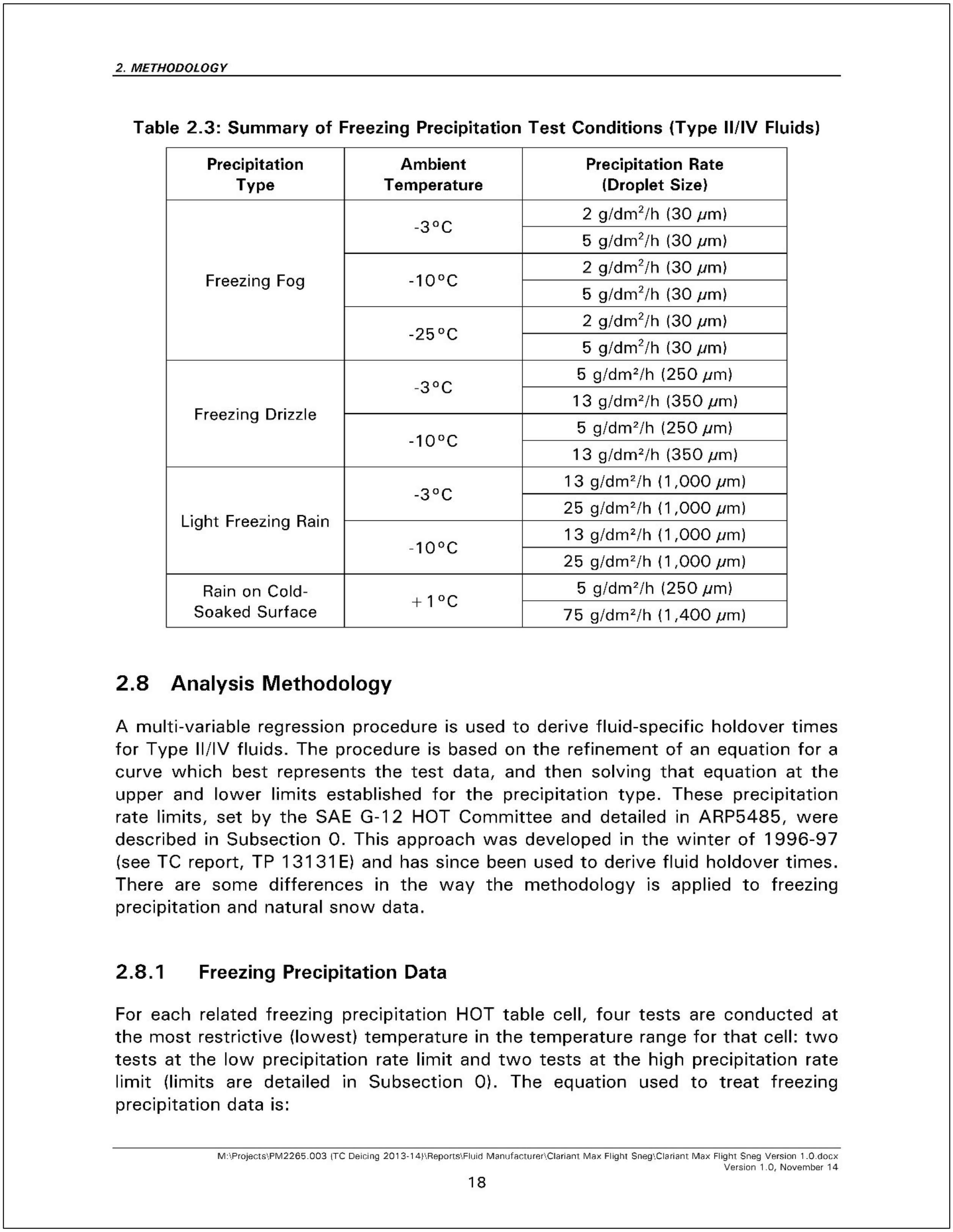


Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-10°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-25°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
Freezing Drizzle	-3°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
	-10°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
Light Freezing Rain	-3°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
	-10°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm^2/h (250 μm)
		75 g/dm^2/h (1,400 μm)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/IV fluids. The procedure is based on the refinement of an equation for a curve which best represents the test data, and then solving that equation at the upper and lower limits established for the precipitation type. These precipitation rate limits, set by the SAE G-12 HOT Committee and detailed in ARP5485, were described in Subsection 0. This approach was developed in the winter of 1996-97 (see TC report, TP 13131E) and has since been used to derive fluid holdover times. There are some differences in the way the methodology is applied to freezing precipitation and natural snow data.

2.8.1 Freezing Precipitation Data

For each related freezing precipitation HOT table cell, four tests are conducted at the most restrictive (lowest) temperature in the temperature range for that cell: two tests at the low precipitation rate limit and two tests at the high precipitation rate limit (limits are detailed in Subsection 0). The equation used to treat freezing precipitation data is:

- $t = 10^I R^a$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.2 Natural Snow Data

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural snow tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather data under all temperatures and precipitation rates encompassed by the HOT tables.

The general form of the regression equation is modified for natural snow to incorporate the variable of temperature and also to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C. The equation used to treat natural snow data is:

- $t = 10^I R^a (2\text{-}T)^b$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.3 Natural Frost Data

Regression analysis is not used in the determination of frost holdover times. The current Type II/III/IV generic frost holdover times were determined based on several years of testing using all fluids which were commercially available at the time. A "minimum values" analysis methodology was used to determine appropriate holdover times from the test data.

The purpose of natural frost testing with new fluids is to verify the fluids can be used with the generic frost holdover times. The analysis methodology is to compare the frost test data collected with the new fluid to the current generic holdover times. If the test data provides holdover times equal to or greater than the generic holdover times then the generic holdover times have been validated for the new fluid.

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural frost tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather several data points with each fluid/dilution.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: Holdover times are rounded to the nearest whole "5" minute, i.e. 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 to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: All holdover time values are capped at maximum values. The caps differ by precipitation type, and in the case of snow, by regulator. The caps are as follows:
    - Freezing Fog holdover time values are capped at 4 hours;
    - Freezing Drizzle, Light Freezing Rain, Rain on Cold Soaked Wing holdover times are capped at 2 hours; and
    - Snow holdover times are capped at 2 hours by Transport Canada and 3 hours by FAA.

2.8.5 Regression Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.8. The plots contain data for one Neat Type IV fluid, in one temperature range (-10°C), in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.9. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The HOT range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

The holdover times for this fluid at -10°C are 20 minutes at 13 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the HOT range for this particular fluid in the light freezing rain, neat fluid, below -3 to -10°C cell. This illustrates the general approach used in the determination of a fluid HOT range for any given cell in the HOT table.

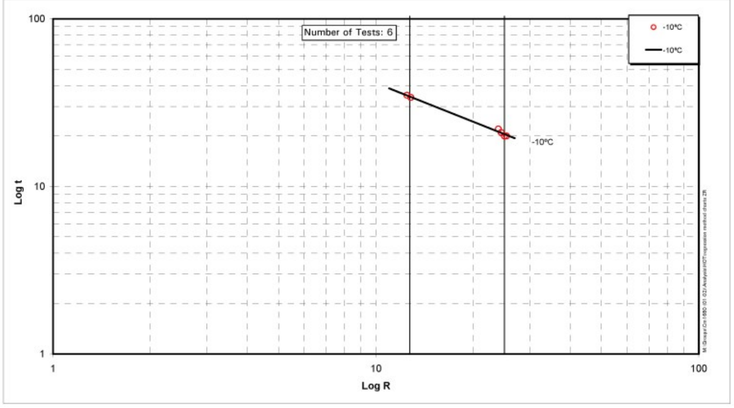


Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

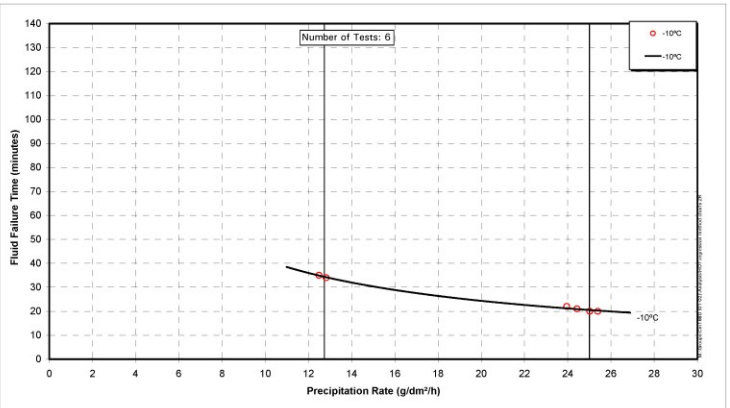


Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

2.8.6 Lowest Usable Precipitation Rates in Snow

A detailed analysis methodology was developed to determine if a snow data set is sufficient to determine holdover times for light and very light snow. Specifically, the analysis determines the lowest usable precipitation rate (LUPR), which is the lowest rate at which the data set is considered robust.

The methodology is a five-factor weighted analysis. The five factors are:

1. Total number of data points;
2. Number of data points with air temperatures below -3°C;
3. Number of data points with precipitation rates below 10 g/dm²/h;
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined; and
5. Scatter from regression curve of low precipitation rate data points (average absolute percent difference between fail time and regression calculated fail time for all points less than or equal to 10 g/dm²/h).

The weights given to each of the five factors are:

1. Total Data Points = 5%;
2. Data Points Below -3°C = 20%;
3. Data Points Below 10 g/dm²/h = 20%;
4. Data Points ≤ Precipitation Rate = 40%; and
5. Low Rate Data Scatter = 15%.

Each data set is given a score of 0, 10, 20, 30 or 40 for each factor. The scoring system is shown in Table 2.4.

This approach provides a score for each data set for each precipitation rate below 10 g/dm²/h. The scores are compared to the minimum acceptance scores:

- 100/0 = 28
- 75/25 = 28
- 50/50 = 19 (lower due to a 0 score for data points below -3°C)

The LUPR is the lowest precipitation rate at which a data set has a passing score.

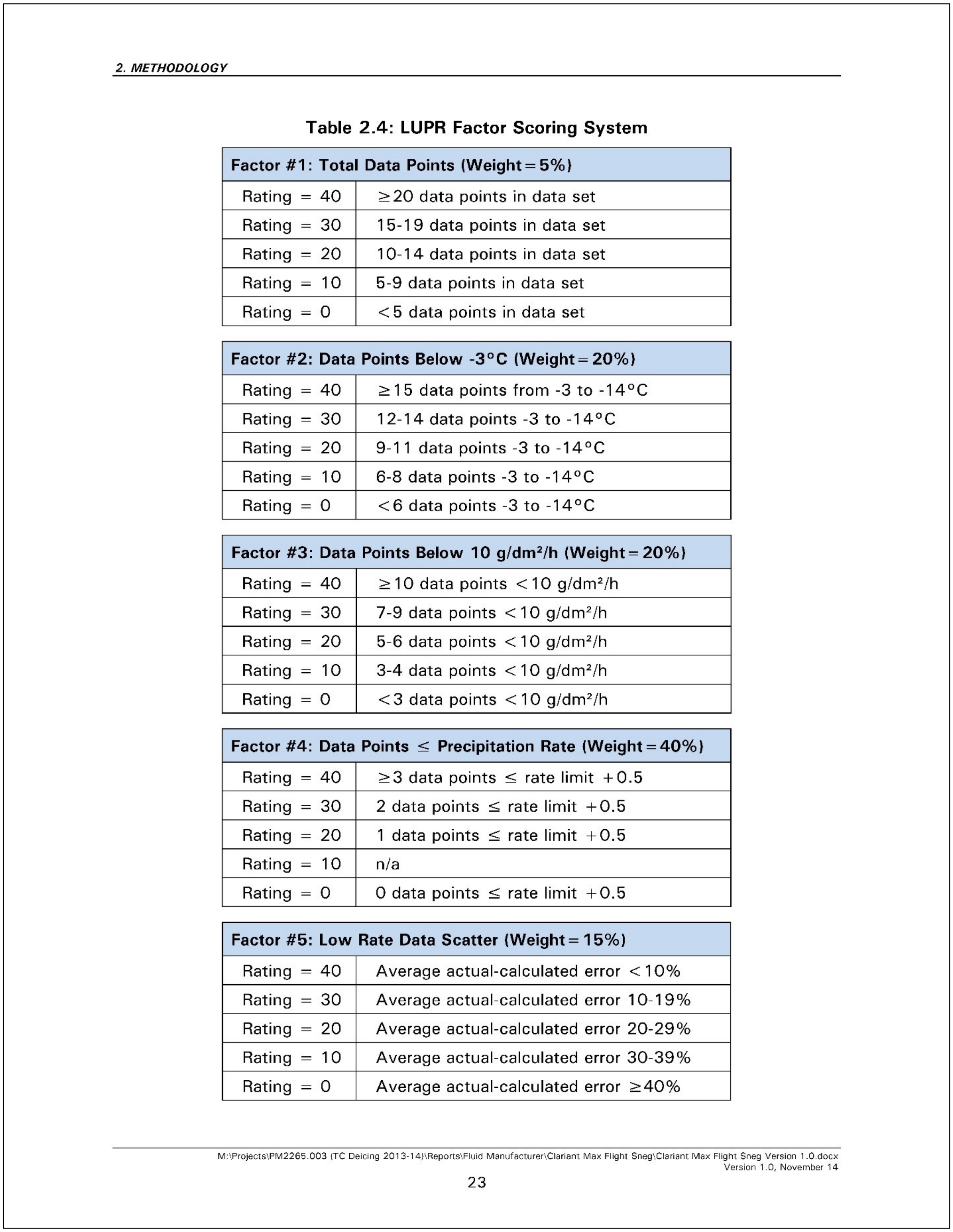


Table 2.4: LUPR Factor Scoring System

Factor #1: Total Data Points (Weight=5%)	
Rating = 40	≥20 data points in data set
Rating = 30	15-19 data points in data set
Rating = 20	10-14 data points in data set
Rating = 10	5-9 data points in data set
Rating = 0	<5 data points in data set

Factor #2: Data Points Below -3°C (Weight=20%)	
Rating = 40	≥15 data points from -3 to -14°C
Rating = 30	12-14 data points -3 to -14°C
Rating = 20	9-11 data points -3 to -14°C
Rating = 10	6-8 data points -3 to -14°C
Rating = 0	<6 data points -3 to -14°C

Factor #3: Data Points Below 10 $g/dm^2/h$ (Weight=20%)	
Rating = 40	≥10 data points <10 $g/dm^2/h$
Rating = 30	7-9 data points <10 $g/dm^2/h$
Rating = 20	5-6 data points <10 $g/dm^2/h$
Rating = 10	3-4 data points <10 $g/dm^2/h$
Rating = 0	<3 data points <10 $g/dm^2/h$

Factor #4: Data Points ≤ Precipitation Rate (Weight=40%)	
Rating = 40	≥3 data points ≤ rate limit +0.5
Rating = 30	2 data points ≤ rate limit +0.5
Rating = 20	1 data points ≤ rate limit +0.5
Rating = 10	n/a
Rating = 0	0 data points ≤ rate limit +0.5

Factor #5: Low Rate Data Scatter (Weight=15%)	
Rating = 40	Average actual-calculated error <10%
Rating = 30	Average actual-calculated error 10-19%
Rating = 20	Average actual-calculated error 20-29%
Rating = 10	Average actual-calculated error 30-39%
Rating = 0	Average actual-calculated error ≥40%

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

.

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility

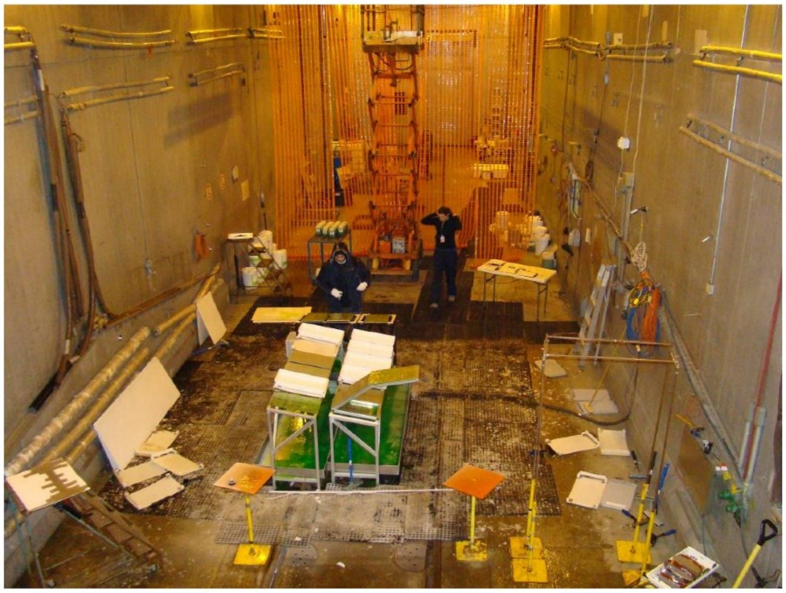


Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

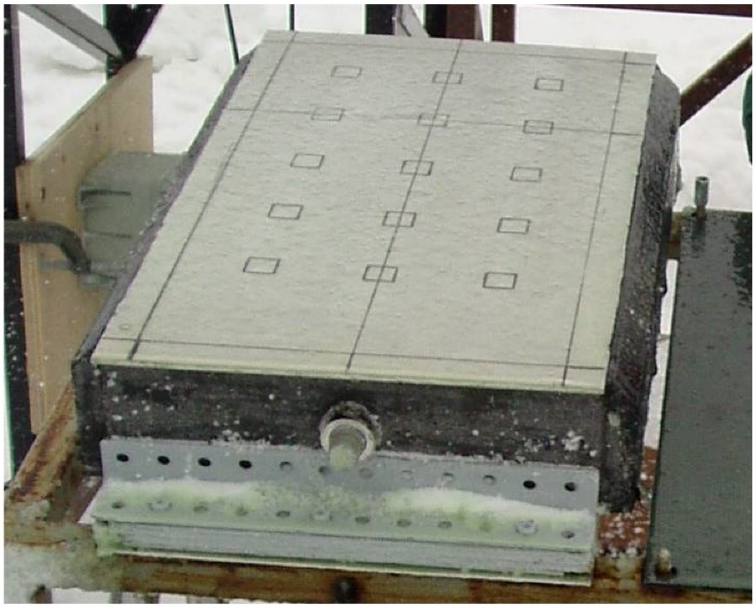


Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

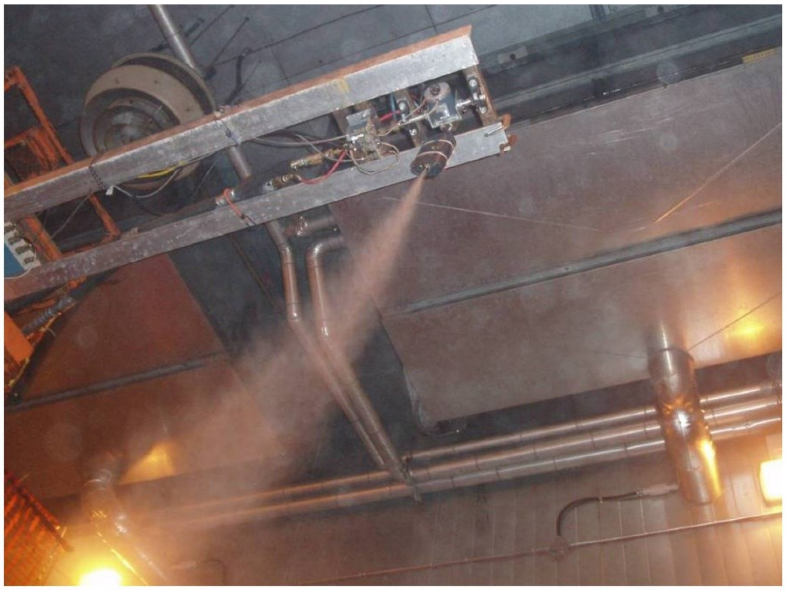


Photo 2.11: Sprayer Nozzle

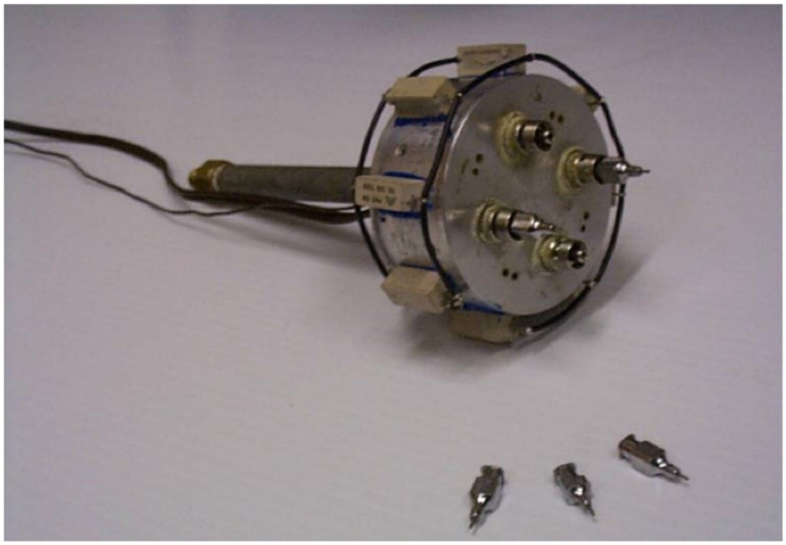
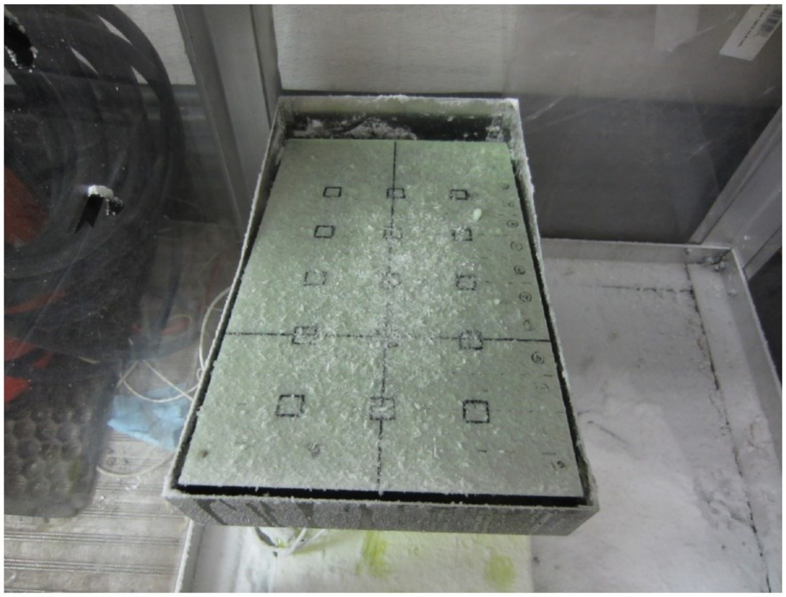


Photo 2.12: Standard Plate Setup for Testing with Artificial Snowmaker



This page intentionally left blank.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

Logs of the tests conducted are provided at the end of this section as follows: Table 3.1 (snow), Table 3.2 (freezing precipitation), and Table 3.3 (frost). The logs provide details of each test conducted.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.1.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	Natural Snow			**Artificial Snow**		
	≥ -3°C	**-3 to -14°C**	**<-14°C**	**-3°C**	**-14°C**	**-25°C**
Neat	7	18	0	0	0	0
75/25	8	18	0	0	0	0
50/50	18	0	0	1	0	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		**Light Freezing Rain**	
	-3°C	**-10°C**	**-3°C**	**-10°C**
Neat	4	4	4	4
75/25	4	4	4	4
50/50	6	0	4	0

3.3 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	**-14°C**	**-25°C**
Neat	4	4	4
75/25	4	4	0
50/50	4	0	0

3.4 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	4
50/50	0

3.5 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥-1°C	**<-1 to -3°C**	**<-3 to -10°C**	**<-10°C**
Neat	0	0	0	1
75/25	0	2	0	0
50/50	0	2	0	0

3.6 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

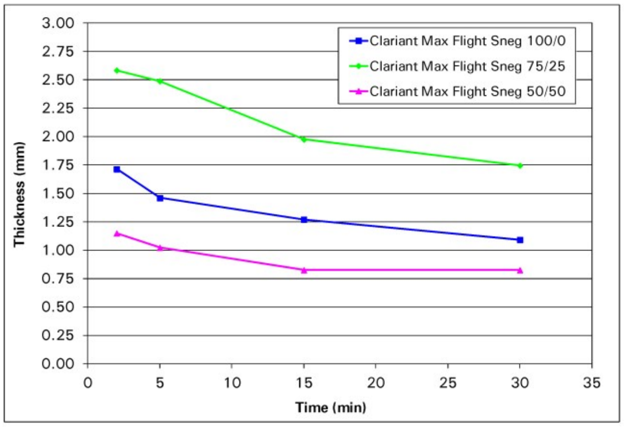


Figure 3.1: Fluid Thickness Profiles of Clariant Max Flight Sneg

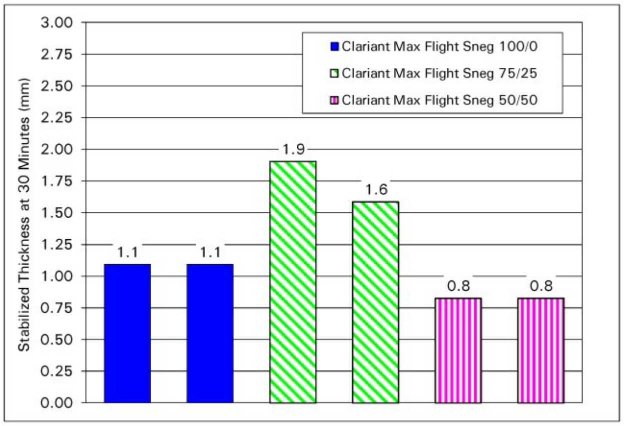


Figure 3.2: Final Fluid Thickness of Clariant Max Flight Sneg

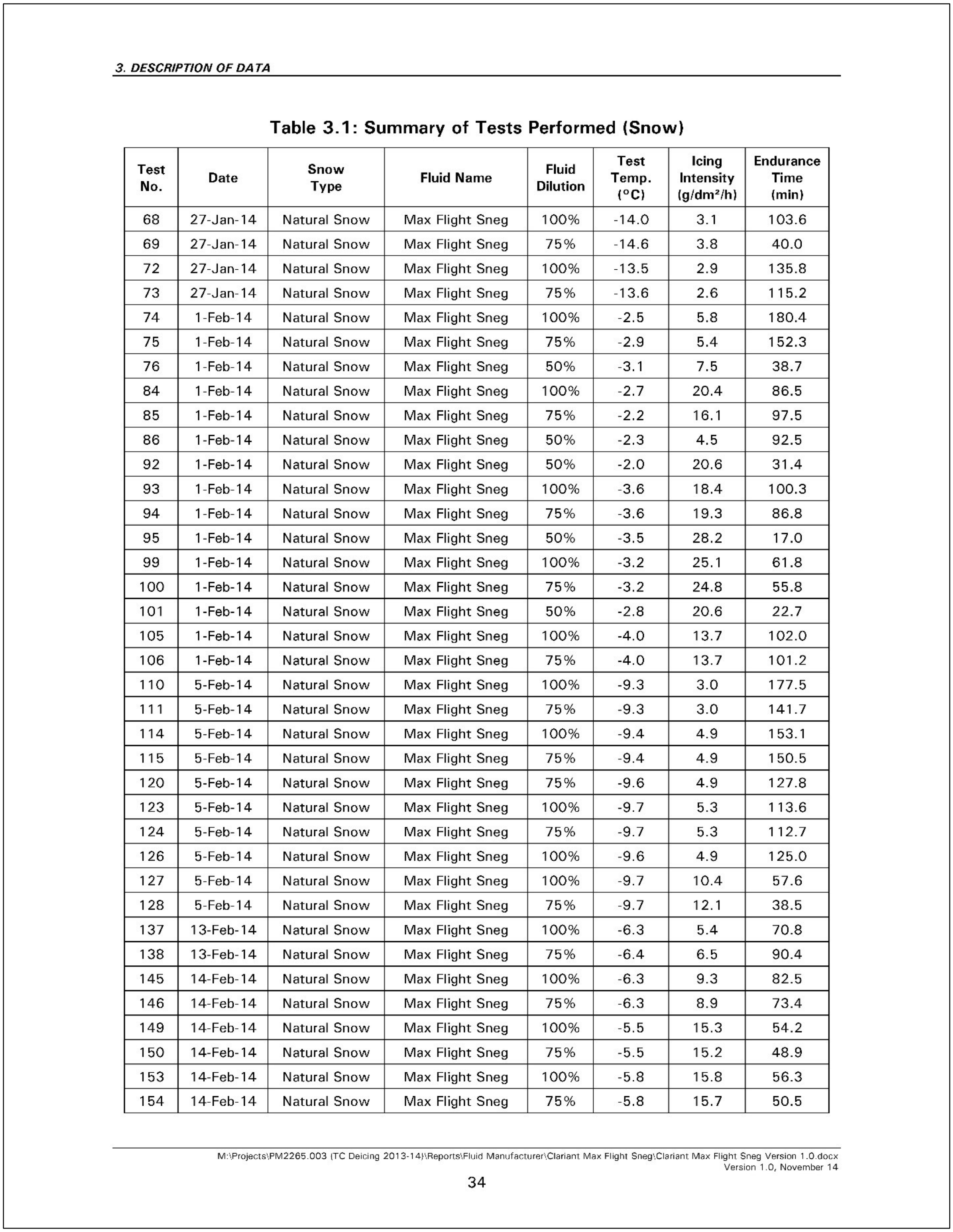


Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
68	27-Jan-14	Natural Snow	Max Flight Sneg	100%	-14.0	3.1	103.6
69	27-Jan-14	Natural Snow	Max Flight Sneg	75%	-14.6	3.8	40.0
72	27-Jan-14	Natural Snow	Max Flight Sneg	100%	-13.5	2.9	135.8
73	27-Jan-14	Natural Snow	Max Flight Sneg	75%	-13.6	2.6	115.2
74	1-Feb-14	Natural Snow	Max Flight Sneg	100%	-2.5	5.8	180.4
75	1-Feb-14	Natural Snow	Max Flight Sneg	75%	-2.9	5.4	152.3
76	1-Feb-14	Natural Snow	Max Flight Sneg	50%	-3.1	7.5	38.7
84	1-Feb-14	Natural Snow	Max Flight Sneg	100%	-2.7	20.4	86.5
85	1-Feb-14	Natural Snow	Max Flight Sneg	75%	-2.2	16.1	97.5
86	1-Feb-14	Natural Snow	Max Flight Sneg	50%	-2.3	4.5	92.5
92	1-Feb-14	Natural Snow	Max Flight Sneg	50%	-2.0	20.6	31.4
93	1-Feb-14	Natural Snow	Max Flight Sneg	100%	-3.6	18.4	100.3
94	1-Feb-14	Natural Snow	Max Flight Sneg	75%	-3.6	19.3	86.8
95	1-Feb-14	Natural Snow	Max Flight Sneg	50%	-3.5	28.2	17.0
99	1-Feb-14	Natural Snow	Max Flight Sneg	100%	-3.2	25.1	61.8
100	1-Feb-14	Natural Snow	Max Flight Sneg	75%	-3.2	24.8	55.8
101	1-Feb-14	Natural Snow	Max Flight Sneg	50%	-2.8	20.6	22.7
105	1-Feb-14	Natural Snow	Max Flight Sneg	100%	-4.0	13.7	102.0
106	1-Feb-14	Natural Snow	Max Flight Sneg	75%	-4.0	13.7	101.2
110	5-Feb-14	Natural Snow	Max Flight Sneg	100%	-9.3	3.0	177.5
111	5-Feb-14	Natural Snow	Max Flight Sneg	75%	-9.3	3.0	141.7
114	5-Feb-14	Natural Snow	Max Flight Sneg	100%	-9.4	4.9	153.1
115	5-Feb-14	Natural Snow	Max Flight Sneg	75%	-9.4	4.9	150.5
120	5-Feb-14	Natural Snow	Max Flight Sneg	75%	-9.6	4.9	127.8
123	5-Feb-14	Natural Snow	Max Flight Sneg	100%	-9.7	5.3	113.6
124	5-Feb-14	Natural Snow	Max Flight Sneg	75%	-9.7	5.3	112.7
126	5-Feb-14	Natural Snow	Max Flight Sneg	100%	-9.6	4.9	125.0
127	5-Feb-14	Natural Snow	Max Flight Sneg	100%	-9.7	10.4	57.6
128	5-Feb-14	Natural Snow	Max Flight Sneg	75%	-9.7	12.1	38.5
137	13-Feb-14	Natural Snow	Max Flight Sneg	100%	-6.3	5.4	70.8
138	13-Feb-14	Natural Snow	Max Flight Sneg	75%	-6.4	6.5	90.4
145	14-Feb-14	Natural Snow	Max Flight Sneg	100%	-6.3	9.3	82.5
146	14-Feb-14	Natural Snow	Max Flight Sneg	75%	-6.3	8.9	73.4
149	14-Feb-14	Natural Snow	Max Flight Sneg	100%	-5.5	15.3	54.2
150	14-Feb-14	Natural Snow	Max Flight Sneg	75%	-5.5	15.2	48.9
153	14-Feb-14	Natural Snow	Max Flight Sneg	100%	-5.8	15.8	56.3
154	14-Feb-14	Natural Snow	Max Flight Sneg	75%	-5.8	15.7	50.5

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
163	14-Feb-14	Natural Snow	Max Flight Sneg	100%	-4.5	6.4	184.0
165	14-Feb-14	Natural Snow	Max Flight Sneg	75%	-4.5	6.2	175.8
168	9-Mar-14	Natural Snow	Max Flight Sneg	100%	-4.7	11.2	102.9
169	9-Mar-14	Natural Snow	Max Flight Sneg	75%	-4.7	11.2	107.4
172	9-Mar-14	Natural Snow	Max Flight Sneg	100%	-4.7	12.7	87.1
173	9-Mar-14	Natural Snow	Max Flight Sneg	75%	-4.7	4.3	115.4
182	12-Mar-14	Natural Snow	Max Flight Sneg	100%	-9.8	15.6	65.7
183	12-Mar-14	Natural Snow	Max Flight Sneg	75%	-9.8	15.9	49.7
192	12-Mar-14	Natural Snow	Max Flight Sneg	100%	-10.9	21.8	70.5
193	12-Mar-14	Natural Snow	Max Flight Sneg	75%	-10.9	21.5	56.9
200	19-Mar-14	Natural Snow	Max Flight Sneg	50%	0.8	33.4	9.4
207	19-Mar-14	Natural Snow	Max Flight Sneg	50%	0.8	34.0	9.9
214	19-Mar-14	Natural Snow	Max Flight Sneg	50%	0.8	23.5	17.9
217	19-Mar-14	Natural Snow	Max Flight Sneg	100%	1.1	5.5	211.8
219	19-Mar-14	Natural Snow	Max Flight Sneg	50%	1.2	2.7	150.0
221	19-Mar-14	Natural Snow	Max Flight Sneg	75%	1.2	4.7	186.5
226	20-Mar-14	Natural Snow	Max Flight Sneg	50%	0.9	14.5	35.5
228	20-Mar-14	Natural Snow	Max Flight Sneg	50%	1.0	7.1	82.5
248	22-Mar-14	Natural Snow	Max Flight Sneg	50%	-3.4	36.2	9.9
250	22-Mar-14	Natural Snow	Max Flight Sneg	100%	-3.3	23.2	64.8
251	22-Mar-14	Natural Snow	Max Flight Sneg	75%	-3.3	21.1	44.8
259	22-Mar-14	Natural Snow	Max Flight Sneg	50%	-3.2	20.6	23.2
261	22-Mar-14	Natural Snow	Max Flight Sneg	75%	-3.4	40.1	37.3
296	28-Mar-14	Natural Snow	Max Flight Sneg	100%	-0.1	32.9	47.2
297	28-Mar-14	Natural Snow	Max Flight Sneg	75%	-0.1	33.1	44.0
298	28-Mar-14	Natural Snow	Max Flight Sneg	50%	-0.5	34.1	17.2
306	28-Mar-14	Natural Snow	Max Flight Sneg	100%	0.3	29.3	68.0
307	28-Mar-14	Natural Snow	Max Flight Sneg	75%	0.3	29.3	66.8
314	28-Mar-14	Natural Snow	Max Flight Sneg	50%	-0.1	31.7	22.2
319	28-Mar-14	Natural Snow	Max Flight Sneg	50%	0.4	48.2	10.0
320	30-Mar-14	Natural Snow	Max Flight Sneg	50%	-1.1	5.5	68.4
322	30-Mar-14	Natural Snow	Max Flight Sneg	50%	-1.1	11.4	47.1
MF1	3-May-14	Artificial Snow	Max Flight Sneg	50%	-3.0	3.0	154.6

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
1	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-25	2.3	43.0
2	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-25	2.3	42.5
7	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-25	5.2	22.3
8	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-25	5.1	19.5
13	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-14	1.9	149.2
14	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-14	1.9	148.1
19	24-Mar-14	Freezing Fog	Max Flight Sneg	75	-14	1.9	92.4
20	24-Mar-14	Freezing Fog	Max Flight Sneg	75	-14	1.9	90.8
25	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-14	5.1	42.1
26	24-Mar-14	Freezing Fog	Max Flight Sneg	100	-14	5.4	41.4
31	24-Mar-14	Freezing Fog	Max Flight Sneg	75	-14	4.8	28.9
32	24-Mar-14	Freezing Fog	Max Flight Sneg	75	-14	4.8	30.9
37	25-Mar-14	Freezing Fog	Max Flight Sneg	100	-3.2	2.0	>240
38	25-Mar-14	Freezing Fog	Max Flight Sneg	100	-3	2.1	>240
43	25-Mar-14	Freezing Fog	Max Flight Sneg	75	-3	1.9	>240
44	25-Mar-14	Freezing Fog	Max Flight Sneg	75	-3	1.9	>240
49	25-Mar-14	Freezing Fog	Max Flight Sneg	50	-3.2	2.2	202.9
50	25-Mar-14	Freezing Fog	Max Flight Sneg	50	-3.2	2.2	181.8
55R	25-Mar-14	Freezing Fog	Max Flight Sneg	100	-3	5.0	144.9
56R	25-Mar-14	Freezing Fog	Max Flight Sneg	100	-3	5.0	143.9
61	25-Mar-14	Freezing Fog	Max Flight Sneg	75	-3	4.6	>240
62	25-Mar-14	Freezing Fog	Max Flight Sneg	75	-3	4.7	235.5
67	25-Mar-14	Freezing Fog	Max Flight Sneg	50	-3	5.4	76.0
68	25-Mar-14	Freezing Fog	Max Flight Sneg	50	-3	5.2	91.0
73	20-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-10	5.0	84.3
74	20-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-10	4.7	96.9
79	20-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-10	5.3	61.8
80	20-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-10	**5.0**	60.9
85	20-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-10	12.8	30.8
86	20-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-10	12.8	32.4
91	20-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-10	13.6	21.6
92	20-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-10	12.8	20.8
97	21-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-3	5.3	>120
98	21-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-3	5.4	>120
103	21-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-3	5.4	>120
104	21-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-3	5.4	>120
109	21-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	5.4	75.4

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
110	21-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	4.8	63.8
115	19-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-3	12.7	123.8
116	19-Mar-14	Freezing Drizzle	Max Flight Sneg	100	-3	13.0	119.5
122	19-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-3	13.2	90.2
122R	19-Mar-14	Freezing Drizzle	Max Flight Sneg	75	-3	12.7	85.6
127	19-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	12.8	37.5
127R	19-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	14.0	44.0
128	19-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	13.6	23.4
128R	19-Mar-14	Freezing Drizzle	Max Flight Sneg	50	-3	13.5	34.6
133	20-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-10	13.1	42.9
134	20-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-10	12.7	42.4
139	20-Mar-14	Light Freezing Rain	Max Flight Sneg	75	-10	12.6	38.0
140	20-Mar-14	Light Freezing Rain	Max Flight Sneg	75	-10	12.8	42.8
145	20-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-10	25.5	20.5
146	20-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-10	25.1	24.4
151	20-Mar-14	Light Freezing Rain	Max Flight Sneg	75	-10	25.7	17.2
152	20-Mar-14	Light Freezing Rain	Max Flight Sneg	75	-10	25.8	20.5
157	19-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-3	12.9	105.2
158	19-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-3	12.9	100.4
169	19-Mar-14	Light Freezing Rain	Max Flight Sneg	50	-3	12.8	30.7
170	19-Mar-14	Light Freezing Rain	Max Flight Sneg	50	-3	12.7	29.7
175	21-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-3	24.8	58.0
176	21-Mar-14	Light Freezing Rain	Max Flight Sneg	100	-3	24.9	47.8
187	21-Mar-14	Light Freezing Rain	Max Flight Sneg	50	-3	25.3	13.0
188	21-Mar-14	Light Freezing Rain	Max Flight Sneg	50	-3	25.0	14.9
M3	23-Apr-14	Light Freezing Rain	Max Flight Sneg	75	-3.0	24.8	73.3
M4	23-Apr-14	Light Freezing Rain	Max Flight Sneg	75	-3.0	24.7	60.5
M7R	23-Apr-14	Light Freezing Rain	Max Flight Sneg	75	-3.2	13.0	83.3
M8	23-Apr-14	Light Freezing Rain	Max Flight Sneg	75	-3.1	13.0	74.8
193	26-Mar-14	Cold Soak Box	Max Flight Sneg	100	1.1	4.9	86.5
194	26-Mar-14	Cold Soak Box	Max Flight Sneg	100	1.0	5.0	97.9
199	26-Mar-14	Cold Soak Box	Max Flight Sneg	75	1.0	4.8	109.0
200	26-Mar-14	Cold Soak Box	Max Flight Sneg	75	1.1	5.3	95.2
205	26-Mar-14	Cold Soak Box	Max Flight Sneg	100	1.2	76.5	18.3
206	26-Mar-14	Cold Soak Box	Max Flight Sneg	100	1.3	76.9	16.6
211	26-Mar-14	Cold Soak Box	Max Flight Sneg	75	1.1	76.5	14.5
212	26-Mar-14	Cold Soak Box	Max Flight Sneg	75	1.1	76.9	15.3

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
4	11-Feb-14	Natural Frost	Max Flight Sneg	100%	598	0.05	-18.5	3.2	67.36	Failed
28	16-Apr-14	Natural Frost	Max Flight Sneg	75%	562	0.03	-3.2	3	78	Did Not Fail
29	16-Apr-14	Natural Frost	Max Flight Sneg	50%	455	0.03	-3.5	3	81	Did Not Fail
39	17-Apr-14	Natural Frost	Max Flight Sneg	75%	378	0.11	-2.7	8	69	Did Not Fail
40	17-Apr-14	Natural Frost	Max Flight Sneg	50%	377	0.11	-2.7	8	69	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The results of the data analyses are presented in this section.

4.1 Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the data collected in natural snow and simulated freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface). These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines.

Multi-variable regression analysis was performed on these data sets as described in Subsection 2.8. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type IV fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.3.1).

It should be noted that one 50/50 artificial snow data point was collected in support of the LUPR analysis. It was not included in the snow regression analysis.

4.2 Natural Frost

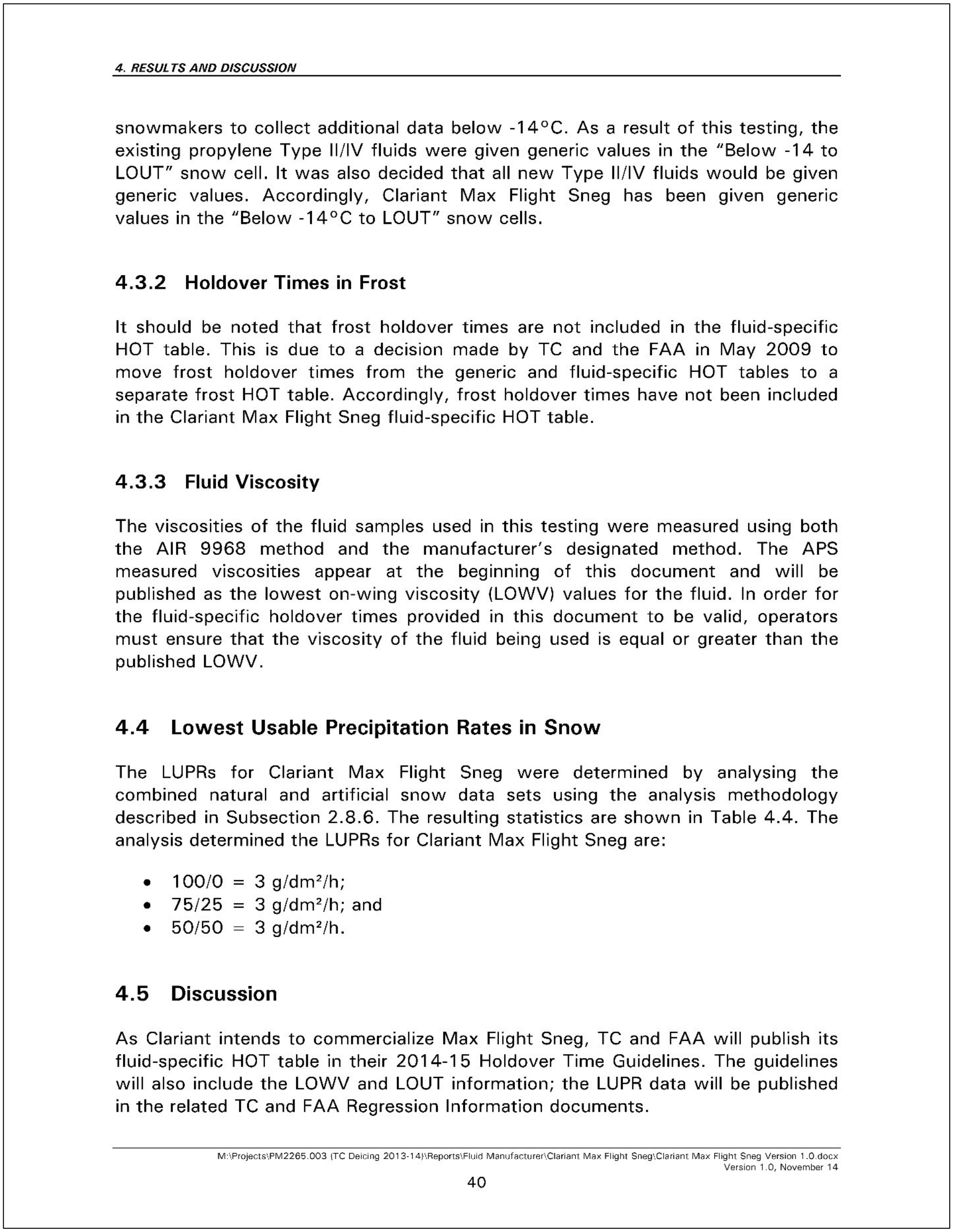
The natural frost data was presented in Table 3.3. The test durations were compared to the generic holdover times. All completed ("failed") tests surpassed the generic holdover times, as did all tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates the generic frost holdover times have been substantiated for Clariant Max Flight Sneg.

4.3 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Clariant Max Flight Sneg. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.3.1 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial



snowmakers to collect additional data below -14°C. As a result of this testing, the existing propylene Type II/IV fluids were given generic values in the "Below -14 to LOUT" snow cell. It was also decided that all new Type II/IV fluids would be given generic values. Accordingly, Clariant Max Flight Sneg has been given generic values in the "Below -14°C to LOUT" snow cells.

4.3.2 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT table. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Clariant Max Flight Sneg fluid-specific HOT table.

4.3.3 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.4 Lowest Usable Precipitation Rates in Snow

The LUPRs for Clariant Max Flight Sneg were determined by analysing the combined natural and artificial snow data sets using the analysis methodology described in Subsection 2.8.6. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Clariant Max Flight Sneg are:

- 100/0 = 3 g/dm²/h;
- 75/25 = 3 g/dm²/h; and
- 50/50 = 3 g/dm²/h.

4.5 Discussion

As Clariant intends to commercialize Max Flight Sneg, TC and FAA will publish its fluid-specific HOT table in their 2014-15 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the LUPR data will be published in the related TC and FAA Regression Information documents.

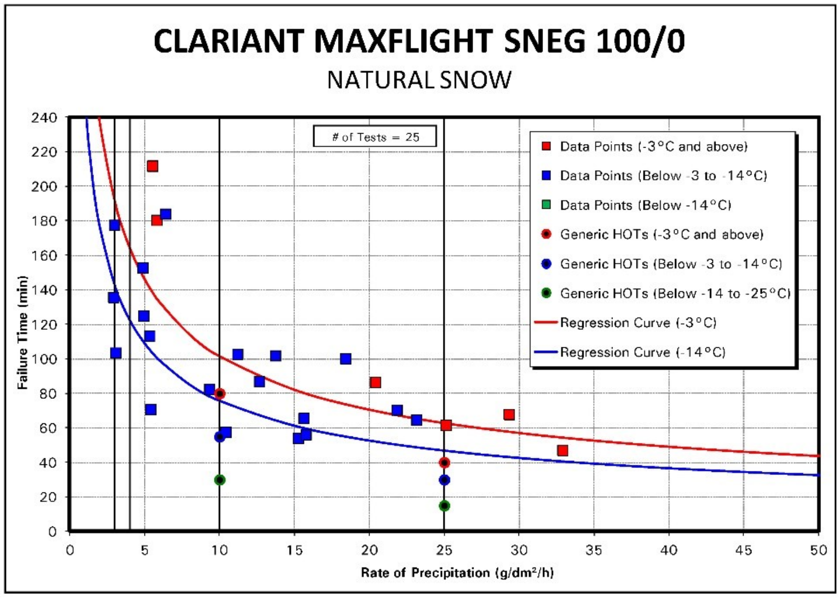


Figure 4.1: Type IV Neat – Natural Snow

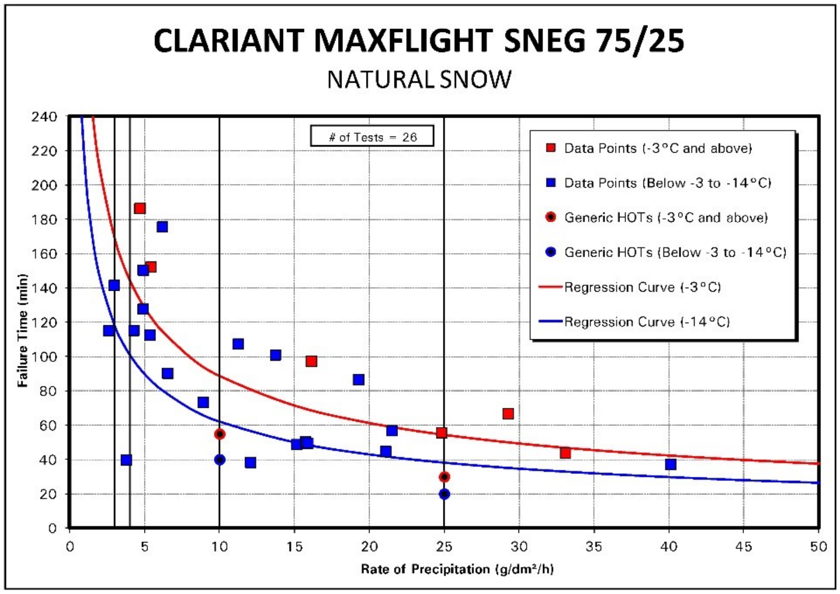


Figure 4.2: Type IV 75/25 – Natural Snow

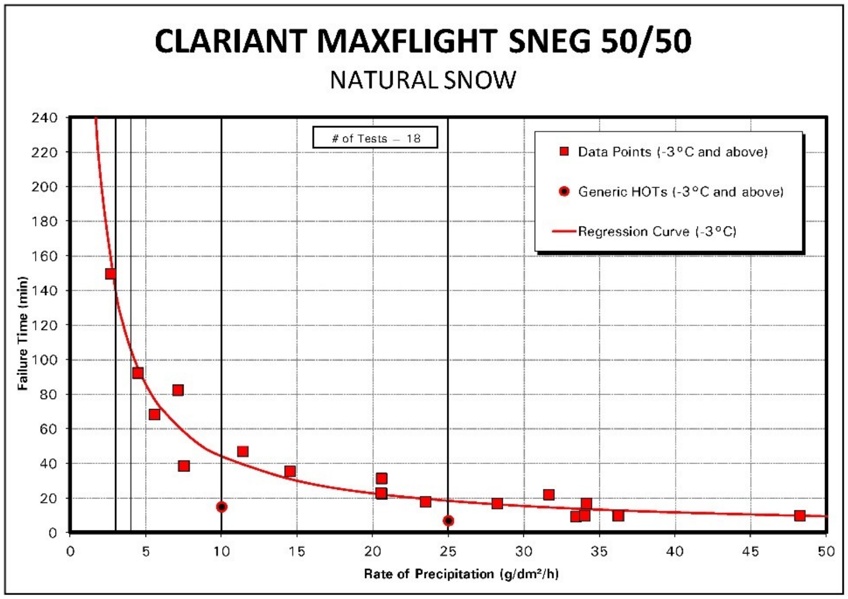


Figure 4.3: Type IV 50/50 – Natural Snow

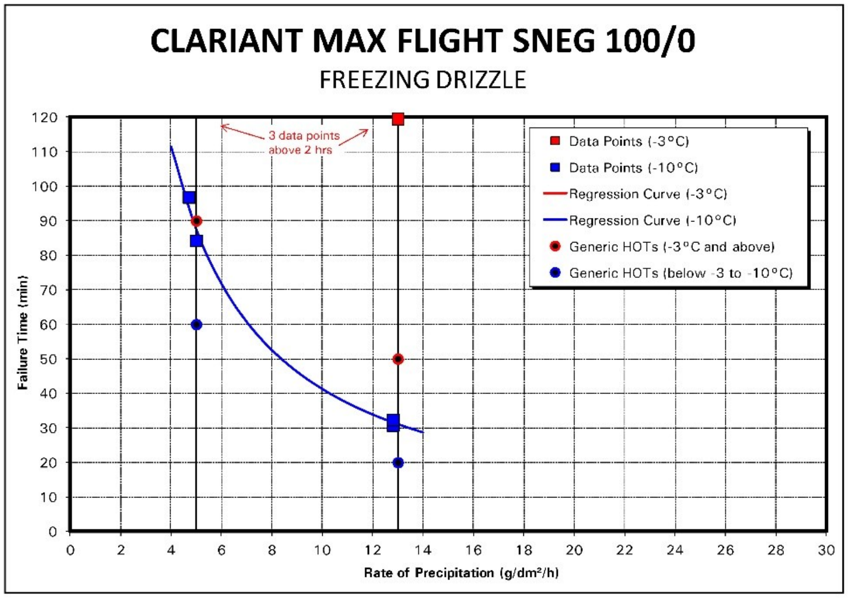


Figure 4.4: Type IV Neat – Freezing Drizzle

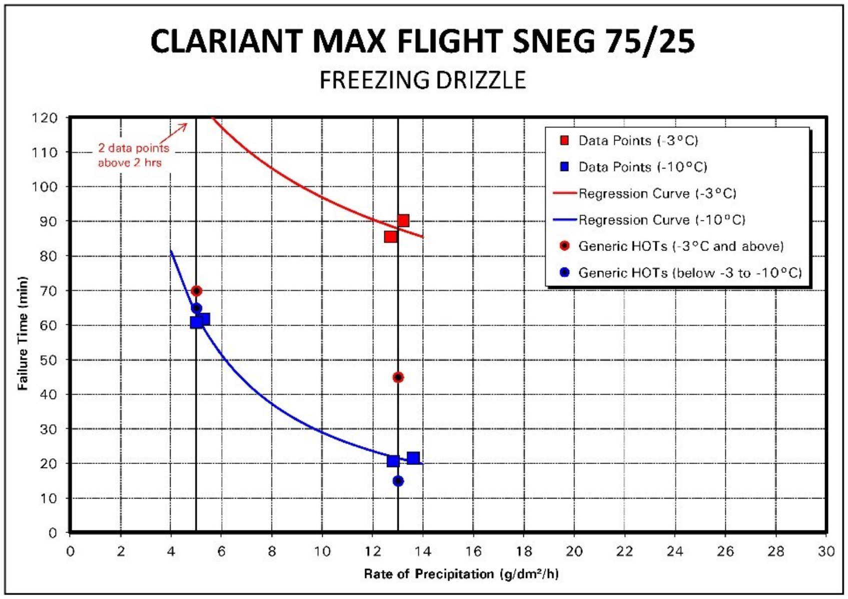


Figure 4.5: Type IV 75/25 – Freezing Drizzle

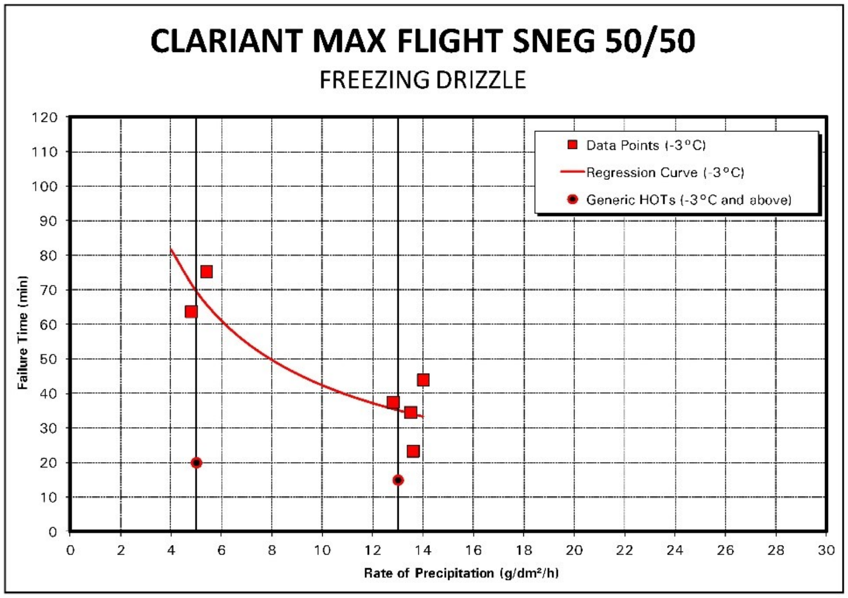


Figure 4.6: Type IV 50/50 – Freezing Drizzle

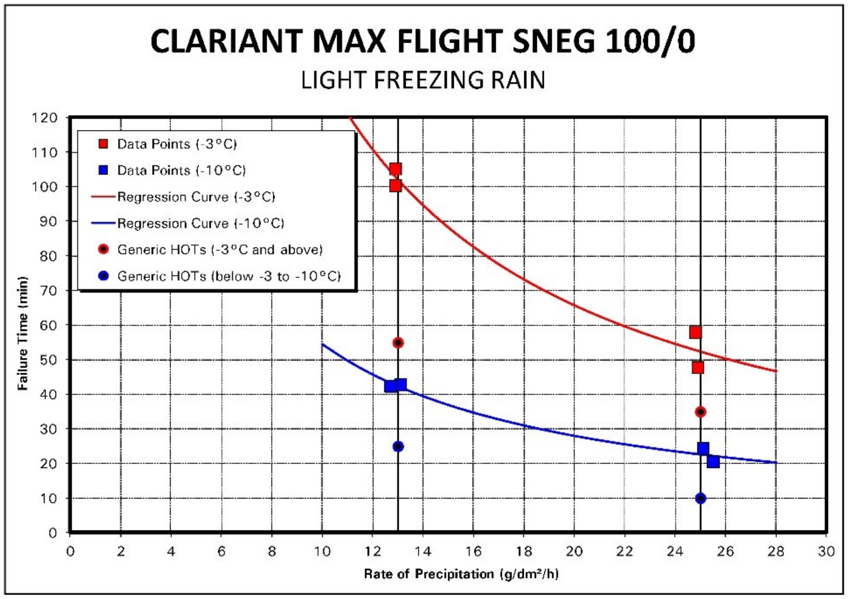


Figure 4.7: Type IV Neat – Light Freezing Rain

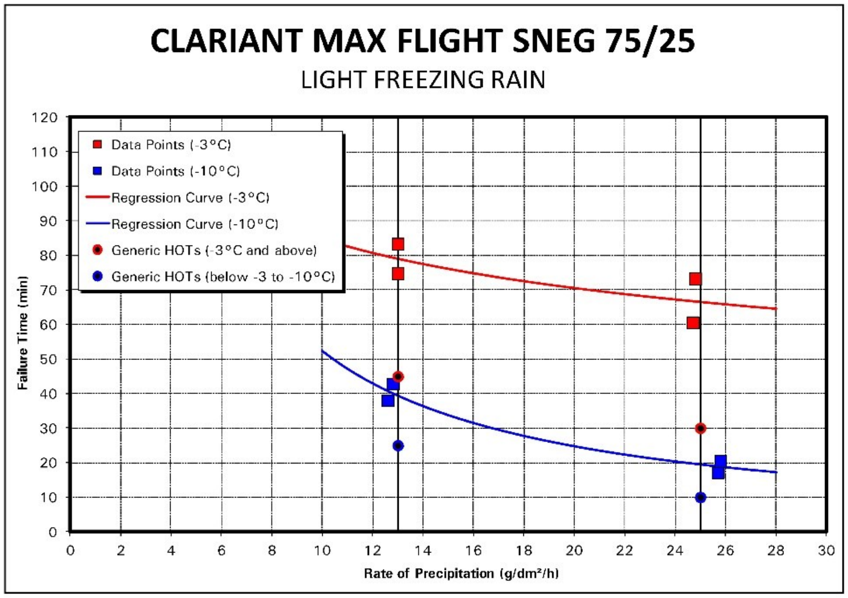


Figure 4.8: Type IV 75/25 – Light Freezing Rain

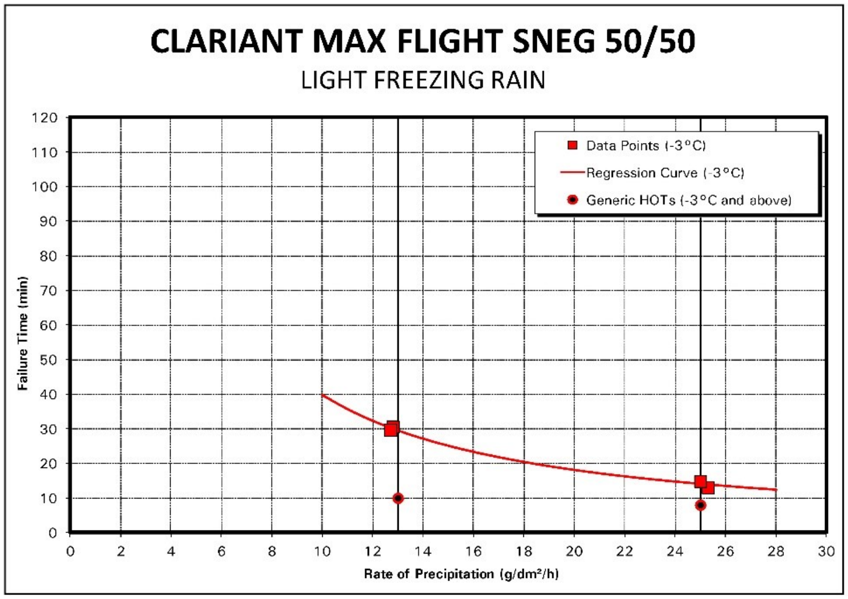


Figure 4.9: Type IV 50/50 – Light Freezing Rain

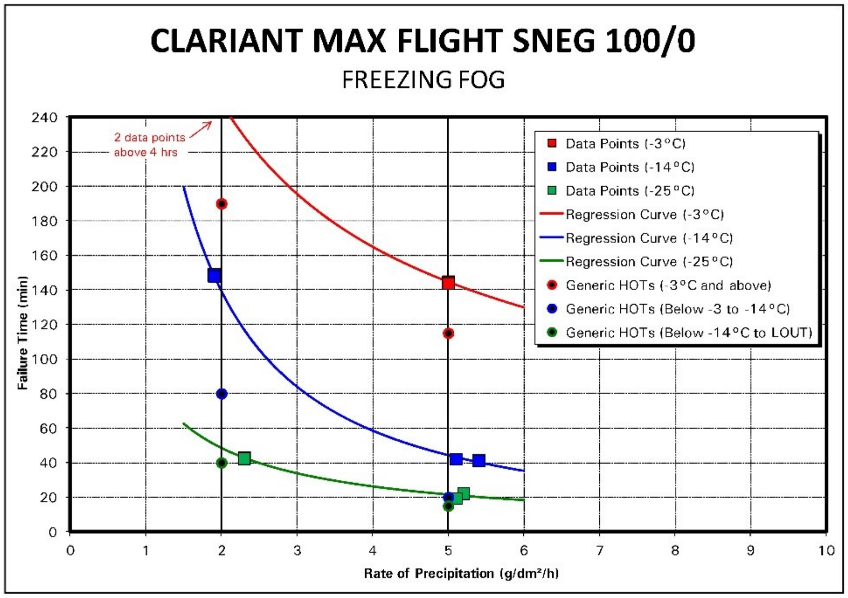
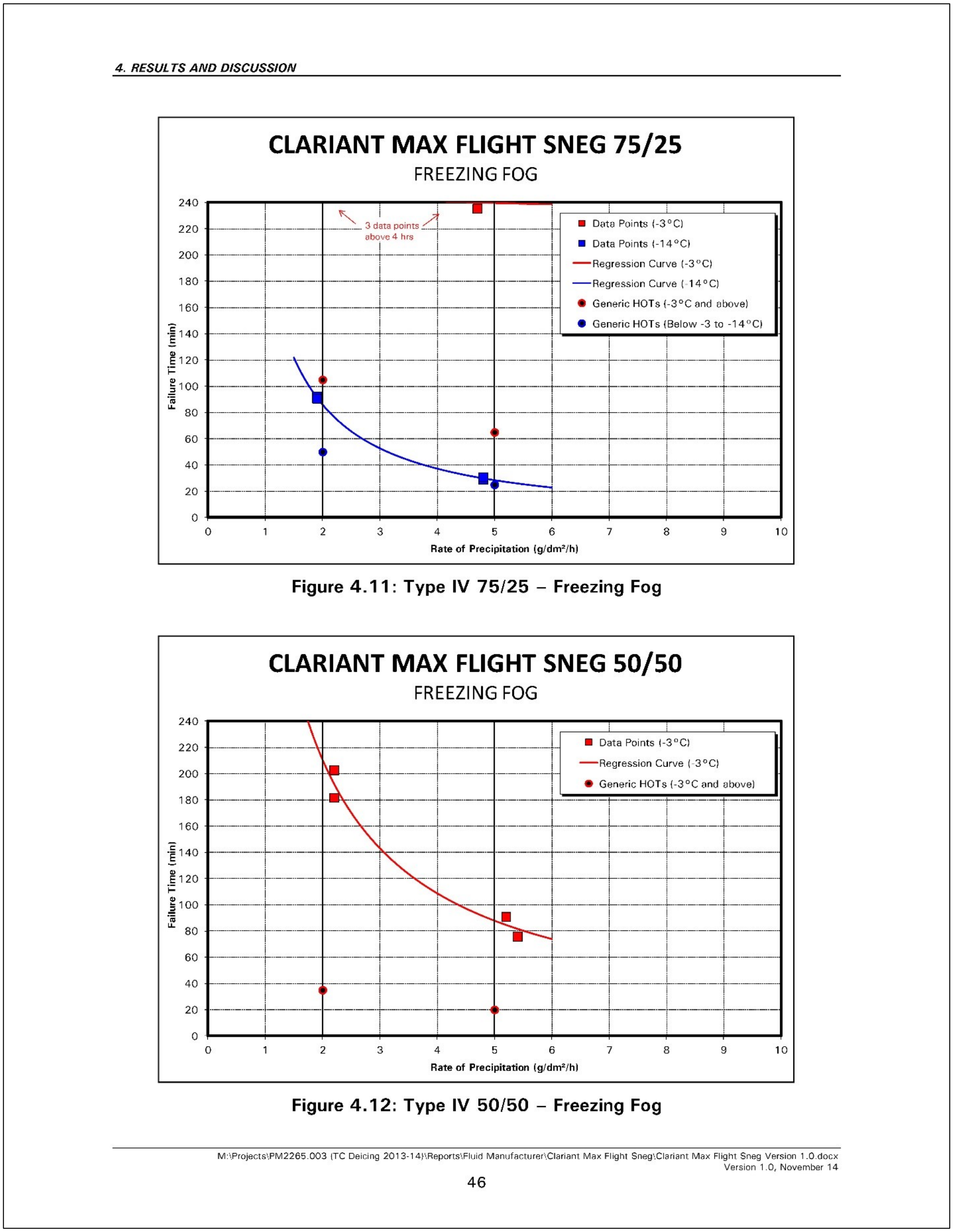


Figure 4.10: Type IV Neat – Freezing Fog



4. RESULTS AND DISCUSSION

Figure 4.11: Type IV 75/25 – Freezing Fog

Figure 4.12: Type IV 50/50 – Freezing Fog

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Reports\Fluid Manufacturer\Clariant Max Flight Sneg\Clariant Max Flight Sneg Version 1.0.docx
Version 1.0, November 14

46

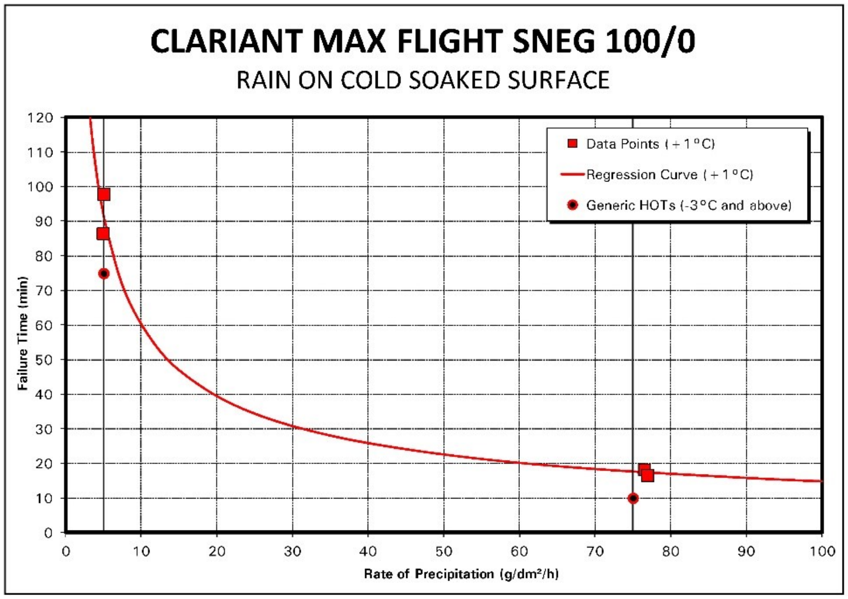


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

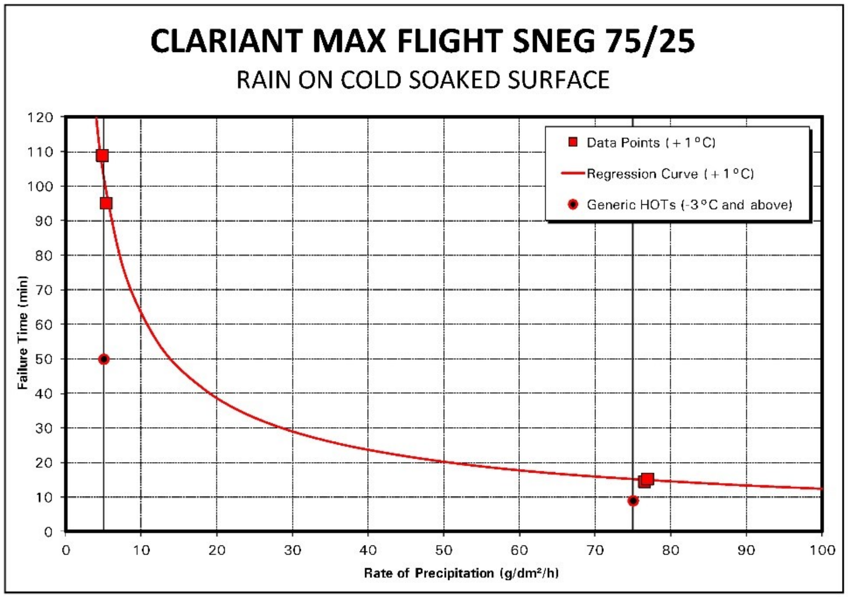


Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

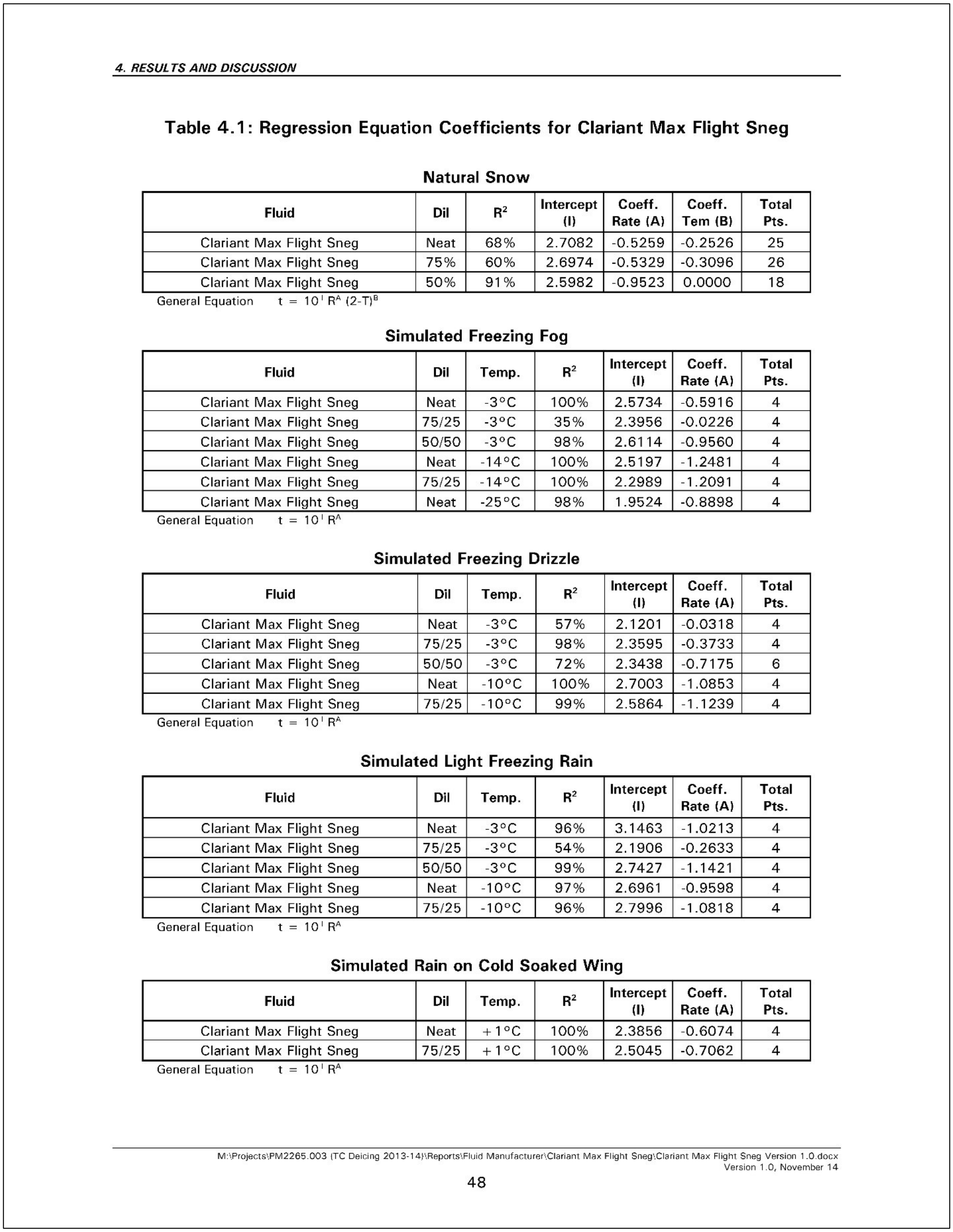


Table 4.1: Regression Equation Coefficients for Clariant Max Flight Sneg

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Clariant Max Flight Sneg	Neat	68%	2.7082	-0.5259	-0.2526	25
Clariant Max Flight Sneg	75%	60%	2.6974	-0.5329	-0.3096	26
Clariant Max Flight Sneg	50%	91%	2.5982	-0.9523	0.0000	18

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

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight Sneg	Neat	-3°C	100%	2.5734	-0.5916	4
Clariant Max Flight Sneg	75/25	-3°C	35%	2.3956	-0.0226	4
Clariant Max Flight Sneg	50/50	-3°C	98%	2.6114	-0.9560	4
Clariant Max Flight Sneg	Neat	-14°C	100%	2.5197	-1.2481	4
Clariant Max Flight Sneg	75/25	-14°C	100%	2.2989	-1.2091	4
Clariant Max Flight Sneg	Neat	-25°C	98%	1.9524	-0.8898	4

General Equation $t = 10^{I} R^{A}$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight Sneg	Neat	-3°C	57%	2.1201	-0.0318	4
Clariant Max Flight Sneg	75/25	-3°C	98%	2.3595	-0.3733	4
Clariant Max Flight Sneg	50/50	-3°C	72%	2.3438	-0.7175	6
Clariant Max Flight Sneg	Neat	-10°C	100%	2.7003	-1.0853	4
Clariant Max Flight Sneg	75/25	-10°C	99%	2.5864	-1.1239	4

General Equation $t = 10^{I} R^{A}$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight Sneg	Neat	-3°C	96%	3.1463	-1.0213	4
Clariant Max Flight Sneg	75/25	-3°C	54%	2.1906	-0.2633	4
Clariant Max Flight Sneg	50/50	-3°C	99%	2.7427	-1.1421	4
Clariant Max Flight Sneg	Neat	-10°C	97%	2.6961	-0.9598	4
Clariant Max Flight Sneg	75/25	-10°C	96%	2.7996	-1.0818	4

General Equation $t = 10^{I} R^{A}$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight Sneg	Neat	+1°C	100%	2.3856	-0.6074	4
Clariant Max Flight Sneg	75/25	+1°C	100%	2.5045	-0.7062	4

General Equation $t = 10^{I} R^{A}$

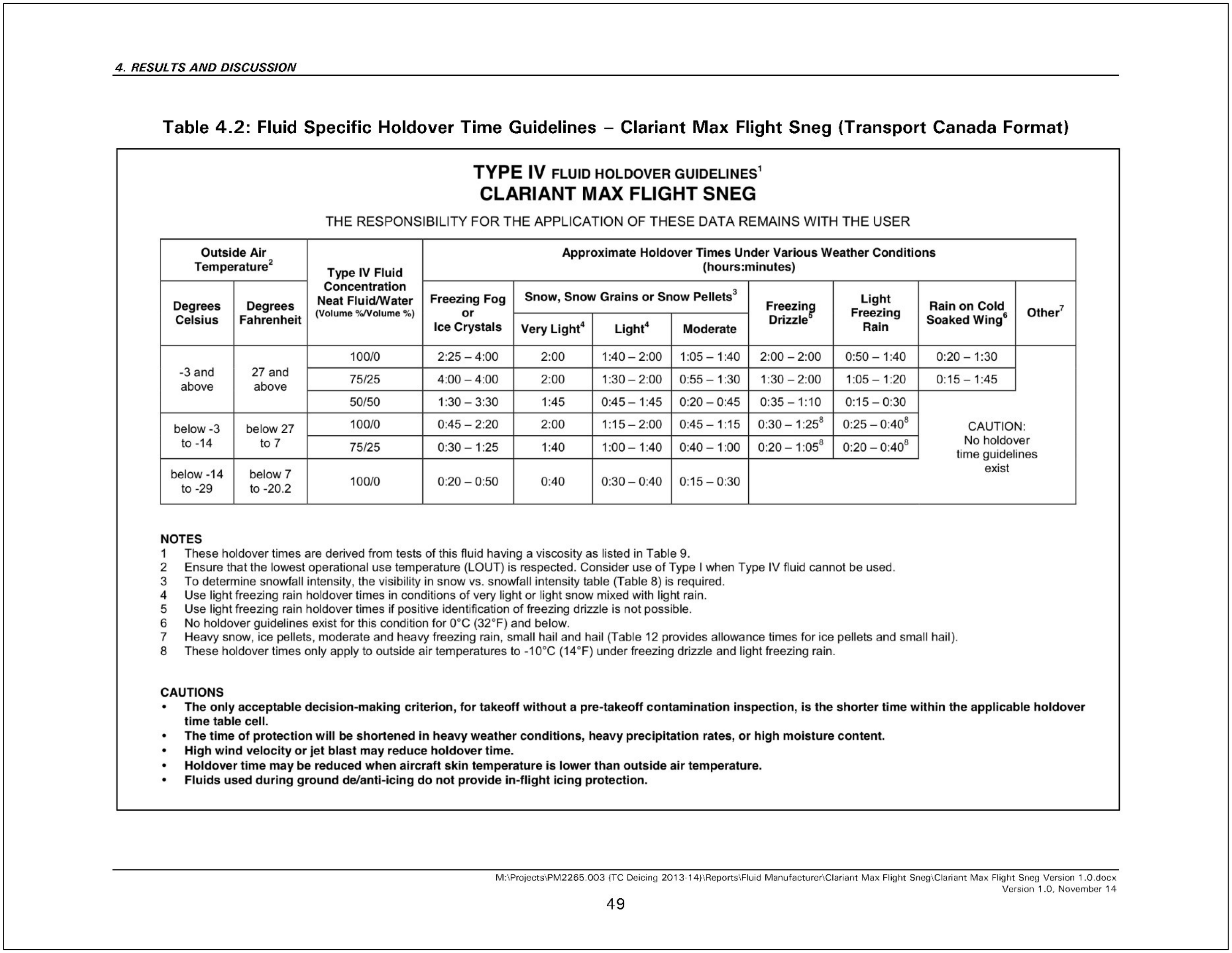


Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Max Flight Sneg (Transport Canada Format)

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CLARIANT MAX FLIGHT SNEG

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Snow, Snow Grains or Snow Pellets[3] Light[4]	Snow, Snow Grains or Snow Pellets[3] Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	2:25 – 4:00	2:00	1:40 – 2:00	1:05 – 1:40	2:00 – 2:00	0:50 – 1:40	0:20 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	4:00 – 4:00	2:00	1:30 – 2:00	0:55 – 1:30	1:30 – 2:00	1:05 – 1:20	0:15 – 1:45	
		50/50	1:30 – 3:30	1:45	0:45 – 1:45	0:20 – 0:45	0:35 – 1:10	0:15 – 0:30		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:20	2:00	1:15 – 2:00	0:45 – 1:15	0:30 – 1:25[8]	0:25 – 0:40[8]		
		75/25	0:30 – 1:25	1:40	1:00 – 1:40	0:40 – 1:00	0:20 – 1:05[8]	0:20 – 0:40[8]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

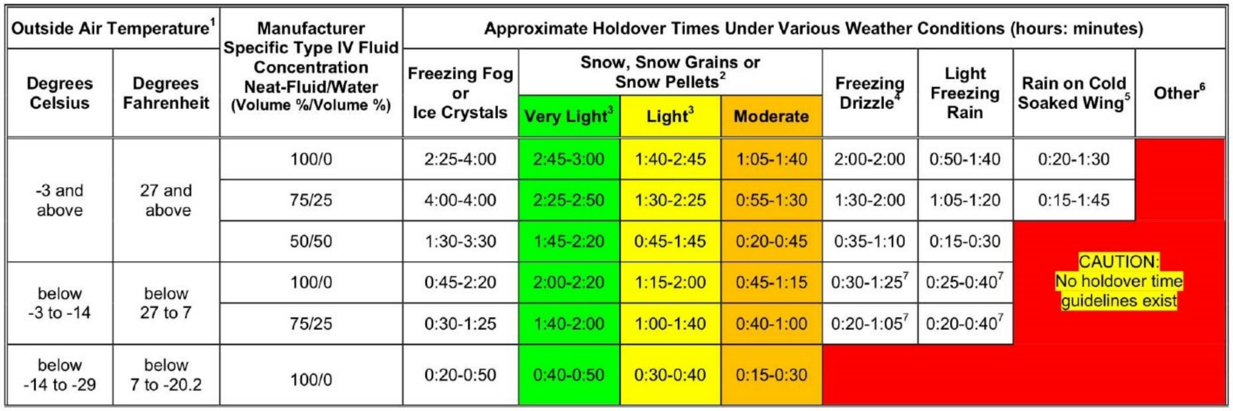
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

Table 4.3: Fluid Specific Holdover Time Guidelines – Clariant Max Flight Sneg (FAA Format)

TABLE 4D. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT MAX FLIGHT SNEG



Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:25-4:00	2:45-3:00	1:40-2:45	1:05-1:40	2:00-2:00	0:50-1:40	0:20-1:30	
		75/25	4:00-4:00	2:25-2:50	1:30-2:25	0:55-1:30	1:30-2:00	1:05-1:20	0:15-1:45	
		50/50	1:30-3:30	1:45-2:20	0:45-1:45	0:20-0:45	0:35-1:10	0:15-0:30	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-2:20	2:00-2:20	1:15-2:00	0:45-1:15	0:30-1:25[7]	0:25-0:40[7]		
		75/25	0:30-1:25	1:40-2:00	1:00-1:40	0:40-1:00	0:20-1:05[7]	0:20-0:40[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT MAX FLIGHT SNEG TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Table 4.4: LUPR Statistics – Clariant Max Flight Sneg

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	25	40	26	40	19	30
Data Points -3 to -14°C	20	40	21	40	n/a	0
Data Points <10.0	11	40	12	4	6	20
Data Points <=9.5	11	40	12	4	6	40
Data Points <=8.5	10	40	11	4	6	40
Data Points <=7.5	10	40	11	40	6	40
Data Points <=6.5	10	40	11	40	4	40
Data Points <=5.5	8	40	9	40	4	40
Data Points <=4.5	3	40	4	40	3	40
Data Points <=3.5	3	40	2	30	2	30
Data Points <=2.5	0	0	0	0	0	0
Scatter 0-10 g	20%	20	26%	20	17%	30

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	37	pass	37	pass	26	pass
8 g/dm²/h	37	pass	37	pass	26	pass
7 g/dm²/h	37	pass	37	pass	26	pass
6 g/dm²/h	37	pass	37	pass	26	pass
5 g/dm²/h	37	pass	37	pass	26	pass
4 g/dm²/h	37	pass	37	pass	26	pass
3 g/dm²/h	37	pass	33	pass	22	pass
2 g/dm²/h	21	fail	21	fail	10	fail

LUPR	100/0	75/25	50/50
	3 g/dm²/h	3 g/dm²/h	3 g/dm²/h

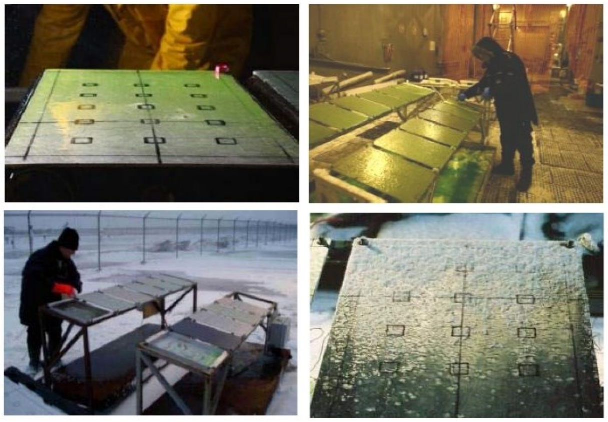
This page intentionally left blank.

APPENDIX F

FLUID MANUFACTURER REPORT: LNT SOLUTIONS E450 (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

LNT Solutions E450 (Type IV)



Prepared for

LNT Solutions

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. L-450 2013-14

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

LNT Solutions E450 (Type IV)

Prepared for

LNT Solutions

Prepared by:

Nov. 28, 2014

Stephanie Bendickson
Project Analyst

Date

Reviewed by:

Nov. 28, 2014

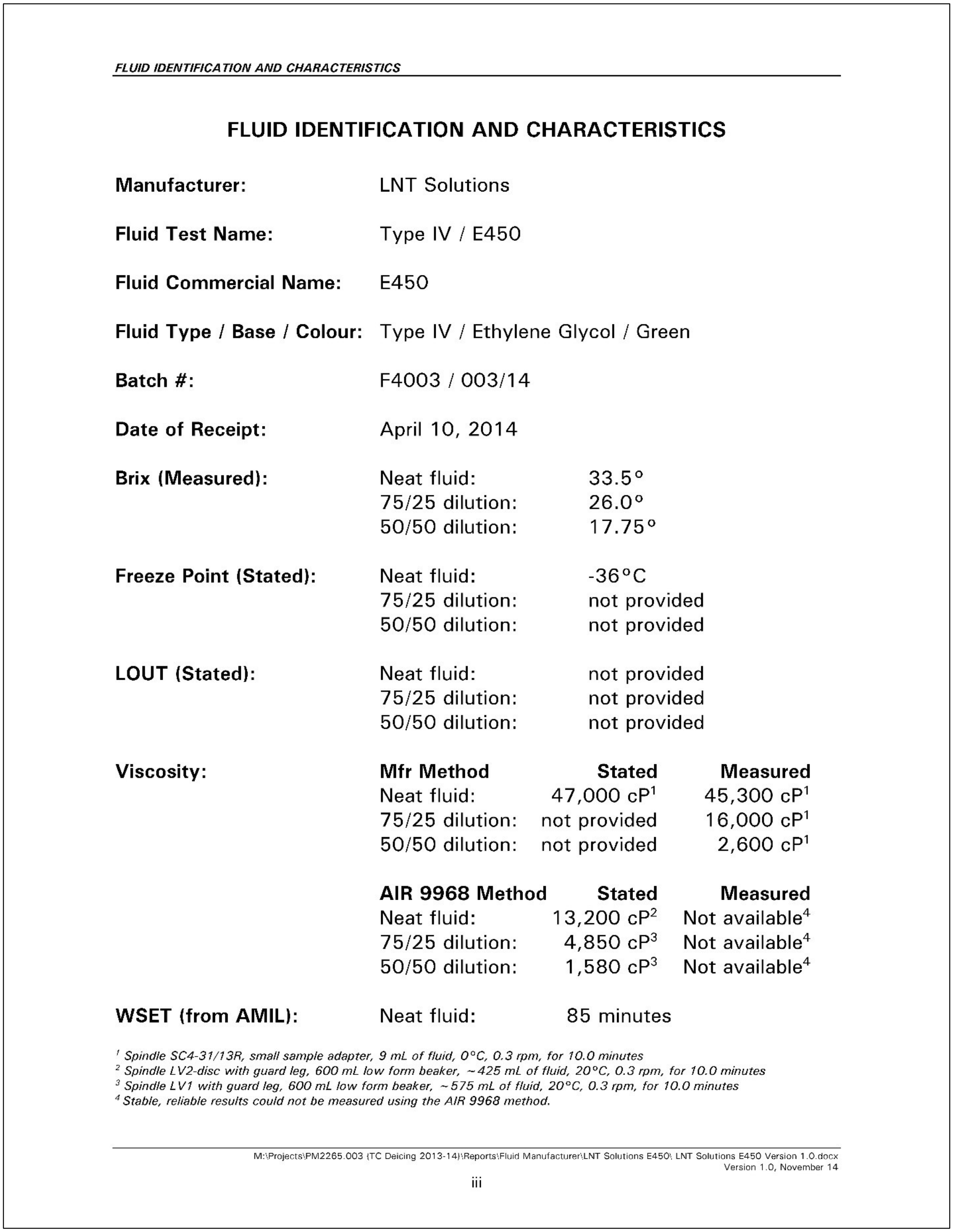
John D'Avirro, Eng.
Program Manager

Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. L-450 2013-14

ii



FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	LNT Solutions		
Fluid Test Name:	Type IV / E450		
Fluid Commercial Name:	E450		
Fluid Type / Base / Colour:	Type IV / Ethylene Glycol / Green		
Batch #:	F4003 / 003/14		
Date of Receipt:	April 10, 2014		
Brix (Measured):	Neat fluid:	33.5°	
	75/25 dilution:	26.0°	
	50/50 dilution:	17.75°	
Freeze Point (Stated):	Neat fluid:	-36°C	
	75/25 dilution:	not provided	
	50/50 dilution:	not provided	
LOUT (Stated):	Neat fluid:	not provided	
	75/25 dilution:	not provided	
	50/50 dilution:	not provided	
Viscosity:	**Mfr Method**	**Stated**	**Measured**
	Neat fluid:	47,000 cP[1]	45,300 cP[1]
	75/25 dilution:	not provided	16,000 cP[1]
	50/50 dilution:	not provided	2,600 cP[1]
	AIR 9968 Method	**Stated**	**Measured**
	Neat fluid:	13,200 cP[2]	Not available[4]
	75/25 dilution:	4,850 cP[3]	Not available[4]
	50/50 dilution:	1,580 cP[3]	Not available[4]
WSET (from AMIL):	Neat fluid:	85 minutes	

[1] Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, 0°C, 0.3 rpm, for 10.0 minutes
[2] Spindle LV2-disc with guard leg, 600 mL low form beaker, ~425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[3] Spindle LV1 with guard leg, 600 mL low form beaker, ~575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[4] Stable, reliable results could not be measured using the AIR 9968 method.

This page intentionally left blank.

SUMMARY

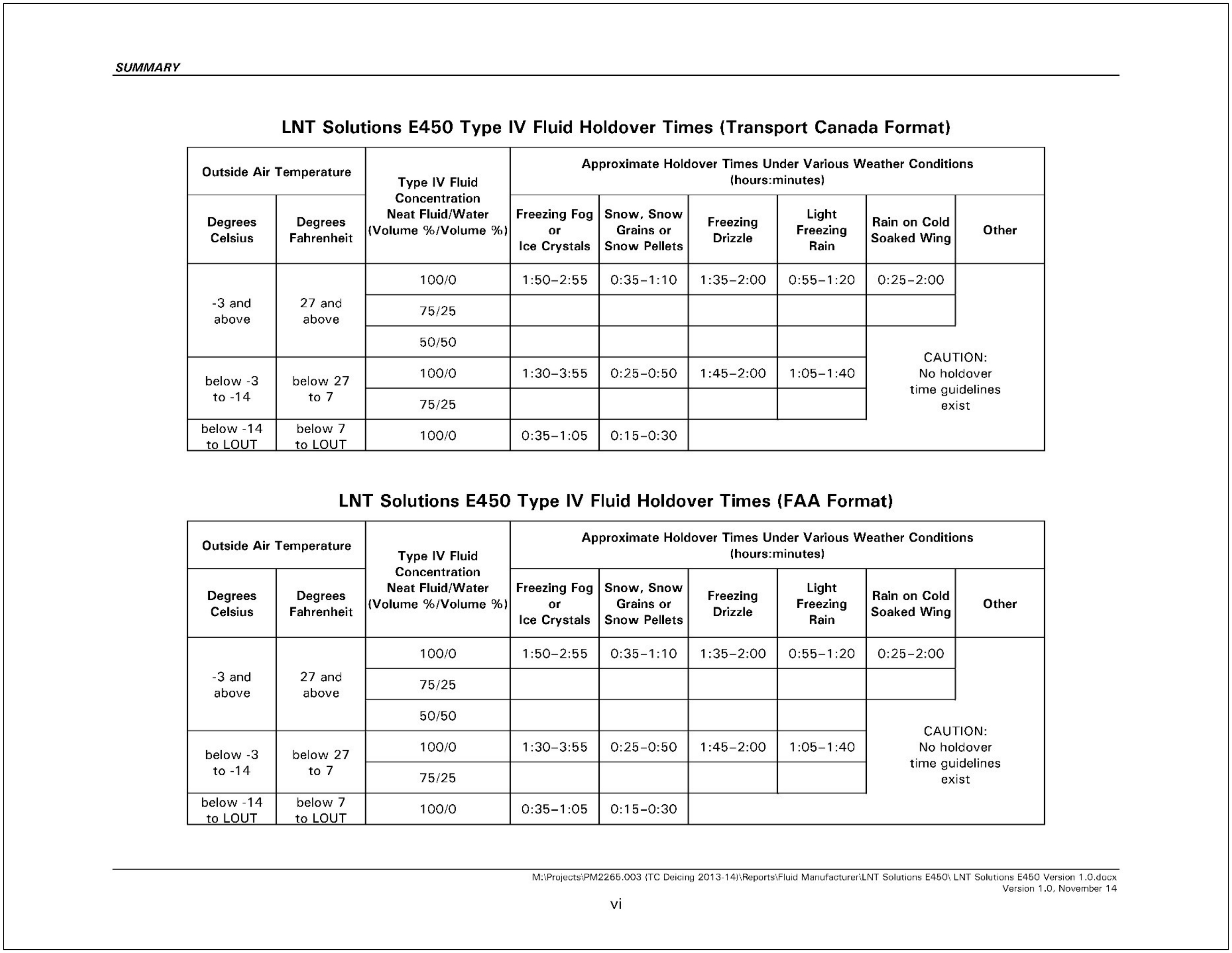
The primary objective of this project was to measure the endurance time performance of **LNT Solutions E450** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

Freezing precipitation de/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific freezing precipitation holdover times shown in the tables on the next page. Generic holdover times were provided for the snow cells based on testing in artificial snow. At the request of the manufacturer, only the 100/0 holdover times have been included in the tables. The tables will be published by regulators for use in the winter 2014-15 operating season.

Additional testing will be carried out in the winter of 2014-15 to obtain data to derive fluid-specific holdover times for snow.



LNT Solutions E450 Type IV Fluid Holdover Times (Transport Canada Format)

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

LNT Solutions E450 Type IV Fluid Holdover Times (FAA Format)

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

TABLE OF CONTENTS Page

1. INTRODUCTION 1

2. METHODOLOGY 3

2.1 Test Sites 3
2.1.1 Natural Snow, Natural Frost and Artificial Snow 3
2.1.2 Freezing Precipitation 3
2.2 Test Equipment 4
2.2.1 Calibration 4
2.2.2 Environmental Chamber Equipment 4
2.2.3 Test Surface Structures 5
2.2.4 Test Surface Materials 6
2.2.5 Test Stands 6
2.2.6 Collection Pans 6
2.2.7 NRC Sprayer Assembly 8
2.2.8 Fluids 8
2.3 Test Procedures 8
2.3.1 Test Protocol – Natural Snow Tests 8
2.3.2 Test Protocol – Natural Frost Tests 9
2.3.3 Test Protocol – Artificial Snow Tests 9
2.3.4 Test Protocol – Simulated Precipitation Tests 9
2.3.5 End Condition Definitions 10
2.3.6 Precipitation Rate Measurement Procedures 10
2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 12
2.4.1 Freezing Fog 14
2.4.2 Freezing Drizzle 14
2.4.3 Light Freezing Rain 15
2.4.4 Rain on a Cold-Soaked Surface 15
2.4.5 Snow 15
2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 15
2.6 Freezing Precipitation Droplet Sizes 16
2.7 Summary of Freezing Precipitation Test Conditions 17
2.8 Analysis Methodology 18
2.8.1 Freezing Precipitation Data 18
2.8.2 Natural Snow Data 19
2.8.3 Natural Frost Data 19
2.8.4 Rounding and Capping Protocols 20
2.8.5 Regression Example 20
2.8.6 Lowest Usable Precipitation Rates in Snow 22

3. DESCRIPTION OF DATA 31

3.1 Natural and Artificial Snow Tests 31
3.2 Freezing Drizzle and Light Freezing Rain Tests 31
3.3 Freezing Fog Tests 32
3.4 Rain on Cold-Soaked Surface Tests 32
3.5 Natural Frost Tests 32
3.6 Fluid Thickness Tests 33

4. RESULTS AND DISCUSSION 39

4.1 Freezing Precipitation 39
4.2 Natural Snow 39
4.3 Artificial Snow 39
4.4 Natural Frost 40
4.5 Holdover Time Table 40
  4.5.1 Holdover Times in Frost 40
  4.5.2 Fluid Viscosity 40
4.6 Lowest Usable Precipitation Rates in Snow 41
4.7 Discussion 41

LIST OF FIGURES Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 6
Figure 2.4: Test Stand Setup Schematic 7
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 12
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 14
Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 21
Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain....................21
Figure 3.1: Fluid Thickness Profiles of LNT Solutions E450 33
Figure 3.2: Final Fluid Thickness of LNT Solutions E450 33
Figure 4.1: Type IV Neat – Natural Snow....................42
Figure 4.2: Type IV 75/25 – Natural Snow....................42
Figure 4.3: Type IV 50/50 – Natural Snow....................43
Figure 4.4: Type IV Neat – Freezing Drizzle 43
Figure 4.5: Type IV 75/25 – Freezing Drizzle 44
Figure 4.6: Type IV 50/50 – Freezing Drizzle 44
Figure 4.7: Type IV Neat – Light Freezing Rain 45
Figure 4.8: Type IV 75/25 – Light Freezing Rain 45
Figure 4.9: Type IV 50/50 – Light Freezing Rain 46
Figure 4.10: Type IV Neat – Freezing Fog 46
Figure 4.11: Type IV 75/25 – Freezing Fog 47
Figure 4.12: Type IV 50/50 – Freezing Fog 47
Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface 48
Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface 48
Figure 4.15: Type IV Neat – Artificial Snow 49
Figure 4.16: Type IV 75/25 – Artificial Snow 49
Figure 4.17: Type IV 50/50 – Artificial Snow 50

LIST OF TABLES Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 16
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 18
Table 2.4: LUPR Factor Scoring System....................23
Table 3.1: Summary of Tests Performed (Snow) 34
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 36
Table 3.3: Summary of Tests Performed (Natural Frost)....................38
Table 4.1: Regression Equation Coefficients for LNT Solutions E450 51
Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions E450 (Transport Canada Format) 52
Table 4.3: Fluid Specific Holdover Time Guidelines – LNT Solutions E450 (FAA Format)....................53

LIST OF PHOTOS **Page**

Photo 2.1: APS Test Site - View from Test Pad 24
Photo 2.2: APS Test Site - View from Trailer 24
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 25
Photo 2.4: Inside View of NRC Climatic Engineering Facility 25
Photo 2.5: Test Plates Mounted on Stand 26
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 26
Photo 2.7: Frost Plate with Insulated Backing 27
Photo 2.8: Collection Pans Used Indoors at the NRC 27
Photo 2.9: Sprayer Assembly 28
Photo 2.10: Sprayer Assembly in Use 28
Photo 2.11: Sprayer Nozzle 29
Photo 2.12: Standard Plate Setup for Testing with Artificial Snowmaker 29

GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

This page intentionally left blank.

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

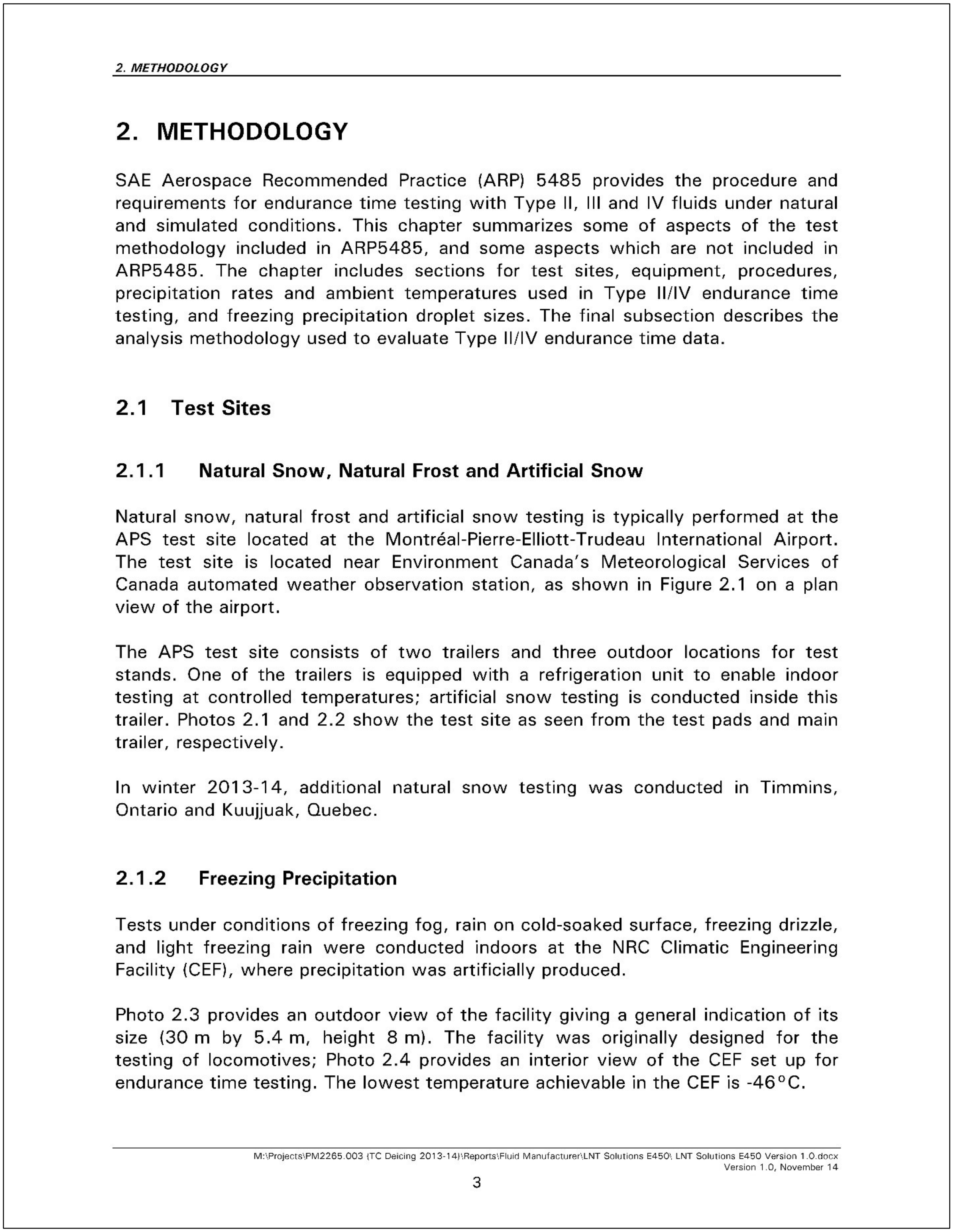
New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **LNT Solutions E450**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

This page intentionally left blank.



2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type II/IV endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type II/IV endurance time data.

2.1 Test Sites

2.1.1 Natural Snow, Natural Frost and Artificial Snow

Natural snow, natural frost and artificial snow testing is typically performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport.

The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures; artificial snow testing is conducted inside this trailer. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

In winter 2013-14, additional natural snow testing was conducted in Timmins, Ontario and Kuujjuak, Quebec.

2.1.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC Climatic Engineering Facility (CEF), where precipitation was artificially produced.

Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

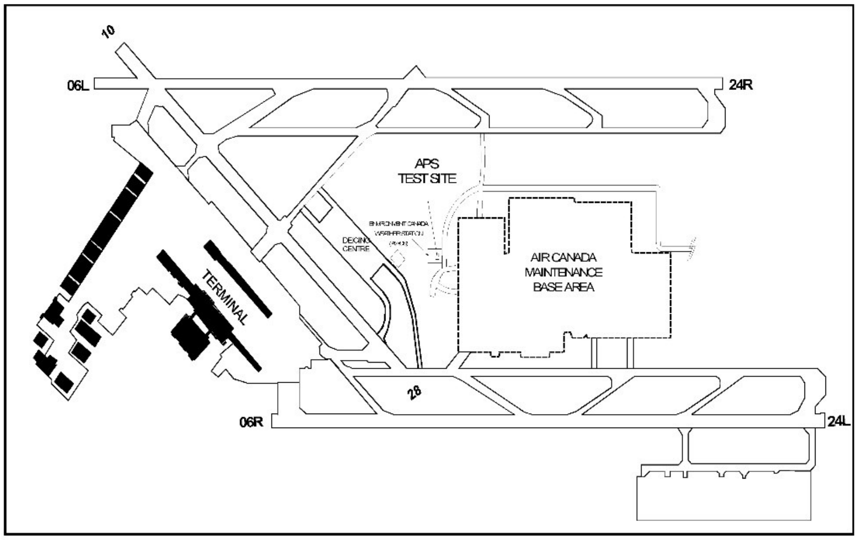


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

2.2 Test Equipment

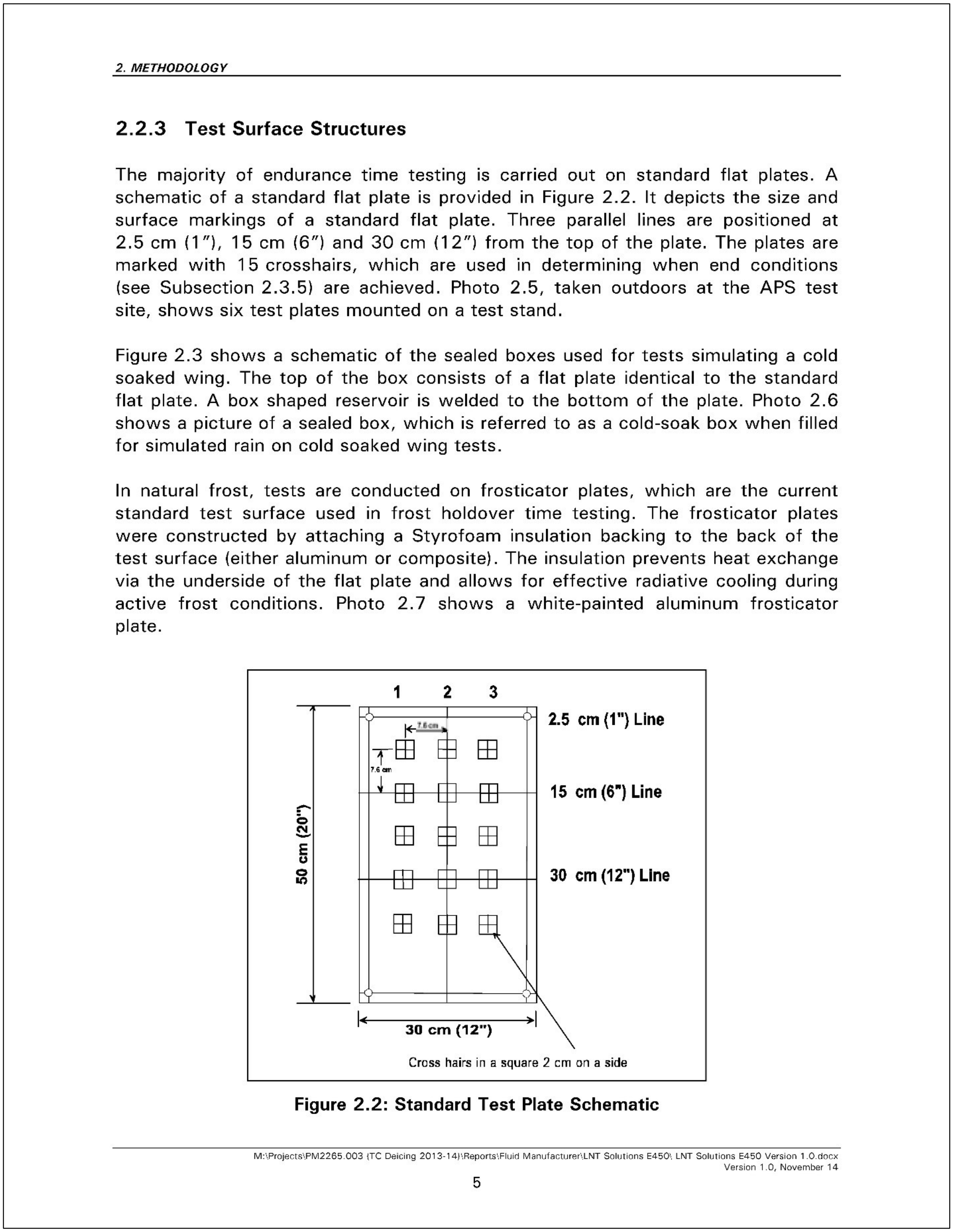
The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

2.2.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

2.2.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5485.



2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1″), 15 cm (6″) and 30 cm (12″) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 2.3.5) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests.

In natural frost, tests are conducted on frosticator plates, which are the current standard test surface used in frost holdover time testing. The frosticator plates were constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 2.7 shows a white-painted aluminum frosticator plate.

Figure 2.2: Standard Test Plate Schematic

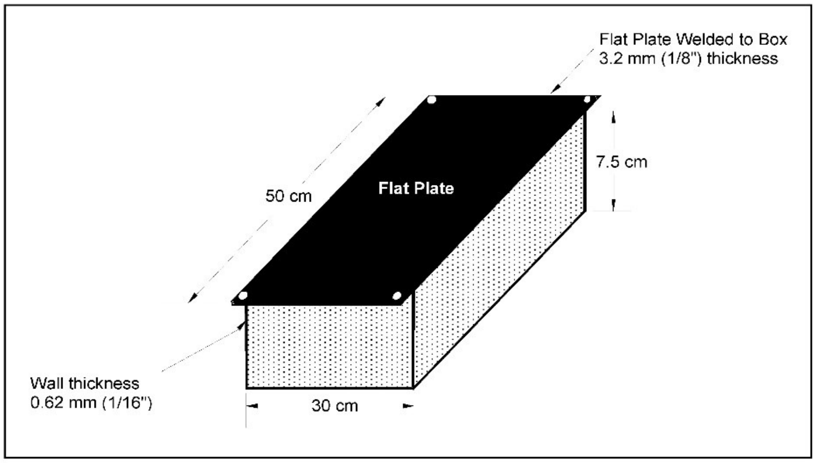


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Testing of Type II, III and IV fluids is carried out exclusively on aluminum surfaces. The aluminum used is 0.32 cm thick Alclad 2024 T3 aluminum.

2.2.5 Test Stands

Figure 2.4 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

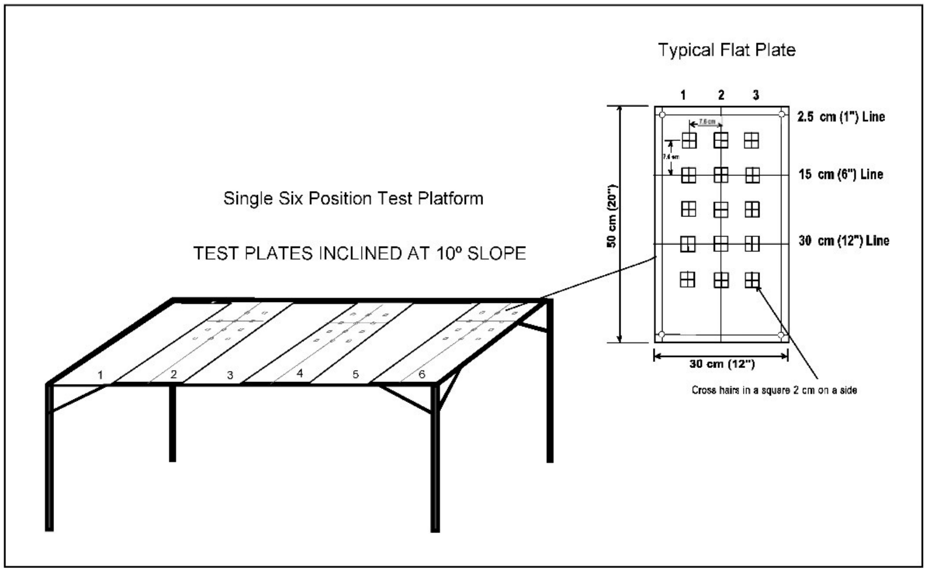


Figure 2.4: Test Stand Setup Schematic

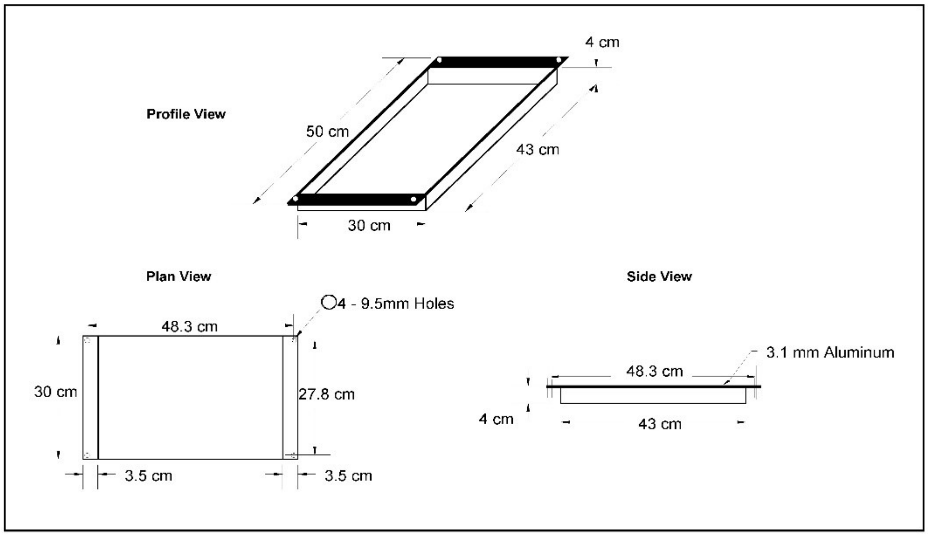


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.11.

2.2.8 Fluids

Testing was carried out with LNT Solutions E450 in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

ARP5485 provides the procedure for endurance time testing of Type II, III and IV fluids under natural and simulated precipitation conditions.

The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 2.3.5), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, natural frost, artificial snow and simulated freezing precipitation testing.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type II, III and IV fluid testing in natural snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted are conducted on standard flat plates (see Section 2.2.3);

- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – Natural Frost Tests

APS developed a specific procedure for Type II/III/IV testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Artificial Snow Tests

APS developed a specific procedure for testing in artificial snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted on a standard plate (shown mounted on the snowmaker scale in Photo 2.12);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type II/III/IV testing in simulated precipitation based on the requirements outlined in ARP5485. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.5 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

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

2.3.6 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.6.1 Simulated precipitation conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.
The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, then the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

2.3.6.2 Natural precipitation conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any HOT test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 2.6 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \times t_1 + R_2 \times t_2 + R_3 \times t_3)}{t_1 + t_2 + t_3}$$

In the example shown in Figure 2.6, the rate is calculated as follows:

$$\frac{(25 \times 10 + 22 \times 8 + 34 \times 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

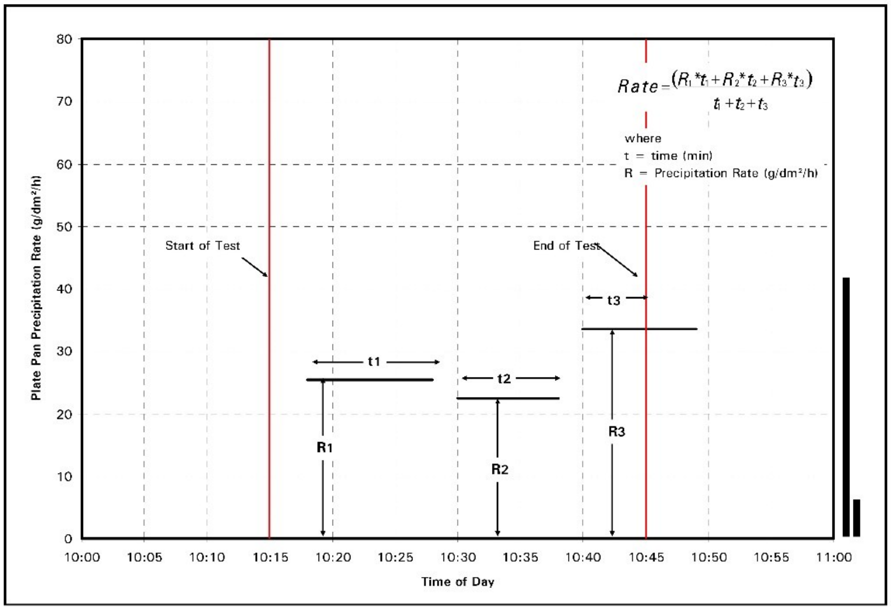


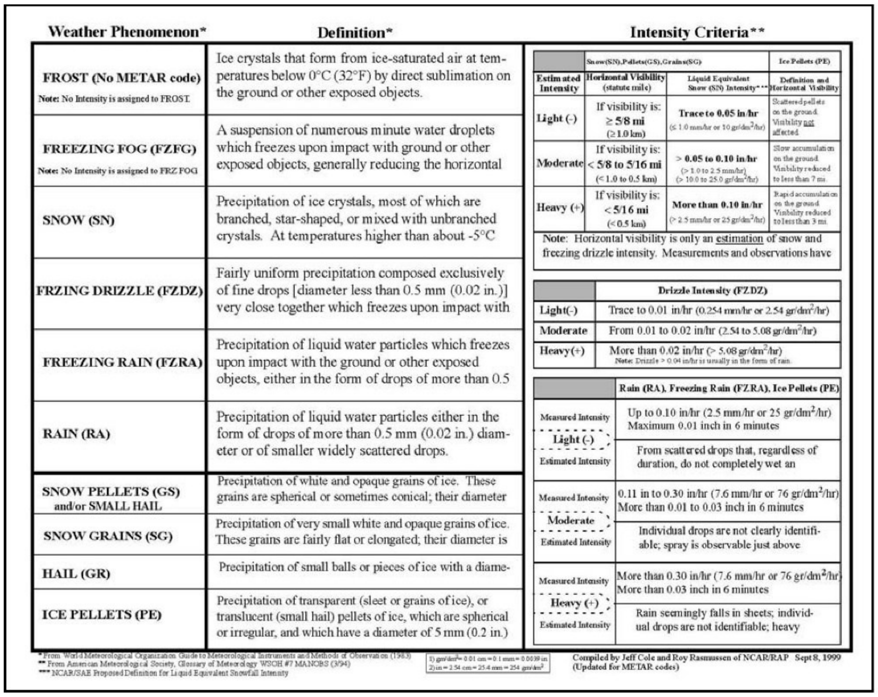
Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS*) (3/94).

The precipitation rate limits established for Type II/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/IV endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 2.1.

Table 2.1: Definition of Weather Phenomenon



Weather Phenomenon*	Definition*
FROST (No METAR code) **Note:** No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) **Note:** No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (SN) Intensity*****	**Definition and Horizontal Visibility**
Light (-)	If visibility is: **≥ 5/8 mi** (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm/hr or 10 gr/dm²/hr)	Scattered pellets on the ground. Visibility not affected.
Moderate	If visibility is: **< 5/8 to 5/16 mi** (< 1.0 to 0.5 km)	**> 0.05 to 0.10 in/hr** (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: **< 5/16 mi** (< 0.5 km)	**More than 0.10 in/hr** (> 2.5 mm/hr or 25 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.

Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) Note: Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm²/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gm/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999
(Updated for METAR codes)

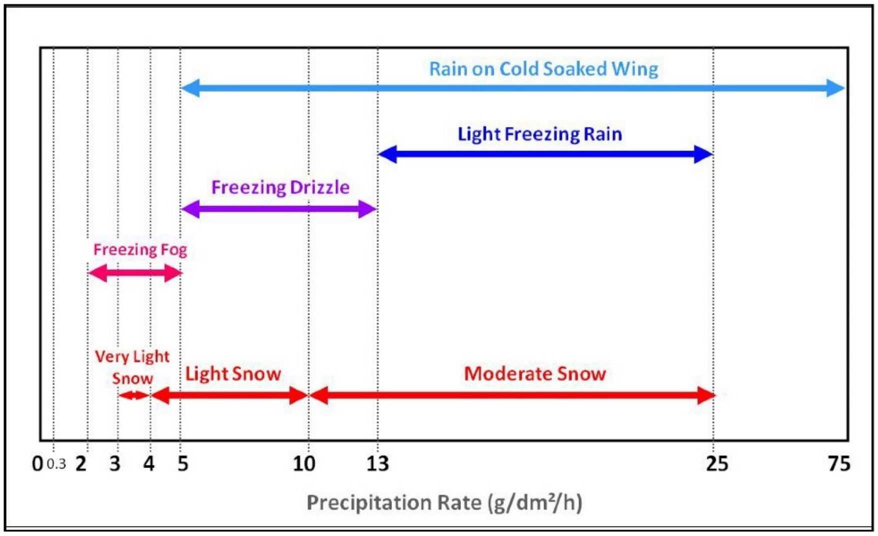


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

2.4.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.

2.4.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.4.4 Rain on a Cold-Soaked Surface

The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 g/dm^2/h. These rate limits encompass very light, light and moderate snow.

2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:

- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation and artificial snow testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -25°C
- Freezing Drizzle: -3°C and -10°C
- Light Freezing Rain: -3°C and -10°C
- Rain on Cold Soaked Surface: +1°C
- Artificial Snow: -3, -14 and/or -25°C

2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

- MVD = (precipitation rate/10) $^{0.23}$, where MVD is in mm and rate of precipitation is in g/dm²/h

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm²/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below.

a) *For the outdoor test:*

Location:	Montreal P.E.T. Airport
Precipitation:	Natural Light Freezing Rain
Precipitation Rate:	20 g/dm^2/h
Calibrated MVD:	1.0 mm

b) *For the indoor test:*

Location:	National Research Council
Precipitation:	Simulated Light Freezing Rain
Precipitation Rate:	25 g/dm^2/h
Calibrated MVD:	1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation.
As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm^2/h): 30 μm
- Freezing Fog, low precipitation rate (2 g/dm^2/h): 30 μm

- Freezing Drizzle, high precipitation rate (13 g/dm^2/h): 350 μm
- Freezing Drizzle, low precipitation rate (5 g/dm^2/h): 250 μm

- Light Freezing Rain, high precipitation rate (25 g/dm^2/h): 1,000 μm
- Light Freezing Rain, low precipitation rate (13 g/dm^2/h): 1,000 μm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm^2/h): 250 μm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm^2/h): 1,400 μm

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/IV fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 16 weather conditions listed in Table 2.3.

Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
	-10°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
	-25°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
Freezing Drizzle	-3°C	5 g/dm²/h (250 μm)
		13 g/dm²/h (350 μm)
	-10°C	5 g/dm²/h (250 μm)
		13 g/dm²/h (350 μm)
Light Freezing Rain	-3°C	13 g/dm²/h (1,000 μm)
		25 g/dm²/h (1,000 μm)
	-10°C	13 g/dm²/h (1,000 μm)
		25 g/dm²/h (1,000 μm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm²/h (250 μm)
		75 g/dm²/h (1,400 μm)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/IV fluids. The procedure is based on the refinement of an equation for a curve which best represents the test data, and then solving that equation at the upper and lower limits established for the precipitation type. These precipitation rate limits, set by the SAE G-12 HOT Committee and detailed in ARP5485, were described in Subsection 2.4. This approach was developed in the winter of 1996-97 (see TC report, TP 13131E) and has since been used to derive fluid holdover times. There are some differences in the way the methodology is applied to freezing precipitation and natural snow data.

2.8.1 Freezing Precipitation Data

For each related freezing precipitation HOT table cell, four tests are conducted at the most restrictive (lowest) temperature in the temperature range for that cell: two tests at the low precipitation rate limit and two tests at the high precipitation rate limit (limits are detailed in Subsection 2.4). The equation used to treat freezing precipitation data is:

- $t = 10^{I}R^{a}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.2 Natural Snow Data

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural snow tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather data under all temperatures and precipitation rates encompassed by the HOT tables.

The general form of the regression equation is modified for natural snow to incorporate the variable of temperature and also to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C. The equation used to treat natural snow data is:

- $t = 10^{I} R^{a} (2\text{-}T)^{b}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.3 Natural Frost Data

Regression analysis is not used in the determination of frost holdover times. The current Type II/III/IV generic frost holdover times were determined based on several years of testing using all fluids which were commercially available at the time. A "minimum values" analysis methodology was used to determine appropriate holdover times from the test data.

The purpose of natural frost testing with new fluids is to verify the fluids can be used with the generic frost holdover times. The analysis methodology is to compare the frost test data collected with the new fluid to the current generic holdover times. If the test data provides holdover times equal to or greater than the generic holdover times then the generic holdover times have been validated for the new fluid.

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural frost tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather several data points with each fluid/dilution.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: Holdover times are rounded to the nearest whole "5" minute, i.e. 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 to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: All holdover time values are capped at maximum values. The caps differ by precipitation type, and in the case of snow, by regulator. The caps are as follows:
    - Freezing Fog holdover time values are capped at 4 hours;
    - Freezing Drizzle, Light Freezing Rain, Rain on Cold Soaked Wing holdover times are capped at 2 hours; and
    - Snow holdover times are capped at 2 hours by Transport Canada and 3 hours by FAA.

2.8.5 Regression Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.8. The plots contain data for one Neat Type IV fluid, in one temperature range (-10°C), in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.9. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The HOT range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

The holdover times for this fluid at -10°C are 20 minutes at 13 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the HOT range for this particular fluid in the light freezing rain, neat fluid, below -3 to -10°C cell. This illustrates the general approach used in the determination of a fluid HOT range for any given cell in the HOT table.

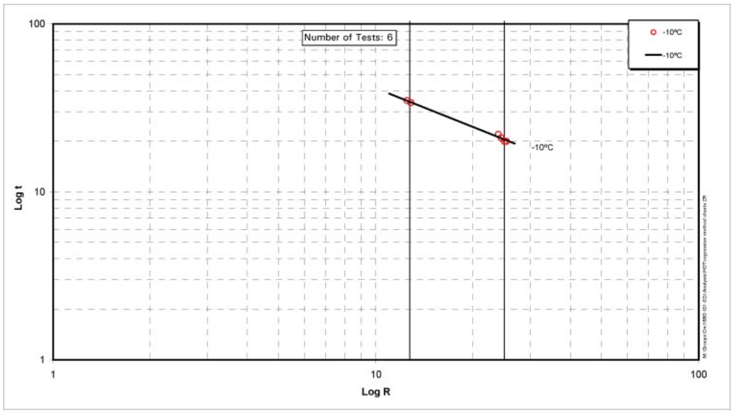


Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

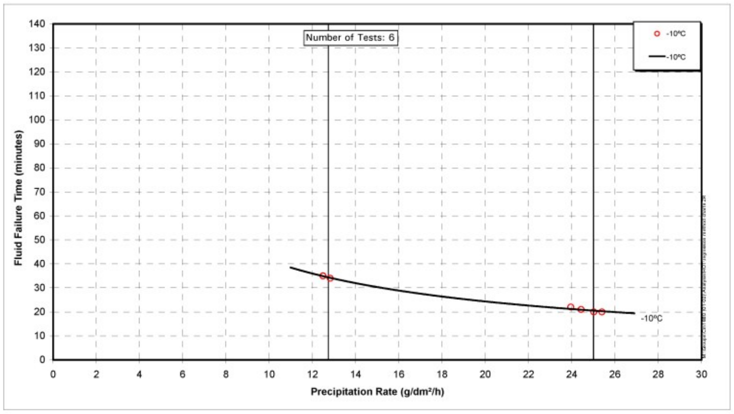


Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

2.8.6 Lowest Usable Precipitation Rates in Snow

A detailed analysis methodology was developed to determine if a snow data set is sufficient to determine holdover times for light and very light snow. Specifically, the analysis determines the lowest usable precipitation rate (LUPR), which is the lowest rate at which the data set is considered robust.

The methodology is a five-factor weighted analysis. The five factors are:

1. Total number of data points;
2. Number of data points with air temperatures below -3°C;
3. Number of data points with precipitation rates below 10 g/dm²/h;
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined; and
5. Scatter from regression curve of low precipitation rate data points (average absolute percent difference between fail time and regression calculated fail time for all points less than or equal to 10 g/dm²/h).

The weights given to each of the five factors are:

1. Total Data Points = 5%;
2. Data Points Below -3°C = 20%;
3. Data Points Below 10 g/dm²/h = 20%;
4. Data Points ≤ Precipitation Rate = 40%; and
5. Low Rate Data Scatter = 15%.

Each data set is given a score of 0, 10, 20, 30 or 40 for each factor. The scoring system is shown in Table 2.4.

This approach provides a score for each data set for each precipitation rate below 10 g/dm²/h. The scores are compared to the minimum acceptance scores:

- 100/0 = 28
- 75/25 = 28
- 50/50 = 19 (lower due to a 0 score for data points below -3°C)

The LUPR is the lowest precipitation rate at which a data set has a passing score.

Table 2.4: LUPR Factor Scoring System

Factor #1: Total Data Points (Weight = 5%)	
Rating = 40	≥20 data points in data set
Rating = 30	15-19 data points in data set
Rating = 20	10-14 data points in data set
Rating = 10	5-9 data points in data set
Rating = 0	<5 data points in data set

Factor #2: Data Points Below -3°C (Weight = 20%)	
Rating = 40	≥15 data points from -3 to -14°C
Rating = 30	12-14 data points -3 to -14°C
Rating = 20	9-11 data points -3 to -14°C
Rating = 10	6-8 data points -3 to -14°C
Rating = 0	<6 data points -3 to -14°C

Factor #3: Data Points Below 10 $g/dm^2/h$ (Weight = 20%)	
Rating = 40	≥10 data points <10 $g/dm^2/h$
Rating = 30	7-9 data points <10 $g/dm^2/h$
Rating = 20	5-6 data points <10 $g/dm^2/h$
Rating = 10	3-4 data points <10 $g/dm^2/h$
Rating = 0	<3 data points <10 $g/dm^2/h$

Factor #4: Data Points ≤ Precipitation Rate (Weight = 40%)	
Rating = 40	≥3 data points ≤ rate limit +0.5
Rating = 30	2 data points ≤ rate limit +0.5
Rating = 20	1 data points ≤ rate limit +0.5
Rating = 10	n/a
Rating = 0	0 data points ≤ rate limit +0.5

Factor #5: Low Rate Data Scatter (Weight = 15%)	
Rating = 40	Average actual-calculated error <10%
Rating = 30	Average actual-calculated error 10-19%
Rating = 20	Average actual-calculated error 20-29%
Rating = 10	Average actual-calculated error 30-39%
Rating = 0	Average actual-calculated error ≥40%

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility

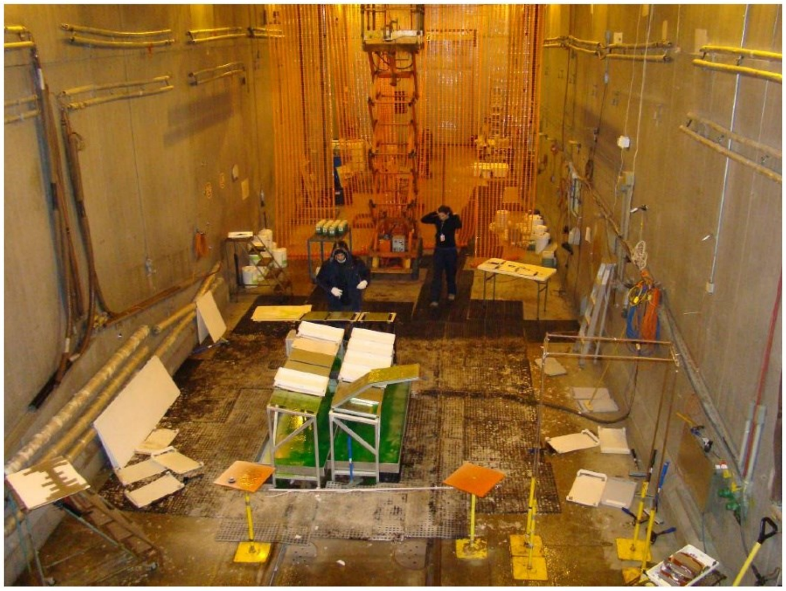


Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

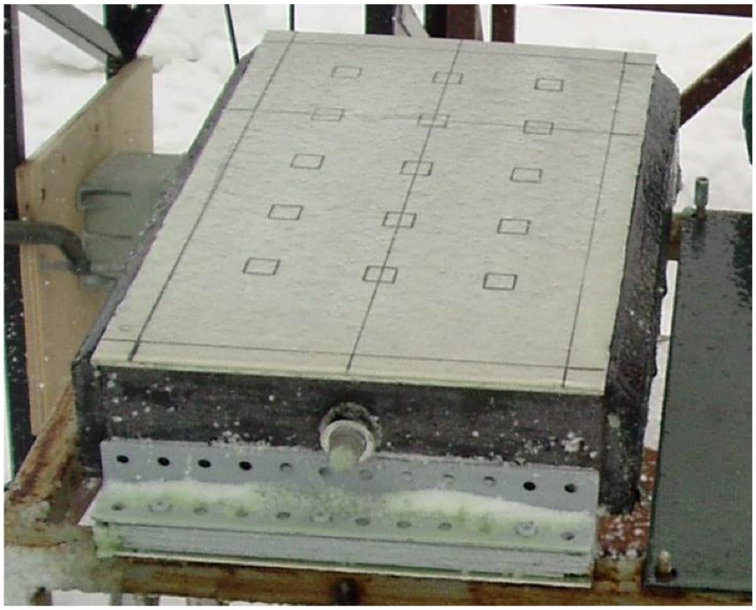


Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

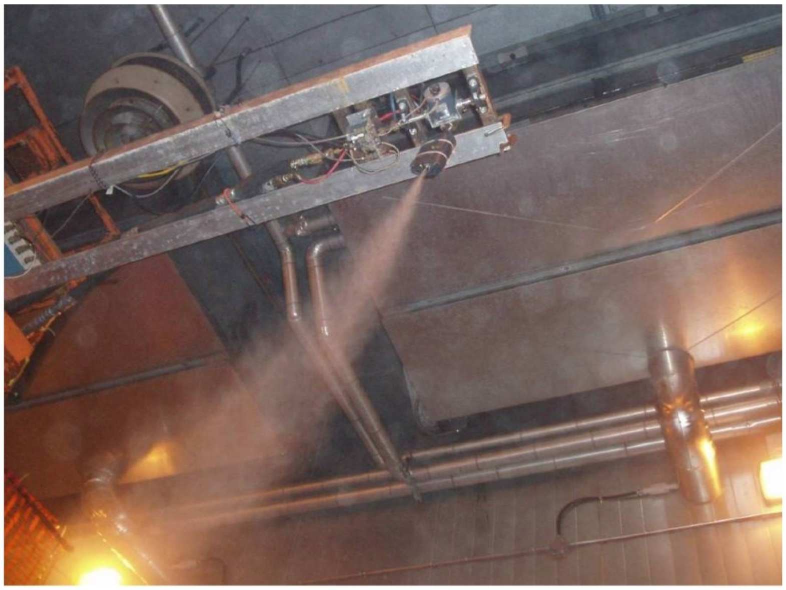


Photo 2.11: Sprayer Nozzle

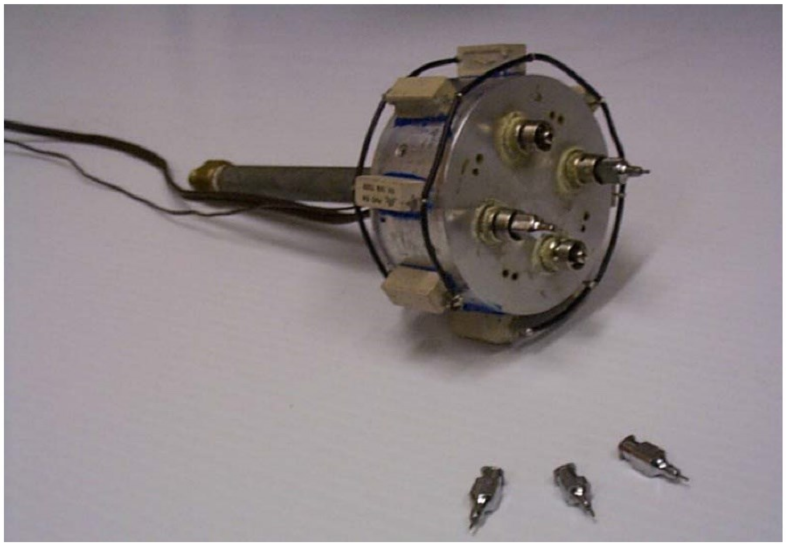
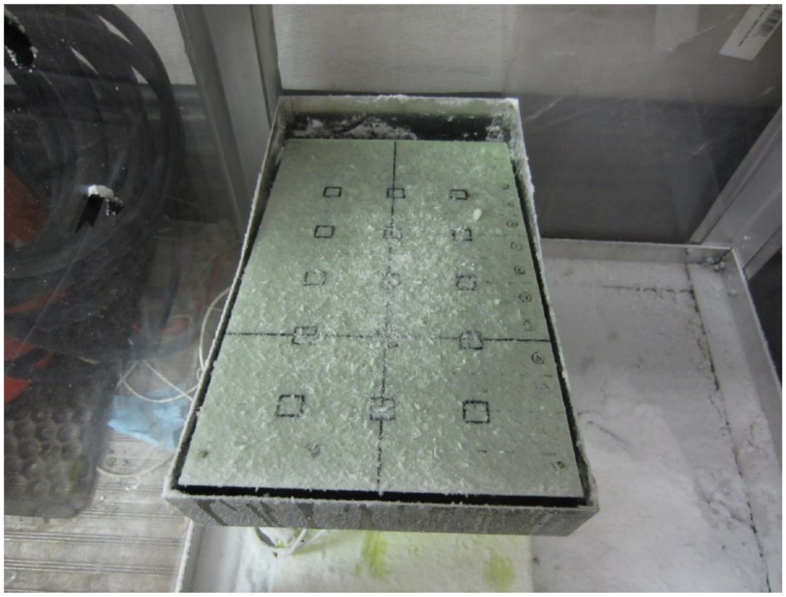


Photo 2.12: Standard Plate Setup for Testing with Artificial Snowmaker



This page intentionally left blank.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

Logs of the tests conducted are provided at the end of this section as follows: Table 3.1 (snow), Table 3.2 (freezing precipitation), and Table 3.3 (frost). The logs provide details of each test conducted.

3.1 Natural and Artificial Snow Tests

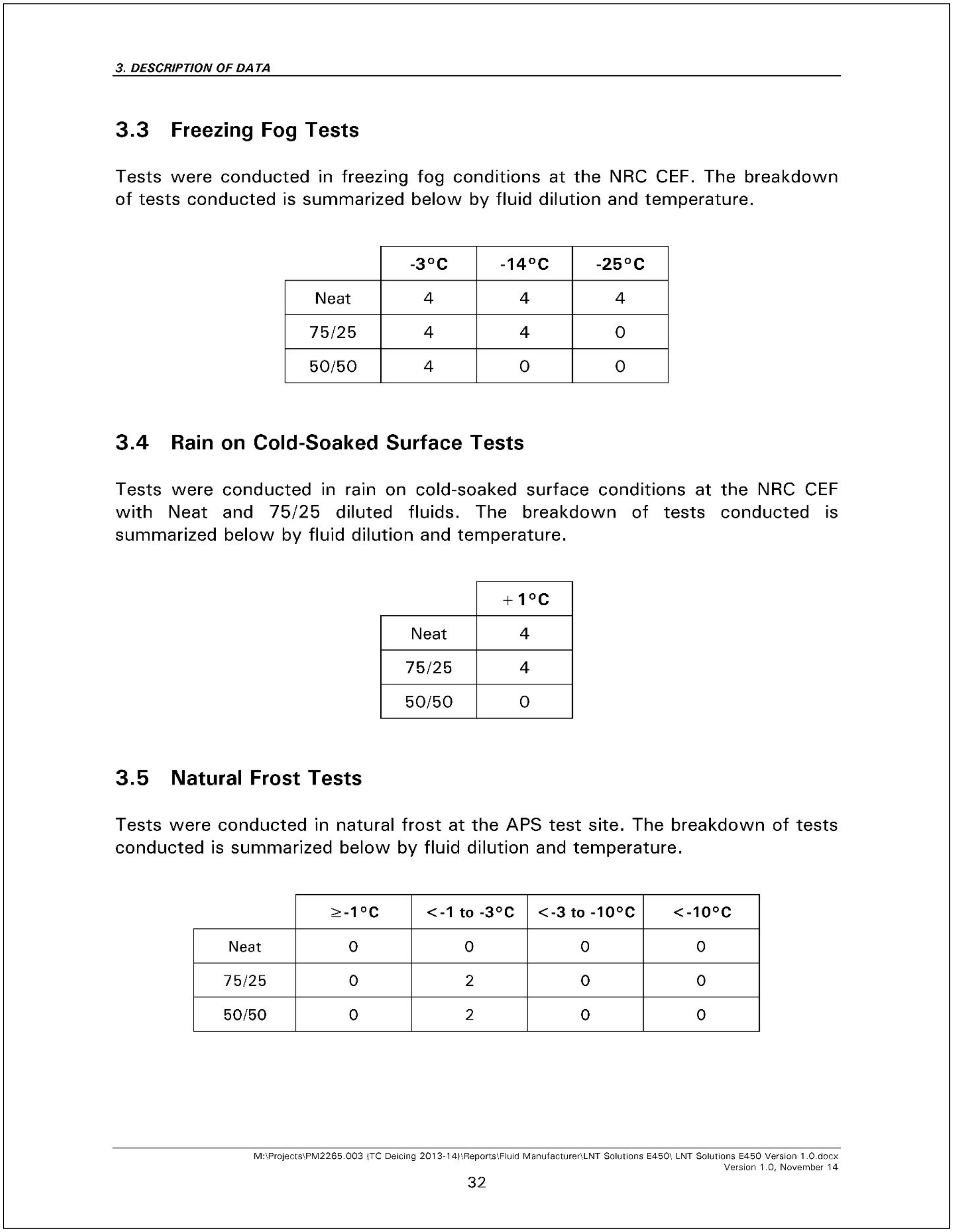
Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.1.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	Natural Snow			**Artificial Snow**		
	≥ -3°C	**-3 to -14°C**	**<-14°C**	**-3°C**	**-14°C**	**-25°C**
Neat	13	3	0	4	4	0
75/25	10	5	0	4	4	0
50/50	10	3	0	4	0	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		**Light Freezing Rain**	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4
75/25	4	4	5	4
50/50	4	0	5	0



3.3 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	-14°C	-25°C
Neat	4	4	4
75/25	4	4	0
50/50	4	0	0

3.4 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	4
50/50	0

3.5 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	0	0
75/25	0	2	0	0
50/50	0	2	0	0

3.6 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

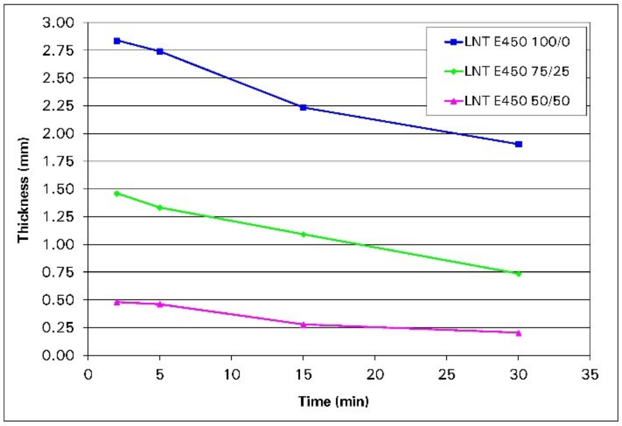


Figure 3.1: Fluid Thickness Profiles of LNT Solutions E450

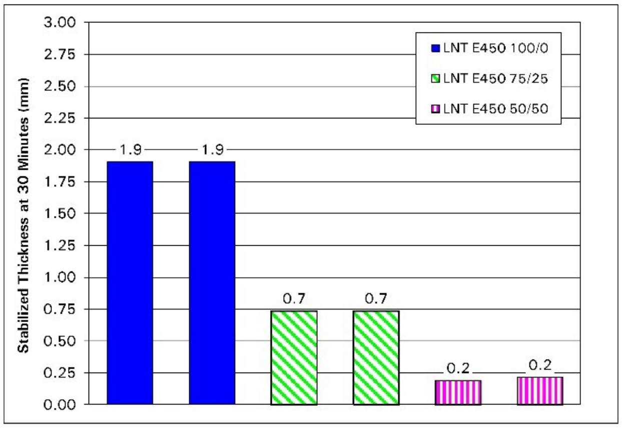


Figure 3.2: Final Fluid Thickness of LNT Solutions E450

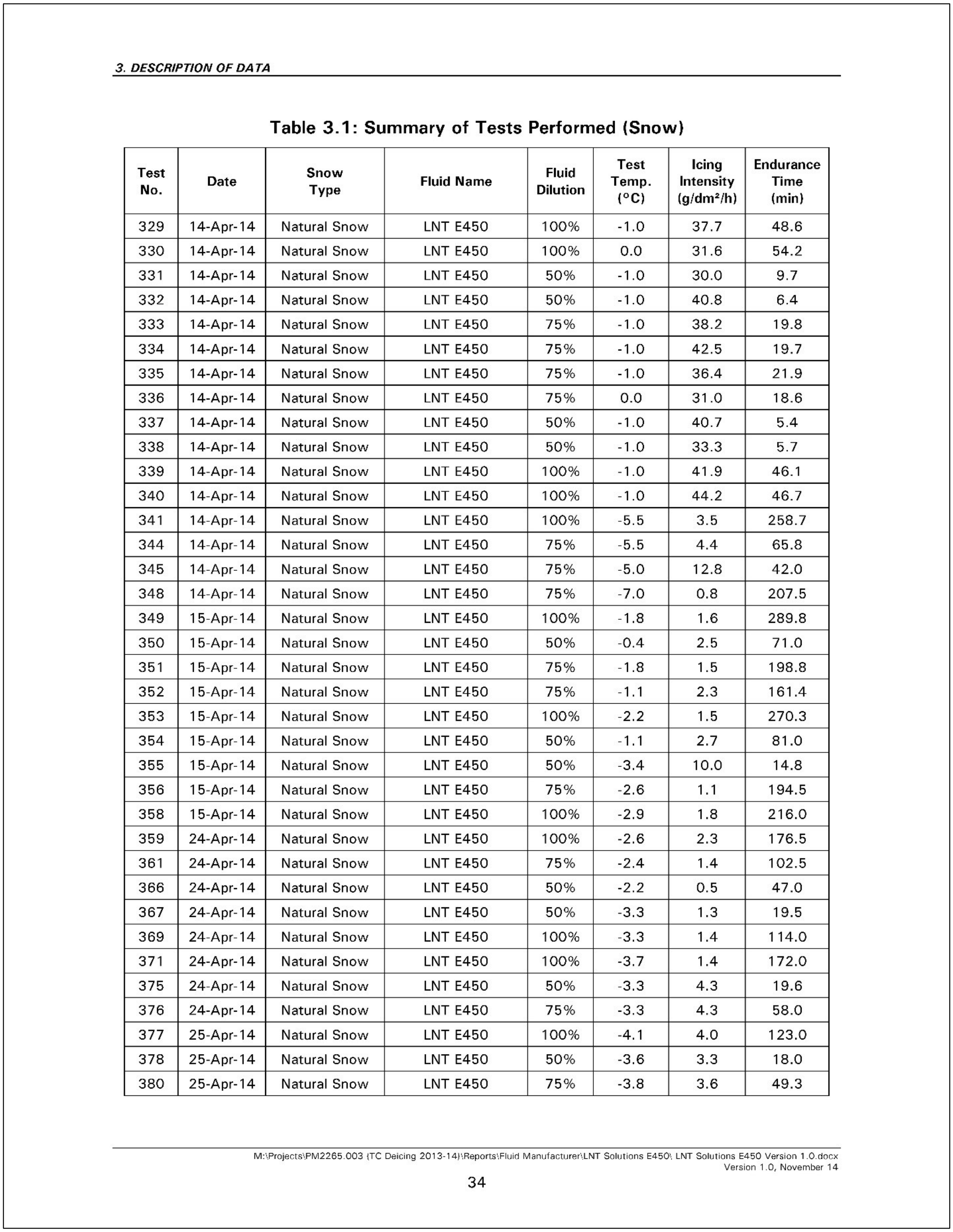


Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
329	14-Apr-14	Natural Snow	LNT E450	100%	-1.0	37.7	48.6
330	14-Apr-14	Natural Snow	LNT E450	100%	0.0	31.6	54.2
331	14-Apr-14	Natural Snow	LNT E450	50%	-1.0	30.0	9.7
332	14-Apr-14	Natural Snow	LNT E450	50%	-1.0	40.8	6.4
333	14-Apr-14	Natural Snow	LNT E450	75%	-1.0	38.2	19.8
334	14-Apr-14	Natural Snow	LNT E450	75%	-1.0	42.5	19.7
335	14-Apr-14	Natural Snow	LNT E450	75%	-1.0	36.4	21.9
336	14-Apr-14	Natural Snow	LNT E450	75%	0.0	31.0	18.6
337	14-Apr-14	Natural Snow	LNT E450	50%	-1.0	40.7	5.4
338	14-Apr-14	Natural Snow	LNT E450	50%	-1.0	33.3	5.7
339	14-Apr-14	Natural Snow	LNT E450	100%	-1.0	41.9	46.1
340	14-Apr-14	Natural Snow	LNT E450	100%	-1.0	44.2	46.7
341	14-Apr-14	Natural Snow	LNT E450	100%	-5.5	3.5	258.7
344	14-Apr-14	Natural Snow	LNT E450	75%	-5.5	4.4	65.8
345	14-Apr-14	Natural Snow	LNT E450	75%	-5.0	12.8	42.0
348	14-Apr-14	Natural Snow	LNT E450	75%	-7.0	0.8	207.5
349	15-Apr-14	Natural Snow	LNT E450	100%	-1.8	1.6	289.8
350	15-Apr-14	Natural Snow	LNT E450	50%	-0.4	2.5	71.0
351	15-Apr-14	Natural Snow	LNT E450	75%	-1.8	1.5	198.8
352	15-Apr-14	Natural Snow	LNT E450	75%	-1.1	2.3	161.4
353	15-Apr-14	Natural Snow	LNT E450	100%	-2.2	1.5	270.3
354	15-Apr-14	Natural Snow	LNT E450	50%	-1.1	2.7	81.0
355	15-Apr-14	Natural Snow	LNT E450	50%	-3.4	10.0	14.8
356	15-Apr-14	Natural Snow	LNT E450	75%	-2.6	1.1	194.5
358	15-Apr-14	Natural Snow	LNT E450	100%	-2.9	1.8	216.0
359	24-Apr-14	Natural Snow	LNT E450	100%	-2.6	2.3	176.5
361	24-Apr-14	Natural Snow	LNT E450	75%	-2.4	1.4	102.5
366	24-Apr-14	Natural Snow	LNT E450	50%	-2.2	0.5	47.0
367	24-Apr-14	Natural Snow	LNT E450	50%	-3.3	1.3	19.5
369	24-Apr-14	Natural Snow	LNT E450	100%	-3.3	1.4	114.0
371	24-Apr-14	Natural Snow	LNT E450	100%	-3.7	1.4	172.0
375	24-Apr-14	Natural Snow	LNT E450	50%	-3.3	4.3	19.6
376	24-Apr-14	Natural Snow	LNT E450	75%	-3.3	4.3	58.0
377	25-Apr-14	Natural Snow	LNT E450	100%	-4.1	4.0	123.0
378	25-Apr-14	Natural Snow	LNT E450	50%	-3.6	3.3	18.0
380	25-Apr-14	Natural Snow	LNT E450	75%	-3.8	3.6	49.3

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
383	25-Apr-14	Natural Snow	LNT E450	100%	-3.2	4.4	111.0
384	25-Apr-14	Natural Snow	LNT E450	50%	-3.8	5.4	14.0
388	25-Apr-14	Natural Snow	LNT E450	75%	-3.6	4.3	59.3
391	25-Apr-14	Natural Snow	LNT E450	50%	-3.6	4.1	18.5
394	25-Apr-14	Natural Snow	LNT E450	100%	-3.0	4.4	95.7
395	25-Apr-14	Natural Snow	LNT E450	100%	-1.7	1.8	409.8
396	25-Apr-14	Natural Snow	LNT E450	100%	-2.1	3.3	131.0
402	25-Apr-14	Natural Snow	LNT E450	75%	-1.8	2.3	130.3
1	28-Apr-14	Artificial Snow	LNT E450	100%	-14.0	10.0	90.0
2	28-Apr-14	Artificial Snow	LNT E450	100%	-14.0	25.0	47.5
3	02-May-14	Artificial Snow	LNT E450	75%	-14.0	10.0	50.1
4	02-May-14	Artificial Snow	LNT E450	75%	-14.0	25.0	20.9
9	01-May-14	Artificial Snow	LNT E450	100%	-3.0	10.0	87.5
10	01-May-14	Artificial Snow	LNT E450	100%	-3.0	25.0	46.0
11	01-May-14	Artificial Snow	LNT E450	75%	-3.0	10.0	54.2
12	01-May-14	Artificial Snow	LNT E450	75%	-3.0	25.0	26.7
13	01-May-14	Artificial Snow	LNT E450	50%	-3.0	10.0	17.8
14	01-May-14	Artificial Snow	LNT E450	50%	-3.0	25.0	6.9
21	16-Jul-14	Artificial Snow	LNT E450	100%	-14.0	10.0	85.0
22	16-Jul-14	Artificial Snow	LNT E450	100%	-14.0	25.0	43.7
23	15-Jul-14	Artificial Snow	LNT E450	75%	-14.0	10.0	46.0
24	15-Jul-14	Artificial Snow	LNT E450	75%	-14.0	25.0	23.0
29	11-Jul-14	Artificial Snow	LNT E450	100%	-3.0	10.0	98.2
30	11-Jul-14	Artificial Snow	LNT E450	100%	-3.0	25.0	52.0
31	03-May-14	Artificial Snow	LNT E450	75%	-3.0	10.0	56.2
32	02-May-14	Artificial Snow	LNT E450	75%	-3.0	25.0	23.4
33	02-May-14	Artificial Snow	LNT E450	50%	-3.0	10.0	23.0
34	02-May-14	Artificial Snow	LNT E450	50%	-3.0	25.0	8.2

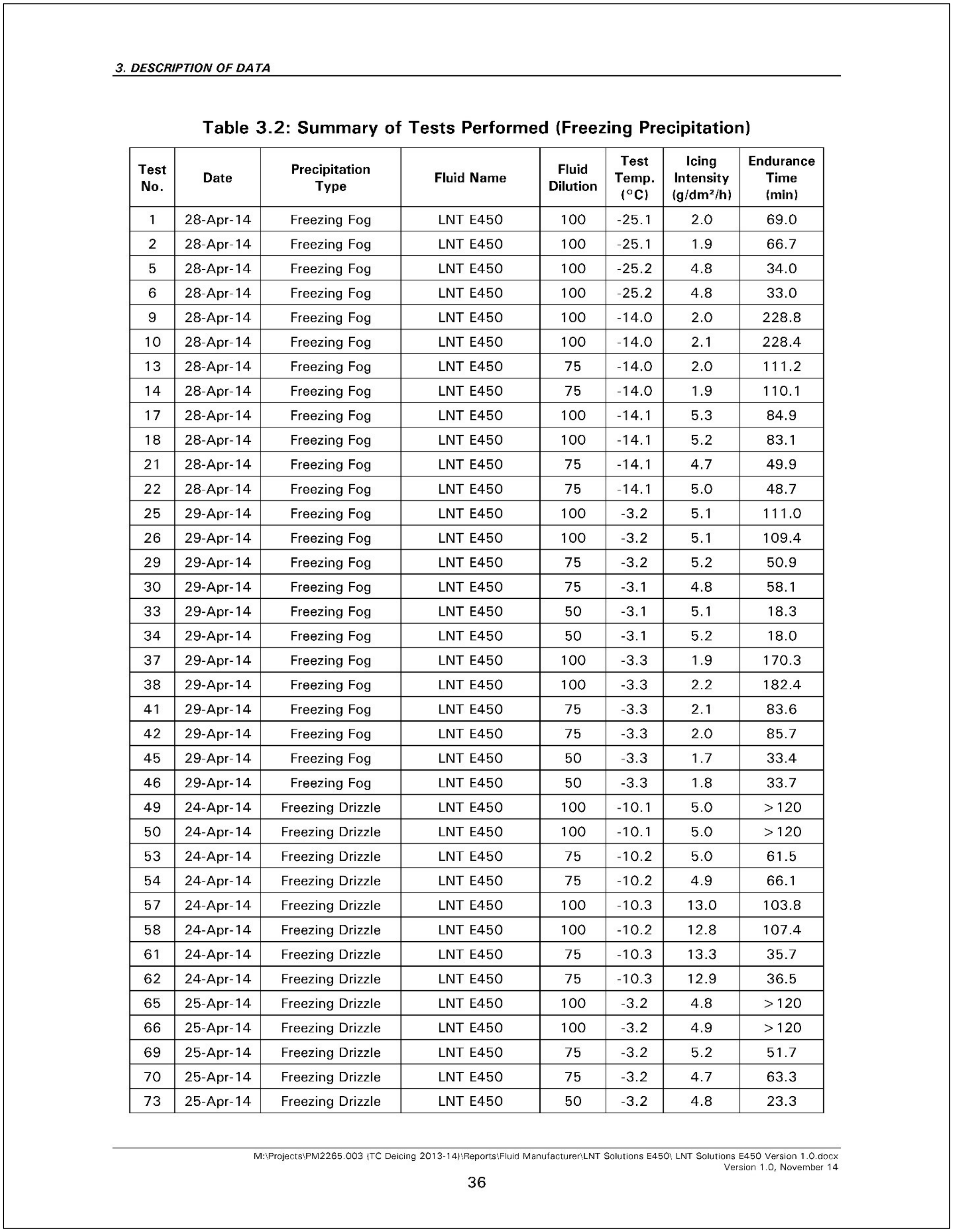


Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
1	28-Apr-14	Freezing Fog	LNT E450	100	-25.1	2.0	69.0
2	28-Apr-14	Freezing Fog	LNT E450	100	-25.1	1.9	66.7
5	28-Apr-14	Freezing Fog	LNT E450	100	-25.2	4.8	34.0
6	28-Apr-14	Freezing Fog	LNT E450	100	-25.2	4.8	33.0
9	28-Apr-14	Freezing Fog	LNT E450	100	-14.0	2.0	228.8
10	28-Apr-14	Freezing Fog	LNT E450	100	-14.0	2.1	228.4
13	28-Apr-14	Freezing Fog	LNT E450	75	-14.0	2.0	111.2
14	28-Apr-14	Freezing Fog	LNT E450	75	-14.0	1.9	110.1
17	28-Apr-14	Freezing Fog	LNT E450	100	-14.1	5.3	84.9
18	28-Apr-14	Freezing Fog	LNT E450	100	-14.1	5.2	83.1
21	28-Apr-14	Freezing Fog	LNT E450	75	-14.1	4.7	49.9
22	28-Apr-14	Freezing Fog	LNT E450	75	-14.1	5.0	48.7
25	29-Apr-14	Freezing Fog	LNT E450	100	-3.2	5.1	111.0
26	29-Apr-14	Freezing Fog	LNT E450	100	-3.2	5.1	109.4
29	29-Apr-14	Freezing Fog	LNT E450	75	-3.2	5.2	50.9
30	29-Apr-14	Freezing Fog	LNT E450	75	-3.1	4.8	58.1
33	29-Apr-14	Freezing Fog	LNT E450	50	-3.1	5.1	18.3
34	29-Apr-14	Freezing Fog	LNT E450	50	-3.1	5.2	18.0
37	29-Apr-14	Freezing Fog	LNT E450	100	-3.3	1.9	170.3
38	29-Apr-14	Freezing Fog	LNT E450	100	-3.3	2.2	182.4
41	29-Apr-14	Freezing Fog	LNT E450	75	-3.3	2.1	83.6
42	29-Apr-14	Freezing Fog	LNT E450	75	-3.3	2.0	85.7
45	29-Apr-14	Freezing Fog	LNT E450	50	-3.3	1.7	33.4
46	29-Apr-14	Freezing Fog	LNT E450	50	-3.3	1.8	33.7
49	24-Apr-14	Freezing Drizzle	LNT E450	100	-10.1	5.0	>120
50	24-Apr-14	Freezing Drizzle	LNT E450	100	-10.1	5.0	>120
53	24-Apr-14	Freezing Drizzle	LNT E450	75	-10.2	5.0	61.5
54	24-Apr-14	Freezing Drizzle	LNT E450	75	-10.2	4.9	66.1
57	24-Apr-14	Freezing Drizzle	LNT E450	100	-10.3	13.0	103.8
58	24-Apr-14	Freezing Drizzle	LNT E450	100	-10.2	12.8	107.4
61	24-Apr-14	Freezing Drizzle	LNT E450	75	-10.3	13.3	35.7
62	24-Apr-14	Freezing Drizzle	LNT E450	75	-10.3	12.9	36.5
65	25-Apr-14	Freezing Drizzle	LNT E450	100	-3.2	4.8	>120
66	25-Apr-14	Freezing Drizzle	LNT E450	100	-3.2	4.9	>120
69	25-Apr-14	Freezing Drizzle	LNT E450	75	-3.2	5.2	51.7
70	25-Apr-14	Freezing Drizzle	LNT E450	75	-3.2	4.7	63.3
73	25-Apr-14	Freezing Drizzle	LNT E450	50	-3.2	4.8	23.3

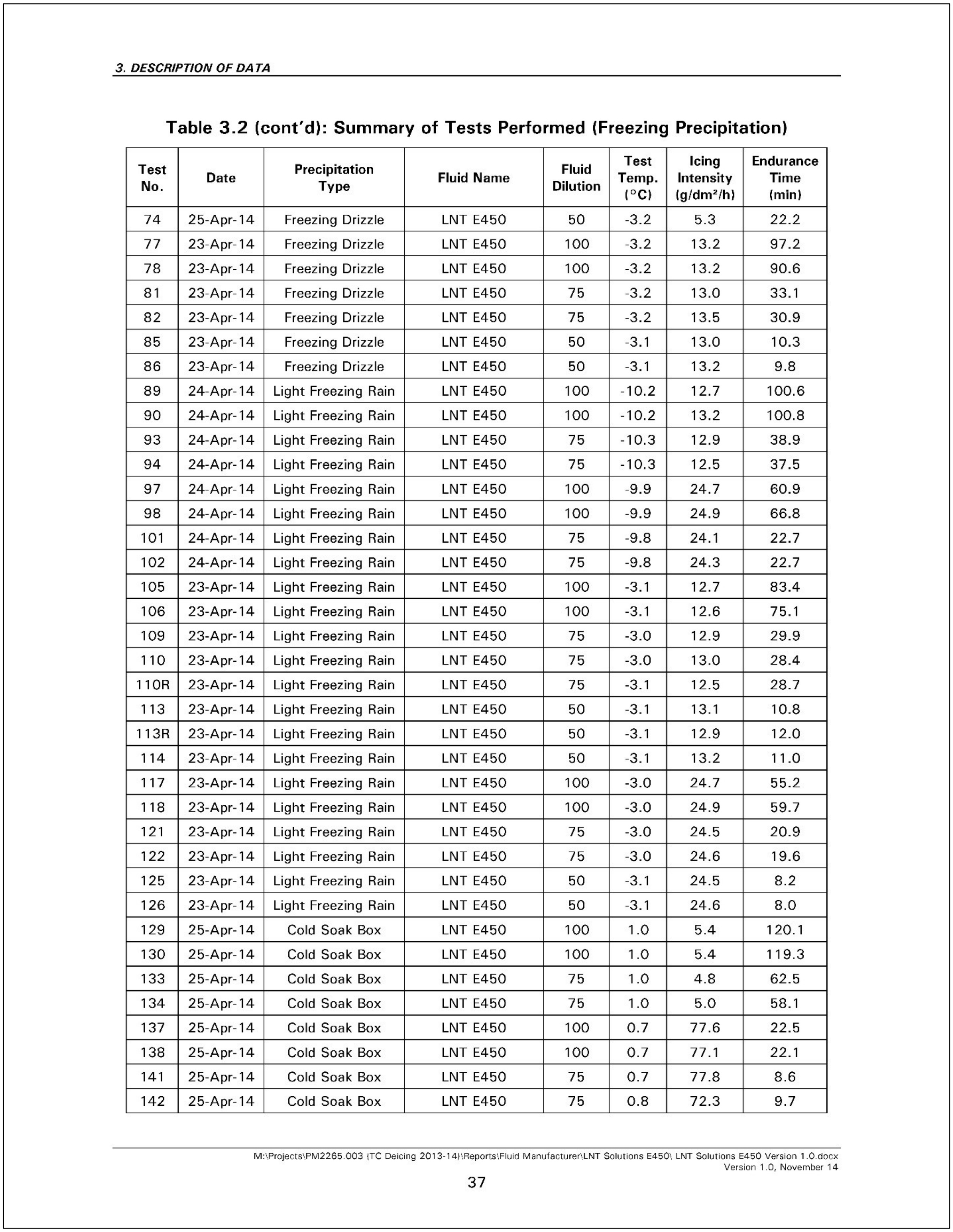


Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
74	25-Apr-14	Freezing Drizzle	LNT E450	50	-3.2	5.3	22.2
77	23-Apr-14	Freezing Drizzle	LNT E450	100	-3.2	13.2	97.2
78	23-Apr-14	Freezing Drizzle	LNT E450	100	-3.2	13.2	90.6
81	23-Apr-14	Freezing Drizzle	LNT E450	75	-3.2	13.0	33.1
82	23-Apr-14	Freezing Drizzle	LNT E450	75	-3.2	13.5	30.9
85	23-Apr-14	Freezing Drizzle	LNT E450	50	-3.1	13.0	10.3
86	23-Apr-14	Freezing Drizzle	LNT E450	50	-3.1	13.2	9.8
89	24-Apr-14	Light Freezing Rain	LNT E450	100	-10.2	12.7	100.6
90	24-Apr-14	Light Freezing Rain	LNT E450	100	-10.2	13.2	100.8
93	24-Apr-14	Light Freezing Rain	LNT E450	75	-10.3	12.9	38.9
94	24-Apr-14	Light Freezing Rain	LNT E450	75	-10.3	12.5	37.5
97	24-Apr-14	Light Freezing Rain	LNT E450	100	-9.9	24.7	60.9
98	24-Apr-14	Light Freezing Rain	LNT E450	100	-9.9	24.9	66.8
101	24-Apr-14	Light Freezing Rain	LNT E450	75	-9.8	24.1	22.7
102	24-Apr-14	Light Freezing Rain	LNT E450	75	-9.8	24.3	22.7
105	23-Apr-14	Light Freezing Rain	LNT E450	100	-3.1	12.7	83.4
106	23-Apr-14	Light Freezing Rain	LNT E450	100	-3.1	12.6	75.1
109	23-Apr-14	Light Freezing Rain	LNT E450	75	-3.0	12.9	29.9
110	23-Apr-14	Light Freezing Rain	LNT E450	75	-3.0	13.0	28.4
110R	23-Apr-14	Light Freezing Rain	LNT E450	75	-3.1	12.5	28.7
113	23-Apr-14	Light Freezing Rain	LNT E450	50	-3.1	13.1	10.8
113R	23-Apr-14	Light Freezing Rain	LNT E450	50	-3.1	12.9	12.0
114	23-Apr-14	Light Freezing Rain	LNT E450	50	-3.1	13.2	11.0
117	23-Apr-14	Light Freezing Rain	LNT E450	100	-3.0	24.7	55.2
118	23-Apr-14	Light Freezing Rain	LNT E450	100	-3.0	24.9	59.7
121	23-Apr-14	Light Freezing Rain	LNT E450	75	-3.0	24.5	20.9
122	23-Apr-14	Light Freezing Rain	LNT E450	75	-3.0	24.6	19.6
125	23-Apr-14	Light Freezing Rain	LNT E450	50	-3.1	24.5	8.2
126	23-Apr-14	Light Freezing Rain	LNT E450	50	-3.1	24.6	8.0
129	25-Apr-14	Cold Soak Box	LNT E450	100	1.0	5.4	120.1
130	25-Apr-14	Cold Soak Box	LNT E450	100	1.0	5.4	119.3
133	25-Apr-14	Cold Soak Box	LNT E450	75	1.0	4.8	62.5
134	25-Apr-14	Cold Soak Box	LNT E450	75	1.0	5.0	58.1
137	25-Apr-14	Cold Soak Box	LNT E450	100	0.7	77.6	22.5
138	25-Apr-14	Cold Soak Box	LNT E450	100	0.7	77.1	22.1
141	25-Apr-14	Cold Soak Box	LNT E450	75	0.7	77.8	8.6
142	25-Apr-14	Cold Soak Box	LNT E450	75	0.8	72.3	9.7

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
23	16-Apr-14	Natural Frost	LNT E450	75%	564	0.03	-3.2	3	78	Did Not Fail
24	16-Apr-14	Natural Frost	LNT E450	50%	457	0.03	-3.5	3	81	Did Not Fail
34	17-Apr-14	Natural Frost	LNT E450	75%	384	0.11	-2.7	8	69	Did Not Fail
35	17-Apr-14	Natural Frost	LNT E450	50%	204	0.08	-2.7	8	69	Failed

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The results of the data analyses are presented in this section.

4.1 Freezing Precipitation

Figures 4.1 to 4.11 present the data collected in simulated freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface). These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the freezing precipitation conditions encompassed by the Type IV HOT guidelines.

Multi-variable regression analysis was performed on these data sets as described in Subsection 2.8. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all freezing precipitation conditions encompassed by Type IV fluid-specific HOT tables.

4.2 Natural Snow

Due to the late submission of the fluid in the winter season, only limited data could be collected in natural snow. The data is plotted in Figures 4.12 to 4.14 (endurance time vs. precipitation rate). It is categorized by temperature using the Type IV fluid-specific HOT table temperature ranges.

There was insufficient data to perform regression analysis on the natural snow data; therefore, no fluid-specific endurance times could be derived from the data.

4.3 Artificial Snow

Data was collected in artificial snow to supplement the natural snow data. Figures 4.15 to 4.17 show the artificial snow data plotted against the Type IV generic snow holdover times.

All 100/0 and 50/50 data points met or exceeded the generic holdover times. As a result, the data indicates E450 100/0 and 50/50 can be used with the Type IV generic snow holdover times.

Several 75/25 data points did not meet the generic holdover times. Therefore, the data does not support the use of the 75/25 dilution with the Type IV generic holdover times.

4.4 Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the generic holdover times. All completed ("failed") tests surpassed the generic holdover times, as did all tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates the generic frost holdover times have been substantiated for LNT Solutions E450.

4.5 Holdover Time Table

A fluid-specific HOT table was created for LNT Solutions E450 based on the results of the endurance time testing. At the request of LNT Solutions, the 75/25 and 50/50 holdover times were not included in the table.

The holdover times described in Subsection 4.1 were used to populate the freezing precipitation cells. The generic Type IV snow holdover times were used to populate the snow cells.

The fluid-specific HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.5.1 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT table. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the LNT Solutions E450 fluid-specific HOT table.

4.5.2 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.6 Lowest Usable Precipitation Rates in Snow

The LUPR analysis was not completed as the natural snow data set was not completed. For the winter of 2014-15, the E450 100/0 LUPR is equivalent to the lowest rate at which it underwent artificial snow testing: 10 g/dm²/h.

4.7 Discussion

As LNT Solutions intends to commercialize E450, TC and FAA will publish its fluid-specific HOT table in their 2014-15 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the LUPR data will be published in the related TC and FAA Regression Information documents. At the request of LNT Solutions, the information for 75/25 and 50/50 will not be included.

Additional natural snow testing will be carried out with all fluid dilutions in the winter of 2014-15 to obtain data to derive fluid-specific holdover times for snow. It is expected these holdover times will be incorporated into the 2015-16 holdover time guidelines.

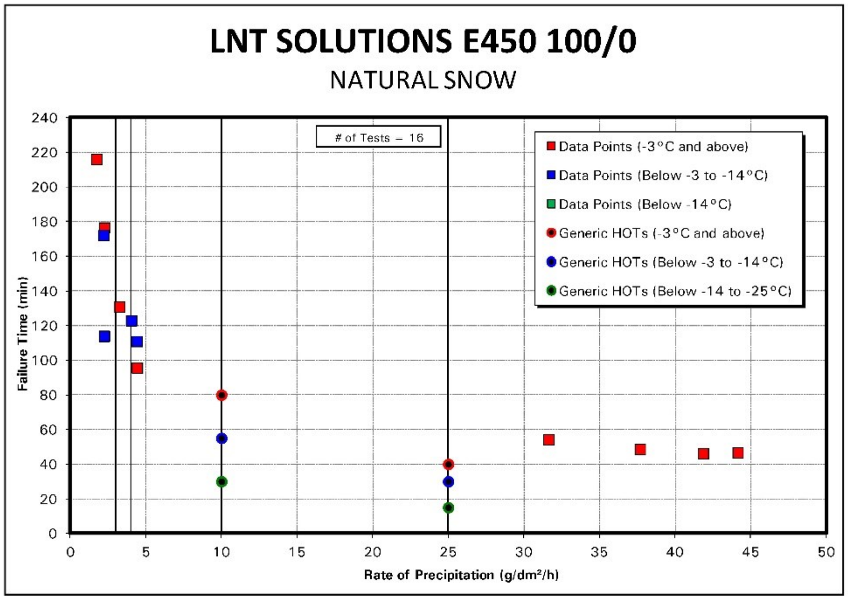


Figure 4.1: Type IV Neat – Natural Snow

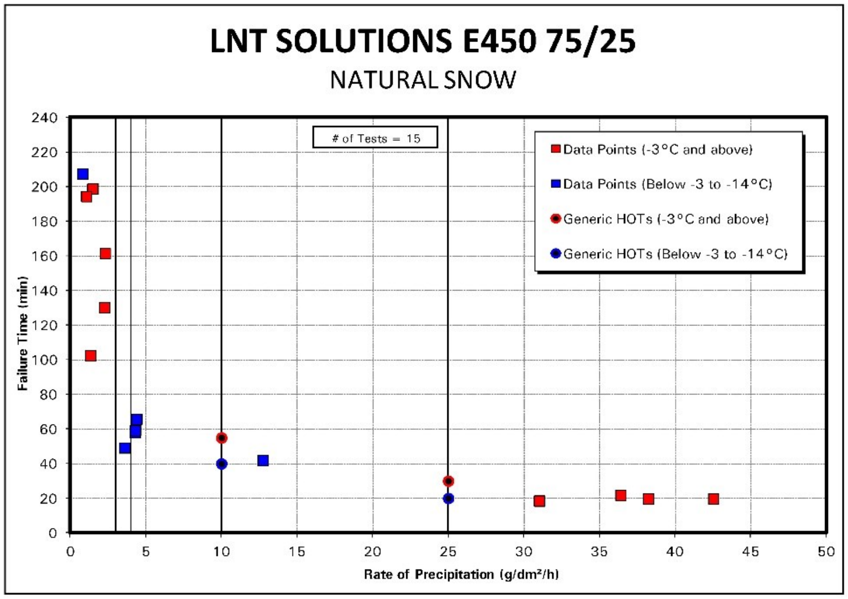


Figure 4.2: Type IV 75/25 – Natural Snow

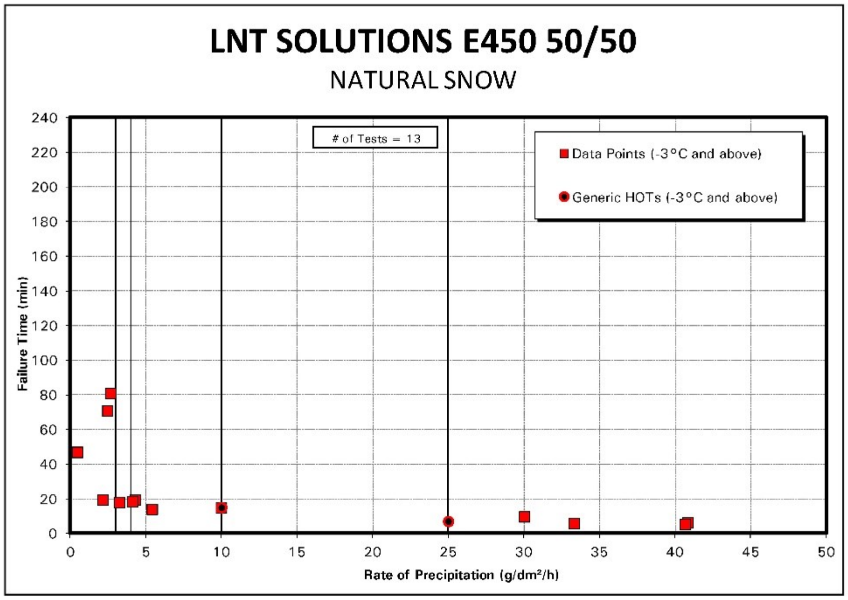


Figure 4.3: Type IV 50/50 – Natural Snow

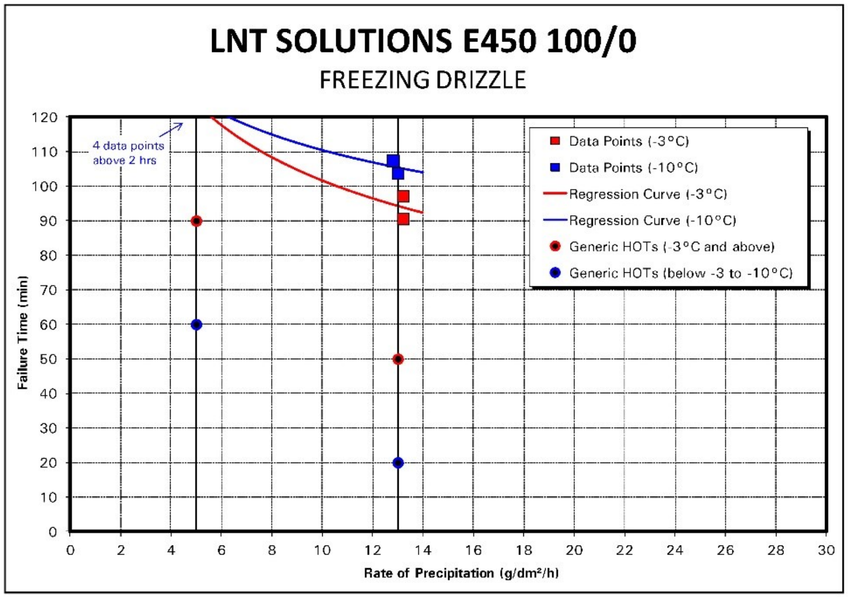


Figure 4.4: Type IV Neat – Freezing Drizzle

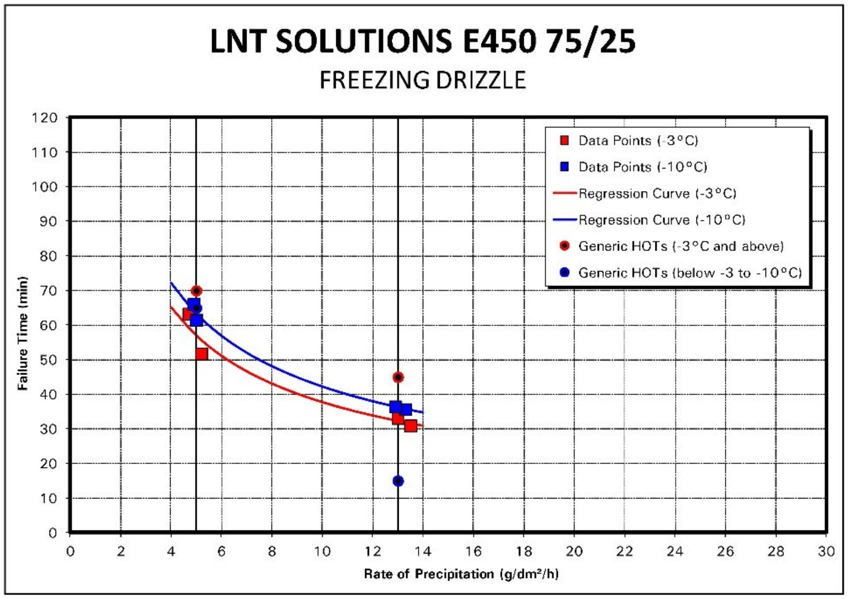


Figure 4.5: Type IV 75/25 – Freezing Drizzle

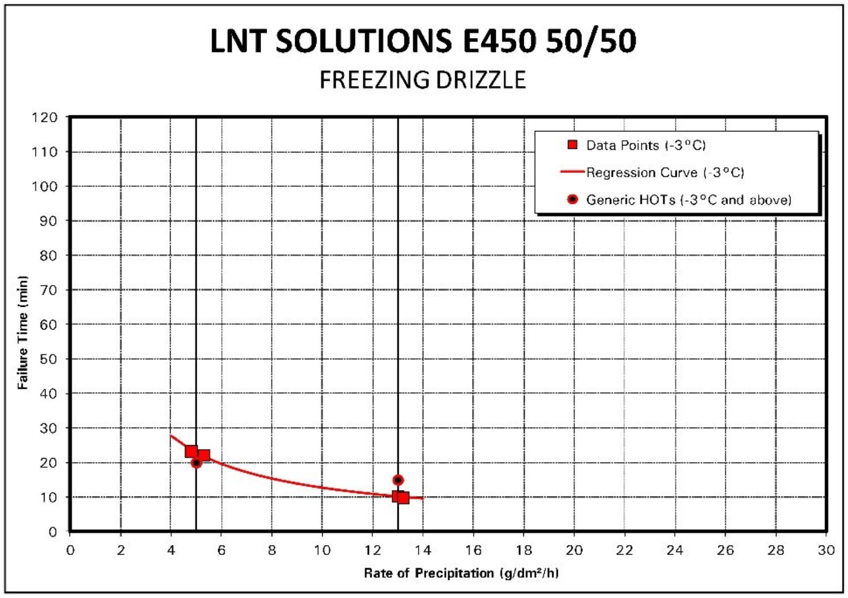


Figure 4.6: Type IV 50/50 – Freezing Drizzle

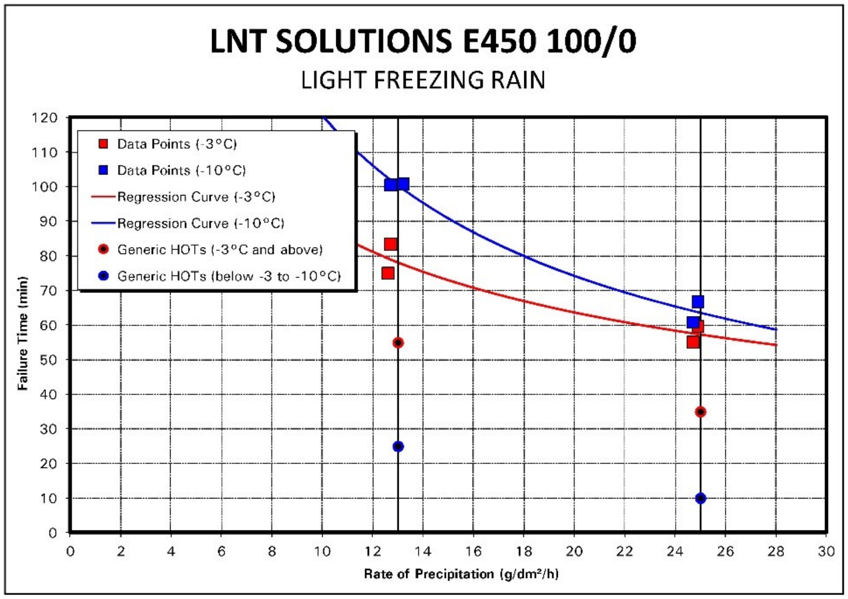


Figure 4.7: Type IV Neat – Light Freezing Rain

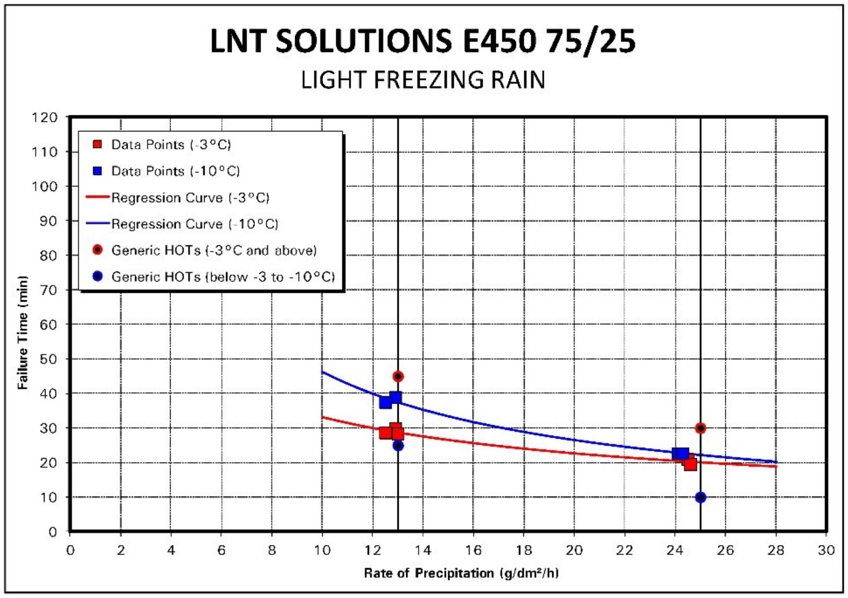


Figure 4.8: Type IV 75/25 – Light Freezing Rain

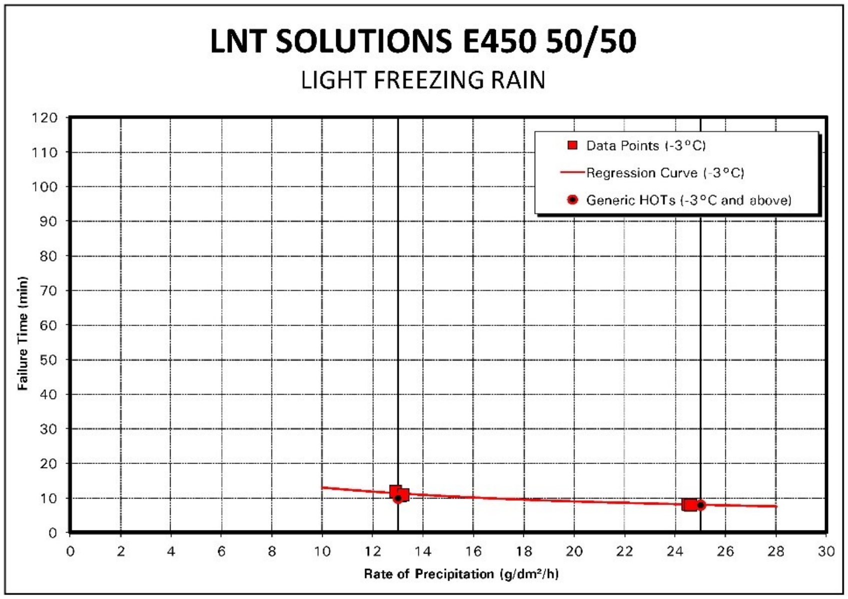


Figure 4.9: Type IV 50/50 – Light Freezing Rain

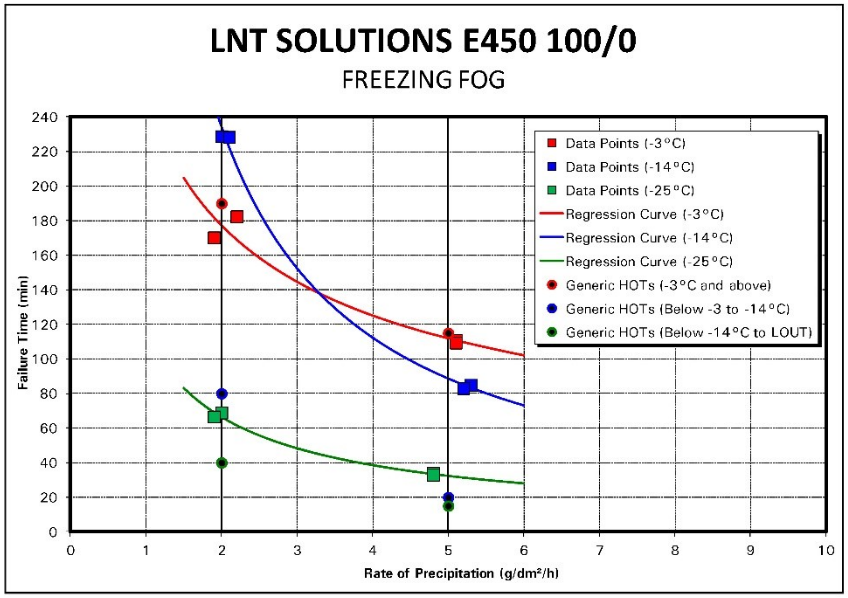


Figure 4.10: Type IV Neat – Freezing Fog

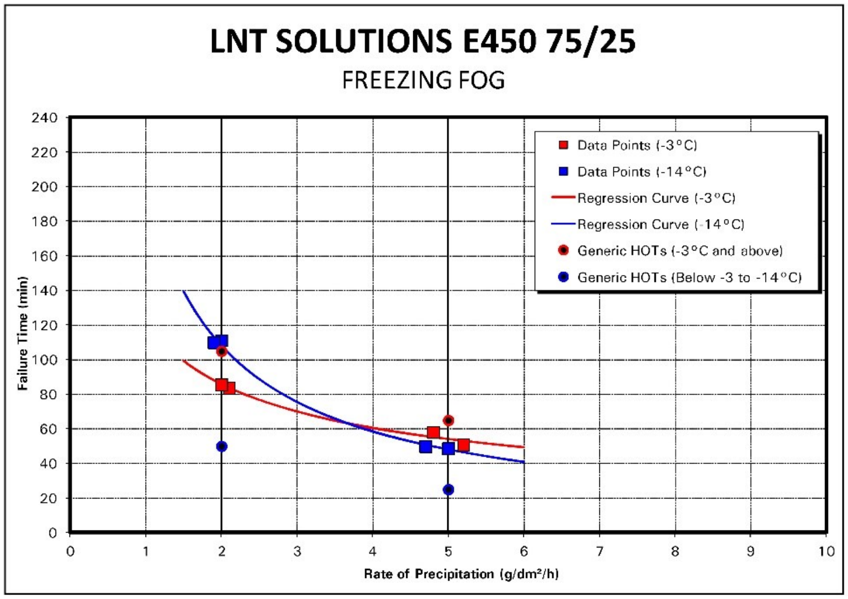


Figure 4.11: Type IV 75/25 – Freezing Fog

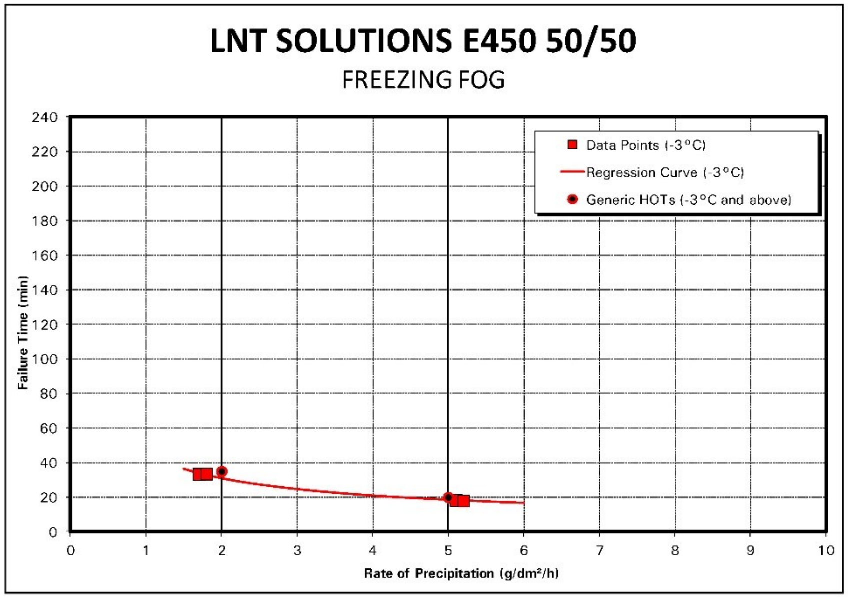


Figure 4.12: Type IV 50/50 – Freezing Fog

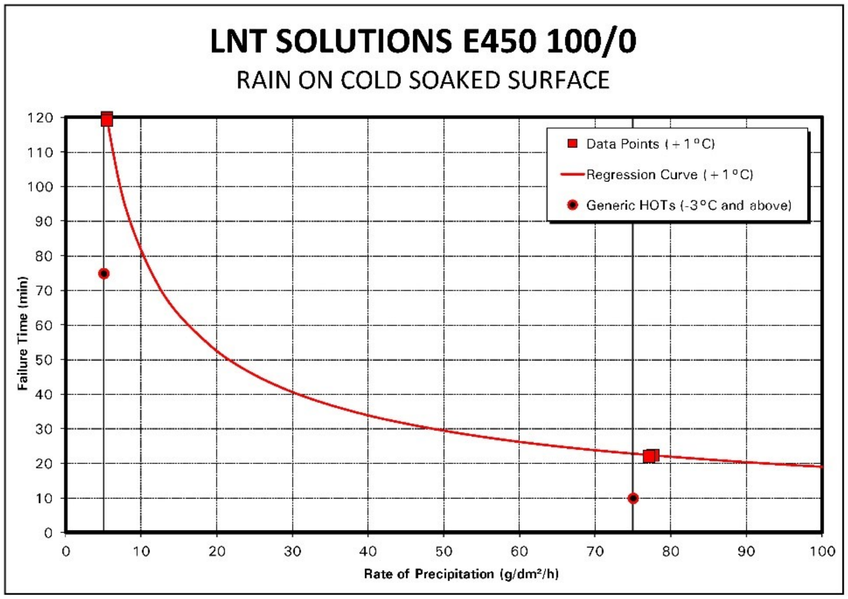


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

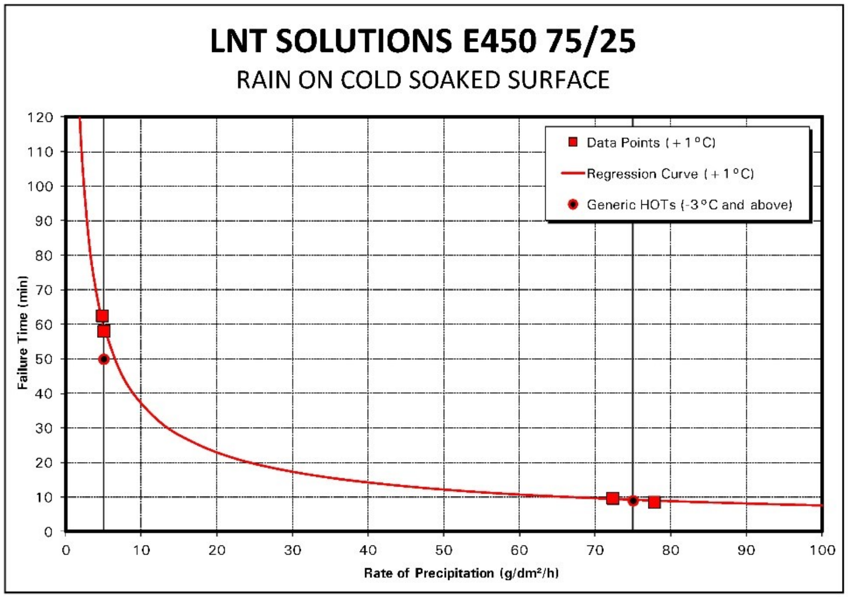


Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

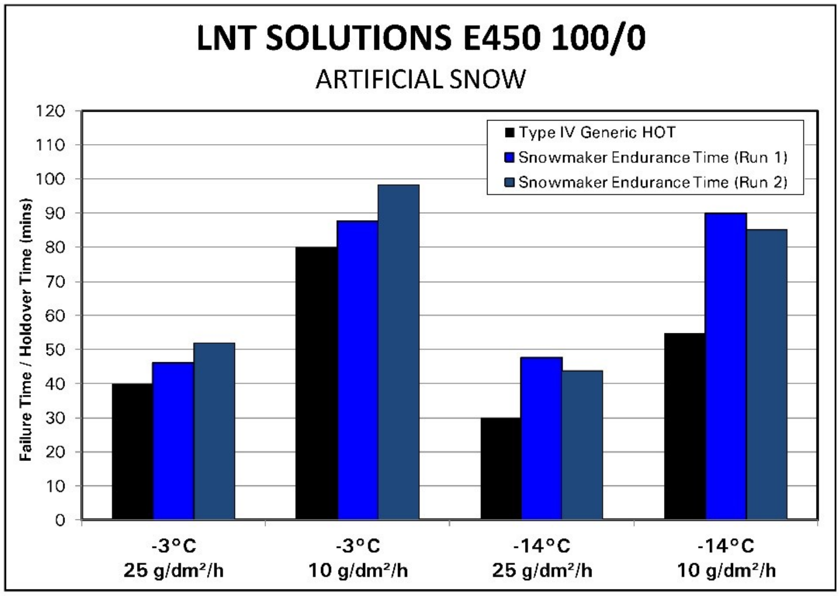


Figure 4.15: Type IV Neat – Artificial Snow

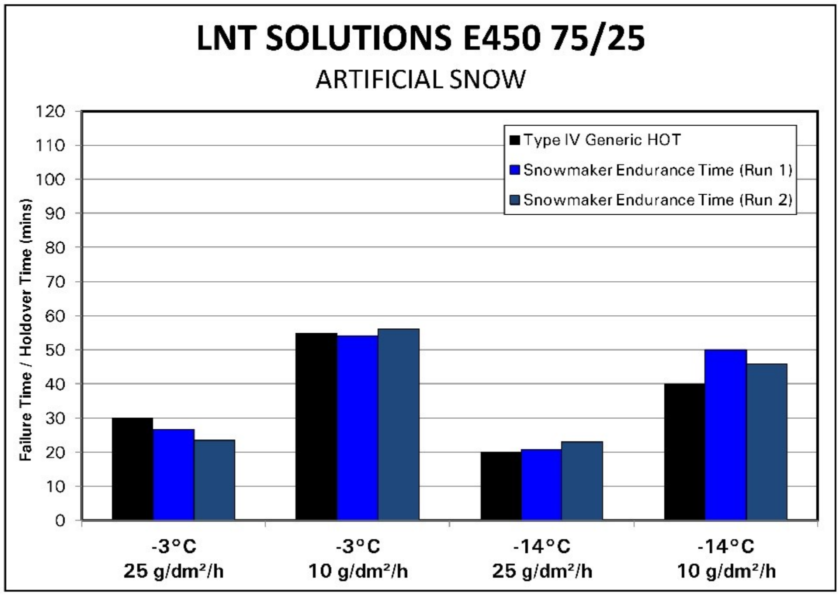


Figure 4.16: Type IV 75/25 – Artificial Snow

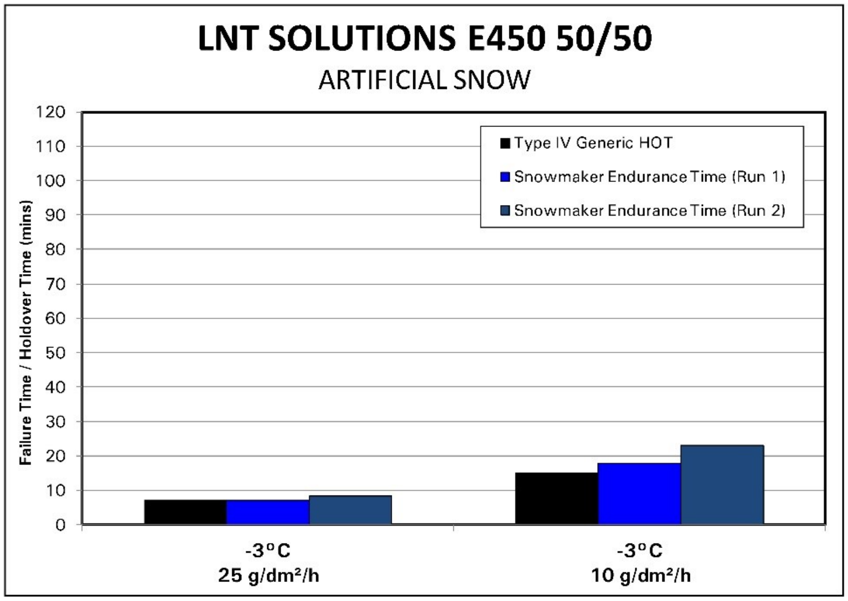


Figure 4.17: Type IV 50/50 – Artificial Snow

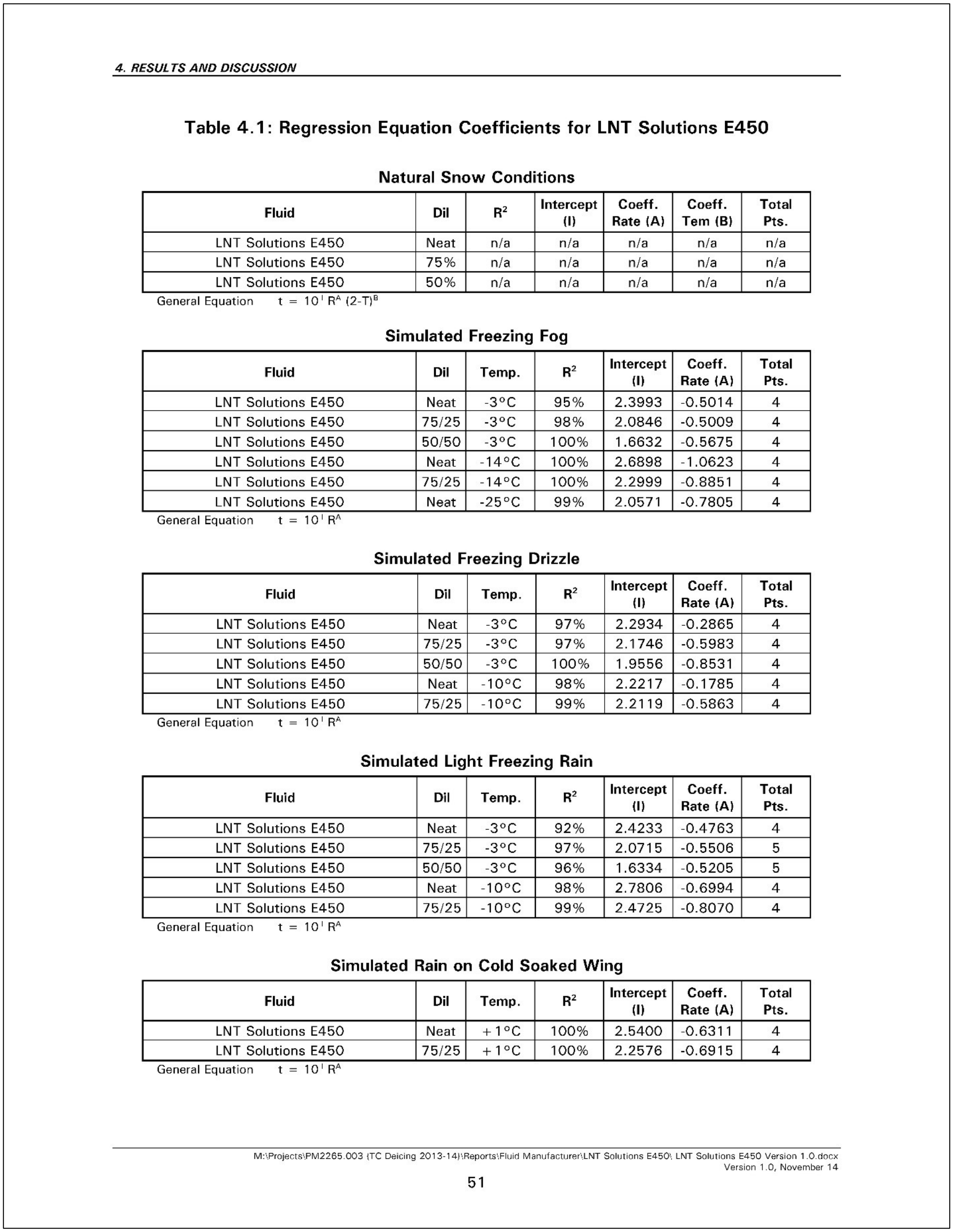


Table 4.1: Regression Equation Coefficients for LNT Solutions E450

Natural Snow Conditions

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
LNT Solutions E450	Neat	n/a	n/a	n/a	n/a	n/a
LNT Solutions E450	75%	n/a	n/a	n/a	n/a	n/a
LNT Solutions E450	50%	n/a	n/a	n/a	n/a	n/a

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

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions E450	Neat	-3°C	95%	2.3993	-0.5014	4
LNT Solutions E450	75/25	-3°C	98%	2.0846	-0.5009	4
LNT Solutions E450	50/50	-3°C	100%	1.6632	-0.5675	4
LNT Solutions E450	Neat	-14°C	100%	2.6898	-1.0623	4
LNT Solutions E450	75/25	-14°C	100%	2.2999	-0.8851	4
LNT Solutions E450	Neat	-25°C	99%	2.0571	-0.7805	4

General Equation $t = 10^{I} R^{A}$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions E450	Neat	-3°C	97%	2.2934	-0.2865	4
LNT Solutions E450	75/25	-3°C	97%	2.1746	-0.5983	4
LNT Solutions E450	50/50	-3°C	100%	1.9556	-0.8531	4
LNT Solutions E450	Neat	-10°C	98%	2.2217	-0.1785	4
LNT Solutions E450	75/25	-10°C	99%	2.2119	-0.5863	4

General Equation $t = 10^{I} R^{A}$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions E450	Neat	-3°C	92%	2.4233	-0.4763	4
LNT Solutions E450	75/25	-3°C	97%	2.0715	-0.5506	5
LNT Solutions E450	50/50	-3°C	96%	1.6334	-0.5205	5
LNT Solutions E450	Neat	-10°C	98%	2.7806	-0.6994	4
LNT Solutions E450	75/25	-10°C	99%	2.4725	-0.8070	4

General Equation $t = 10^{I} R^{A}$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions E450	Neat	+1°C	100%	2.5400	-0.6311	4
LNT Solutions E450	75/25	+1°C	100%	2.2576	-0.6915	4

General Equation $t = 10^{I} R^{A}$

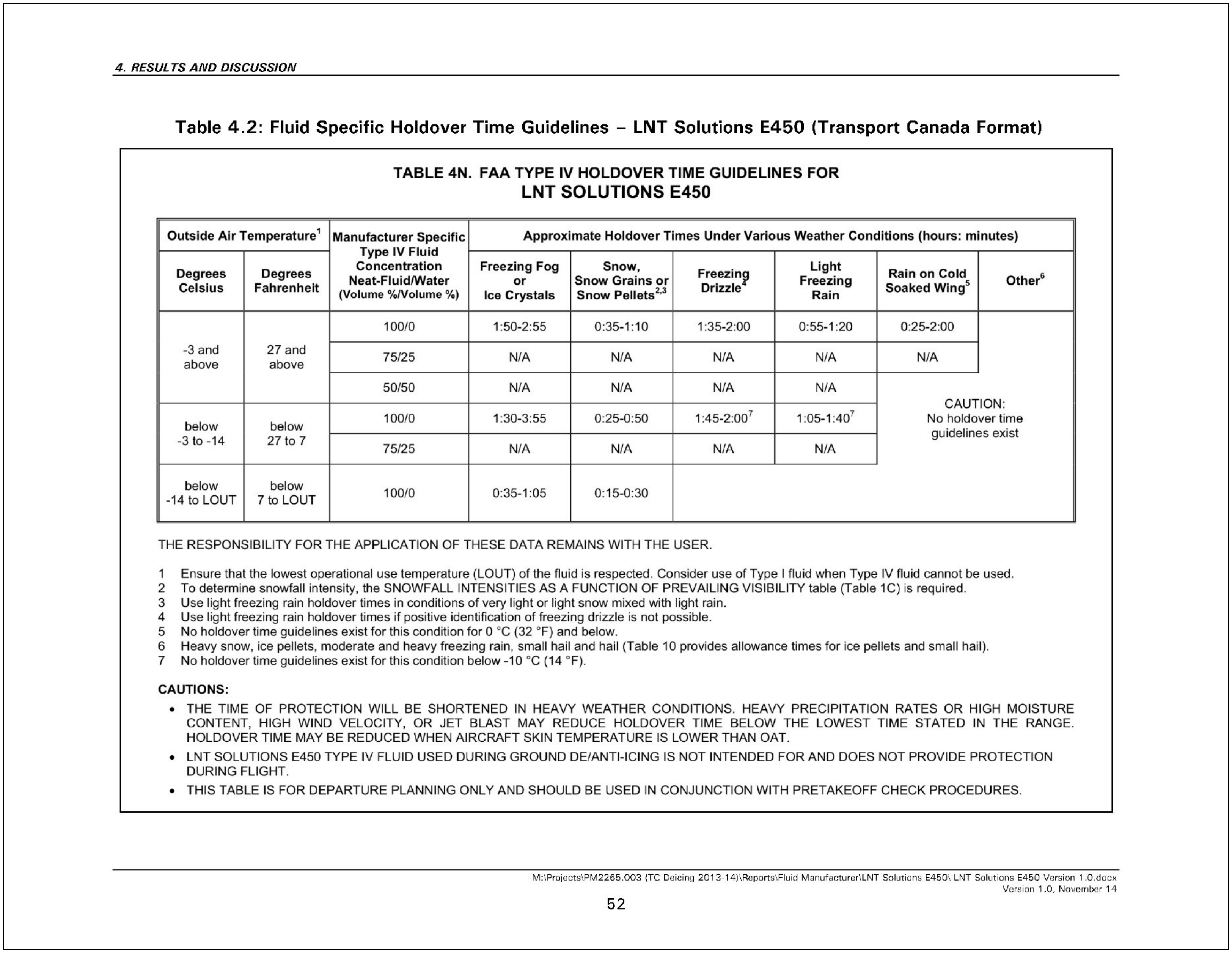


Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions E450 (Transport Canada Format)

TABLE 4N. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
LNT SOLUTIONS E450

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

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- LNT SOLUTIONS E450 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

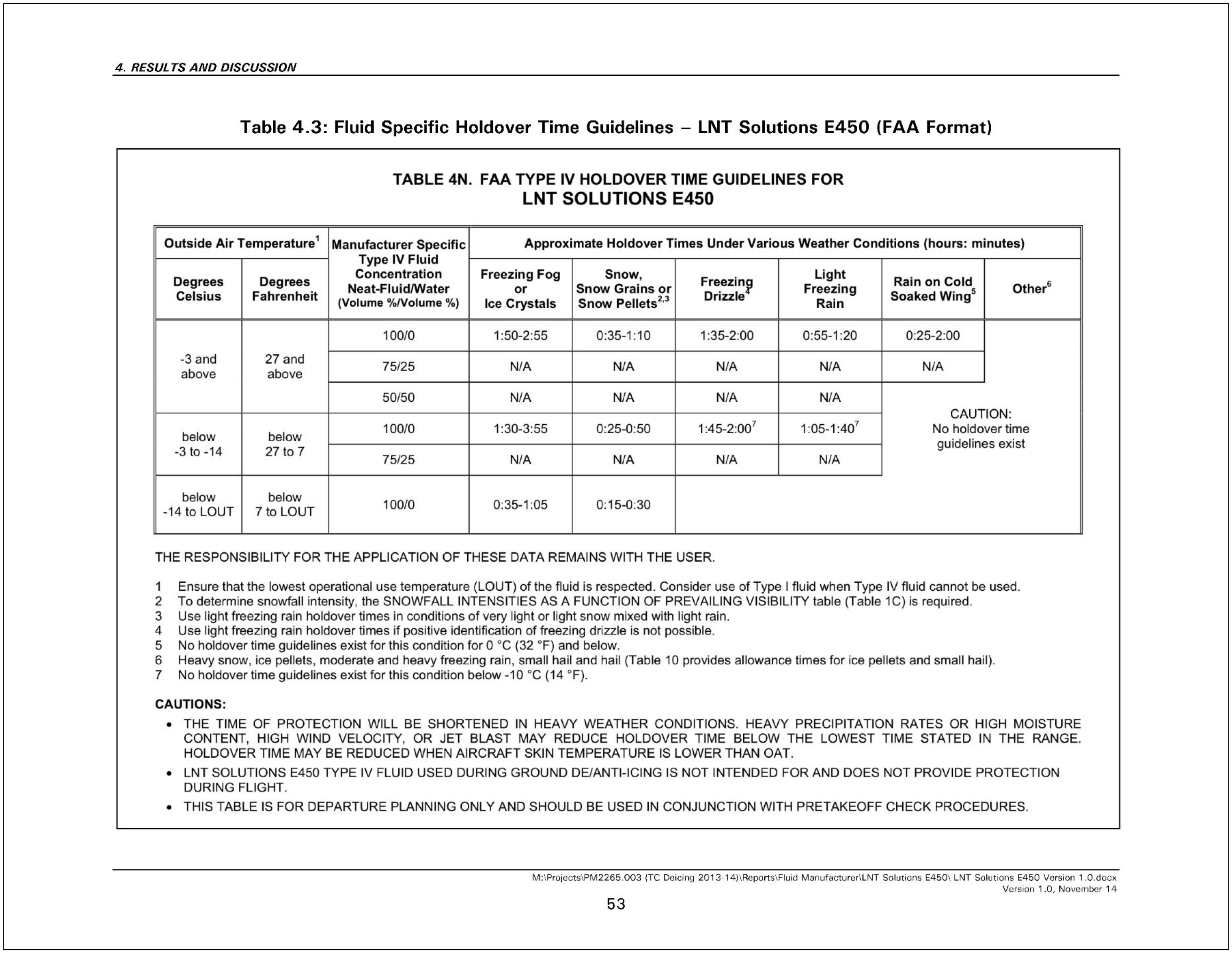


Table 4.3: Fluid Specific Holdover Time Guidelines – LNT Solutions E450 (FAA Format)

TABLE 4N. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS E450

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

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- LNT SOLUTIONS E450 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

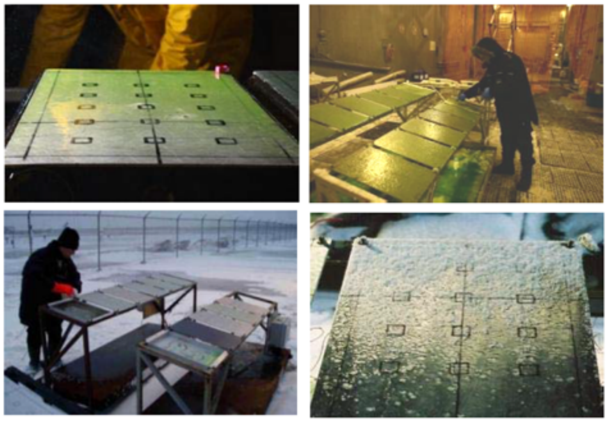
This page intentionally left blank.

APPENDIX G

FLUID MANUFACTURER REPORT:
NEWAVE AEROCHEMICAL FCY 9311 (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Newave Aerochemical FCY 9311 (Type IV)



Prepared for

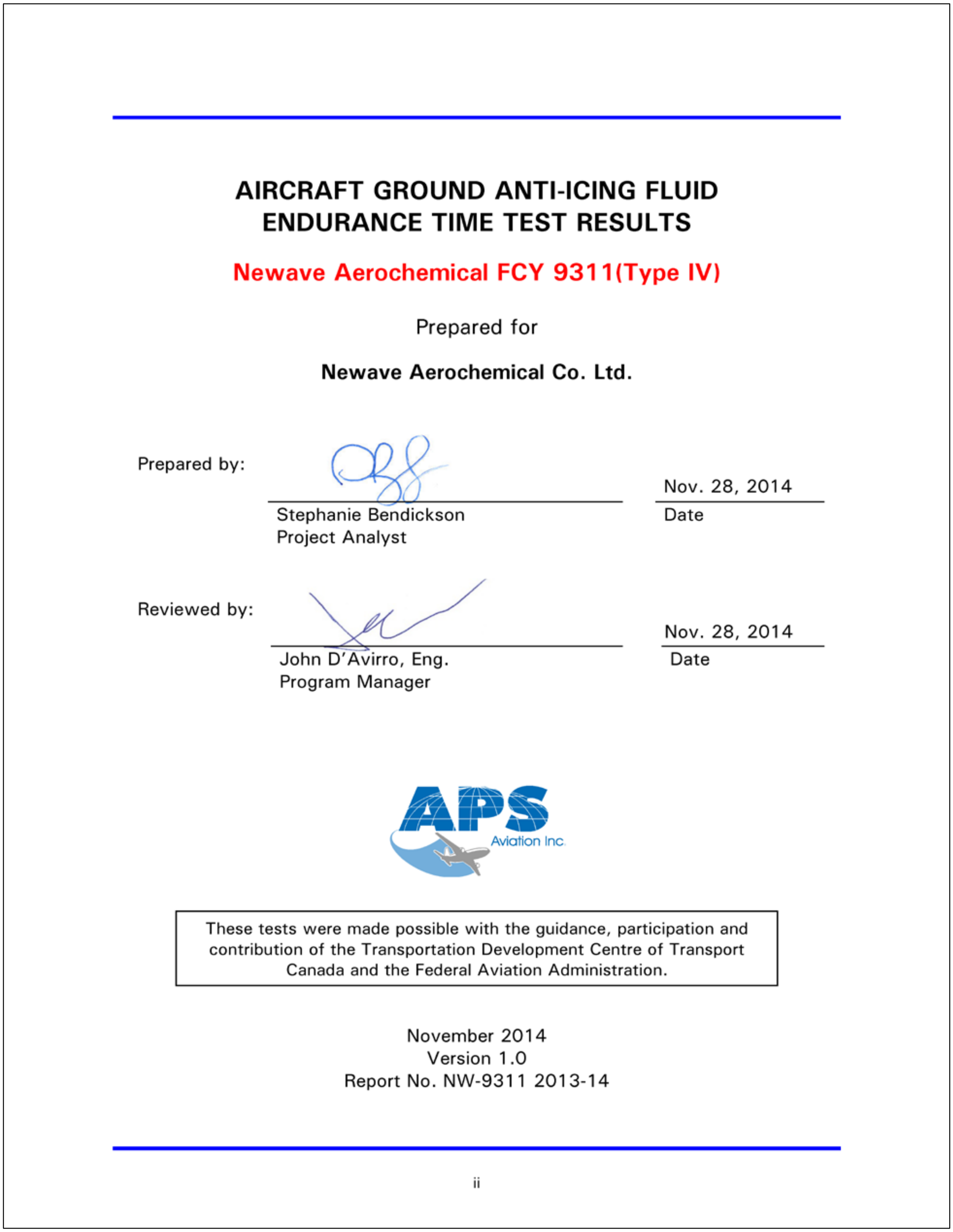
Newave Aerochemical Co. Ltd.

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. NW-9311 2013-14



AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Newave Aerochemical FCY 9311(Type IV)

Prepared for

Newave Aerochemical Co. Ltd.

Prepared by:

Stephanie Bendickson
Project Analyst

Nov. 28, 2014
Date

Reviewed by:

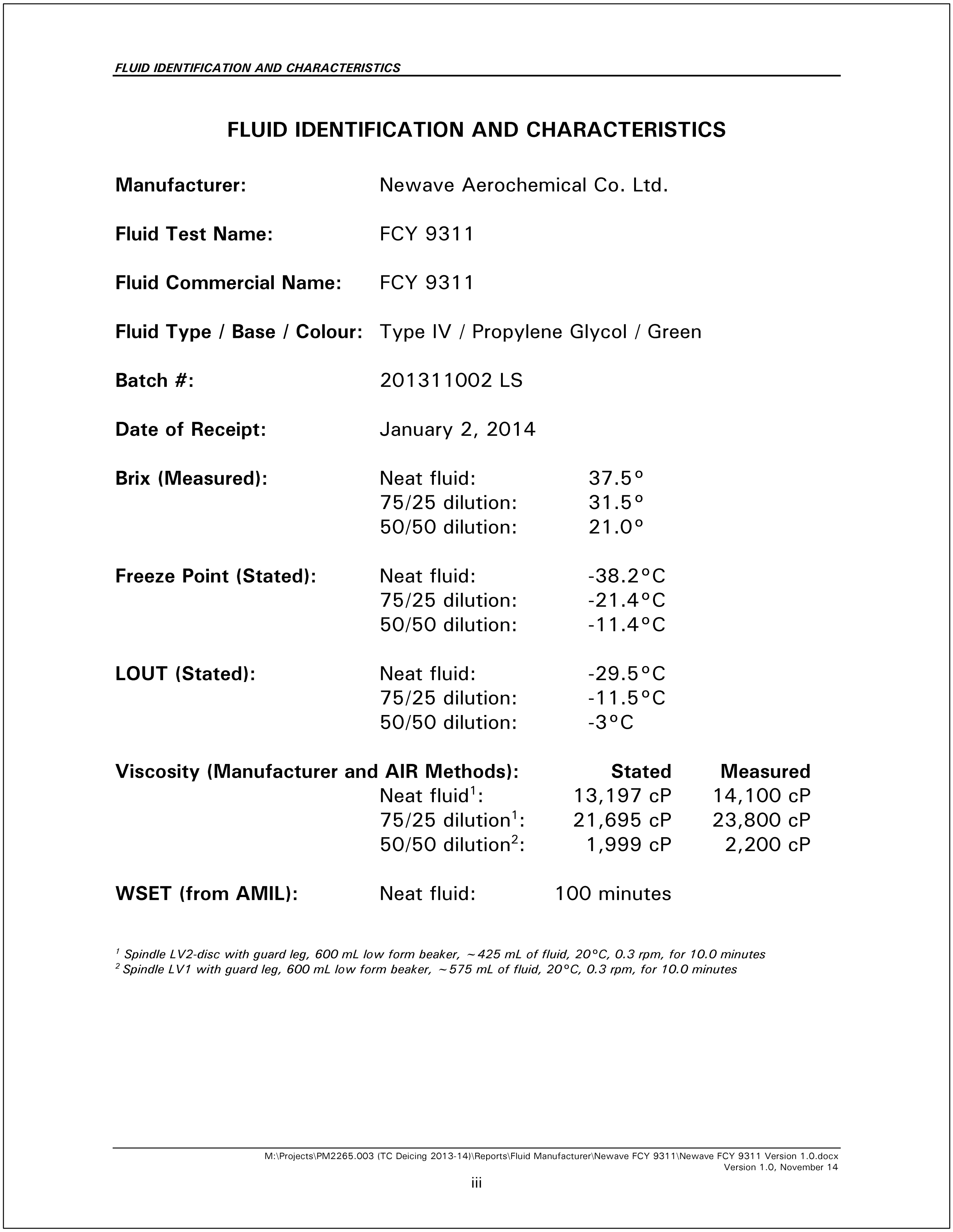
John D'Avirro, Eng.
Program Manager

Nov. 28, 2014
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

November 2014
Version 1.0
Report No. NW-9311 2013-14

ii



FLUID IDENTIFICATION AND CHARACTERISTICS

FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Newave Aerochemical Co. Ltd.	
Fluid Test Name:	FCY 9311	
Fluid Commercial Name:	FCY 9311	
Fluid Type / Base / Colour:	Type IV / Propylene Glycol / Green	
Batch #:	201311002 LS	
Date of Receipt:	January 2, 2014	
Brix (Measured):	Neat fluid:	37.5°
	75/25 dilution:	31.5°
	50/50 dilution:	21.0°
Freeze Point (Stated):	Neat fluid:	-38.2°C
	75/25 dilution:	-21.4°C
	50/50 dilution:	-11.4°C
LOUT (Stated):	Neat fluid:	-29.5°C
	75/25 dilution:	-11.5°C
	50/50 dilution:	-3°C

Viscosity (Manufacturer and AIR Methods):	**Stated**	**Measured**
Neat fluid[1]:	13,197 cP	14,100 cP
75/25 dilution[1]:	21,695 cP	23,800 cP
50/50 dilution[2]:	1,999 cP	2,200 cP

WSET (from AMIL):	Neat fluid:	100 minutes

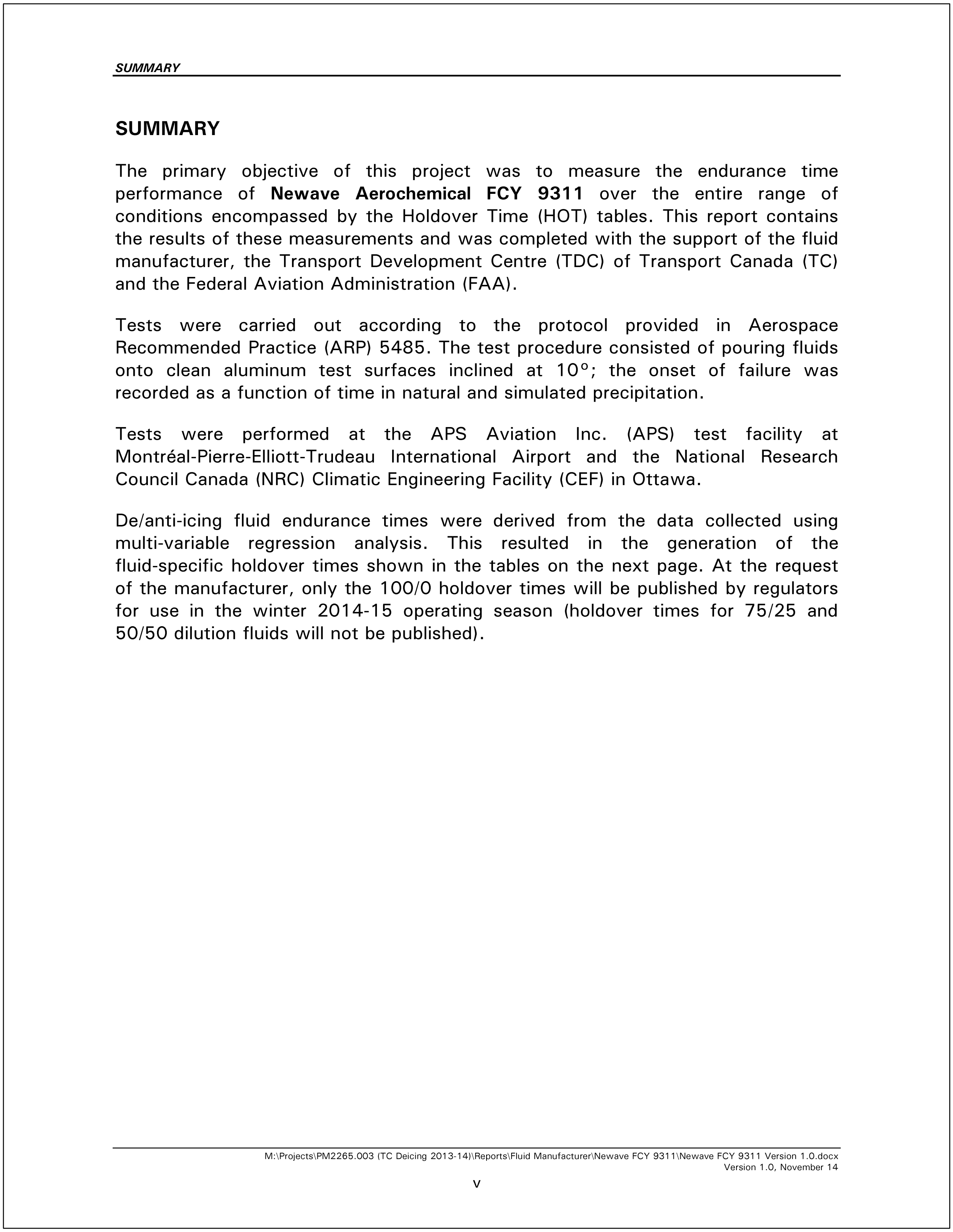
[1] *Spindle LV2-disc with guard leg, 600 mL low form beaker, ~425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*

[2] *Spindle LV1 with guard leg, 600 mL low form beaker, ~575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes*

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Reports\Fluid Manufacturer\Newave FCY 9311\Newave FCY 9311 Version 1.0.docx
Version 1.0, November 14

iii

This page intentionally left blank.



SUMMARY

The primary objective of this project was to measure the endurance time performance of **Newave Aerochemical FCY 9311** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown in the tables on the next page. At the request of the manufacturer, only the 100/0 holdover times will be published by regulators for use in the winter 2014-15 operating season (holdover times for 75/25 and 50/50 dilution fluids will not be published).

Newave Aerochemical FCY 9311 Type IV Fluid Holdover Times (Transport Canada Format)

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume % /Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
				Very Light	Light	Moderate				
-3 and above	27 and above	100/0	1:55-4:00	2:00	1:10-2:00	0:35-1:10	1:10-2:00	0:40-1:05	0:15–1:25	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35	0:50-1:35	0:25-0:50	0:35-1:20	0:20-0:35		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40	0:30-0:40	0:15-0:30				

Newave Aerochemical FCY 9311 Type IV Fluid Holdover Times (FAA Format)

Outside Air Temperature		Type IV Fluid Concentration Neat Fluid/Water (Volume % /Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
				Very Light	Light	Moderate				
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20	0:20-0:35		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40-0:50	0:30-0:40	0:15-0:30				

TABLE OF CONTENTS

Page

1. INTRODUCTION 1
2. METHODOLOGY 3
   - 2.1 Test Sites 3
     - 2.1.1 Natural Snow and Natural Frost 3
     - 2.1.2 Freezing Precipitation 3
   - 2.2 Test Equipment 4
     - 2.2.1 Calibration 4
     - 2.2.2 Environmental Chamber Equipment 4
     - 2.2.3 Test Surface Structures 5
     - 2.2.4 Test Surface Materials 6
     - 2.2.5 Test Stands 6
     - 2.2.6 Collection Pans 6
     - 2.2.7 NRC Sprayer Assembly 8
     - 2.2.8 Fluids 8
   - 2.3 Test Procedures 8
     - 2.3.1 Test Protocol – Natural Snow Tests 8
     - 2.3.2 Test Protocol – Natural Frost Tests 9
     - 2.3.3 Test Protocol – Simulated Precipitation Tests 9
     - 2.3.4 End Condition Definitions 9
     - 2.3.5 Precipitation Rate Measurement Procedures 10
   - 2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 12
     - 2.4.1 Freezing Fog 14
     - 2.4.2 Freezing Drizzle 14
     - 2.4.3 Light Freezing Rain 14
     - 2.4.4 Rain on a Cold-Soaked Surface 14
     - 2.4.5 Snow 14
   - 2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 14
   - 2.6 Freezing Precipitation Droplet Sizes 15
   - 2.7 Summary of Freezing Precipitation Test Conditions 16
   - 2.8 Analysis Methodology 17
     - 2.8.1 Freezing Precipitation Data 17
     - 2.8.2 Natural Snow Data 18
     - 2.8.3 Natural Frost Data 18
     - 2.8.4 Rounding and Capping Protocols 19
     - 2.8.5 Regression Example 19
     - 2.8.6 Lowest Usable Precipitation Rates in Snow 21
3. DESCRIPTION OF DATA 29
   - 3.1 Natural Snow Tests 29
   - 3.2 Freezing Drizzle and Light Freezing Rain Tests 29
   - 3.3 Freezing Fog Tests 30
   - 3.4 Rain on Cold-Soaked Surface Tests 30
   - 3.5 Natural Frost Tests 30
   - 3.6 Fluid Thickness Tests 31
4. RESULTS AND DISCUSSION 37
   - 4.1 Natural Snow and Freezing Precipitation 37

4.2 Natural Frost 37
4.3 Holdover Time Table 37
  4.3.1 Holdover Times in Snow, Below -14°C to LOUT 37
  4.3.2 Holdover Times in Frost 38
  4.3.3 Fluid Viscosity 38
4.4 Lowest Usable Precipitation Rates in Snow 38
4.5 Discussion 38

LIST OF FIGURES Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 6
Figure 2.4: Test Stand Setup Schematic 7
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 12
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 13
Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 20
Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain....................20
Figure 3.1: Fluid Thickness Profiles of Newave Aerochemical FCY 9311 31
Figure 3.2: Final Fluid Thickness of Newave Aerochemical FCY 9311....................31
Figure 4.1: Type IV Neat – Natural Snow....................39
Figure 4.2: Type IV 75/25 – Natural Snow....................39
Figure 4.3: Type IV 50/50 – Natural Snow....................40
Figure 4.4: Type IV Neat – Freezing Drizzle 40
Figure 4.5: Type IV 75/25 – Freezing Drizzle 41
Figure 4.6: Type IV 50/50 – Freezing Drizzle 41
Figure 4.7: Type IV Neat – Light Freezing Rain 42
Figure 4.8: Type IV 75/25 – Light Freezing Rain 42
Figure 4.9: Type IV 50/50 – Light Freezing Rain 43
Figure 4.10: Type IV Neat – Freezing Fog 43
Figure 4.11: Type IV 75/25 – Freezing Fog 44
Figure 4.12: Type IV 50/50 – Freezing Fog 44
Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface 45
Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface 45

LIST OF TABLES Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 15
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 17
Table 2.4: LUPR Factor Scoring System....................22
Table 3.1: Summary of Tests Performed (Snow) 32
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 34
Table 3.3: Summary of Tests Performed (Natural Frost) 36
Table 4.1: Regression Equation Coefficients for Newave Aerochemical FCY 9311 46
Table 4.2: Fluid Specific Holdover Time Guidelines – Newave Aerochemical FCY 9311 (Transport Canada Format)....................47
Table 4.3: Fluid Specific Holdover Time Guidelines – Newave Aerochemical FCY 9311 (FAA Format) 48
Table 4.4: LUPR Statistics – Newave Aerochemical FCY 9311 49

LIST OF PHOTOS Page

Photo 2.1: APS Test Site - View from Test Pad 23
Photo 2.2: APS Test Site - View from Trailer 23
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 24
Photo 2.4: Inside View of NRC Climatic Engineering Facility 24
Photo 2.5: Test Plates Mounted on Stand 25
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 25
Photo 2.7: Frost Plate with Insulated Backing 26
Photo 2.8: Collection Pans Used Indoors at the NRC 26
Photo 2.9: Sprayer Assembly 27
Photo 2.10: Sprayer Assembly in Use 27
Photo 2.11: Sprayer Nozzle 28

GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

This page intentionally left blank.

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Newave Aerochemical FCY 9311**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

This page intentionally left blank.

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type II/IV endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type II/IV endurance time data.

2.1 Test Sites

2.1.1 Natural Snow and Natural Frost

Natural snow and natural frost testing is typically performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport.

The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

In winter 2013-14, additional natural snow testing was conducted in Ottawa, Ontario.

2.1.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC Climatic Engineering Facility (CEF), where precipitation was artificially produced.

Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

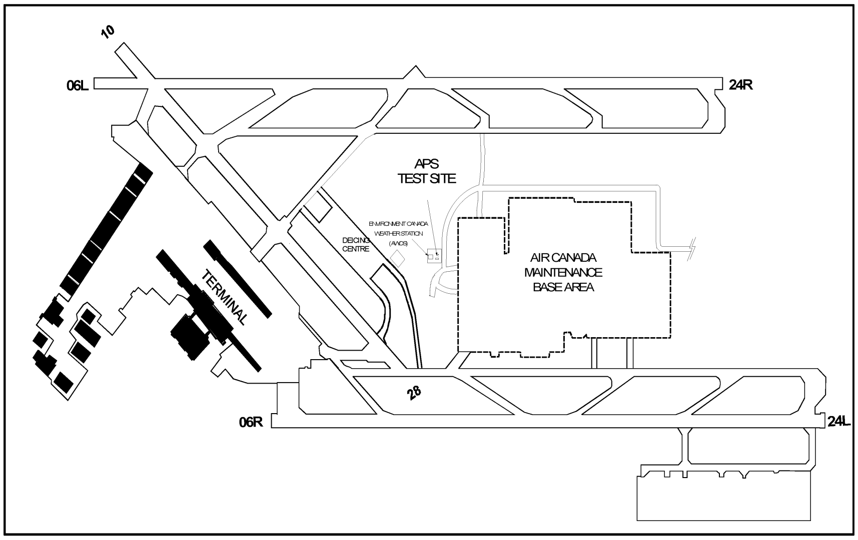


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

2.2 Test Equipment

The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

2.2.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

2.2.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5485.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1”), 15 cm (6”) and 30 cm (12”) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 2.3.4) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests.

In natural frost, tests are conducted on frosticator plates, which are the current standard test surface used in frost holdover time testing. The frosticator plates were constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 2.7 shows a white-painted aluminum frosticator plate.

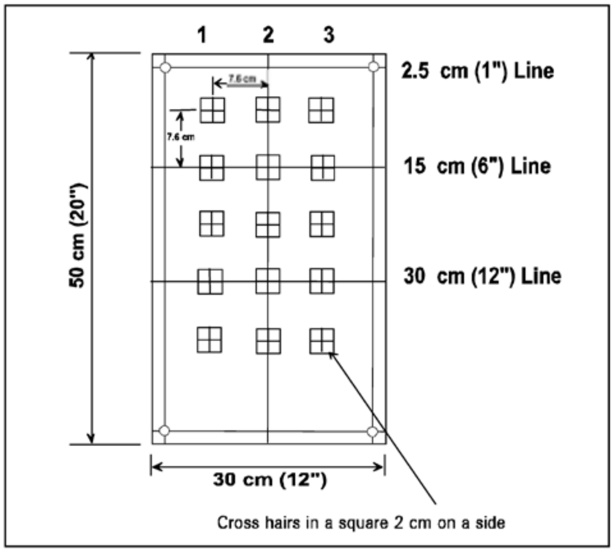


Figure 2.2: Standard Test Plate Schematic

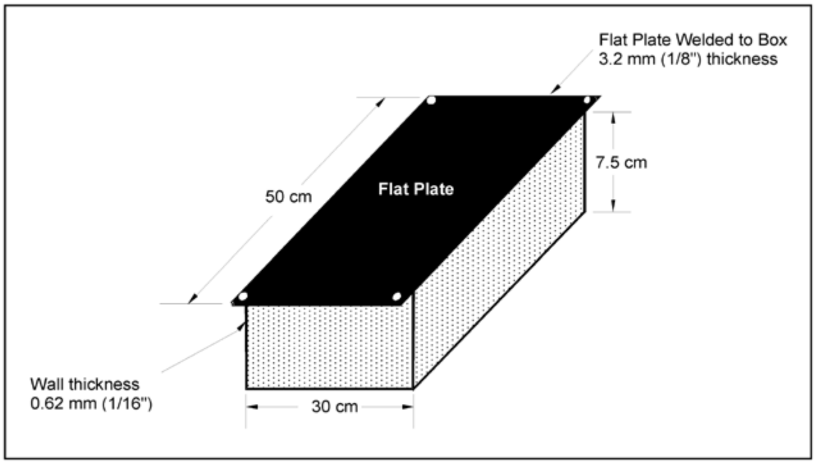


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Testing of Type II, III and IV fluids is carried out exclusively on aluminum surfaces. The aluminum used is 0.32 cm thick Alclad 2024 T3 aluminum.

2.2.5 Test Stands

Figure 2.4 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

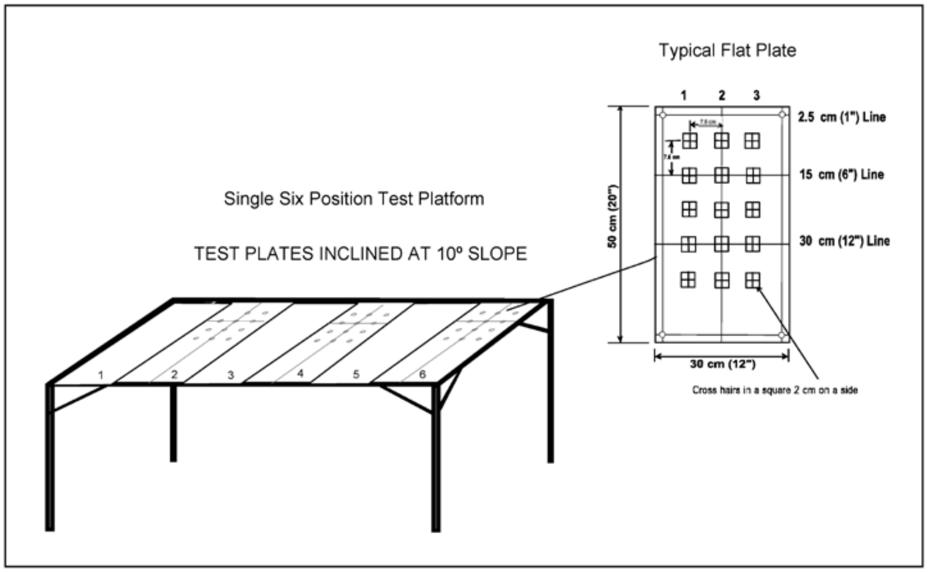


Figure 2.4: Test Stand Setup Schematic

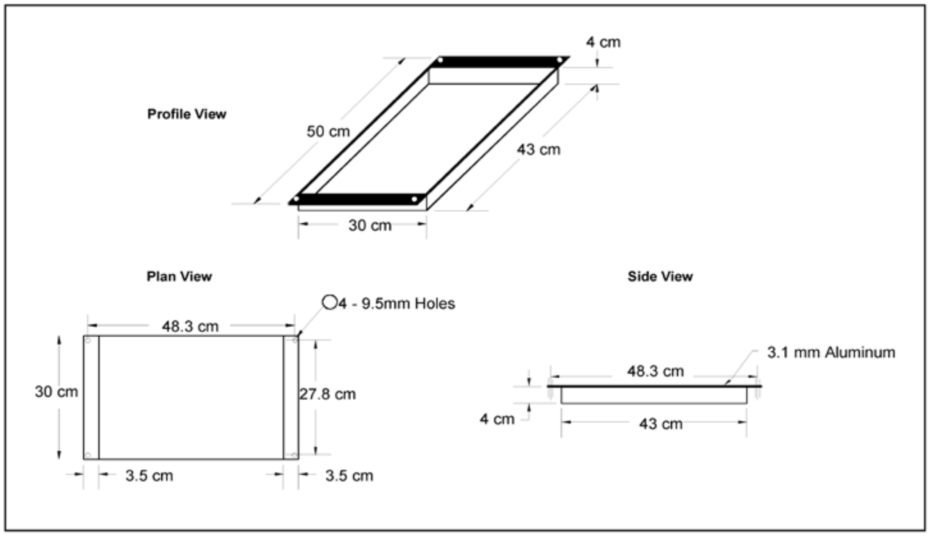
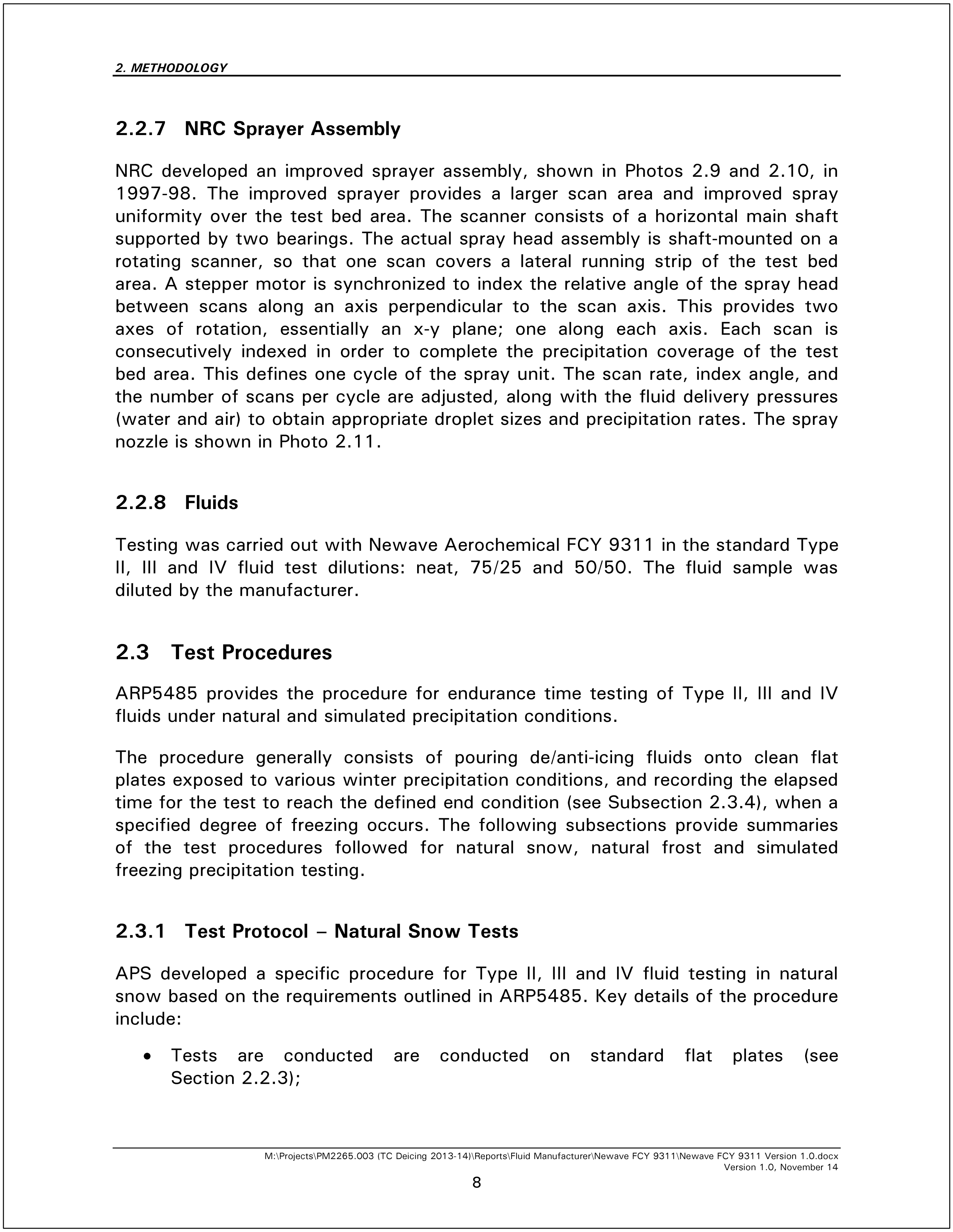


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan



2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 2.11.

2.2.8 Fluids

Testing was carried out with Newave Aerochemical FCY 9311 in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

ARP5485 provides the procedure for endurance time testing of Type II, III and IV fluids under natural and simulated precipitation conditions.

The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 2.3.4), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, natural frost and simulated freezing precipitation testing.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type II, III and IV fluid testing in natural snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted are conducted on standard flat plates (see Section 2.2.3);

- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – Natural Frost Tests

APS developed a specific procedure for Type II/III/IV testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type II/III/IV testing in simulated precipitation based on the requirements outlined in ARP5485. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

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

2.3.5 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.5.1 Simulated precipitation conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, then the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

2.3.5.2 Natural precipitation conditions

Two rate collection pans per test stand are used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand has failed.

The rate for any HOT test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 2.6 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \text{ x } t_1 + R_2 \text{ x } t_2 + R_3 \text{ x } t_3)}{t_1 + t_2 + t_3}$$

In the example shown in Figure 2.6, the rate is calculated as follows:

$$\frac{(25 \text{ x } 10 + 22 \text{ x } 8 + 34 \text{ x } 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

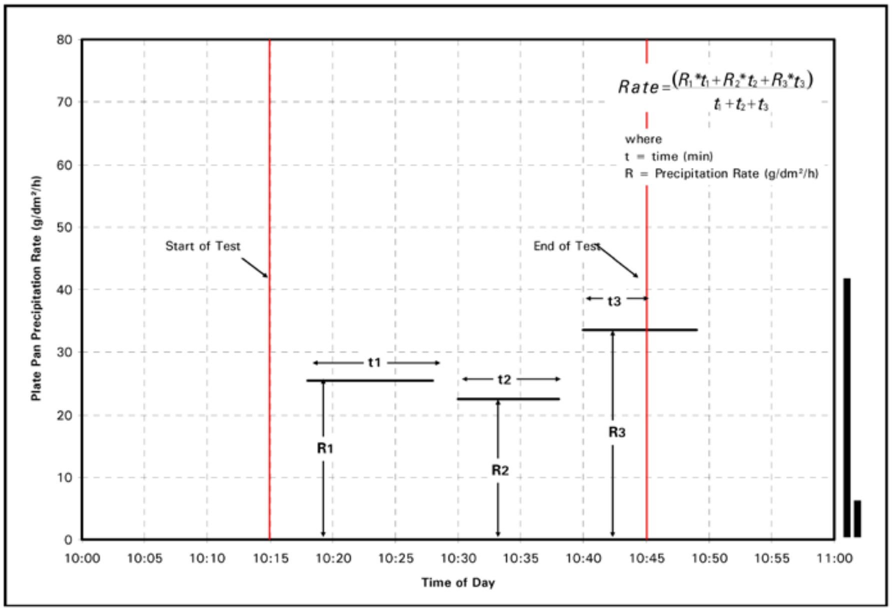


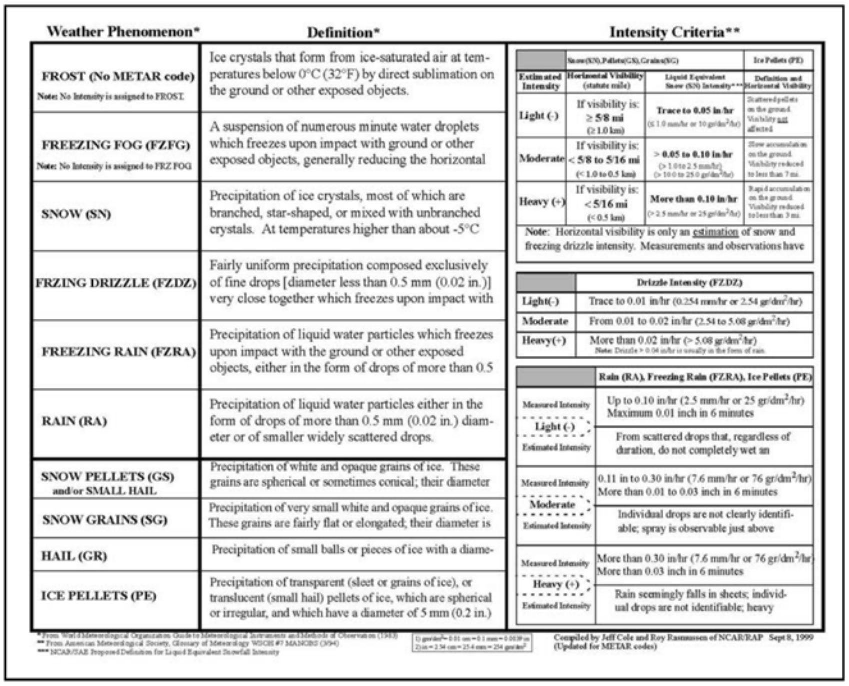
Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS*) (3/94).

The precipitation rate limits established for Type II/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/IV endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 2.1.

Table 2.1: Definition of Weather Phenomenon



Weather Phenomenon*	Definition*
FROST (No METAR code) Note: No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) Note: No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (SN) Intensity***	**Definition and Horizontal Visibility**
Light (-)	If visibility is: **≥ 5/8 mi** (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm/hr or 10 gr/dm²/hr)	Scattered pellets on the ground. Visibility not affected.
Moderate	If visibility is: **< 5/8 to 5/16 mi** (< 1.0 to 0.5 km)	**> 0.05 to 0.10 in/hr** (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: **< 5/16 mi** (< 0.5 km)	**More than 0.10 in/hr** (> 2.5 mm/hr or 25 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.

Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) Note: Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm²/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gr/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gr/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999
(Updated for METAR codes)

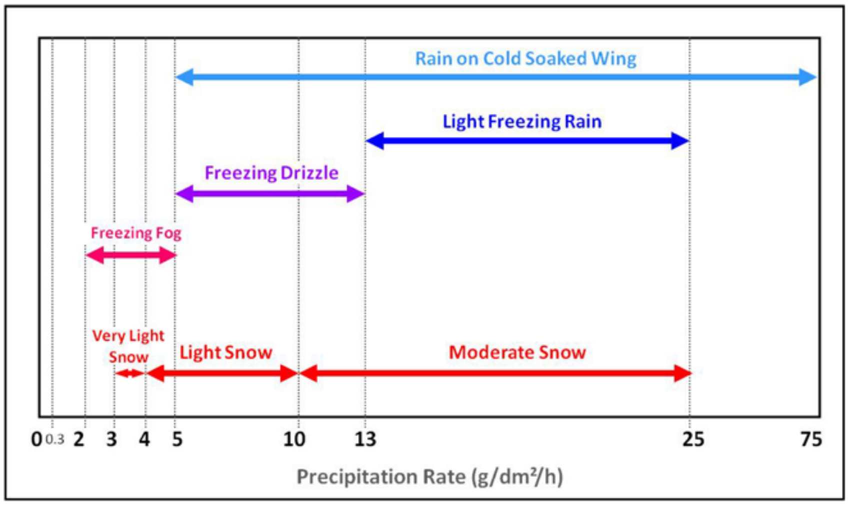


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

2.4.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.

2.4.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

2.4.4 Rain on a Cold-Soaked Surface

The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 g/dm^2/h. These rate limits encompass very light, light and moderate snow.

2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:

- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -25°C
- Freezing Drizzle: -3°C and -10°C
- Light Freezing Rain: -3°C and -10°C
- Rain on Cold Soaked Surface: +1°C

2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

- MVD = (precipitation rate/10) $^{0.23}$, where MVD is in mm and rate of precipitation is in g/dm^2/h

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm^2/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm^2/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm^2/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm^2/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm^2/h)	0.35	< 0.5
Fog		< 0.1

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below:

a) *For the outdoor test:*

Location:	Montreal P.E.T. Airport
Precipitation:	Natural Light Freezing Rain
Precipitation Rate:	20 g/dm^2/h
Calibrated MVD:	1.0 mm

b) *For the indoor test:*

Location:	National Research Council
Precipitation:	Simulated Light Freezing Rain
Precipitation Rate:	25 g/dm^2/h
Calibrated MVD:	1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation.
As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm^2/h): 30 μm
- Freezing Fog, low precipitation rate (2 g/dm^2/h): 30 μm

- Freezing Drizzle, high precipitation rate (13 g/dm^2/h): 350 μm
- Freezing Drizzle, low precipitation rate (5 g/dm^2/h): 250 μm

- Light Freezing Rain, high precipitation rate (25 g/dm^2/h): 1,000 μm
- Light Freezing Rain, low precipitation rate (13 g/dm^2/h): 1,000 μm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm^2/h): 250 μm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm^2/h): 1,400 μm

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/IV fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 16 weather conditions listed in Table 2.3.

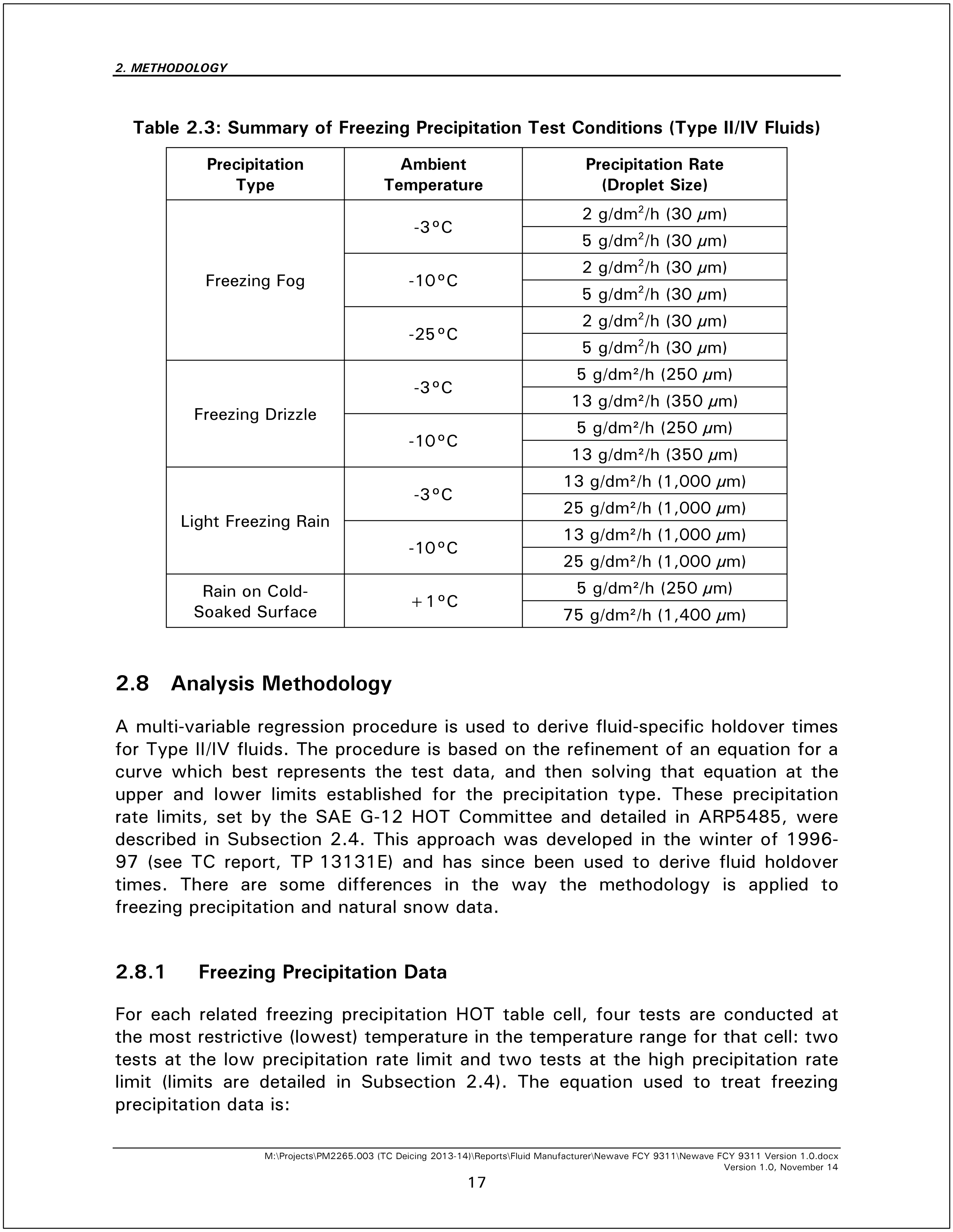


Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-10°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-25°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
Freezing Drizzle	-3°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
	-10°C	5 g/dm^2/h (250 μm)
		13 g/dm^2/h (350 μm)
Light Freezing Rain	-3°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
	-10°C	13 g/dm^2/h (1,000 μm)
		25 g/dm^2/h (1,000 μm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm^2/h (250 μm)
		75 g/dm^2/h (1,400 μm)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/IV fluids. The procedure is based on the refinement of an equation for a curve which best represents the test data, and then solving that equation at the upper and lower limits established for the precipitation type. These precipitation rate limits, set by the SAE G-12 HOT Committee and detailed in ARP5485, were described in Subsection 2.4. This approach was developed in the winter of 1996-97 (see TC report, TP 13131E) and has since been used to derive fluid holdover times. There are some differences in the way the methodology is applied to freezing precipitation and natural snow data.

2.8.1 Freezing Precipitation Data

For each related freezing precipitation HOT table cell, four tests are conducted at the most restrictive (lowest) temperature in the temperature range for that cell: two tests at the low precipitation rate limit and two tests at the high precipitation rate limit (limits are detailed in Subsection 2.4). The equation used to treat freezing precipitation data is:

- $t = 10^{I}R^{a}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.42.8.4.

2.8.2 Natural Snow Data

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural snow tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather data under all temperatures and precipitation rates encompassed by the HOT tables.

The general form of the regression equation is modified for natural snow to incorporate the variable of temperature and also to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C. The equation used to treat natural snow data is:

- $t = 10^{I} R^{a} (2\text{-}T)^{b}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.4.

2.8.3 Natural Frost Data

Regression analysis is not used in the determination of frost holdover times. The current Type II/III/IV generic frost holdover times were determined based on several years of testing using all fluids which were commercially available at the time. A “minimum values” analysis methodology was used to determine appropriate holdover times from the test data.

The purpose of natural frost testing with new fluids is to verify the fluids can be used with the generic frost holdover times. The analysis methodology is to compare the frost test data collected with the new fluid to the current generic holdover times. If the test data provides holdover times equal to or greater than the generic holdover times then the generic holdover times have been validated for the new fluid.

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural frost tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather several data points with each fluid/dilution.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: Holdover times are rounded to the nearest whole "5" minute, i.e. 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 to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: All holdover time values are capped at maximum values. The caps differ by precipitation type, and in the case of snow, by regulator. The caps are as follows:
    - Freezing Fog holdover time values are capped at 4 hours;
    - Freezing Drizzle, Light Freezing Rain, Rain on Cold Soaked Wing holdover times are capped at 2 hours; and
    - Snow holdover times are capped at 2 hours by Transport Canada and 3 hours by FAA.

2.8.5 Regression Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.8. The plots contain data for one Neat Type IV fluid, in one temperature range (-10°C), in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.9. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The HOT range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

The holdover times for this fluid at -10°C are 20 minutes at 13 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the HOT range for this particular fluid in the light freezing rain, neat fluid, below -3 to -10°C cell. This illustrates the general approach used in the determination of a fluid HOT range for any given cell in the HOT table.

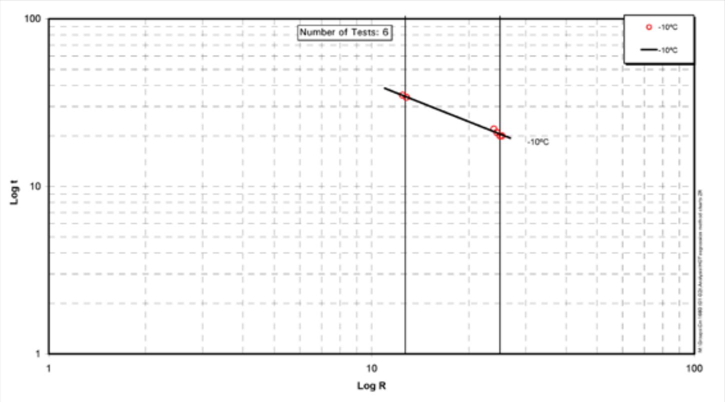


Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

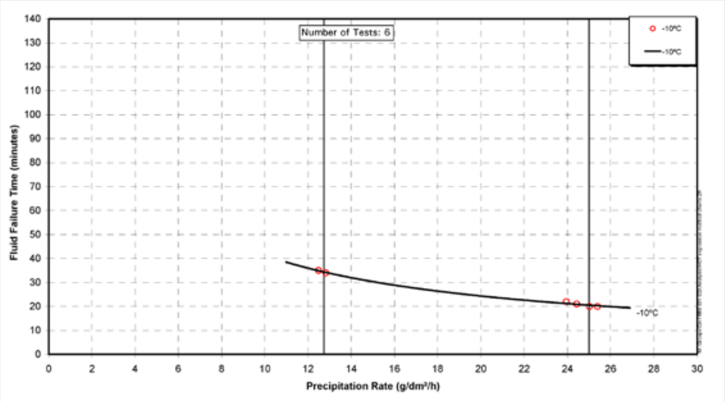


Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

2.8.6 Lowest Usable Precipitation Rates in Snow

A detailed analysis methodology was developed to determine if a snow data set is sufficient to determine holdover times for light and very light snow. Specifically, the analysis determines the lowest usable precipitation rate (LUPR), which is the lowest rate at which the data set is considered robust.

The methodology is a five-factor weighted analysis. The five factors are:

1. Total number of data points;
2. Number of data points with air temperatures below -3°C;
3. Number of data points with precipitation rates below 10 g/dm²/h;
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined; and
5. Scatter from regression curve of low precipitation rate data points (average absolute percent difference between fail time and regression calculated fail time for all points less than or equal to 10 g/dm²/h).

The weights given to each of the five factors are:

1. Total Data Points = 5%;
2. Data Points Below -3°C = 20%;
3. Data Points Below 10 g/dm²/h = 20%;
4. Data Points ≤ Precipitation Rate = 40%; and
5. Low Rate Data Scatter = 15%.

Each data set is given a score of 0, 10, 20, 30 or 40 for each factor. The scoring system is shown in Table 2.4.

This approach provides a score for each data set for each precipitation rate below 10 g/dm²/h. The scores are compared to the minimum acceptance scores:

- 100/0 = 28
- 75/25 = 28
- 50/50 = 19 (lower due to a 0 score for data points below -3°C)

The LUPR is the lowest precipitation rate at which a data set has a passing score.

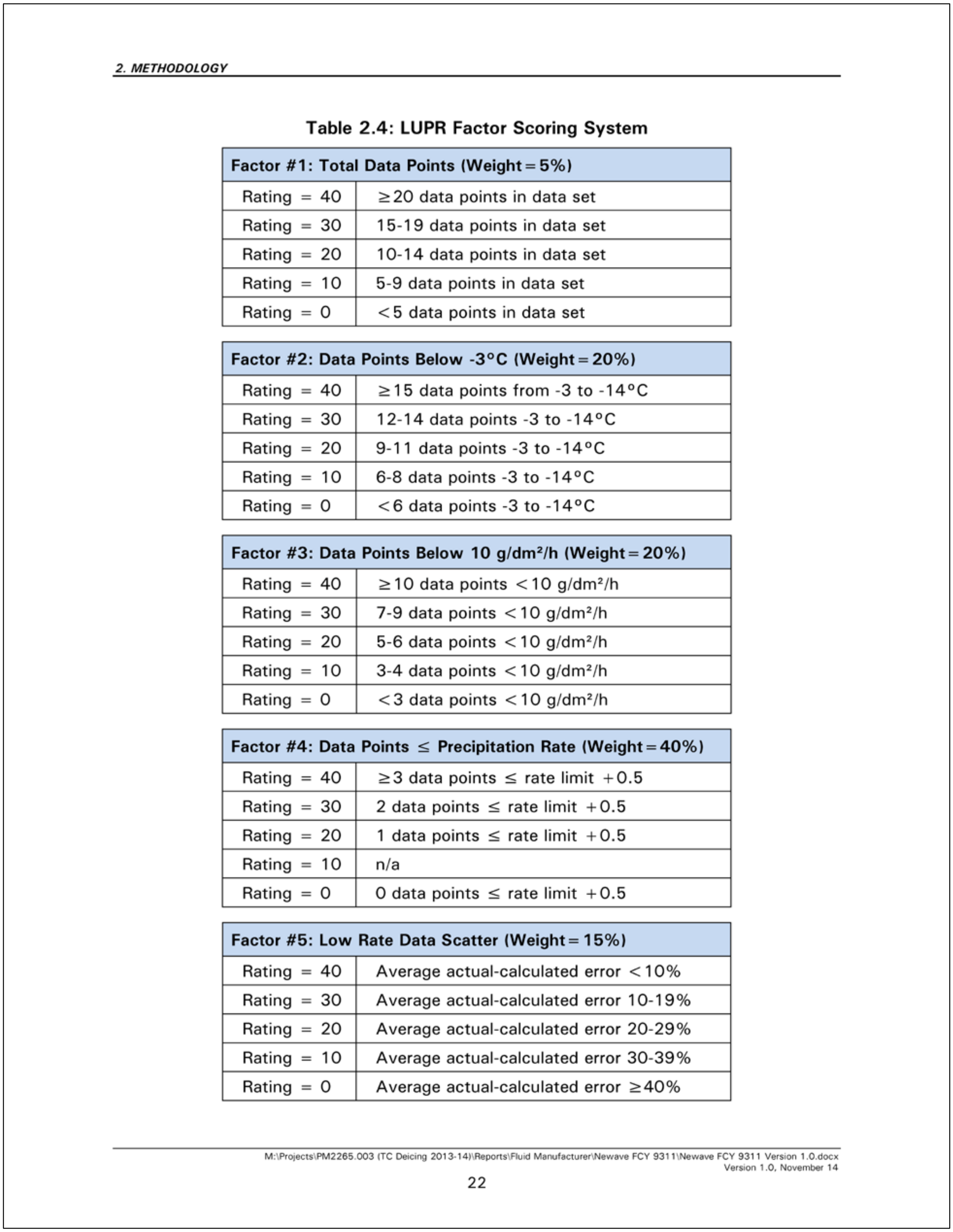


Table 2.4: LUPR Factor Scoring System

Factor #1: Total Data Points (Weight = 5%)	
Rating = 40	≥20 data points in data set
Rating = 30	15-19 data points in data set
Rating = 20	10-14 data points in data set
Rating = 10	5-9 data points in data set
Rating = 0	<5 data points in data set

Factor #2: Data Points Below -3°C (Weight = 20%)	
Rating = 40	≥15 data points from -3 to -14°C
Rating = 30	12-14 data points -3 to -14°C
Rating = 20	9-11 data points -3 to -14°C
Rating = 10	6-8 data points -3 to -14°C
Rating = 0	<6 data points -3 to -14°C

Factor #3: Data Points Below 10 g/dm²/h (Weight = 20%)	
Rating = 40	≥10 data points <10 g/dm²/h
Rating = 30	7-9 data points <10 g/dm²/h
Rating = 20	5-6 data points <10 g/dm²/h
Rating = 10	3-4 data points <10 g/dm²/h
Rating = 0	<3 data points <10 g/dm²/h

Factor #4: Data Points ≤ Precipitation Rate (Weight = 40%)	
Rating = 40	≥3 data points ≤ rate limit +0.5
Rating = 30	2 data points ≤ rate limit +0.5
Rating = 20	1 data points ≤ rate limit +0.5
Rating = 10	n/a
Rating = 0	0 data points ≤ rate limit +0.5

Factor #5: Low Rate Data Scatter (Weight = 15%)	
Rating = 40	Average actual-calculated error <10%
Rating = 30	Average actual-calculated error 10-19%
Rating = 20	Average actual-calculated error 20-29%
Rating = 10	Average actual-calculated error 30-39%
Rating = 0	Average actual-calculated error ≥40%

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility

Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

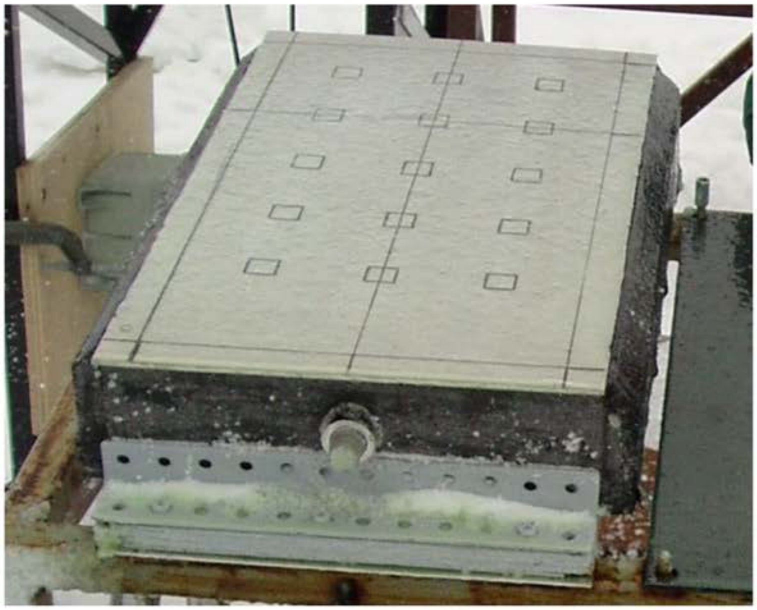


Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

Photo 2.11: Sprayer Nozzle

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

Logs of the tests conducted are provided at the end of this section as follows: Table 3.1 (snow), Table 3.2 (freezing precipitation), and Table 3.3 (frost). The logs provide details of each test conducted.

3.1 Natural Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.1.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥ -3°C	**-3 to -14°C**	**<-14°C**
Neat	7	17	0
75/25	8	19	0
50/50	16	0	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		**Light Freezing Rain**	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4
75/25	5	4	4	4
50/50	4	0	4	0

3.3 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	**-14°C**	**-25°C**
Neat	6	4	4
75/25	4	4	0
50/50	4	0	0

3.4 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	5
50/50	0

3.5 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥-1°C	**<-1 to -3°C**	**<-3 to -10°C**	**<-10°C**
Neat	0	0	0	1
75/25	0	2	0	0
50/50	0	2	0	0

3.6 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

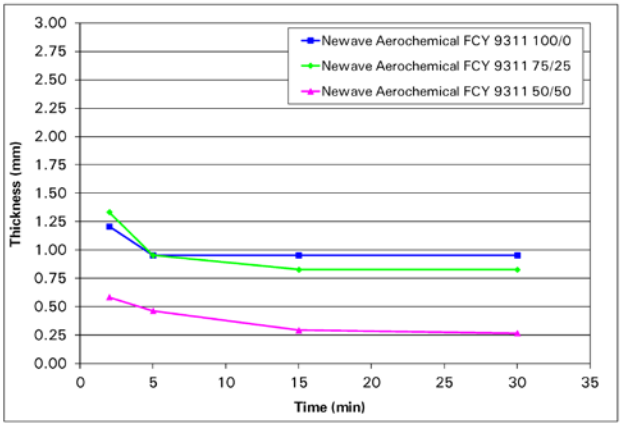


Figure 3.1: Fluid Thickness Profiles of Newave Aerochemical FCY 9311

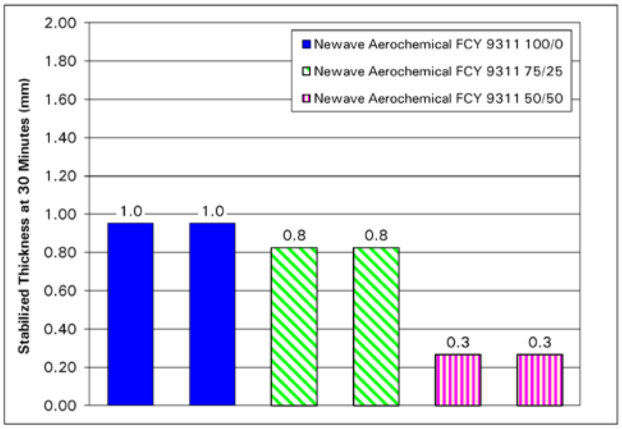


Figure 3.2: Final Fluid Thickness of Newave Aerochemical FCY 9311

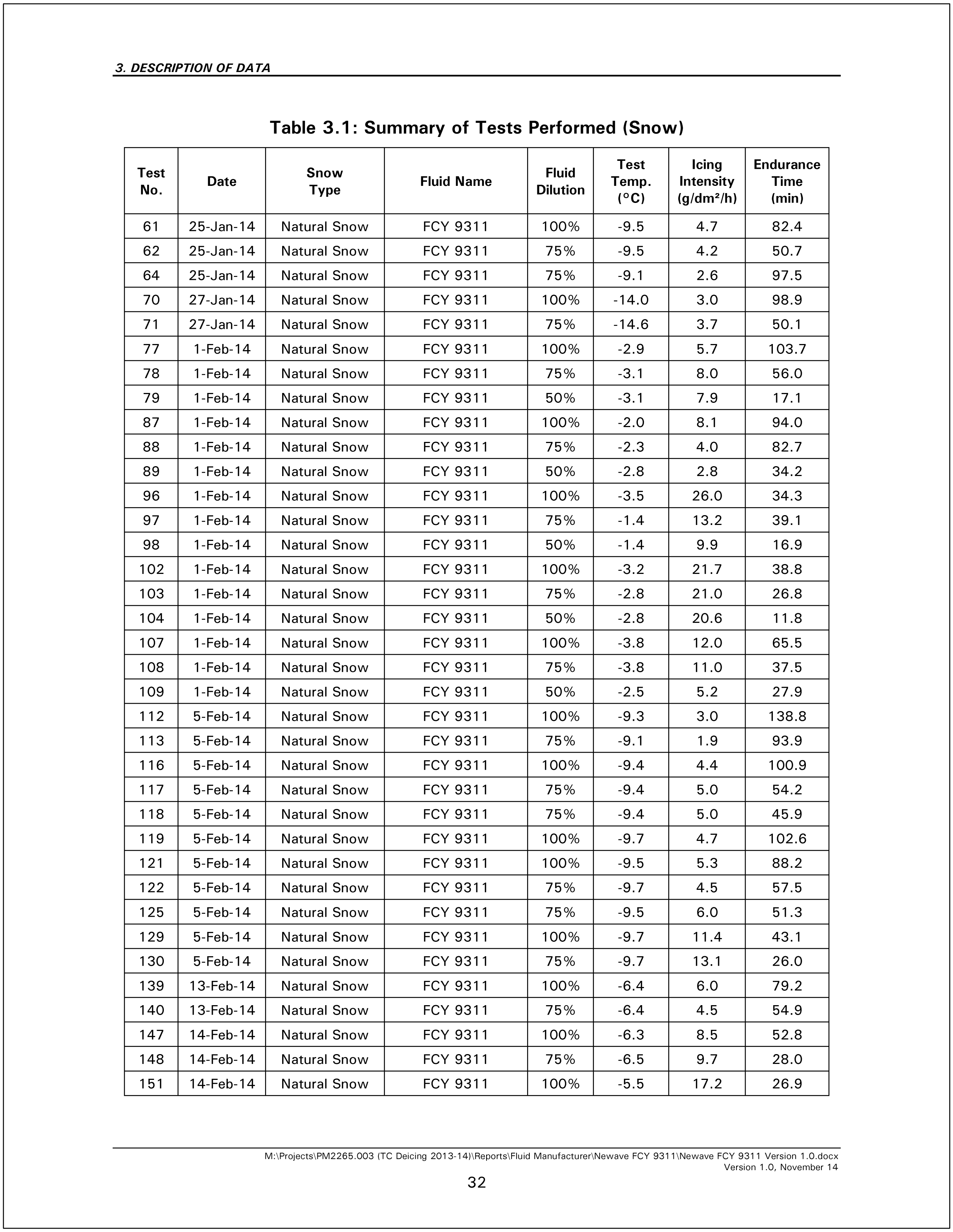


Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
61	25-Jan-14	Natural Snow	FCY 9311	100%	-9.5	4.7	82.4
62	25-Jan-14	Natural Snow	FCY 9311	75%	-9.5	4.2	50.7
64	25-Jan-14	Natural Snow	FCY 9311	75%	-9.1	2.6	97.5
70	27-Jan-14	Natural Snow	FCY 9311	100%	-14.0	3.0	98.9
71	27-Jan-14	Natural Snow	FCY 9311	75%	-14.6	3.7	50.1
77	1-Feb-14	Natural Snow	FCY 9311	100%	-2.9	5.7	103.7
78	1-Feb-14	Natural Snow	FCY 9311	75%	-3.1	8.0	56.0
79	1-Feb-14	Natural Snow	FCY 9311	50%	-3.1	7.9	17.1
87	1-Feb-14	Natural Snow	FCY 9311	100%	-2.0	8.1	94.0
88	1-Feb-14	Natural Snow	FCY 9311	75%	-2.3	4.0	82.7
89	1-Feb-14	Natural Snow	FCY 9311	50%	-2.8	2.8	34.2
96	1-Feb-14	Natural Snow	FCY 9311	100%	-3.5	26.0	34.3
97	1-Feb-14	Natural Snow	FCY 9311	75%	-1.4	13.2	39.1
98	1-Feb-14	Natural Snow	FCY 9311	50%	-1.4	9.9	16.9
102	1-Feb-14	Natural Snow	FCY 9311	100%	-3.2	21.7	38.8
103	1-Feb-14	Natural Snow	FCY 9311	75%	-2.8	21.0	26.8
104	1-Feb-14	Natural Snow	FCY 9311	50%	-2.8	20.6	11.8
107	1-Feb-14	Natural Snow	FCY 9311	100%	-3.8	12.0	65.5
108	1-Feb-14	Natural Snow	FCY 9311	75%	-3.8	11.0	37.5
109	1-Feb-14	Natural Snow	FCY 9311	50%	-2.5	5.2	27.9
112	5-Feb-14	Natural Snow	FCY 9311	100%	-9.3	3.0	138.8
113	5-Feb-14	Natural Snow	FCY 9311	75%	-9.1	1.9	93.9
116	5-Feb-14	Natural Snow	FCY 9311	100%	-9.4	4.4	100.9
117	5-Feb-14	Natural Snow	FCY 9311	75%	-9.4	5.0	54.2
118	5-Feb-14	Natural Snow	FCY 9311	75%	-9.4	5.0	45.9
119	5-Feb-14	Natural Snow	FCY 9311	100%	-9.7	4.7	102.6
121	5-Feb-14	Natural Snow	FCY 9311	100%	-9.5	5.3	88.2
122	5-Feb-14	Natural Snow	FCY 9311	75%	-9.7	4.5	57.5
125	5-Feb-14	Natural Snow	FCY 9311	75%	-9.5	6.0	51.3
129	5-Feb-14	Natural Snow	FCY 9311	100%	-9.7	11.4	43.1
130	5-Feb-14	Natural Snow	FCY 9311	75%	-9.7	13.1	26.0
139	13-Feb-14	Natural Snow	FCY 9311	100%	-6.4	6.0	79.2
140	13-Feb-14	Natural Snow	FCY 9311	75%	-6.4	4.5	54.9
147	14-Feb-14	Natural Snow	FCY 9311	100%	-6.3	8.5	52.8
148	14-Feb-14	Natural Snow	FCY 9311	75%	-6.5	9.7	28.0
151	14-Feb-14	Natural Snow	FCY 9311	100%	-5.5	17.2	26.9

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
152	14-Feb-14	Natural Snow	FCY 9311	75%	-5.5	16.0	18.4
155	14-Feb-14	Natural Snow	FCY 9311	100%	-5.8	15.8	36.0
156	14-Feb-14	Natural Snow	FCY 9311	75%	-5.8	15.0	22.7
164	14-Feb-14	Natural Snow	FCY 9311	100%	-4.4	5.7	126.0
166	14-Feb-14	Natural Snow	FCY 9311	75%	-4.4	7.0	57.8
167	18-Feb-14	Natural Snow	FCY 9311	75%	-12.1	12.9	25.4
170	9-Mar-14	Natural Snow	FCY 9311	100%	-4.7	10.6	76.9
171	9-Mar-14	Natural Snow	FCY 9311	75%	-4.7	8.7	39.4
174	9-Mar-14	Natural Snow	FCY 9311	100%	-4.7	13.1	63.9
175	9-Mar-14	Natural Snow	FCY 9311	75%	-4.7	12.9	37.8
194	12-Mar-14	Natural Snow	FCY 9311	100%	-10.9	21.8	40.6
195	12-Mar-14	Natural Snow	FCY 9311	75%	-10.9	23.3	25.2
201	19-Mar-14	Natural Snow	FCY 9311	50%	0.8	28.6	6.0
208	19-Mar-14	Natural Snow	FCY 9311	50%	0.8	35.2	3.5
211	19-Mar-14	Natural Snow	FCY 9311	50%	0.8	19.4	22.2
213	19-Mar-14	Natural Snow	FCY 9311	50%	0.8	24.3	8.6
234	22-Mar-14	Natural Snow	FCY 9311	50%	-3.5	52.2	7.5
249	22-Mar-14	Natural Snow	FCY 9311	50%	-3.4	34.5	5.2
252	22-Mar-14	Natural Snow	FCY 9311	100%	-3.3	23.9	33.9
253	22-Mar-14	Natural Snow	FCY 9311	75%	-3.3	25.3	23.6
257	22-Mar-14	Natural Snow	FCY 9311	50%	-3.2	14.6	19.1
258	22-Mar-14	Natural Snow	FCY 9311	75%	-3.2	19.8	30.7
262	22-Mar-14	Natural Snow	FCY 9311	100%	-3.4	37.2	33.8
299	28-Mar-14	Natural Snow	FCY 9311	50%	-0.3	30.9	6.0
303	28-Mar-14	Natural Snow	FCY 9311	100%	-0.3	34.8	25.4
304	28-Mar-14	Natural Snow	FCY 9311	75%	-0.3	34.2	17.0
317	28-Mar-14	Natural Snow	FCY 9311	50%	0.2	29.7	7.3
323	30-Mar-14	Natural Snow	FCY 9311	50%	-1.1	8.1	20.1
325	30-Mar-14	Natural Snow	FCY 9311	50%	-1.1	3.2	47.0
326	30-Mar-14	Natural Snow	FCY 9311	100%	-1.1	9.8	107.5
327	30-Mar-14	Natural Snow	FCY 9311	75%	-1.1	6.3	71.9

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
3	24-Mar-14	Freezing Fog	FCY 9311	100	-25	2.3	48.7
4	24-Mar-14	Freezing Fog	FCY 9311	100	-25	2.3	48.3
9	24-Mar-14	Freezing Fog	FCY 9311	100	-25	4.9	29.2
10	24-Mar-14	Freezing Fog	FCY 9311	100	-25	5.3	28.1
15	24-Mar-14	Freezing Fog	FCY 9311	100	-14	2.0	123.5
16	24-Mar-14	Freezing Fog	FCY 9311	100	-14	2.0	122.4
21	24-Mar-14	Freezing Fog	FCY 9311	75	-14	2.0	77.0
22	24-Mar-14	Freezing Fog	FCY 9311	75	-14	2.0	85.3
27	24-Mar-14	Freezing Fog	FCY 9311	100	-14	4.8	41.3
28	24-Mar-14	Freezing Fog	FCY 9311	100	-14	4.8	36.9
33	24-Mar-14	Freezing Fog	FCY 9311	75	-14	4.8	38.9
34	24-Mar-14	Freezing Fog	FCY 9311	75	-14	4.8	34.8
39	25-Mar-14	Freezing Fog	FCY 9311	100	-3.2	1.9	>240
40	25-Mar-14	Freezing Fog	FCY 9311	100	-3.2	1.8	>240
45	25-Mar-14	Freezing Fog	FCY 9311	75	-3.2	1.9	123.8
46	25-Mar-14	Freezing Fog	FCY 9311	75	-3.2	2.2	122.1
51	25-Mar-14	Freezing Fog	FCY 9311	50	-3.2	2.0	41.2
52	25-Mar-14	Freezing Fog	FCY 9311	50	-3.2	2.1	35.9
57	25-Mar-14	Freezing Fog	FCY 9311	100	-3	4.9	136.6
57R	25-Mar-14	Freezing Fog	FCY 9311	100	-3	4.6	130.5
58	25-Mar-14	Freezing Fog	FCY 9311	100	-3	5.2	105.4
58R	25-Mar-14	Freezing Fog	FCY 9311	100	-3	5.0	105.8
63	25-Mar-14	Freezing Fog	FCY 9311	75	-3	5.2	57.8
64	25-Mar-14	Freezing Fog	FCY 9311	75	-3	5.1	62.0
69	25-Mar-14	Freezing Fog	FCY 9311	50	-3	5.4	20.5
70	25-Mar-14	Freezing Fog	FCY 9311	50	-3	5.1	17.1
75	20-Mar-14	Freezing Drizzle	FCY 9311	100	-10	4.7	81.1
76	20-Mar-14	Freezing Drizzle	FCY 9311	100	-10	4.8	88.2
81	20-Mar-14	Freezing Drizzle	FCY 9311	75	-10	5.0	41.1
82	20-Mar-14	Freezing Drizzle	FCY 9311	75	-10	**5.1**	39.4
87	20-Mar-14	Freezing Drizzle	FCY 9311	100	-10	12.8	36.9
88	20-Mar-14	Freezing Drizzle	FCY 9311	100	-10	12.8	37.2
93	20-Mar-14	Freezing Drizzle	FCY 9311	75	-10	13.3	28.9
94	20-Mar-14	Freezing Drizzle	FCY 9311	75	-10	12.8	28.1
99	21-Mar-14	Freezing Drizzle	FCY 9311	100	-3	4.8	128.4
100	21-Mar-14	Freezing Drizzle	FCY 9311	100	-3	4.9	128.5
105	21-Mar-14	Freezing Drizzle	FCY 9311	75	-3	4.9	72.9
106	21-Mar-14	Freezing Drizzle	FCY 9311	75	-3	5.4	59.2

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
111	21-Mar-14	Freezing Drizzle	FCY 9311	50	-3	4.8	18.1
112	21-Mar-14	Freezing Drizzle	FCY 9311	50	-3	4.6	18.0
117	19-Mar-14	Freezing Drizzle	FCY 9311	100	-3	13.5	69.6
118	19-Mar-14	Freezing Drizzle	FCY 9311	100	-3	12.6	71.9
123	19-Mar-14	Freezing Drizzle	FCY 9311	75	-3	12.7	32.5
124	19-Mar-14	Freezing Drizzle	FCY 9311	75	-3	12.6	32.5
124R	19-Mar-14	Freezing Drizzle	FCY 9311	75	-3	12.6	32.1
129	19-Mar-14	Freezing Drizzle	FCY 9311	50	-3	**13.5**	10.1
130	19-Mar-14	Freezing Drizzle	FCY 9311	50	-3	12.7	11.3
135	20-Mar-14	Light Freezing Rain	FCY 9311	100	-10	12.9	35.4
136	20-Mar-14	Light Freezing Rain	FCY 9311	100	-10	13.3	31.4
141	20-Mar-14	Light Freezing Rain	FCY 9311	75	-10	12.6	22.8
142	20-Mar-14	Light Freezing Rain	FCY 9311	75	-10	12.6	22.4
147	20-Mar-14	Light Freezing Rain	FCY 9311	100	-10	24.7	19.6
148	20-Mar-14	Light Freezing Rain	FCY 9311	100	-10	24.6	23.0
153	20-Mar-14	Light Freezing Rain	FCY 9311	75	-10	25.7	16.1
154	20-Mar-14	Light Freezing Rain	FCY 9311	75	-10	24.7	17.0
159	19-Mar-14	Light Freezing Rain	FCY 9311	100	-3	12.9	61.2
160	19-Mar-14	Light Freezing Rain	FCY 9311	100	-3	12.9	69.1
165	19-Mar-14	Light Freezing Rain	FCY 9311	75	-3	12.9	31.5
166	19-Mar-14	Light Freezing Rain	FCY 9311	75	-3	12.7	30.8
171	19-Mar-14	Light Freezing Rain	FCY 9311	50	-3	12.9	12.9
172	19-Mar-14	Light Freezing Rain	FCY 9311	50	-3	12.7	12.2
177	21-Mar-14	Light Freezing Rain	FCY 9311	100	-3	25.3	38.0
178	21-Mar-14	Light Freezing Rain	FCY 9311	100	-3	24.7	38.5
183	21-Mar-14	Light Freezing Rain	FCY 9311	75	-3	24.5	20.5
184	21-Mar-14	Light Freezing Rain	FCY 9311	75	-3	24.7	19.7
189	21-Mar-14	Light Freezing Rain	FCY 9311	50	-3	24.8	8.6
190	21-Mar-14	Light Freezing Rain	FCY 9311	50	-3	25.1	7.7
195	26-Mar-14	Cold Soak Box	FCY 9311	100	1.1	5.1	81.7
196	26-Mar-14	Cold Soak Box	FCY 9311	100	0.8	4.9	86.4
201	26-Mar-14	Cold Soak Box	FCY 9311	75	0.9	5.1	45.5
201R	26-Mar-14	Cold Soak Box	FCY 9311	75	0.8	5.0	45.2
202	26-Mar-14	Cold Soak Box	FCY 9311	75	0.7	5.3	56.4
207	26-Mar-14	Cold Soak Box	FCY 9311	100	1.1	75.2	12.9
208	26-Mar-14	Cold Soak Box	FCY 9311	100	1.1	73.2	12.6
213	26-Mar-14	Cold Soak Box	FCY 9311	75	1.3	75.4	8.2
214	26-Mar-14	Cold Soak Box	FCY 9311	75	1.3	75.4	7.7

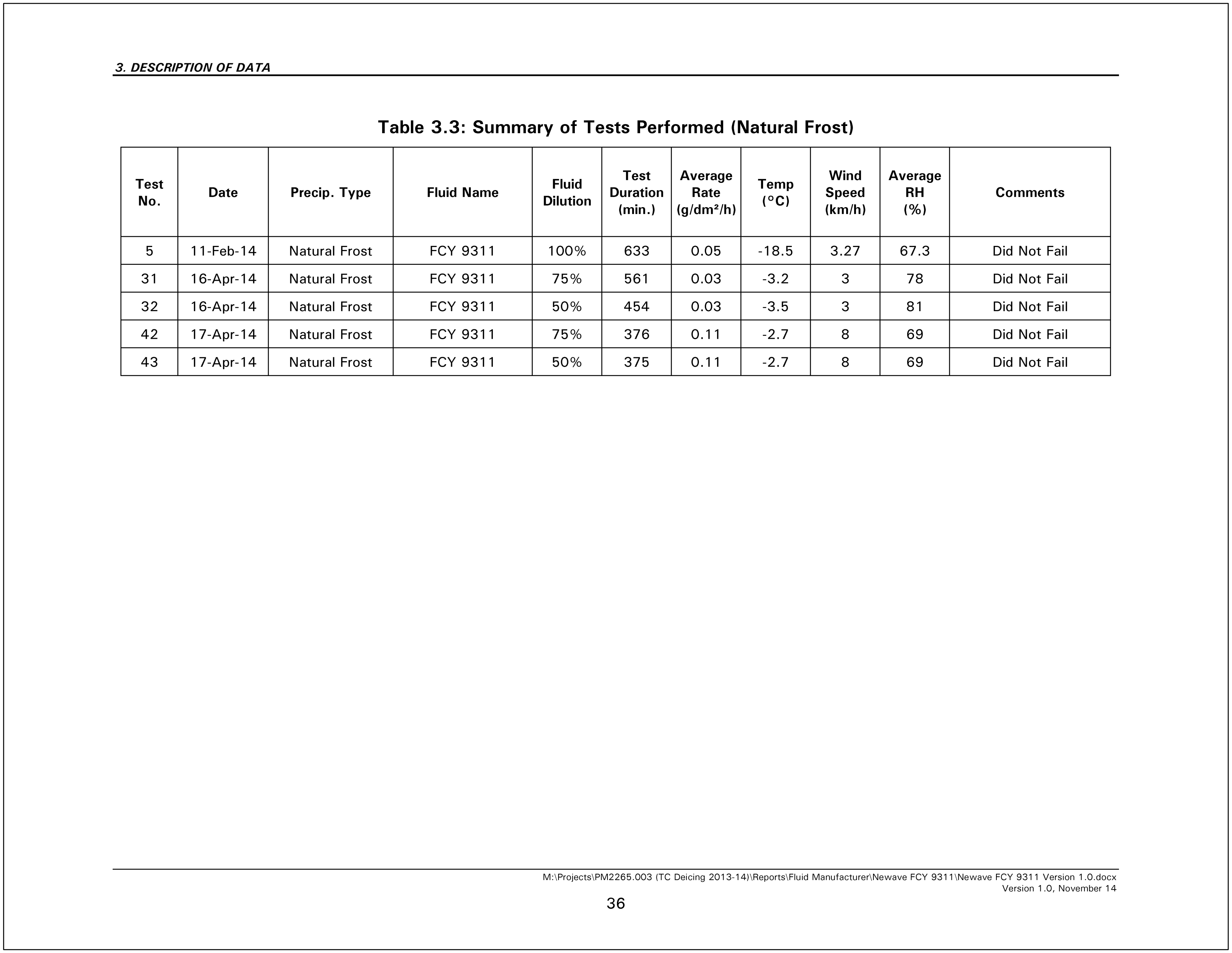


Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
5	11-Feb-14	Natural Frost	FCY 9311	100%	633	0.05	-18.5	3.27	67.3	Did Not Fail
31	16-Apr-14	Natural Frost	FCY 9311	75%	561	0.03	-3.2	3	78	Did Not Fail
32	16-Apr-14	Natural Frost	FCY 9311	50%	454	0.03	-3.5	3	81	Did Not Fail
42	17-Apr-14	Natural Frost	FCY 9311	75%	376	0.11	-2.7	8	69	Did Not Fail
43	17-Apr-14	Natural Frost	FCY 9311	50%	375	0.11	-2.7	8	69	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The results of the data analyses are presented in this section.

4.1 Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the data collected in natural snow and simulated freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface). These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines.

Multi-variable regression analysis was performed on these data sets as described in Subsection 2.8. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type II fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.3.1).

4.2 Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the generic holdover times. All tests surpassed the generic holdover times, including tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates the generic frost holdover times have been substantiated for Newave Aerochemical FCY 9311.

4.3 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for FCY 9311. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter. It should be noted that Newave requested the 75/25 and 50/50 holdover times not be published. They have therefore not been included in the HOT tables.

4.3.1 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, the existing propylene Type II/IV fluids were given generic values in the "Below -14 to LOUT" snow cell. It was also decided that all new Type II/IV fluids would be given generic values. Accordingly, Newave Aerochemical FCY 9311 has been given generic values in the "Below -14°C to LOUT" snow cells.

4.3.2 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT table. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Newave Aerochemical FCY 9311 fluid-specific HOT table.

4.3.3 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.4 Lowest Usable Precipitation Rates in Snow

The LUPRs for Newave Aerochemical FCY 9311 were determined by analysing the natural snow data using the analysis methodology described in Subsection 2.8.6. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Newave Aerochemical FCY 9311 are:

- 100/0 = 3 g/dm²/h;
- 75/25 = 2 g/dm²/h; and
- 50/50 = 3 g/dm²/h.

4.5 Discussion

As Newave intends to commercialize FCY 9311, TC and FAA will publish its fluid-specific HOT table in their 2014-15 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the LUPR data will be published in the related TC and FAA Regression Information documents. At the request of the manufacturer, the 75/25 and 50/50 holdover times will not be included.

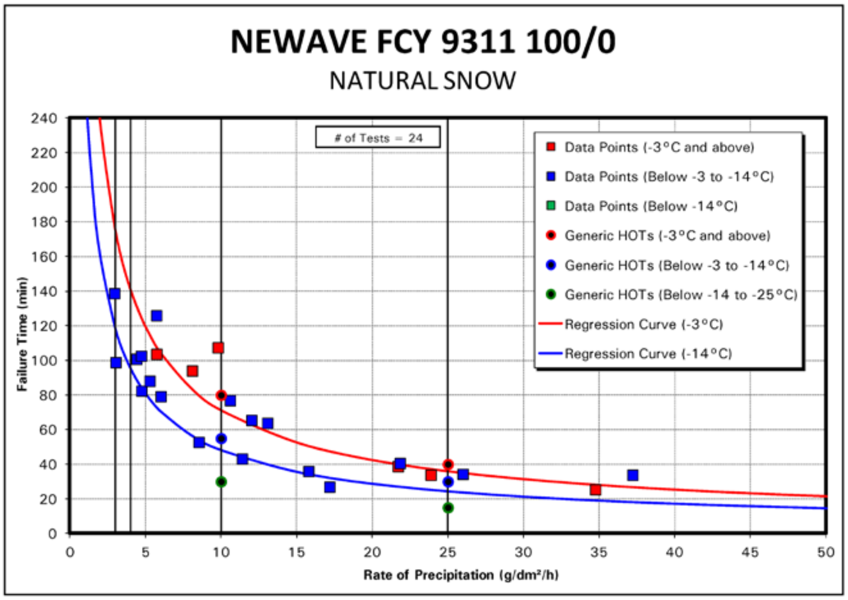


Figure 4.1: Type IV Neat – Natural Snow

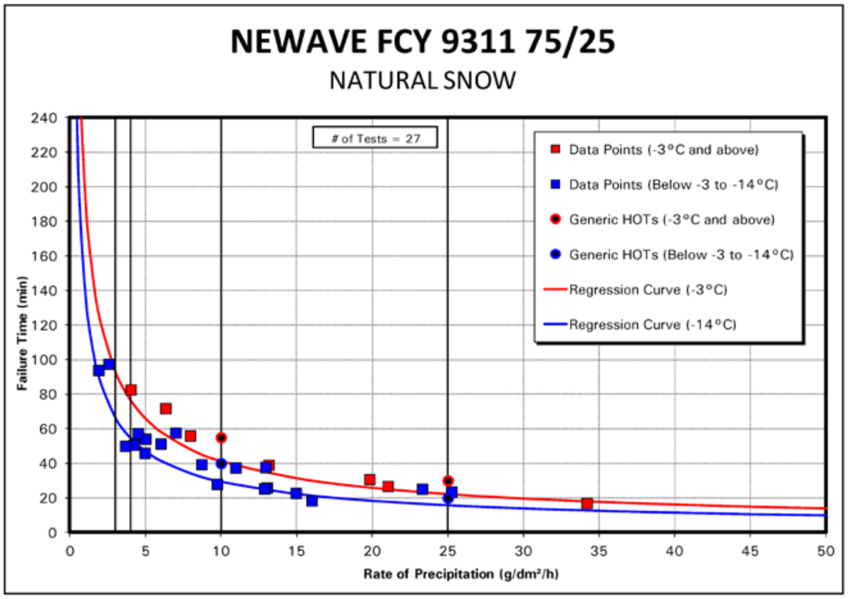


Figure 4.2: Type IV 75/25 – Natural Snow

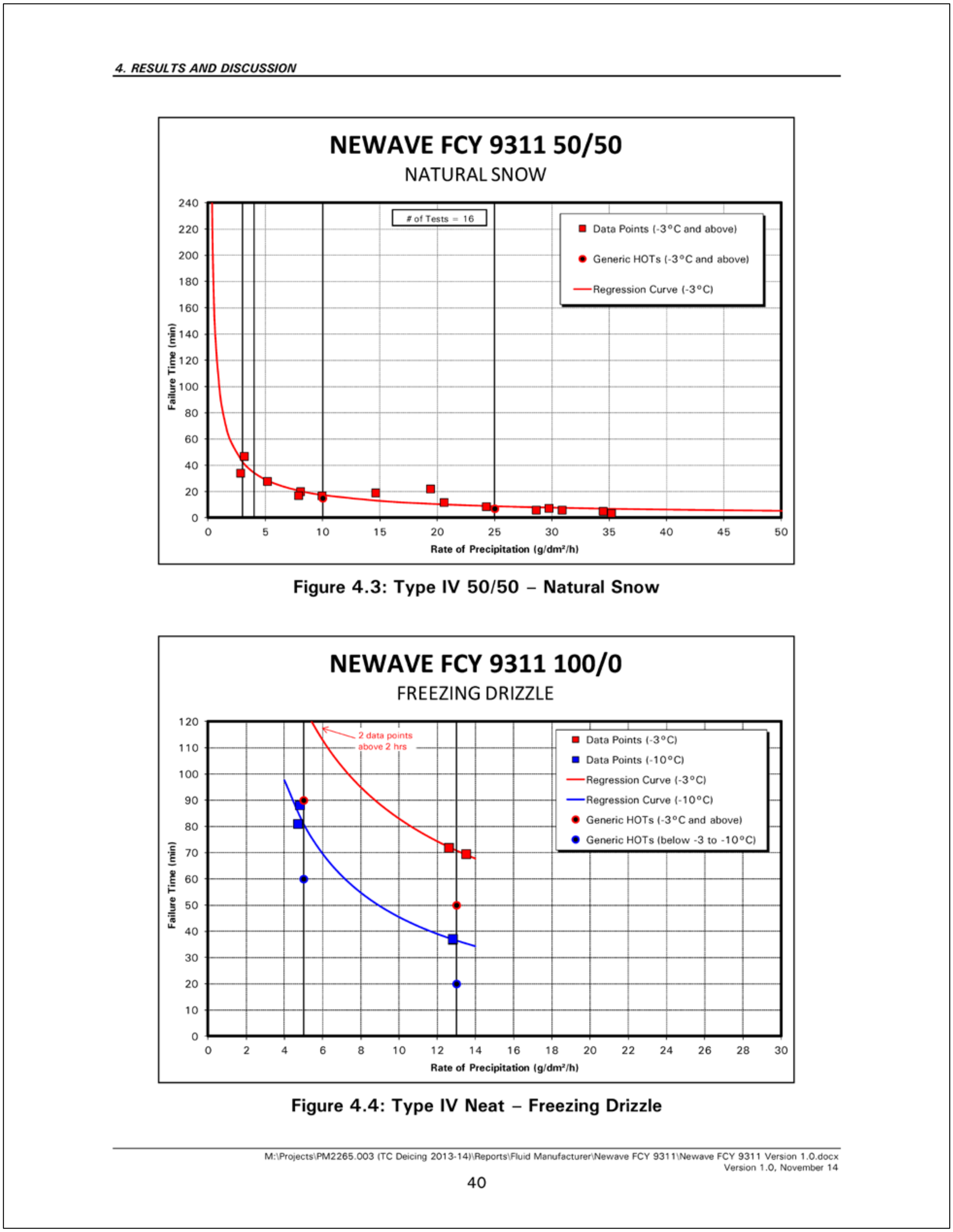


Figure 4.3: Type IV 50/50 – Natural Snow

Figure 4.4: Type IV Neat – Freezing Drizzle

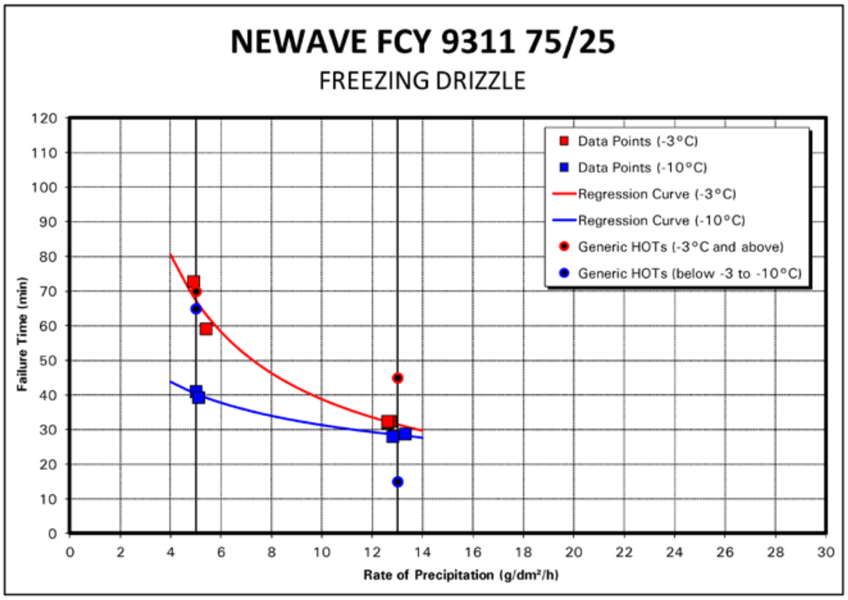


Figure 4.5: Type IV 75/25 – Freezing Drizzle

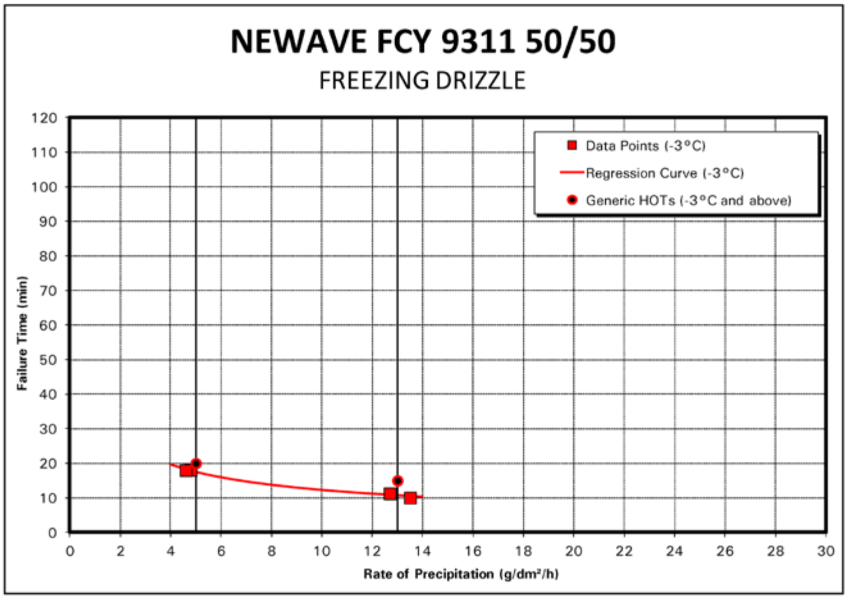
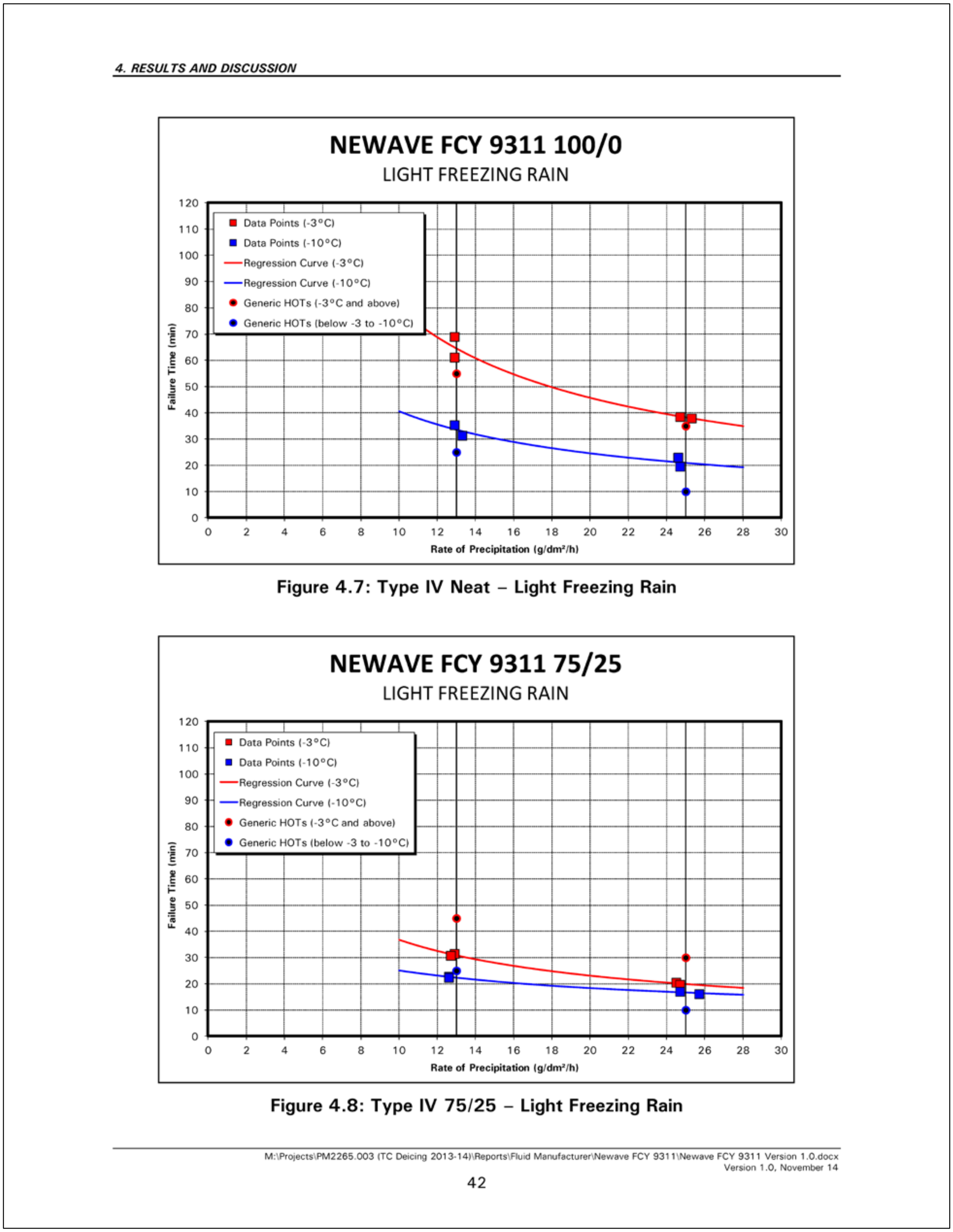


Figure 4.6: Type IV 50/50 – Freezing Drizzle



4. RESULTS AND DISCUSSION

Figure 4.7: Type IV Neat – Light Freezing Rain

Figure 4.8: Type IV 75/25 – Light Freezing Rain

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Reports\Fluid Manufacturer\Newave FCY 9311\Newave FCY 9311 Version 1.0.docx
Version 1.0, November 14

42

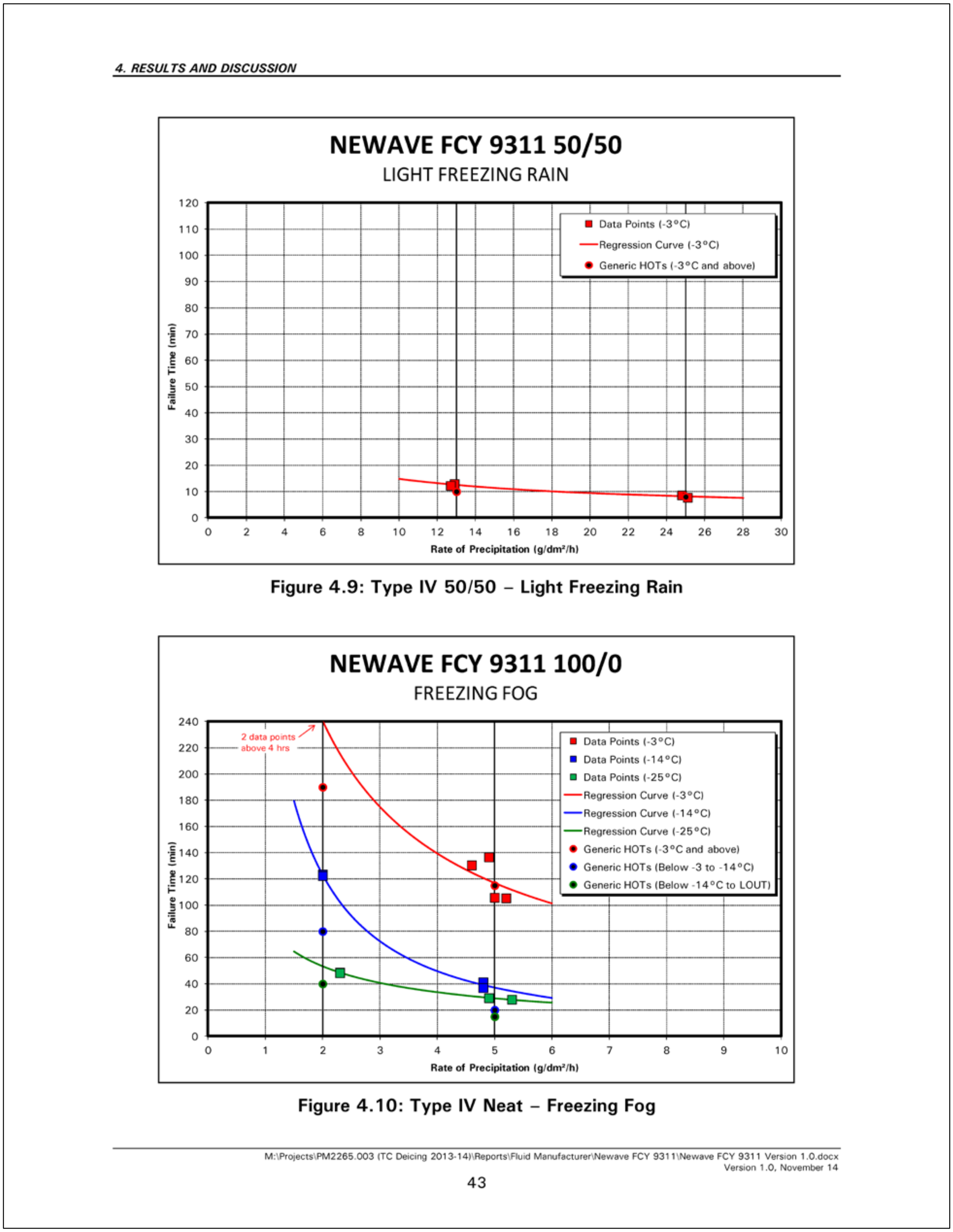
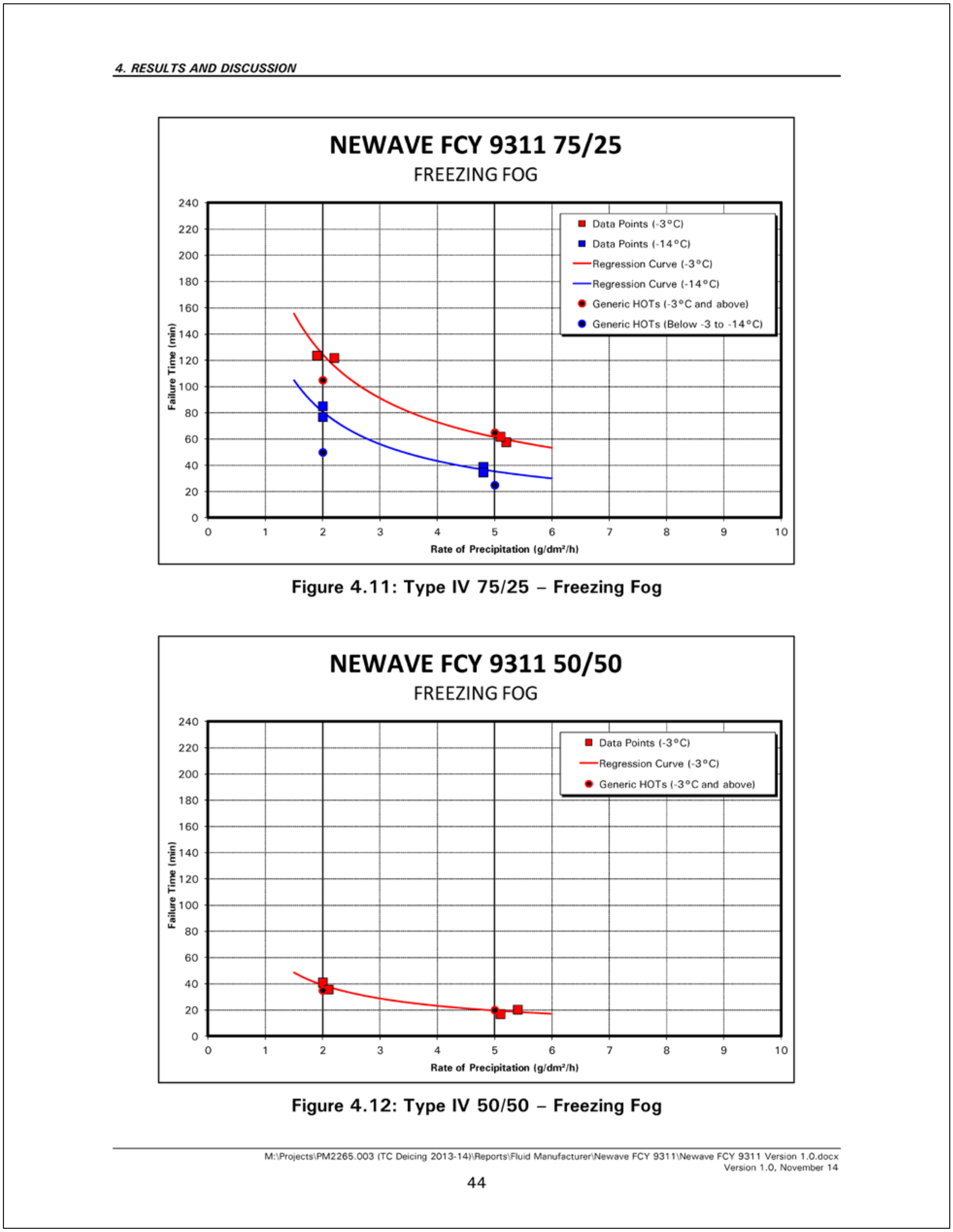


Figure 4.9: Type IV 50/50 – Light Freezing Rain

Figure 4.10: Type IV Neat – Freezing Fog



4. RESULTS AND DISCUSSION

Figure 4.11: Type IV 75/25 – Freezing Fog

Figure 4.12: Type IV 50/50 – Freezing Fog

M:\Projects\PM2265.003 (TC Deicing 2013-14)\Reports\Fluid Manufacturer\Newave FCY 9311\Newave FCY 9311 Version 1.0.docx
Version 1.0, November 14

44

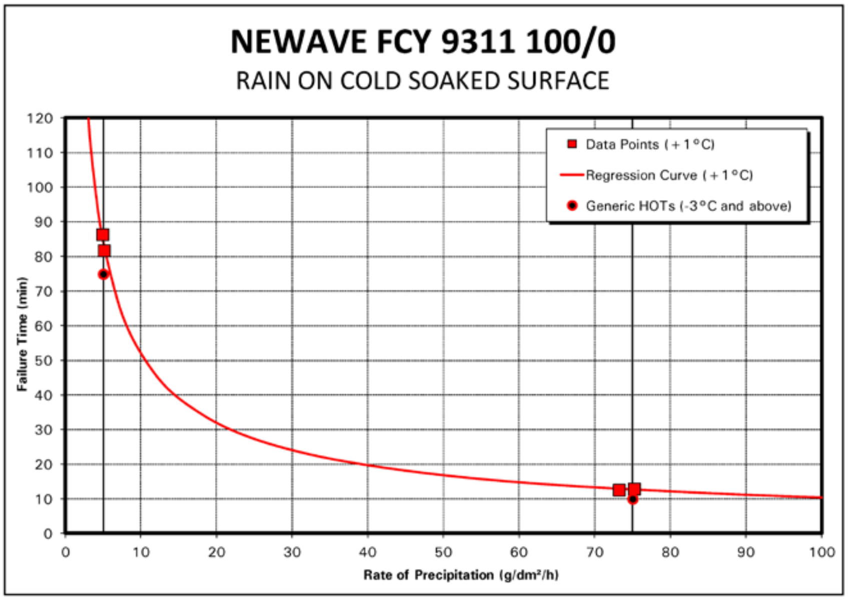


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

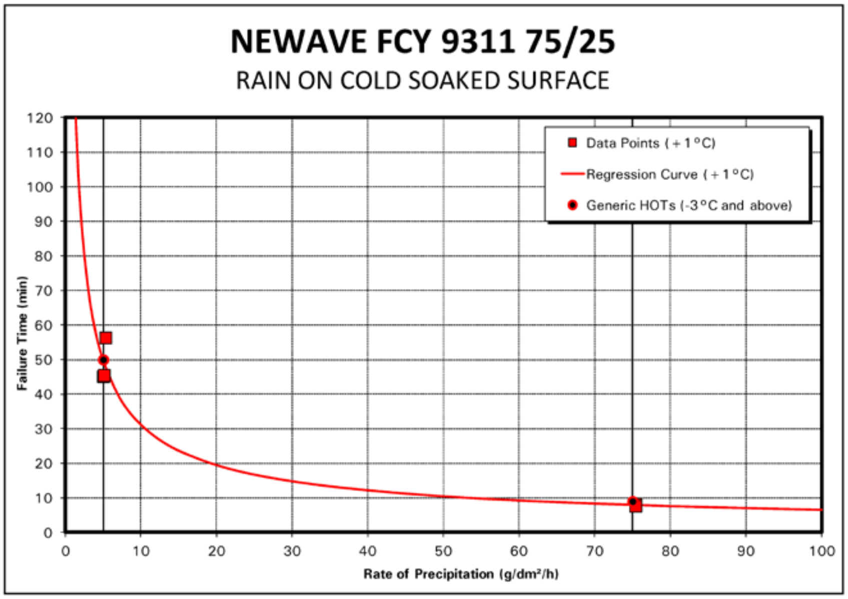


Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

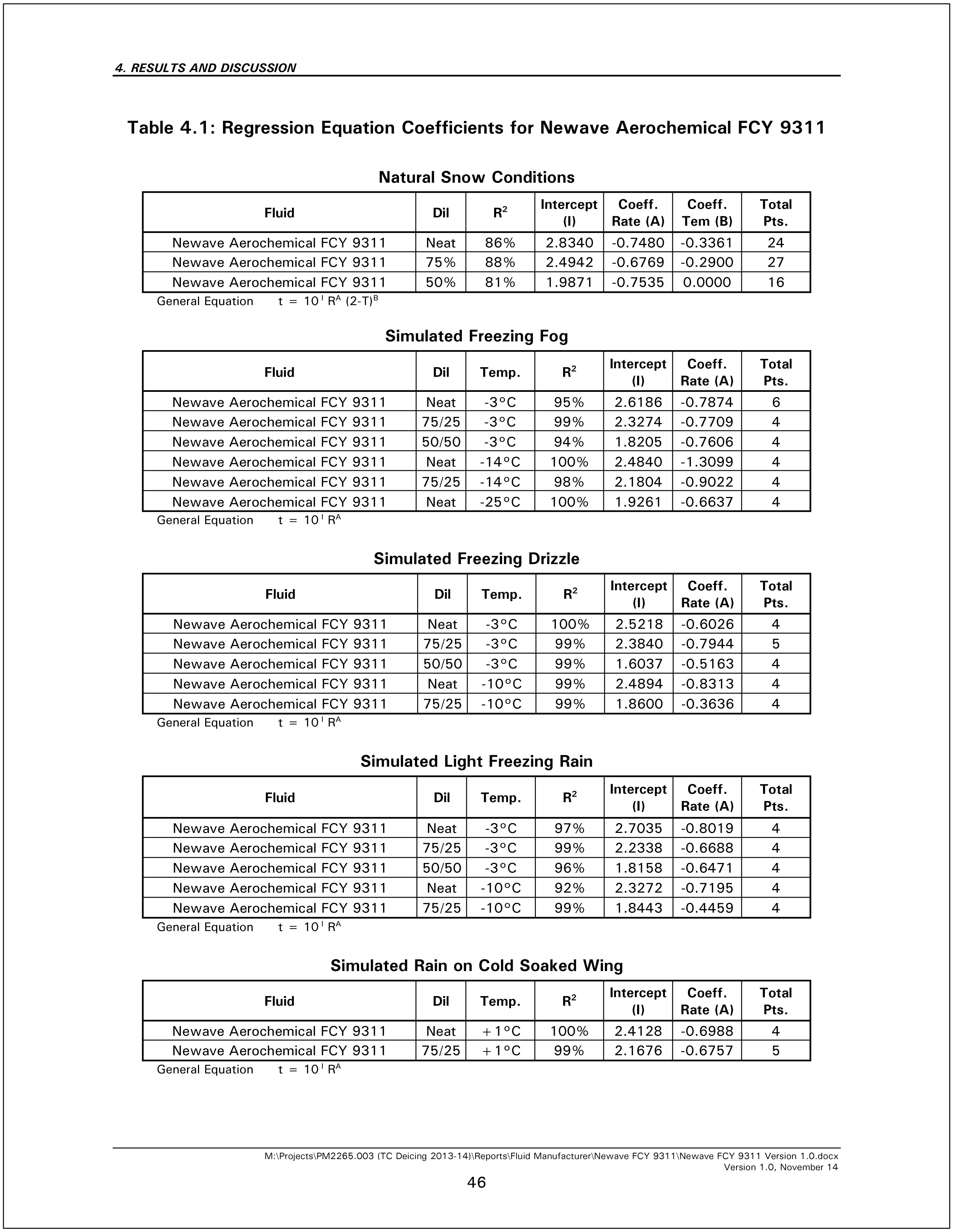


Table 4.1: Regression Equation Coefficients for Newave Aerochemical FCY 9311

Natural Snow Conditions

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Newave Aerochemical FCY 9311	Neat	86%	2.8340	-0.7480	-0.3361	24
Newave Aerochemical FCY 9311	75%	88%	2.4942	-0.6769	-0.2900	27
Newave Aerochemical FCY 9311	50%	81%	1.9871	-0.7535	0.0000	16

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

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Newave Aerochemical FCY 9311	Neat	-3°C	95%	2.6186	-0.7874	6
Newave Aerochemical FCY 9311	75/25	-3°C	99%	2.3274	-0.7709	4
Newave Aerochemical FCY 9311	50/50	-3°C	94%	1.8205	-0.7606	4
Newave Aerochemical FCY 9311	Neat	-14°C	100%	2.4840	-1.3099	4
Newave Aerochemical FCY 9311	75/25	-14°C	98%	2.1804	-0.9022	4
Newave Aerochemical FCY 9311	Neat	-25°C	100%	1.9261	-0.6637	4

General Equation $t = 10^{I} R^{A}$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Newave Aerochemical FCY 9311	Neat	-3°C	100%	2.5218	-0.6026	4
Newave Aerochemical FCY 9311	75/25	-3°C	99%	2.3840	-0.7944	5
Newave Aerochemical FCY 9311	50/50	-3°C	99%	1.6037	-0.5163	4
Newave Aerochemical FCY 9311	Neat	-10°C	99%	2.4894	-0.8313	4
Newave Aerochemical FCY 9311	75/25	-10°C	99%	1.8600	-0.3636	4

General Equation $t = 10^{I} R^{A}$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Newave Aerochemical FCY 9311	Neat	-3°C	97%	2.7035	-0.8019	4
Newave Aerochemical FCY 9311	75/25	-3°C	99%	2.2338	-0.6688	4
Newave Aerochemical FCY 9311	50/50	-3°C	96%	1.8158	-0.6471	4
Newave Aerochemical FCY 9311	Neat	-10°C	92%	2.3272	-0.7195	4
Newave Aerochemical FCY 9311	75/25	-10°C	99%	1.8443	-0.4459	4

General Equation $t = 10^{I} R^{A}$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Newave Aerochemical FCY 9311	Neat	+1°C	100%	2.4128	-0.6988	4
Newave Aerochemical FCY 9311	75/25	+1°C	99%	2.1676	-0.6757	5

General Equation $t = 10^{I} R^{A}$

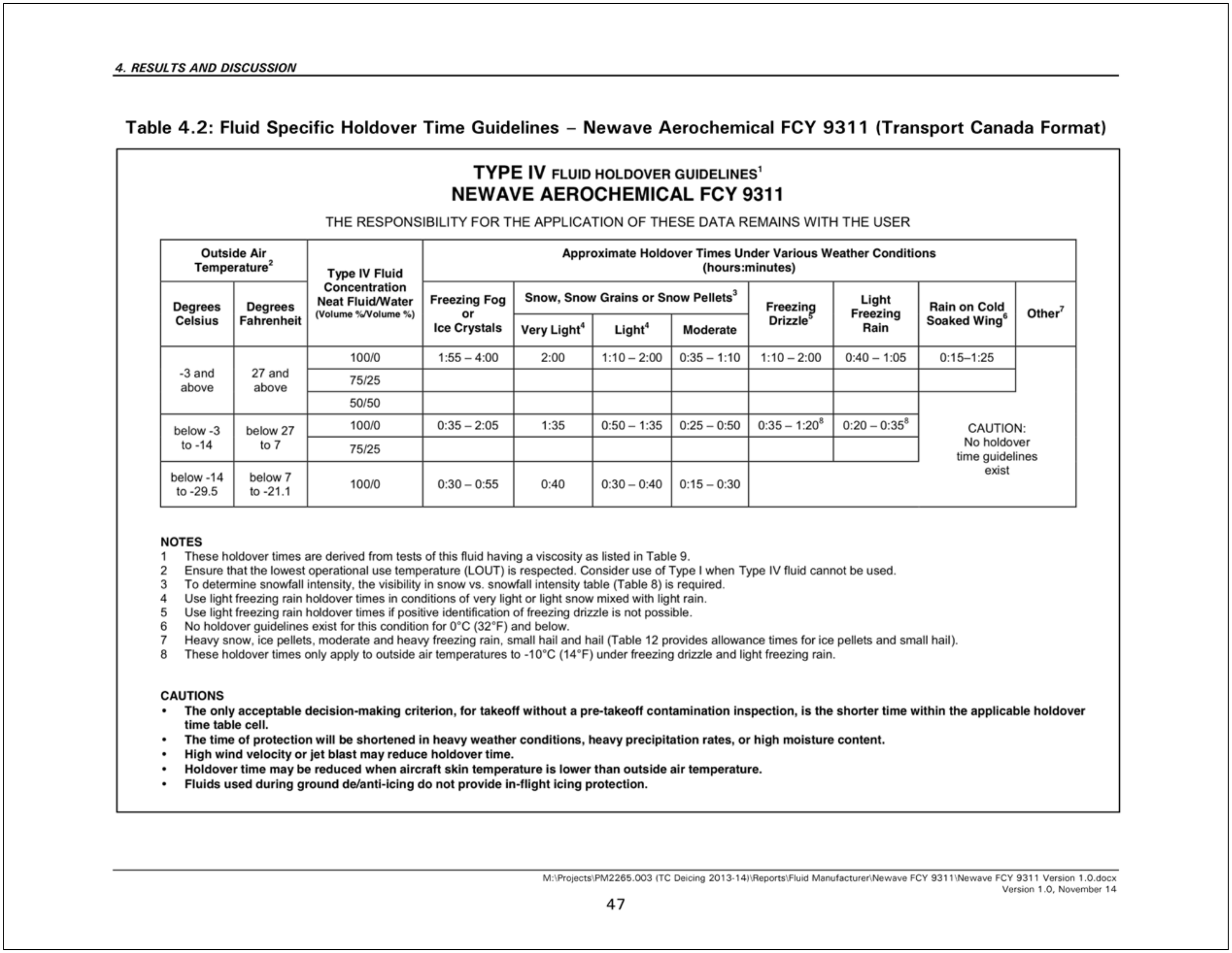


Table 4.2: Fluid Specific Holdover Time Guidelines – Newave Aerochemical FCY 9311 (Transport Canada Format)

TYPE IV FLUID HOLDOVER GUIDELINES[1]
NEWAVE AEROCHEMICAL FCY 9311

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	1:55 – 4:00	2:00	1:10 – 2:00	0:35 – 1:10	1:10 – 2:00	0:40 – 1:05	0:15–1:25	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:35 – 2:05	1:35	0:50 – 1:35	0:25 – 0:50	0:35 – 1:20[8]	0:20 – 0:35[8]		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:30 – 0:55	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

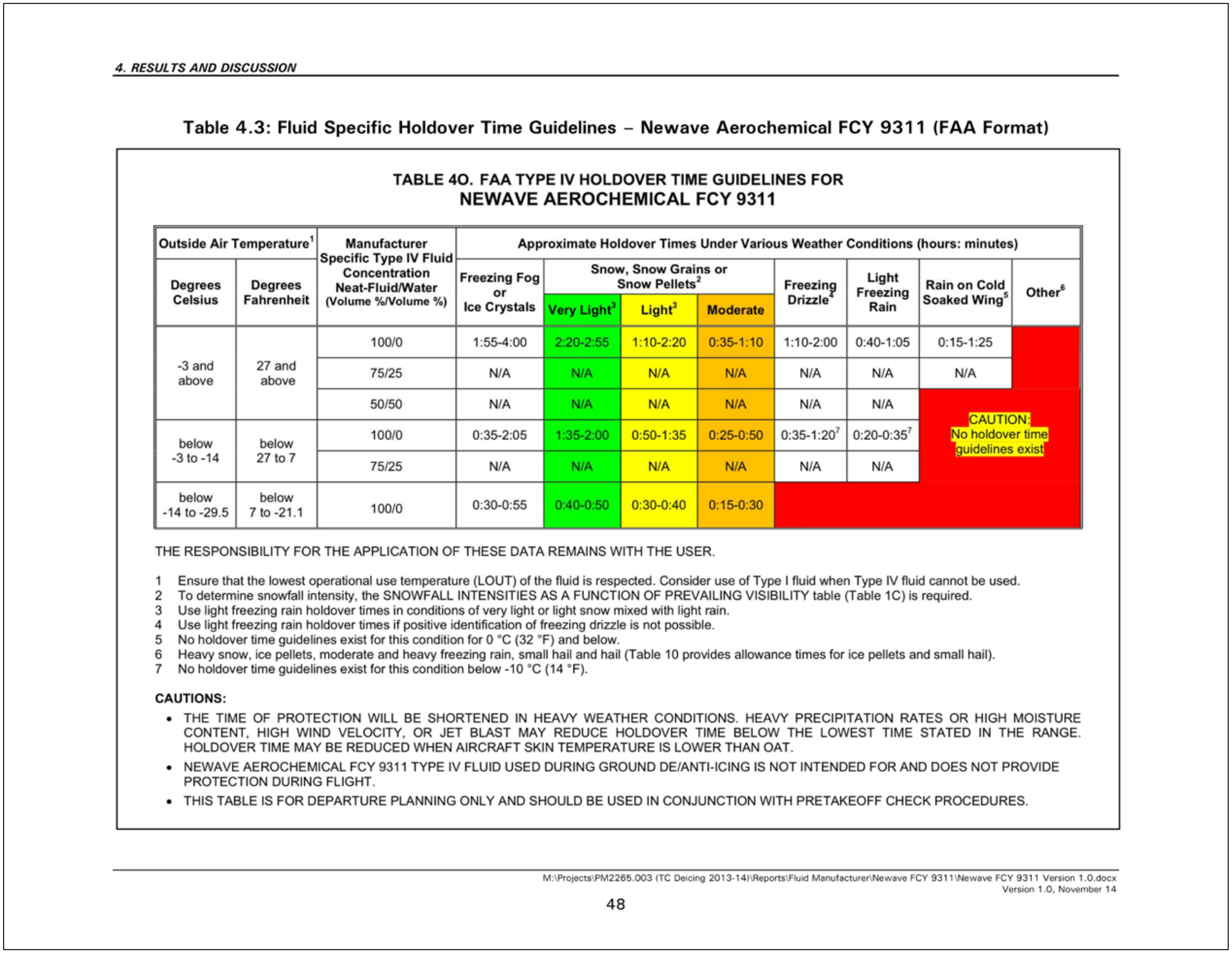


Table 4.3: Fluid Specific Holdover Time Guidelines – Newave Aerochemical FCY 9311 (FAA Format)

TABLE 4O. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY 9311

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow, Snow Grains or Snow Pellets[2]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	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		
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20[7]	0:20-0:35[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY 9311 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

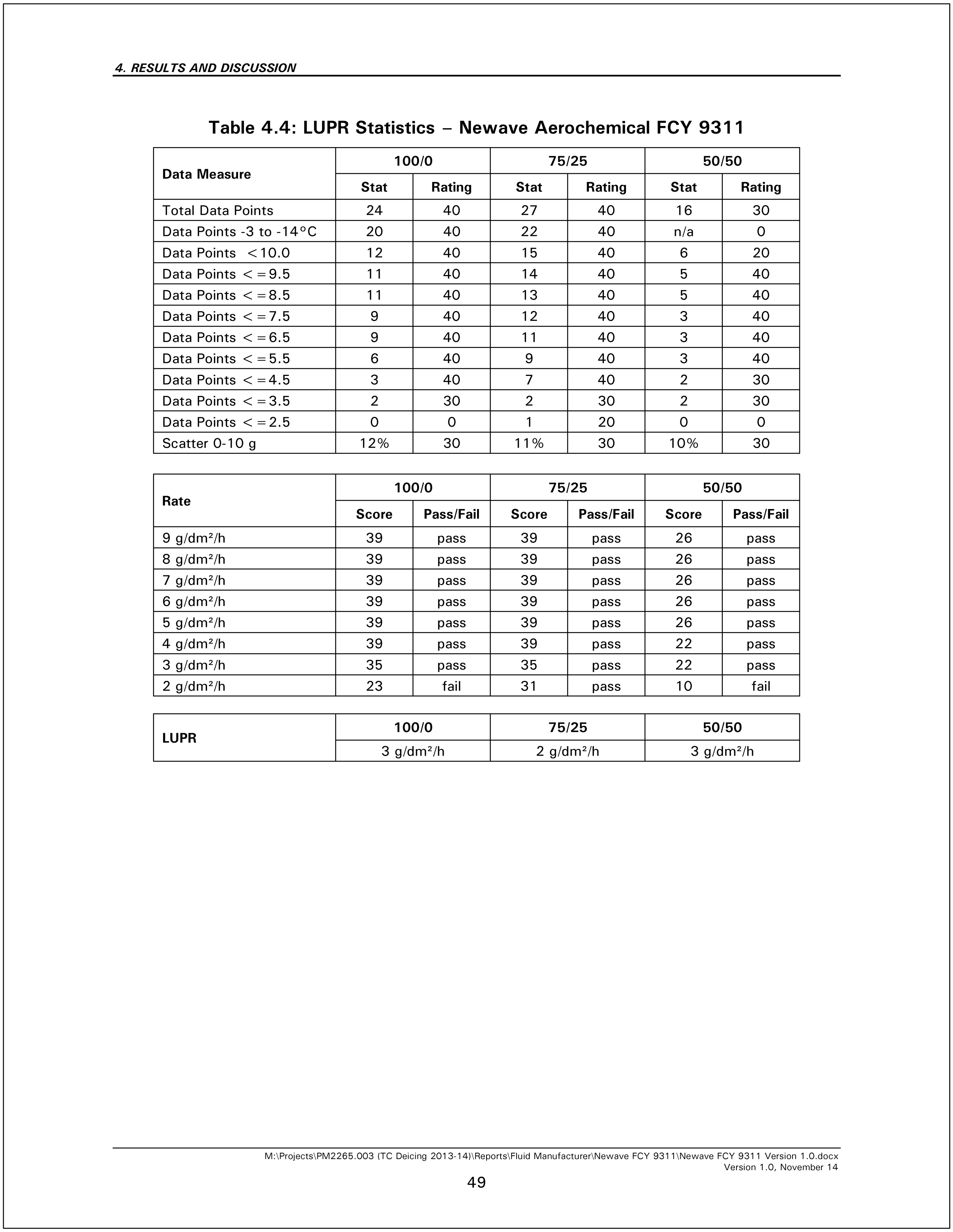


Table 4.4: LUPR Statistics – Newave Aerochemical FCY 9311

Data Measure	**100/0**		**75/25**		**50/50**	
	Stat	**Rating**	**Stat**	**Rating**	**Stat**	**Rating**
Total Data Points	24	40	27	40	16	30
Data Points -3 to -14°C	20	40	22	40	n/a	0
Data Points <10.0	12	40	15	40	6	20
Data Points <=9.5	11	40	14	40	5	40
Data Points <=8.5	11	40	13	40	5	40
Data Points <=7.5	9	40	12	40	3	40
Data Points <=6.5	9	40	11	40	3	40
Data Points <=5.5	6	40	9	40	3	40
Data Points <=4.5	3	40	7	40	2	30
Data Points <=3.5	2	30	2	30	2	30
Data Points <=2.5	0	0	1	20	0	0
Scatter 0-10 g	12%	30	11%	30	10%	30

Rate	**100/0**		**75/25**		**50/50**	
	Score	**Pass/Fail**	**Score**	**Pass/Fail**	**Score**	**Pass/Fail**
9 g/dm²/h	39	pass	39	pass	26	pass
8 g/dm²/h	39	pass	39	pass	26	pass
7 g/dm²/h	39	pass	39	pass	26	pass
6 g/dm²/h	39	pass	39	pass	26	pass
5 g/dm²/h	39	pass	39	pass	26	pass
4 g/dm²/h	39	pass	39	pass	22	pass
3 g/dm²/h	35	pass	35	pass	22	pass
2 g/dm²/h	23	fail	31	pass	10	fail

LUPR	**100/0**	**75/25**	**50/50**
	3 g/dm²/h	2 g/dm²/h	3 g/dm²/h

This page intentionally left blank.

APPENDIX H

TRANSPORT CANADA AND FEDERAL AVIATION ADMINISTRATION 2014-15 HOLDOVER TIME GUIDELINES

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2014-2015

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2014-2015

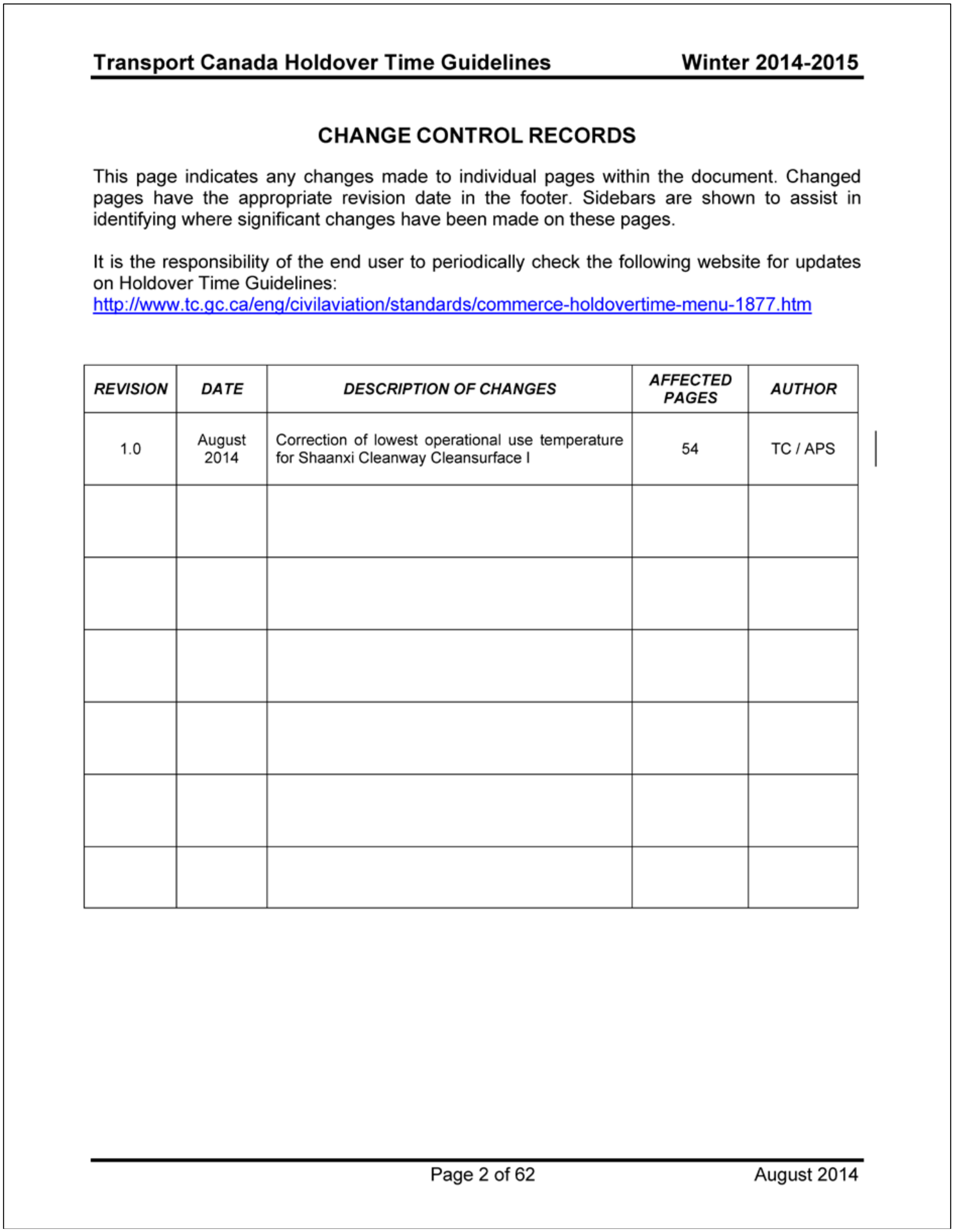
Original Issue, August 2014
Revision 1.0, August 2014

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

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

Questions or comments on the content of the holdover time guidelines should be addressed to
Transport Canada Civil Aviation Communication Centre Telephone 1-800-305-2059
Facsimile 613-949-4204 TTY (613) 990-4500 services@tc.gc.ca

To receive notification of HOT Guideline updates, subscribe to or update your e-news subscription at the following Transport Canada Web site: http://wwwapps.tc.gc.ca/Comm/5/ListServ/menu.aspx
Subscribing to e-news will require an email address and selecting Holdover Time (HOT) Guidelines under Publications / Air Transportation / Aviation Safety - Safety Information.



Transport Canada Holdover Time Guidelines **Winter 2014-2015**

CHANGE CONTROL RECORDS

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

It is the responsibility of the end user to periodically check the following website for updates on Holdover Time Guidelines:
http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm

REVISION	***DATE***	***DESCRIPTION OF CHANGES***	***AFFECTED PAGES***	***AUTHOR***
1.0	August 2014	Correction of lowest operational use temperature for Shaanxi Cleanway Cleansurface I	54	TC / APS

Page 2 of 62 August 2014

SUMMARY OF CHANGES FROM PREVIOUS YEAR

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

Active Frost

- The active frost holdover time (HOT) guidelines are unchanged.

Type I Fluid

- The Type I HOT guidelines are unchanged.

Type II Fluid

- A fluid-specific HOT guideline has been created for the new Type II fluid LNT Solutions P250.
- Kilfrost ABC-2000 has been removed from the Type II guidelines as per the protocol for removing obsolete fluids.
- The Type II generic HOT guidelines are unchanged.

Type III Fluid

- The Type III generic HOT guideline values are unchanged. However, a note has been added to the guideline to indicate it can only be used when fluid is applied unheated. Recent research indicates holdover times of Type III fluid can be shorter in some conditions when fluid is applied heated.

Type IV Fluid

- Fluid-specific HOT guidelines have been created for three new Type IV fluids: Clariant Max Flight Sneg, LNT Solutions E450, and Newave Aerochemical FCY 9311. Note that no holdover times are provided for 75/25 or 50/50 dilutions of E450 and FCY 9311.
- Lyondell Arctic Shield has been removed from the Type IV guidelines as per the protocol for removing obsolete fluids.
- Six decreases have been made to the Type IV generic HOT guidelines as a result of the addition of the new Type IV fluids.

Use of Visibility in Snow vs. Snowfall Intensity Table (Table 8)

- Table 8 must be used to determine snowfall intensity for the purpose of using the holdover time guidelines. A note has been added to all HOT guidelines to further clarify that Table 8 is the only acceptable means by which to assess snowfall intensity when using the HOT guidelines.

Guidance on Hail and Small Hail

- The meteorological conditions “hail” and “small hail” are not equivalent. No holdover times exist for either of these conditions; however, it has been determined that small hail is meteorologically equivalent to moderate ice pellets and therefore moderate ice pellet allowance times can be used in small hail conditions. The following changes have been made to provide clearer guidance on the use of holdover times and allowance times in hail and small hail conditions:
    - Small hail has been added to the list of “other” weather conditions for which holdover times do not exist. This list is provided as a note in each of the Type I, II, III and IV HOT guidelines.
    - Additional text has been added to the “other” weather conditions note in the Type III and Type IV HOT guidelines to guide users to the allowance time tables in ice pellet and small hail conditions.
    - Small hail has been added to the allowance time tables (Table 11 and Table 12).
    - A section on hail and small hail has been added to TP 14052E.

Ice Pellet and Small Hail Allowance Times

- Transport Canada has conducted research to provide additional guidance for aircraft operations during ice pellet conditions when operating with undiluted (100/0) Type III fluid applied unheated. A separate ice pellet allowance time table has been developed for Type III fluids and is included in this document (Table 11).
- Small hail has been added to the allowance time tables as it has been determined to be meteorologically equivalent to moderate ice pellets (see previous section). It has also been added to the titles of the allowance time guidance section and allowance time tables (Table 11 and Table 12).
- Research has indicated that Type IV propylene glycol (PG) fluids are removed less effectively during take-off when contaminated with moderate ice pellets at temperatures below -16°C. Therefore operations in these conditions are not recommended and no allowance times exist for PG fluids in conditions of moderate ice pellets at temperatures below -16°C, irrespective of aircraft rotation speed.
- Research has provided data to support a new Type IV allowance time of 7 minutes for light ice pellets mixed with moderate snow at temperatures below -5 to -10°C.

Interpretation of METAR Code GS

- The World Meteorological Organization (WMO) states METAR code GS is used for two meteorological conditions: “snow pellets” and “small hail.” However, investigation has determined that not all countries follow these guidelines. The use of the reported GS code can potentially lead to difficulties in determining which condition (snow pellets or small hail) is occurring and therefore in establishing the appropriate holdover time/allowance time. Consequently, a new section has been added to TP 14052E to provide guidance for determining which holdover times/allowance times should be used with METAR code GS.
- The SAE G-12 Holdover Time Committee passed a resolution requesting the WMO to consider establishing an international method to have separate METAR codes for small hail and snow pellets, similar to the reporting methods currently in use in the United States.

Note on Operations with Deployed Flaps/Slats

- Transport Canada is conducting research to provide additional guidance for aircraft operations with deployed flaps/slats. Transport Canada has determined that further research is necessary, therefore no changes to the operational and HOT guidelines with respect to deployed flaps/slats have been made for winter 2014-15. Further guidance is available in the *Changes to TP14052E* (Section 12.3) provided in this document.

CHANGES TO *Guidelines for Aircraft Ground-Icing Operations* (TP 14052E, second ed., April 2005)

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

Replace Sub-Paragraph 8.1.2 (2nd paragraph), "Fluid Description", with the following:

Anti-icing fluids are similar in composition except that they also contain polymeric thickeners. They are formulated to prevent formation of unabsorbed frozen contamination for a longer period of time than deicing fluids; however, the protection is still for a limited period of time. Although Type I fluids may be used for anti-icing, Type II, III and IV fluids are typically used in the anti-icing role because they can last for a significantly longer period of time than the Type I fluids.

Replace entire contents of Sub-Paragraph 8.1.4, "Certification Applicable to Qualified Fluids", with the following:

8.1.4 Acceptable Fluids

Transport Canada does not approve or qualify de/anti-icing fluids.

The aircraft manufacturer will generally indicate in the Aircraft Maintenance Manual the applicable industry specification for aircraft consumable materials. The industry fluid specifications for de/anti-icing fluids was discussed in Section 8.1.3.

The SAE specifications require numerous chemical and physical tests at a specialized laboratory. These tests are principally for measuring the compatibility of materials used in aircraft construction and the physical properties of the fluid against the appropriate SAE specification.

Also, the SAE specifications require a series of anti-icing and aerodynamic performance tests. The aerodynamic performance tests are conducted in a calibrated wind tunnel, in a specialized laboratory, for the purpose of measuring the aerodynamic and "flow off" characteristics of the fluid against the appropriate SAE specification.

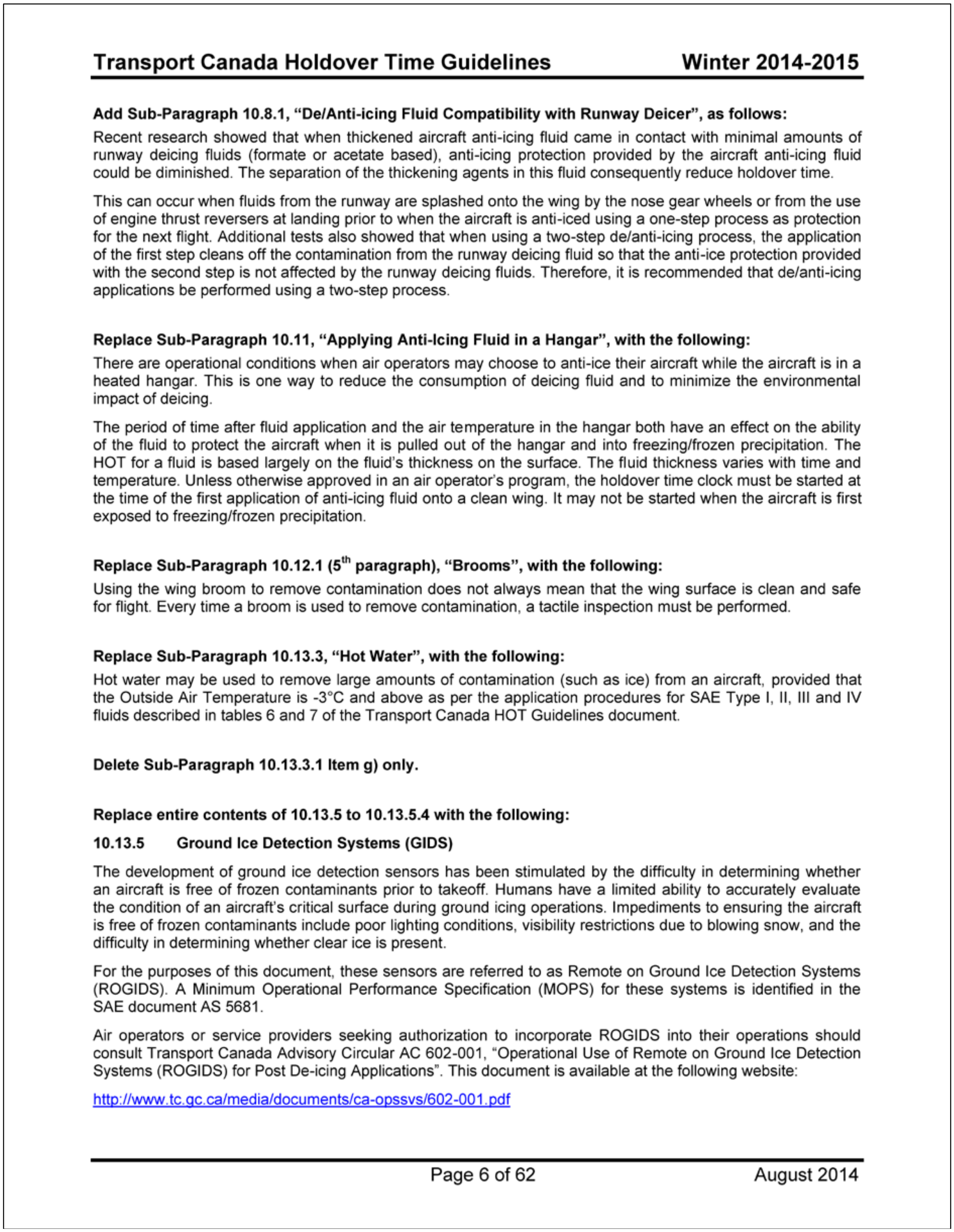
Further, fluids undergo HOT evaluation to assess their HOT characteristics and establish the values for the HOT guidelines for that particular fluid.

Replace Sub-Paragraph 10.4 (6th paragraph), "Procedure Selection", with the following:

The temperature of cold soaked wings can be considerably below the ambient temperature; therefore frost can build up in localized areas. When active frost is anticipated, the holdover times will be shortened when the wings are cold soaked, particularly when using Type I fluids. Consider applying SAE Type II or IV fluid to the surfaces as these will provide greater holdover times than Type I, along with better safety margins to prevent frost accumulation. Both wings should receive a symmetrical treatment for aerodynamic reasons.

Replace Sub-Paragraph 10.4.2 (2nd paragraph), "Two Step De/Anti-Icing", with the following:

If a two-step procedure is used, the first step is typically performed using a deicing fluid; however, alternate deicing technology or mechanical methods may be used depending on the circumstances. The selection of fluid type and concentration depends on the ambient temperature, the weather conditions and the desired holdover time. When performing a two-step process, the freezing point of a fluid used for the first step must not be more than 3°C above ambient temperature. The freezing point of an SAE Type I fluid used for a one-step process, or as the second step of a two-step operation, must be at least 10°C below the ambient temperature. The second step is to be performed before the first step freezes, typically within 3 minutes. This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area. When deicing fluid is used in step 1, the application of the second step fluid will flush away the first step fluid and leave a film of anti-icing fluid, which is designed to be of adequate thickness. If freezing of the deicing fluid has occurred, step 1 must be repeated. Refer to the SAE ARP 4737 document for additional details.



Add Sub-Paragraph 10.8.1, "De/Anti-icing Fluid Compatibility with Runway Deicer", as follows:

Recent research showed that when thickened aircraft anti-icing fluid came in contact with minimal amounts of runway deicing fluids (formate or acetate based), anti-icing protection provided by the aircraft anti-icing fluid could be diminished. The separation of the thickening agents in this fluid consequently reduce holdover time.

This can occur when fluids from the runway are splashed onto the wing by the nose gear wheels or from the use of engine thrust reversers at landing prior to when the aircraft is anti-iced using a one-step process as protection for the next flight. Additional tests also showed that when using a two-step de/anti-icing process, the application of the first step cleans off the contamination from the runway deicing fluid so that the anti-ice protection provided with the second step is not affected by the runway deicing fluids. Therefore, it is recommended that de/anti-icing applications be performed using a two-step process.

Replace Sub-Paragraph 10.11, "Applying Anti-Icing Fluid in a Hangar", with the following:

There are operational conditions when air operators may choose to anti-ice their aircraft while the aircraft is in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely on the fluid's thickness on the surface. The fluid thickness varies with time and temperature. Unless otherwise approved in an air operator's program, the holdover time clock must be started at the time of the first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to freezing/frozen precipitation.

Replace Sub-Paragraph 10.12.1 (5th paragraph), "Brooms", with the following:

Using the wing broom to remove contamination does not always mean that the wing surface is clean and safe for flight. Every time a broom is used to remove contamination, a tactile inspection must be performed.

Replace Sub-Paragraph 10.13.3, "Hot Water", with the following:

Hot water may be used to remove large amounts of contamination (such as ice) from an aircraft, provided that the Outside Air Temperature is -3°C and above as per the application procedures for SAE Type I, II, III and IV fluids described in tables 6 and 7 of the Transport Canada HOT Guidelines document.

Delete Sub-Paragraph 10.13.3.1 Item g) only.

Replace entire contents of 10.13.5 to 10.13.5.4 with the following:

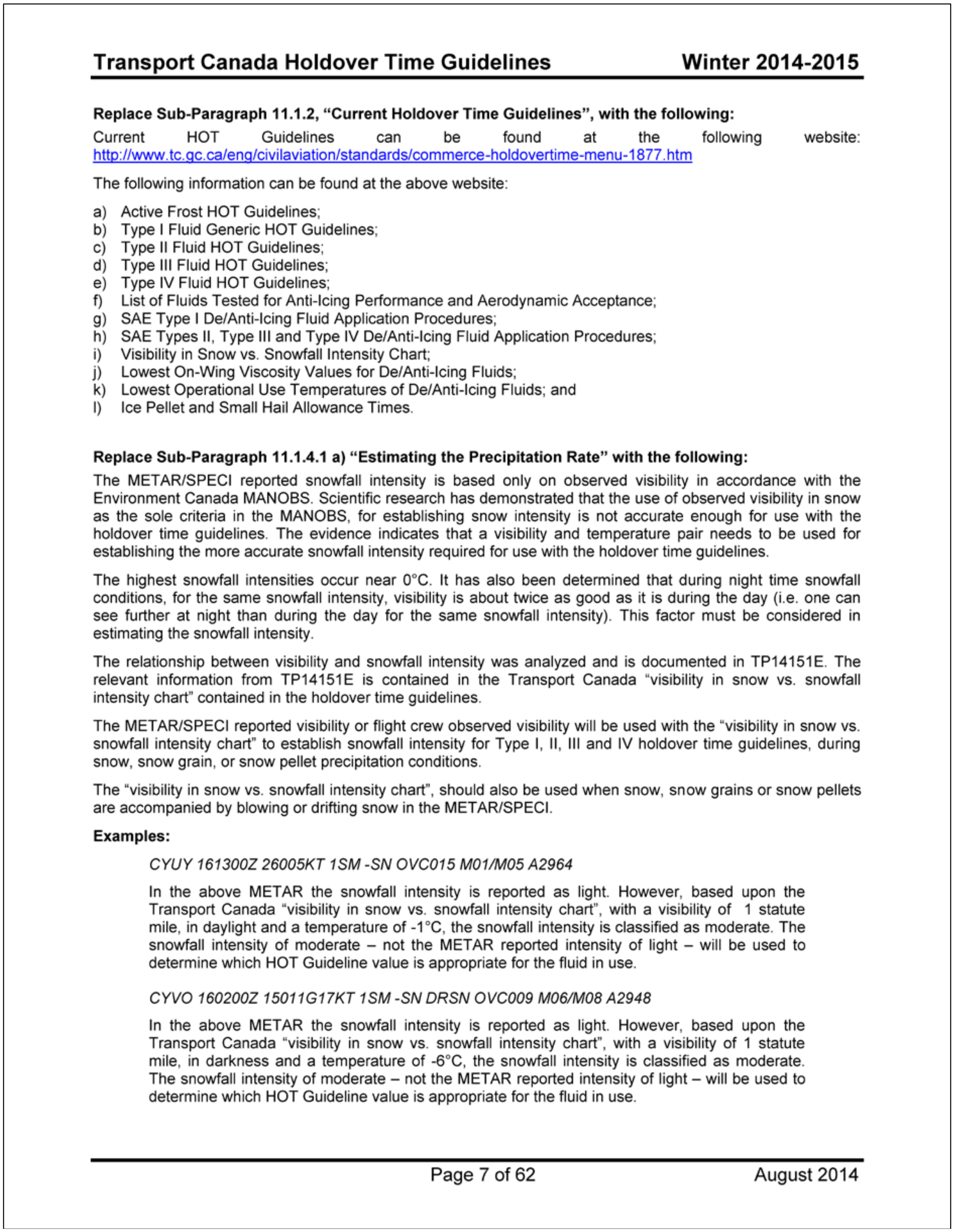
10.13.5 Ground Ice Detection Systems (GIDS)

The development of ground ice detection sensors has been stimulated by the difficulty in determining whether an aircraft is free of frozen contaminants prior to takeoff. Humans have a limited ability to accurately evaluate the condition of an aircraft's critical surface during ground icing operations. Impediments to ensuring the aircraft is free of frozen contaminants include poor lighting conditions, visibility restrictions due to blowing snow, and the difficulty in determining whether clear ice is present.

For the purposes of this document, these sensors are referred to as Remote on Ground Ice Detection Systems (ROGIDS). A Minimum Operational Performance Specification (MOPS) for these systems is identified in the SAE document AS 5681.

Air operators or service providers seeking authorization to incorporate ROGIDS into their operations should consult Transport Canada Advisory Circular AC 602-001, "Operational Use of Remote on Ground Ice Detection Systems (ROGIDS) for Post De-icing Applications". This document is available at the following website:

http://www.tc.gc.ca/media/documents/ca-opssvs/602-001.pdf



Replace Sub-Paragraph 11.1.2, "Current Holdover Time Guidelines", with the following:

Current HOT Guidelines can be found at the following website: http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm

The following information can be found at the above website:

a) Active Frost HOT Guidelines;
b) Type I Fluid Generic HOT Guidelines;
c) Type II Fluid HOT Guidelines;
d) Type III Fluid HOT Guidelines;
e) Type IV Fluid HOT Guidelines;
f) List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance;
g) SAE Type I De/Anti-Icing Fluid Application Procedures;
h) SAE Types II, Type III and Type IV De/Anti-Icing Fluid Application Procedures;
i) Visibility in Snow vs. Snowfall Intensity Chart;
j) Lowest On-Wing Viscosity Values for De/Anti-Icing Fluids;
k) Lowest Operational Use Temperatures of De/Anti-Icing Fluids; and
l) Ice Pellet and Small Hail Allowance Times.

Replace Sub-Paragraph 11.1.4.1 a) "Estimating the Precipitation Rate" with the following:

The METAR/SPECI reported snowfall intensity is based only on observed visibility in accordance with the Environment Canada MANOBS. Scientific research has demonstrated that the use of observed visibility in snow as the sole criteria in the MANOBS, for establishing snow intensity is not accurate enough for use with the holdover time guidelines. The evidence indicates that a visibility and temperature pair needs to be used for establishing the more accurate snowfall intensity required for use with the holdover time guidelines.

The highest snowfall intensities occur near 0°C. It has also been determined that during night time snowfall conditions, for the same snowfall intensity, visibility is about twice as good as it is during the day (i.e. one can see further at night than during the day for the same snowfall intensity). This factor must be considered in estimating the snowfall intensity.

The relationship between visibility and snowfall intensity was analyzed and is documented in TP14151E. The relevant information from TP14151E is contained in the Transport Canada "visibility in snow vs. snowfall intensity chart" contained in the holdover time guidelines.

The METAR/SPECI reported visibility or flight crew observed visibility will be used with the "visibility in snow vs. snowfall intensity chart" to establish snowfall intensity for Type I, II, III and IV holdover time guidelines, during snow, snow grain, or snow pellet precipitation conditions.

The "visibility in snow vs. snowfall intensity chart", should also be used when snow, snow grains or snow pellets are accompanied by blowing or drifting snow in the METAR/SPECI.

Examples:

CYUY 161300Z 26005KT 1SM -SN OVC015 M01/M05 A2964

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "visibility in snow vs. snowfall intensity chart", with a visibility of 1 statute mile, in daylight and a temperature of -1°C, the snowfall intensity is classified as moderate. The snowfall intensity of moderate – not the METAR reported intensity of light – will be used to determine which HOT Guideline value is appropriate for the fluid in use.

CYVO 160200Z 15011G17KT 1SM -SN DRSN OVC009 M06/M08 A2948

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "visibility in snow vs. snowfall intensity chart", with a visibility of 1 statute mile, in darkness and a temperature of -6°C, the snowfall intensity is classified as moderate. The snowfall intensity of moderate – not the METAR reported intensity of light – will be used to determine which HOT Guideline value is appropriate for the fluid in use.

Rarely, there may be circumstances where the METAR/SPECI reported visibility or flight crew observed visibility is substantially reduced due to obscuration conditions such as fog, mist, freezing fog, dust, haze, or smoke. These obscuration conditions contribute very little to the overall catch rate at the wing surface and using the "visibility in snow vs. snowfall intensity chart", would likely over estimate the snow fall intensity.

Under these conditions and with a careful assessment by the flight crew to ensure that the obscuration conditions are not concealing significant snowfall intensities, the METAR/SPECI reported snowfall intensity can be used.

Example:

> *CYTS 231000Z 21003KT ½ SM SN FZFG OVC003 M03/M03 A2969*
>
> In the above METAR, the snowfall intensity is reported as moderate. Based on the Transport Canada "visibility in snow vs. snowfall intensity chart", with a visibility of ½ statute mile, in darkness and a temperature of -3°C, the snowfall intensity is classified as heavy. However, since freezing fog is present as an obscuring condition, a moderate snowfall intensity (as reported in the METAR) can be used to determine which HOT Guideline value is appropriate for the fluid in use, provided the crew can ensure that the obscuration is not concealing significant snowfall intensities.

NOTE: The Transport Canada 'visibility in snow vs. snowfall intensity' chart can be found along with the current HOT Guidelines through the Transport Canada website: www.tc.gc.ca.

Use of Runway Visual Range (RVR) with the TC "Visibility in Snow vs Snowfall Intensity" Chart

There has been some confusion regarding the values indicated below the visibility (in parentheses) on the Snowfall Intensity Chart. The values indicated in parentheses refer to the visibility in metres and not an RVR.

RVR should not be used to determine visibility for the following reasons:

a) RVR transmissometers were never intended to measure visibility with respect to snowfall intensity for use with holdover time guidelines.

b) The RVR equipment is designed to provide pilots with an expected visual range along the runway, based on an associated runway edge and centerline lighting intensity. For a given obscuration phenomenon and precipitation intensity (fog, snow, etc.) the RVR will vary based on the selected runway lighting level. Therefore multiple RVR are possible for a given condition even though the meteorological conditions remain the same.

c) Furthermore RVR's in excess of 6000 ft are simply reported as 6000+. This level of resolution, only allows limited use of the Snowfall Intensity Chart (for example in darkness and at a temperature of -1°C and an RVR of 6000+, the only conclusion that can be drawn from the Snowfall Intensity Chart is that we are not in heavy snow, and that we could be in Moderate, Light or Very Light Snow conditions).

Varying Weather Conditions After Completion of Anti-Icing Procedure

During periods when the weather conditions are varying after completion of the anti-icing procedure, crews should reassess the previously selected holdover time. When doing so crews need to consider the following:

1) Improving weather conditions – if the snowfall intensity decreases, the original HOT should be retained;

2) Worsening weather conditions – if the snowfall intensity increases, a new lower HOT should be established and used.

Replace Sub-Paragraph 11.1.5, "Elapsed time is less than the lowest time in the HOT cell", with the following:

Transport Canada has previously considered that, under an approved ground icing program, if the lowest time in a cell has NOT been exceeded for conditions covered by the Guidelines, there is no requirement to inspect the aircraft's critical surfaces prior to commencing a takeoff.

This position was based on evidence gained during fluids testing. The HOT values are conservative for the lowest number in the cell, if:

a) The conditions present are NOT in excess of those conditions represented by the table (e.g. for snow, it would be a moderate snow condition); and

b) The impact of other factors (e.g. jet blast) has been considered and deemed not to affect the HOT.

If there is doubt surrounding the conditions associated with using the lowest time as a decision-making criterion, an inspection prior to takeoff would be prudent. This inspection should be conducted in accordance with the procedures described in the Air Operator's Approved Ground Icing Program.

Replace Sub-Paragraph 11.1.8, "Meteorological Conditions for which the HOT Guidelines are not applicable", with the following:

The HOT Guidelines do not include guidelines for all meteorological conditions. Holdover time guidelines have not been assessed for the following conditions: a) Hail; b) Moderate and Heavy Freezing Rain; and c) Heavy Snow.

Note: Operators need to assess whether operations can be safely conducted under these conditions.

Additionally, holdover time guidelines have not been assessed for Ice Pellets or Small Hail, since a formal protocol for this testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have yet been identified for these conditions. Instead, allowance times have been developed for operations during ice pellet conditions as a result of research carried out by Transport Canada and the FAA. As it has been determined small hail is equivalent to moderate ice pellets, allowance times are also provided for small hail conditions.

Replace entire contents of Sub-Paragraph 11.1.9, "Use of approved fluids", with the following:

11.1.9 Use of De/Anti-icing Fluids

The operator is ultimately responsible for ensuring that only fluids tested to SAE AMS 1424 or SAE AMS 1428 are applied when the HOT Guidelines will be utilized operationally.

The Transport Canada Holdover Time Guidelines document, published on an annual basis, contains lists of fluids that have been tested with respect to anti-icing performance (SAE AMS 1424 or SAE AMS 1428) and aerodynamic acceptance (SAE AMS 1424 or SAE AMS 1428) only.

Therefore, the end user is cautioned that they must confirm that other SAE AMS 1424 or SAE AMS 1428 technical requirement tests such as fluid stability, toxicity, materials compatibility, etc. have been conducted. The fluid manufacturer will supply all samples for testing and, is responsible for obtaining independent laboratory confirmation of conformance to these requirements of AMS 1424 or AMS 1428. The fluid manufacturer should provide certificates of conformance upon request.

Add Sub-Paragraph 11.1.12, "Type I HOT Guidelines for Aircraft with Critical Surfaces Constructed Using Composite Materials", as follows:

The recent introduction of new aircraft constructed primarily with composite materials required a review of Type I fluid holdover time performance when used on these aircraft. This review has shown that the holdover time performance of Type I fluids on composite surfaces is reduced when compared to aluminum surfaces. Type I fluid holdover time evaluations were conducted and holdover times have been developed for use with aircraft critical surfaces constructed primarily with composite materials.

It is not the intent that the composite holdover times be used on aircraft where previous experience has shown the acceptable use of aluminum holdover times (unless those aircraft have predominately or entirely composite critical surfaces). If there is any doubt, consult with the aircraft manufacturer to determine whether to use aluminum or composite holdover times.

Add Sub-Paragraph 11.1.13, "Longer Holdover Times for 75/25 Dilutions", as follows:

For some brand-specific fluids, protection is increased in some cells when fluid concentration is reduced. The addition of certain quantities of water to some neat fluids can enhance their performance up to a certain point. Without knowing about this particular fluid mix phenomenon, an operator may think that the data presented in the tables are in error.

Add Sub-Paragraph 11.1.14, "Holdover Times for Non-Standard Dilutions of Type II, III and IV fluids", as follows:

When a Type II, III, or IV fluid is diluted to other than the published 100/0, 75/25 or 50/50 dilutions, the more conservative holdover time and LOUT associated with either the dilution above or below the selected dilution are applicable.

For example:

1) The holdover time and LOUT of a 80/20 dilution would be the more conservative holdover time and LOUT of either the 100/0 or 75/25 dilutions;
2) The holdover time and LOUT of a 60/40 dilution would be the more conservative holdover time and LOUT of either the 75/25 or 50/50 dilutions.

Replace Sub-Paragraph 12.1.2, "Ice Pellet Conditions", with the following:

Holdover time guidelines have not been assessed for ice pellets, since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have been identified for ice pellet conditions.

However, comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for allowance times for operations in light and moderate ice pellets, as well as allowance times for operations in light ice pellets mixed with other forms of precipitation.

Replace Sub-Paragraph 12.1.6, "Cold Dry Snow Falling on a Cold Dry Wing", with the following:

12.1.6 Cold Dry Snow (or Ice Crystals) Falling on a Cold Dry Wing

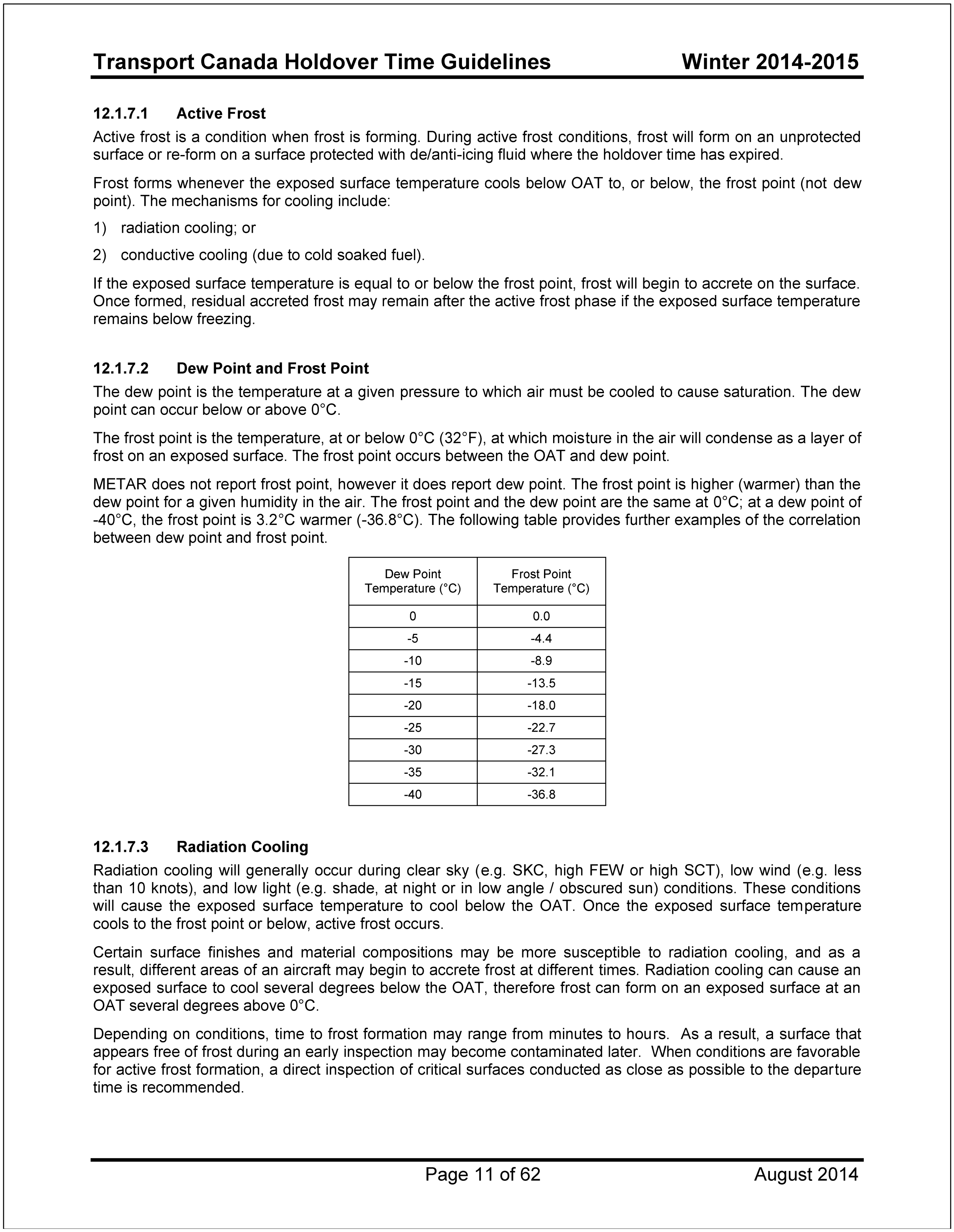
Conditions are encountered whereby cold dry snow (or ice crystals) are falling onto the cold wing of an aircraft. The wind often causes the snow (or ice crystals) to swirl and move across the surface of the wing and it is evident that the snow (or ice crystals) is not adhering to the wing surface. Under these circumstances the application of deicing/anti-icing fluid to the wing of the aircraft would likely result in the snow (or ice crystals) sticking to the fluid. Under such operational conditions it may not be prudent to apply fluids to the wing.

However, if snow or ice crystals have accumulated at any location on the wing surface it must be removed prior to take-off. It cannot be assumed that snow or ice crystals on a wing will "blow off" during the take-off. For example, refueling with fuel warmer than the wing skin temperature may create a condition whereby previously non adhering contaminants may adhere to the wing surfaces.

Replace entire contents of Sub-Paragraph 12.1.7 "Frost", with the following:

12.1.7 Frost

Frost occurs frequently during winter operating conditions. Frost due to radiation cooling is a uniform thin white deposit of fine crystalline texture, which forms on exposed surfaces that are below freezing, generally on calm cloudless nights where the air at the surface is close to saturation. When the deposit is thin enough for surface features underneath the frost, such as paint lines, markings and lettering, to be distinguished it is often referred to as hoarfrost. Frost can also form on the upper or lower surfaces of the wing due to cold soaked fuel. Frost has the appearance of being a minor contaminant and therefore does not offer the same obvious signal of danger as do other types of contamination such as snow or ice. However, frost is an insidious threat to the safety of aircraft operations because it always adheres to the aircraft surface, is rough and causes significant lift degradation and increased drag.



12.1.7.1 Active Frost

Active frost is a condition when frost is forming. During active frost conditions, frost will form on an unprotected surface or re-form on a surface protected with de/anti-icing fluid where the holdover time has expired.

Frost forms whenever the exposed surface temperature cools below OAT to, or below, the frost point (not dew point). The mechanisms for cooling include:

1) radiation cooling; or
2) conductive cooling (due to cold soaked fuel).

If the exposed surface temperature is equal to or below the frost point, frost will begin to accrete on the surface. Once formed, residual accreted frost may remain after the active frost phase if the exposed surface temperature remains below freezing.

12.1.7.2 Dew Point and Frost Point

The dew point is the temperature at a given pressure to which air must be cooled to cause saturation. The dew point can occur below or above 0°C.

The frost point is the temperature, at or below 0°C (32°F), at which moisture in the air will condense as a layer of frost on an exposed surface. The frost point occurs between the OAT and dew point.

METAR does not report frost point, however it does report dew point. The frost point is higher (warmer) than the dew point for a given humidity in the air. The frost point and the dew point are the same at 0°C; at a dew point of -40°C, the frost point is 3.2°C warmer (-36.8°C). The following table provides further examples of the correlation between dew point and frost point.

Dew Point Temperature (°C)	Frost Point Temperature (°C)
0	0.0
-5	-4.4
-10	-8.9
-15	-13.5
-20	-18.0
-25	-22.7
-30	-27.3
-35	-32.1
-40	-36.8

12.1.7.3 Radiation Cooling

Radiation cooling will generally occur during clear sky (e.g. SKC, high FEW or high SCT), low wind (e.g. less than 10 knots), and low light (e.g. shade, at night or in low angle / obscured sun) conditions. These conditions will cause the exposed surface temperature to cool below the OAT. Once the exposed surface temperature cools to the frost point or below, active frost occurs.

Certain surface finishes and material compositions may be more susceptible to radiation cooling, and as a result, different areas of an aircraft may begin to accrete frost at different times. Radiation cooling can cause an exposed surface to cool several degrees below the OAT, therefore frost can form on an exposed surface at an OAT several degrees above 0°C.

Depending on conditions, time to frost formation may range from minutes to hours. As a result, a surface that appears free of frost during an early inspection may become contaminated later. When conditions are favorable for active frost formation, a direct inspection of critical surfaces conducted as close as possible to the departure time is recommended.

12.1.7.4 Cold Soaked Fuel Cooling

Cold soaked fuel cooling results from conductive cooling due to very cold fuel on board at destination or from refueling with fuel that may be cooler than the OAT. Cold soaked fuel conditions are highly variable and therefore, only direct surface temperature readings are accurate, but not available at most stations. Fuel temperature does not accurately predict cold soaked fuel conditions but may provide an initial indication, particularly in the period after landing and prior to fuelling. The presence of frost under the wing is a good indication of cold soaked fuel conditions.

In extreme cases, cold soaking may reduce the surface temperature below the fluid LOUT and cause aerodynamic performance degradation due to fluid freezing or the inability of the fluid to adequately flow off the treated surface.

12.1.7.5 Combined Radiation and Cold Soaked Fuel Cooling Effects

Cold soaked fuel cooling combined with radiation cooling effects can cause reductions in active frost holdover times. This is particularly true for Type I fluid holdover times as these are shorter in duration, and therefore use of a thickened anti-icing fluid should be considered.

12.1.7.6 De/Anti-Icing in Active Frost Conditions

Frost reforming after removal is an indication of active frost. During active frost, anti-icing protection is required and operations should be conducted in accordance with holdover time guidelines and minimum fluid quantity and temperature application procedures therein. Applications such as misting or mopping of Type I fluid may not provide adequate heat or fluid quantity to use the holdover times in active frost conditions.

In active frost conditions, deicing alone is insufficient, therefore, once the frost has been removed, a preventative anti-icing coating is required.

12.1.7.7 Fluid Holdover Times for Active Frost Conditions

Fluid holdover times in active frost conditions differ from holdover times in other conditions as they incorporate an allowance for the temperature differential (typically 6 to 8°C) between the OAT and the exposed surface temperature due to radiation cooling. As a result of this allowance, the OAT should be used to determine the appropriate active frost holdover time.

Active frost holdover times may be reduced in the presence of combined cooling effects or extreme surface cooling. In extreme cases, the surface temperature may be below the fluid LOUT and cause aerodynamic performance degradation due to fluid freezing or the inability of the fluid to adequately flow off the treated surface.

12.1.7.8 Frost on the Underside of the Wing

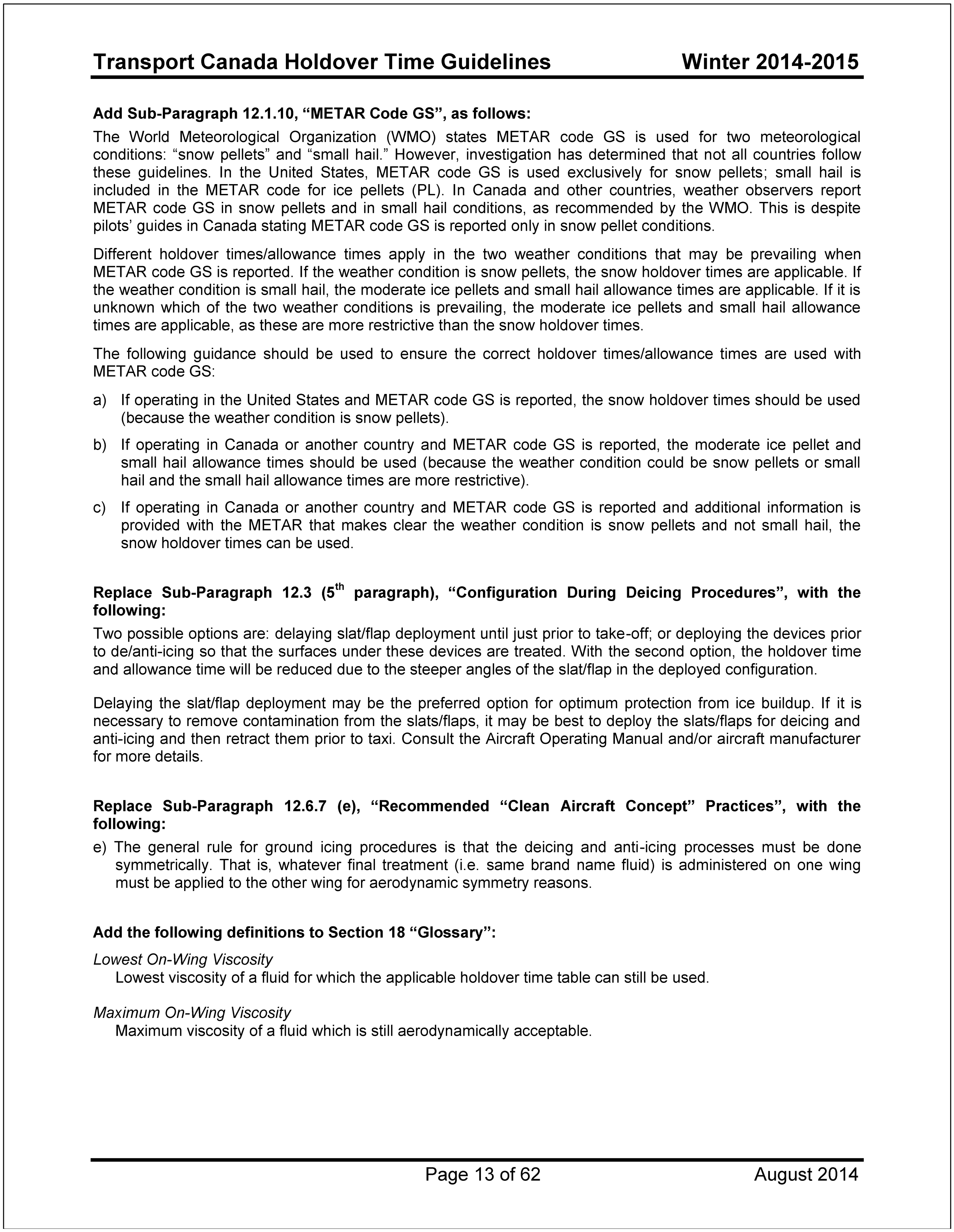
CAR 602.11(3) states: Notwithstanding subsection (12.1.7.9), a person may conduct a take-off in an aircraft that has frost adhering to the underside of its wings that is caused by cold-soaked fuel, if the take-off is conducted in accordance with the aircraft manufacturer's instructions for take-off under those conditions.

12.1.7.9 Frost on the Fuselage

Despite the requirement to clean contamination from critical surfaces, it is acceptable for aircraft, including those with aft fuselage mounted engines, to take-off when hoarfrost is adhering to the upper surface of the fuselage if it is the only remaining contaminant, provided all vents and ports are clear. Contact the aircraft manufacturer for further details.

Add Sub-Paragraph 12.1.9, "Hail and Small Hail", as follows:

The meteorological conditions "Hail" and "Small Hail" are different. Hail is a more intense condition for which holdover times do not exist. Small hail is a lighter condition, meteorologically equivalent to moderate ice pellets, for which allowance times are provided.



Add Sub-Paragraph 12.1.10, "METAR Code GS", as follows:

The World Meteorological Organization (WMO) states METAR code GS is used for two meteorological conditions: "snow pellets" and "small hail." However, investigation has determined that not all countries follow these guidelines. In the United States, METAR code GS is used exclusively for snow pellets; small hail is included in the METAR code for ice pellets (PL). In Canada and other countries, weather observers report METAR code GS in snow pellets and in small hail conditions, as recommended by the WMO. This is despite pilots' guides in Canada stating METAR code GS is reported only in snow pellet conditions.

Different holdover times/allowance times apply in the two weather conditions that may be prevailing when METAR code GS is reported. If the weather condition is snow pellets, the snow holdover times are applicable. If the weather condition is small hail, the moderate ice pellets and small hail allowance times are applicable. If it is unknown which of the two weather conditions is prevailing, the moderate ice pellets and small hail allowance times are applicable, as these are more restrictive than the snow holdover times.

The following guidance should be used to ensure the correct holdover times/allowance times are used with METAR code GS:

a) If operating in the United States and METAR code GS is reported, the snow holdover times should be used (because the weather condition is snow pellets).

b) If operating in Canada or another country and METAR code GS is reported, the moderate ice pellet and small hail allowance times should be used (because the weather condition could be snow pellets or small hail and the small hail allowance times are more restrictive).

c) If operating in Canada or another country and METAR code GS is reported and additional information is provided with the METAR that makes clear the weather condition is snow pellets and not small hail, the snow holdover times can be used.

Replace Sub-Paragraph 12.3 (5th paragraph), "Configuration During Deicing Procedures", with the following:

Two possible options are: delaying slat/flap deployment until just prior to take-off; or deploying the devices prior to de/anti-icing so that the surfaces under these devices are treated. With the second option, the holdover time and allowance time will be reduced due to the steeper angles of the slat/flap in the deployed configuration.

Delaying the slat/flap deployment may be the preferred option for optimum protection from ice buildup. If it is necessary to remove contamination from the slats/flaps, it may be best to deploy the slats/flaps for deicing and anti-icing and then retract them prior to taxi. Consult the Aircraft Operating Manual and/or aircraft manufacturer for more details.

Replace Sub-Paragraph 12.6.7 (e), "Recommended "Clean Aircraft Concept" Practices", with the following:

e) The general rule for ground icing procedures is that the deicing and anti-icing processes must be done symmetrically. That is, whatever final treatment (i.e. same brand name fluid) is administered on one wing must be applied to the other wing for aerodynamic symmetry reasons.

Add the following definitions to Section 18 "Glossary":

Lowest On-Wing Viscosity
Lowest viscosity of a fluid for which the applicable holdover time table can still be used.

Maximum On-Wing Viscosity
Maximum viscosity of a fluid which is still aerodynamically acceptable.

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2014-2015

Table 0	Active Frost Holdover Guidelines
Table 1-A	SAE Type I Fluid Holdover Guidelines on Aluminum Wing Surfaces
Table 1-C	SAE Type I Fluid Holdover Guidelines on Composite Wing Surfaces
Table 2-Generic	SAE Type II Fluid Holdover Guidelines
Table 2-A-E26	Type II Fluid Holdover Guidelines - ABAX Ecowing 26
Table 2-AS-CW II	Type II Fluid Holdover Guidelines - Aviation Shaanxi Hi-Tech Cleanwing II
Table 2-C-FLIGHT	Type II Fluid Holdover Guidelines - Clariant Safewing MP II FLIGHT
Table 2-C-FLIGHT+	Type II Fluid Holdover Guidelines - Clariant Safewing MP II FLIGHT PLUS
Table 2-CR-PG-II	Type II Fluid Holdover Guidelines - Cryotech Polar Guard II
Table 2-K-ABC-K+	Type II Fluid Holdover Guidelines - Kilfrost ABC-K Plus
Table 2-L-P250	Type II Fluid Holdover Guidelines - LNT Solutions P250
Table 2-N-FCY-2	Type II Fluid Holdover Guidelines - Newave Aerochemical FCY-2
Table 3	SAE Type III Fluid Holdover Guidelines
Table 4-Generic	SAE Type IV Fluid Holdover Guidelines
Table 4-A-AD-480	Type IV Fluid Holdover Guidelines - ABAX AD-480
Table 4-A-E-AD-49	Type IV Fluid Holdover Guidelines - ABAX Ecowing AD-49
Table 4-C-MF-04	Type IV Fluid Holdover Guidelines - Clariant Max Flight 04
Table 4-C-MF-SNEG	Type IV Fluid Holdover Guidelines - Clariant Max Flight Sneg
Table 4-C-LAUNCH	Type IV Fluid Holdover Guidelines - Clariant Safewing MP IV LAUNCH
Table 4-C-LAUNCH+	Type IV Fluid Holdover Guidelines - Clariant Safewing MP IV LAUNCH PLUS
Table 4-CR-PG	Type IV Fluid Holdover Guidelines - Cryotech Polar Guard
Table 4-CR-PG-A	Type IV Fluid Holdover Guidelines - Cryotech Polar Guard Advance
Table 4-D-E106	Type IV Fluid Holdover Guidelines - Dow Chemical UCAR™ Endurance EG106
Table 4-D-AD-480	Type IV Fluid Holdover Guidelines - Dow Chemical UCAR™ FlightGuard AD-480
Table 4-D-AD-49	Type IV Fluid Holdover Guidelines - Dow Chemical UCAR™ FlightGuard AD-49
Table 4-K-ABC-S	Type IV Fluid Holdover Guidelines - Kilfrost ABC-S
Table 4-K-ABC-S+	Type IV Fluid Holdover Guidelines - Kilfrost ABC-S Plus
Table 4-L-E450	Type IV Fluid Holdover Guidelines - LNT Solutions E450
Table 4-N-F-9311	Type IV Fluid Holdover Guidelines - Newave Aerochemical FCY 9311
Table 5	List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance
Table 6	SAE Type I De/Anti-icing Fluid Application Procedures
Table 7	SAE Type II, Type III and Type IV De/Anti-Icing Fluid Application Procedures
Table 8	Visibility in Snow vs. Snowfall Intensity Chart
Table 9	Lowest On-Wing Viscosity Values for De/Anti-Icing Fluids
Table 10	Lowest Operational Use Temperatures of De/Anti-Icing Fluids
Table 11	SAE Type III Ice Pellet and Small Hail Allowance Times
Table 12	SAE Type IV Ice Pellet and Small Hail Allowance Times

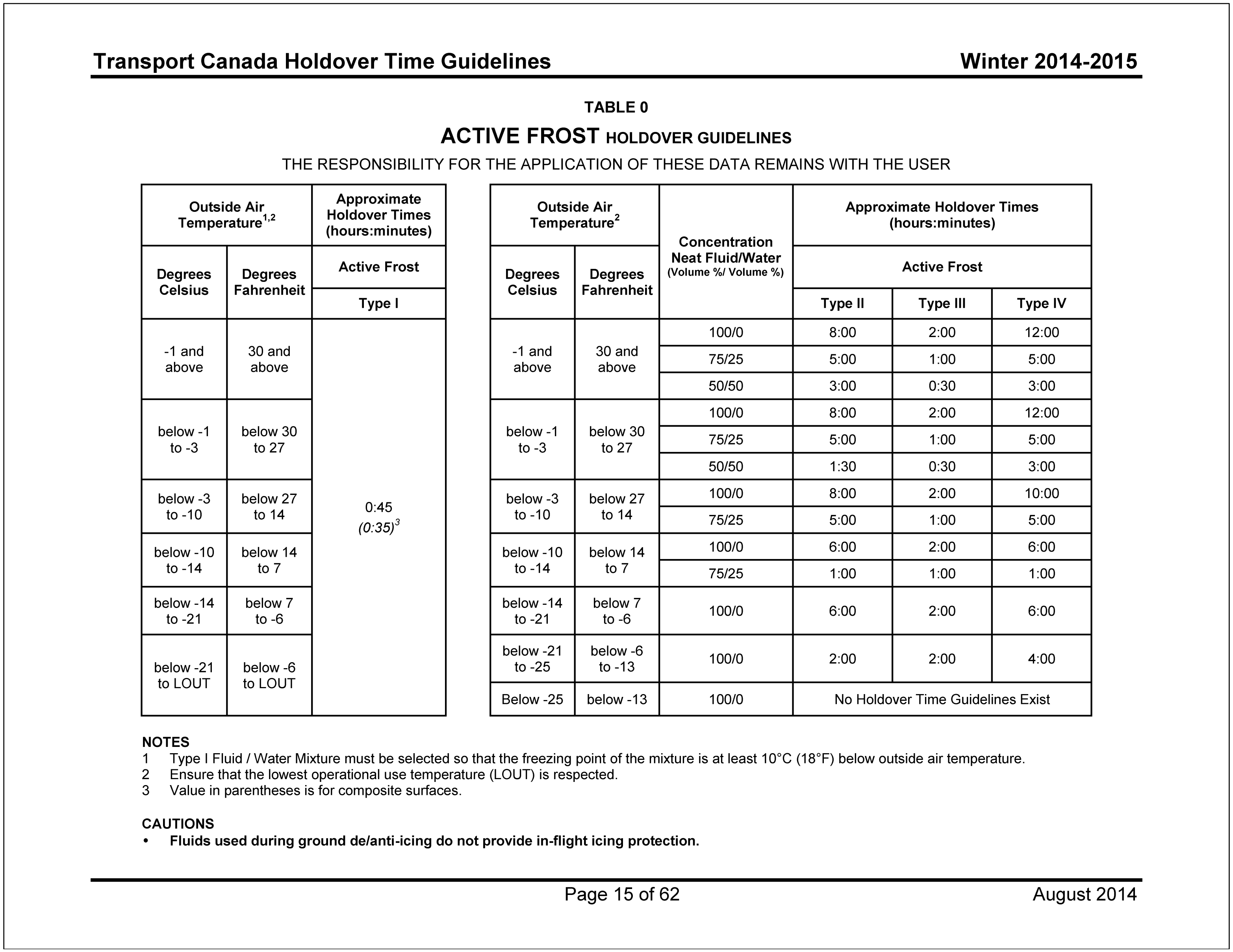


TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES

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

Outside Air Temperature[1,2]		Approximate Holdover Times (hours:minutes)
		Active Frost
Degrees Celsius	Degrees Fahrenheit	Type I
-1 and above	30 and above	0:45 *(0:35)*[3]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2]		Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes)		
			Active Frost		
Degrees Celsius	Degrees Fahrenheit		Type II	Type III	Type IV
-1 and above	30 and above	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0	8:00	2:00	10:00
		75/25	5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0	6:00	2:00	6:00
		75/25	1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0	6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0	2:00	2:00	4:00
Below -25	below -13	100/0	No Holdover Time Guidelines Exist		

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Value in parentheses is for composite surfaces.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES[1]

This table applies to aircraft with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

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

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

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

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

TABLE 1-C

SAE TYPE I FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES[1]

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.

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

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

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

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

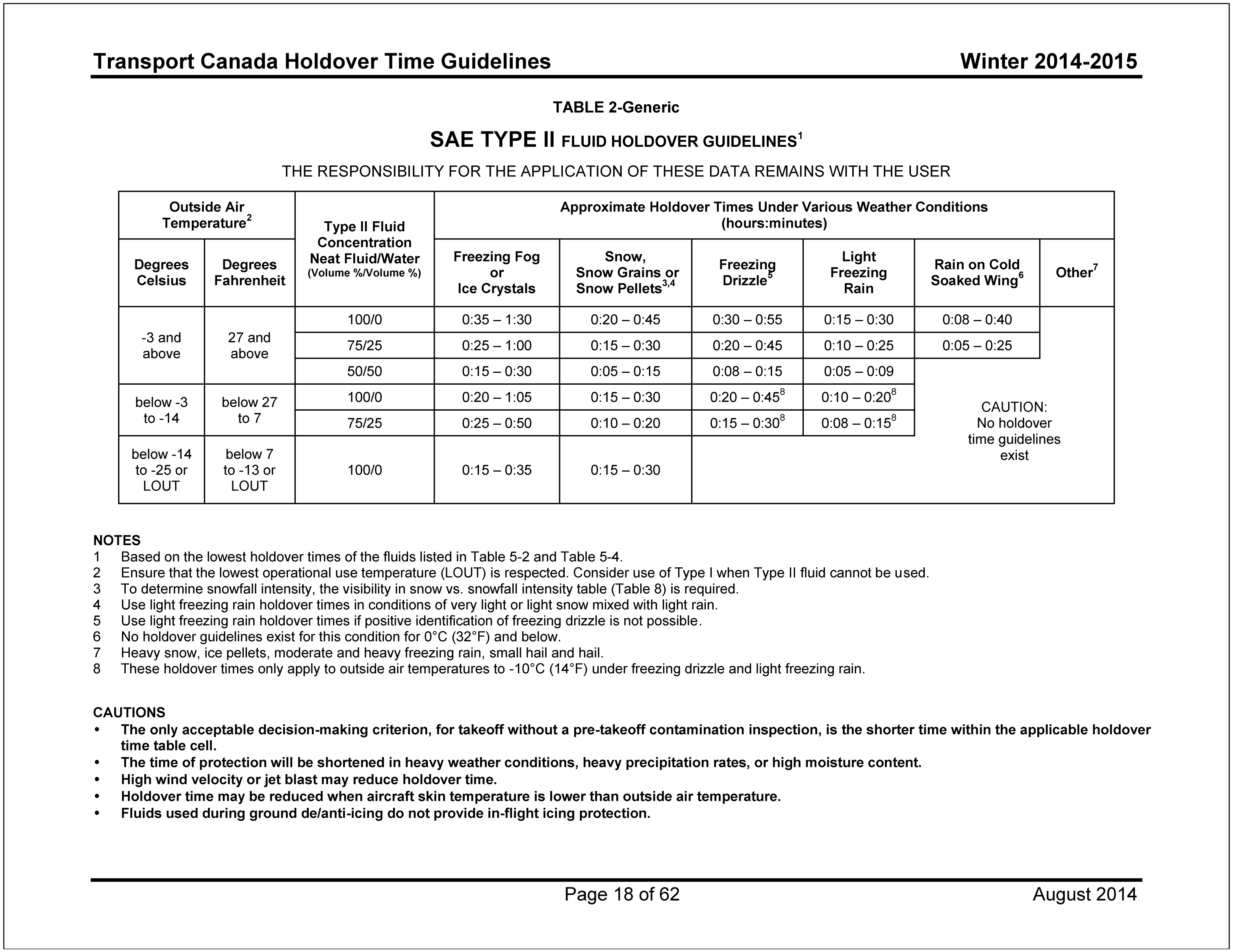


TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES[1]

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	0:08 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	0:08 – 0:15	0:05 – 0:09		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[8]	0:10 – 0:20[8]		
		75/25	0:25 – 0:50	0:10 – 0:20	0:15 – 0:30[8]	0:08 – 0:15[8]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 2-A-E26

TYPE II FLUID HOLDOVER GUIDELINES[1]
ABAX ECOWING 26

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	100/0	1:25 – 2:35	1:35	1:00 – 1:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:55	1:15	0:45 – 1:15	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:40	0:20 – 0:40	0:10 – 0:20	0:15 – 0:25	0:08 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	1:25	0:55 – 1:25	0:35 – 0:55	0:30 – 1:10[8]	0:15 – 0:35[8]		
		75/25	0:35 – 1:15	0:55	0:40 – 0:55	0:25 – 0:40	0:20 – 0:50[8]	0:15 – 0:25[8]		
below -14 to -25	below 7 to -13	100/0	0:25 – 0:45	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 2-AS-CW II

TYPE II FLUID HOLDOVER GUIDELINES[1]
AVIATION SHAANXI HI-TECH CLEANWING II

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	0:55 – 1:50	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:10 – 0:55	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:20	0:25 – 0:45	0:35 – 1:00	0:20 – 0:30	0:07 – 0:50	
		50/50	0:35 – 1:00	0:15 – 0:30	0:20 – 0:40	0:10 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:30 – 0:55	0:30 – 0:55[8]	0:20 – 0:25[8]		
		75/25	0:40 – 1:45	0:25 – 0:45	0:35 – 0:40[8]	0:20 – 0:25[8]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 2-C-FLIGHT

TYPE II FLUID HOLDOVER GUIDELINES[1]
CLARIANT SAFEWING MP II FLIGHT

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

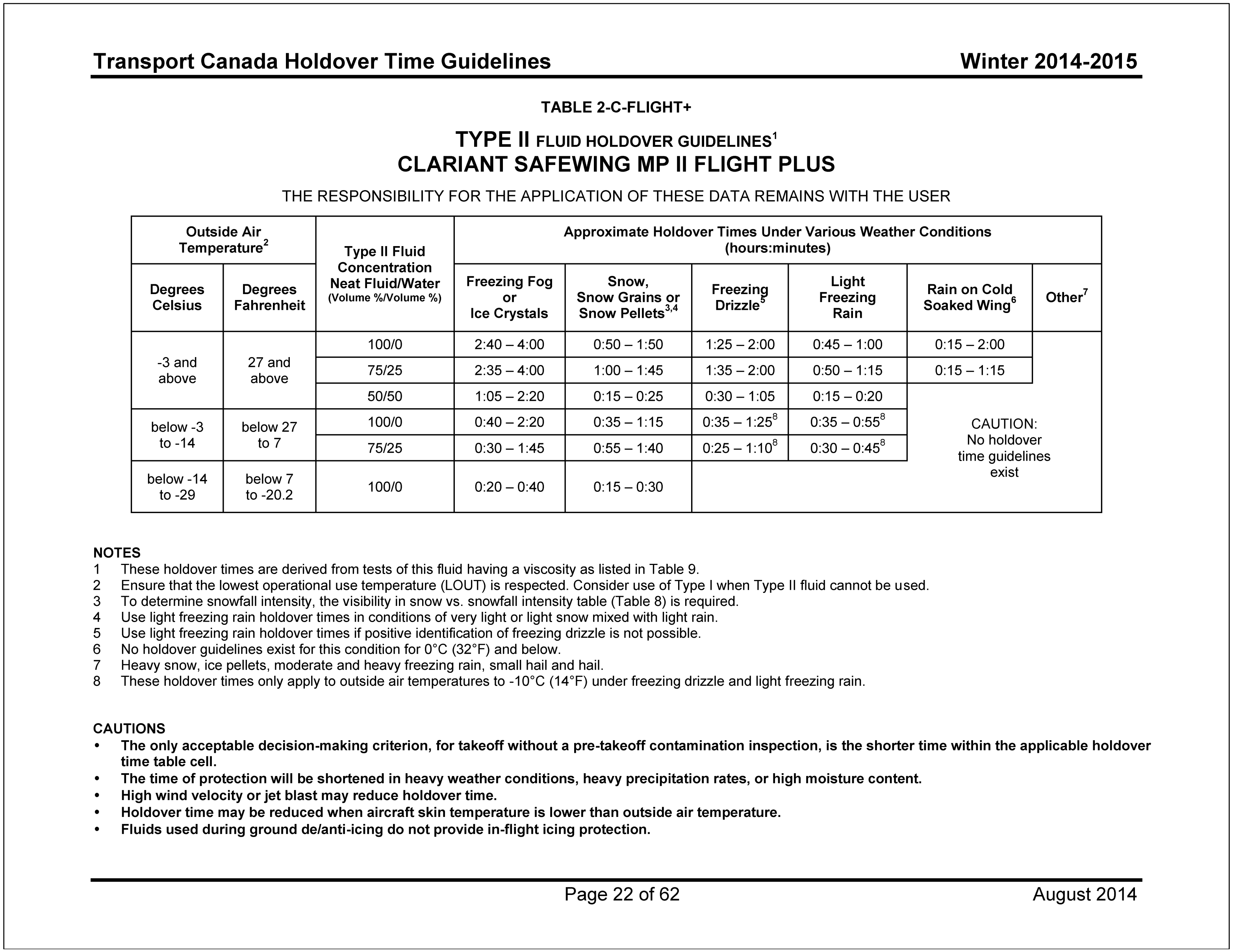
Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	3:30 – 4:00	2:00	1:35 – 2:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	1:50 – 2:45	2:00	1:20 – 2:00	0:40 – 1:20	1:10 – 1:30	0:30 – 0:55	0:06 – 0:50	
		50/50	0:55 – 1:45	0:45	0:25 – 0:45	0:10 – 0:25	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:55 – 1:45	1:50	1:05 – 1:50	0:40 – 1:05	0:35 – 1:30[8]	0:25 – 0:45[8]		
		75/25	0:25 – 1:05	1:20	0:40 – 1:20	0:20 – 0:40	0:25 – 1:10[8]	0:20 – 0:35[8]		
below -14 to -29	below 7 to -20.2	100/0	0:30 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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



Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 2-C-FLIGHT+

TYPE II FLUID HOLDOVER GUIDELINES[1]
CLARIANT SAFEWING MP II FLIGHT PLUS

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	2:40 – 4:00	0:50 – 1:50	1:25 – 2:00	0:45 – 1:00	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:35 – 4:00	1:00 – 1:45	1:35 – 2:00	0:50 – 1:15	0:15 – 1:15	
		50/50	1:05 – 2:20	0:15 – 0:25	0:30 – 1:05	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:40 – 2:20	0:35 – 1:15	0:35 – 1:25[8]	0:35 – 0:55[8]		
		75/25	0:30 – 1:45	0:55 – 1:40	0:25 – 1:10[8]	0:30 – 0:45[8]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

Page 22 of 62 August 2014

TABLE 2-CR-PG-II

TYPE II FLUID HOLDOVER GUIDELINES[1]
CRYOTECH POLAR GUARD II

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:50 – 2:00	1:20 – 1:50	1:35 – 2:00	1:15 – 1:30	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:30 – 4:00	2:00	1:20 – 2:00	0:45 – 1:20	1:40 – 2:00	0:40 – 1:10	0:09 – 1:40	
		50/50	0:50 – 1:25	1:20	0:35 – 1:20	0:15 – 0:35	0:20 – 0:45	0:09 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:30	1:45	1:15 – 1:45	0:55 – 1:15	0:35 – 1:35[8]	0:35 – 0:45[8]		
		75/25	0:40 – 1:30	1:45	1:00 – 1:45	0:35 – 1:00	0:25 – 1:05[8]	0:35 – 0:45[8]		
below -14 to -30.5	below 7 to -22.9	100/0	0:25 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 2-K-ABC-K+

TYPE II FLUID HOLDOVER GUIDELINES[1]
KILFROST ABC-K PLUS

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	2:15 – 3:45	1:00 – 1:40	1:50 – 2:00	1:00 – 1:25	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:30	0:35 – 1:10	1:25 – 2:00	0:50 – 1:10	0:15 – 2:00	
		50/50	0:35 – 1:05	0:07 – 0:15	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:30 – 1:05	0:50 – 1:25	0:25 – 1:00[8]	0:15 – 0:35[8]		
		75/25	0:25 – 1:25	0:35 – 1:05	0:20 – 0:55[8]	0:09 – 0:30[8]		
below -14 to -29	below 7 to -20.2	100/0	0:30 – 0:55	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 2-L-P250

TYPE II FLUID HOLDOVER GUIDELINES[1]
LNT SOLUTIONS P250

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

Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:10 – 4:00	2:00	1:45 – 2:00	0:55 – 1:45	1:35 – 2:00	0:50 - 1:25	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:50 – 2:35	2:00	1:25 – 2:00	0:45 – 1:25	1:20 – 1:35	0:40 – 1:00	0:10 – 1:50	
		50/50	0:35 – 0:50	0:35	0:30 – 0:35	0:15 – 0:30	0:20 – 0:35	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:20	2:00	1:40 – 2:00	0:50 – 1:40	0:25 – 1:20[8]	0:25 – 0:35[8]		
		75/25	0:35 – 1:45	2:00	1:25 – 2:00	0:45 – 1:25	0:20 – 1:15[8]	0:20 – 0:30[8]		
below -14 to LOUT	below 7 to LOUT	100/0	0:20 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 2-N-FCY-2

TYPE II FLUID HOLDOVER GUIDELINES[1]
NEWAVE AEROCHEMICAL FCY-2

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

Outside Air Temperature[2]		**Type II Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	1:15 – 2:25	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:08 – 0:45	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:30	0:20 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:25	
		50/50	0:25 – 0:35	0:15 – 0:25	0:10 – 0:20	0:07 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45[8]	0:15 – 0:20[8]		
		75/25	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30[8]	0:08 – 0:15[8]		
below -14 to -28	below 7 to -18.4	100/0	0:25 – 0:35	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES[1]

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

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	CAUTION: No holdover time guidelines exist
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6		
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30[8]	25[8]	10 – 25[8]	7 – 10[8]	9 – 12[8]	6 – 9[8]		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for Type III fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 11 provides allowance times for ice pellets and small hail).
8 For aircraft with a take-off profile conforming to the low speed aerodynamic test criterion (refer to Section 8.1.6.1 f) of TP 14052E), these holdover times only apply to outside air temperatures from below -3°C to -9°C (below 27°F to 15.8°F). If uncertain whether the aircraft performance conforms to this criterion, consult the aircraft manufacturer.

CAUTIONS

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

Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES[1]

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	1:50 – 2:55	0:35 – 1:10	0:50 – 1:30	0:35 – 0:55	0:10 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:30 – 0:45	0:09 – 0:50	
		50/50	0:20 – 0:35	0:07 – 0:15	0:15 – 0:20	0:08 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:25 – 0:50	0:20 – 1:00[8]	0:10 – 0:25[8]		
		75/25	0:25 – 0:50[9]	0:20 – 0:40[9]	0:15 – 1:05[8,9]	0:10 – 0:25[8,9]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40[10]	0:15 – 0:30[10]				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
9 For Cryotech Polar Guard the temperature is limited to -5.5°C (22.1°F). If the fluid is unknown, these holdover times only apply down to -5.5°C (22.1°F).
10 For Cryotech Polar Guard and Clariant Max Flight 04, the temperature is limited to -23.5°C (-10.3°F). If the fluid is unknown, these holdover times only apply down to -23.5°C (-10.3°F).

CAUTIONS

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

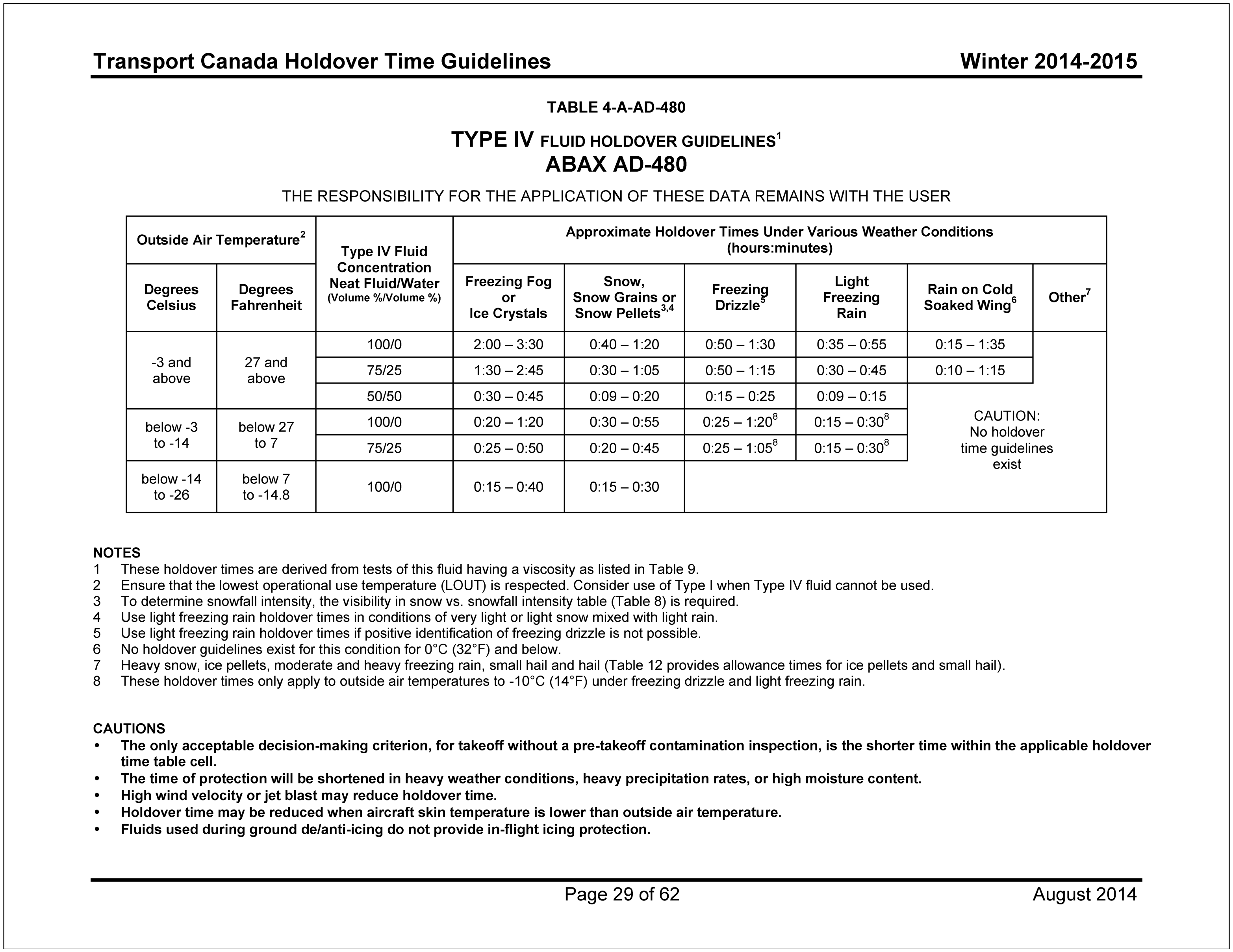


TABLE 4-A-AD-480

TYPE IV FLUID HOLDOVER GUIDELINES[1]

ABAX AD-480

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3,4]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:09 – 0:20	0:15 – 0:25	0:09 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[8]	0:15 – 0:30[8]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[8]	0:15 – 0:30[8]		
below -14 to -26	below 7 to -14.8	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-A-E-AD-49

TYPE IV FLUID HOLDOVER GUIDELINES[1]
ABAX ECOWING AD-49

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	3:20 – 4:00	2:00	1:50 – 2:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25 – 4:00	2:00	1:40 – 2:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:40	0:25 – 0:40	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	2:00	1:50 – 2:00	1:10 – 1:50	0:25 – 1:25[8]	0:20 – 0:25[8]		
		75/25	0:30 – 1:10	2:00	1:40 – 2:00	1:20 – 1:40	0:15 – 1:05[8]	0:15 – 0:25[8]		
below -14 to -26	below 7 to -14.8	100/0	0:25 – 0:40	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-C-MF-04

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CLARIANT MAX FLIGHT 04

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:40 – 4:00	2:00	2:00 – 2:00	1:25 – 2:00	2:00 – 2:00	1:10 – 1:30	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:50 – 2:30	2:00	1:10 – 2:00	0:35 – 1:10	0:25 – 1:30[8]	0:20 – 0:40[8]		
		75/25								
below -14 to -23.5	below 7 to -10.3	100/0	0:20 – 0:45	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-C-MF-SNEG

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CLARIANT MAX FLIGHT SNEG

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	100/0	2:25 – 4:00	2:00	1:40 – 2:00	1:05 – 1:40	2:00 – 2:00	0:50 – 1:40	0:20 – 1:30	CAUTION: No holdover time guidelines exist
		75/25	4:00 – 4:00	2:00	1:30 – 2:00	0:55 – 1:30	1:30 – 2:00	1:05 – 1:20	0:15 – 1:45	
		50/50	1:30 – 3:30	1:45	0:45 – 1:45	0:20 – 0:45	0:35 – 1:10	0:15 – 0:30		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:20	2:00	1:15 – 2:00	0:45 – 1:15	0:30 – 1:25[8]	0:25 – 0:40[8]		
		75/25	0:30 – 1:25	1:40	1:00 – 1:40	0:40 – 1:00	0:20 – 1:05[8]	0:20 – 0:40[8]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-C-LAUNCH

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CLARIANT SAFEWING MP IV LAUNCH

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	100/0	4:00 – 4:00	2:00	1:45 – 2:00	1:05 – 1:45	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		75/25	3:40 – 4:00	2:00	1:45 – 2:00	1:00 – 1:45	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45	
		50/50	1:25 – 2:45	1:25	0:45 – 1:25	0:25 – 0:45	0:30 – 0:50	0:20 – 0:25		
below -3 to -14	below 27 to 7	100/0	1:00 – 1:55	2:00	1:20 – 2:00	0:50 – 1:20	0:35 – 1:40[8]	0:25 – 0:45[8]		
		75/25	0:40 – 1:20	2:00	1:25 – 2:00	0:45 – 1:25	0:25 – 1:10[8]	0:25 – 0:45[8]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-C-LAUNCH+

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CLARIANT SAFEWING MP IV LAUNCH PLUS

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	3:55 – 4:00	2:00	2:00 – 2:00	0:55 – 2:00	2:00 – 2:00	1:00 – 2:00	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	3:55 – 4:00	2:00	1:55 – 2:00	0:50 – 1:55	2:00 – 2:00	1:20 – 1:25	0:20 – 1:50	
		50/50	1:15 – 1:50	1:35	0:45 – 1:35	0:20 – 0:45	0:25 – 1:00	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:15	2:00	1:25 – 2:00	0:40 – 1:25	0:25 – 1:35[8]	0:25 – 0:40[8]		
		75/25	0:40 – 2:00	2:00	1:15 – 2:00	0:30 – 1:15	0:20 – 1:05[8]	0:20 – 0:30[8]		
below -14 to -29	below 7 to -20.2	100/0	0:25 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-CR-PG

TYPE IV FLUID HOLDOVER GUIDELINES[1]
CRYOTECH POLAR GUARD

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3,4]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	2:15 – 3:30	0:50 – 1:30	1:15 – 2:00	0:50 – 1:15	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:40	0:35 – 1:10	1:05 – 1:25	0:35 – 1:00	0:10 – 1:15	
		50/50	0:25 – 0:40	0:10 – 0:15	0:15 – 0:25	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:45	0:30 – 0:55	0:25 – 1:10[8]	0:15 – 0:35[8]		
		75/25	0:35 – 1:30[9]	0:20 – 0:40[9]	0:25 – 1:05[9]	0:20 – 0:30[9]		
below -14 to -23.5	below 7 to -10.3	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
9 These holdover times only apply to outside air temperatures to -5.5°C (22.1°F) and above.

CAUTIONS

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

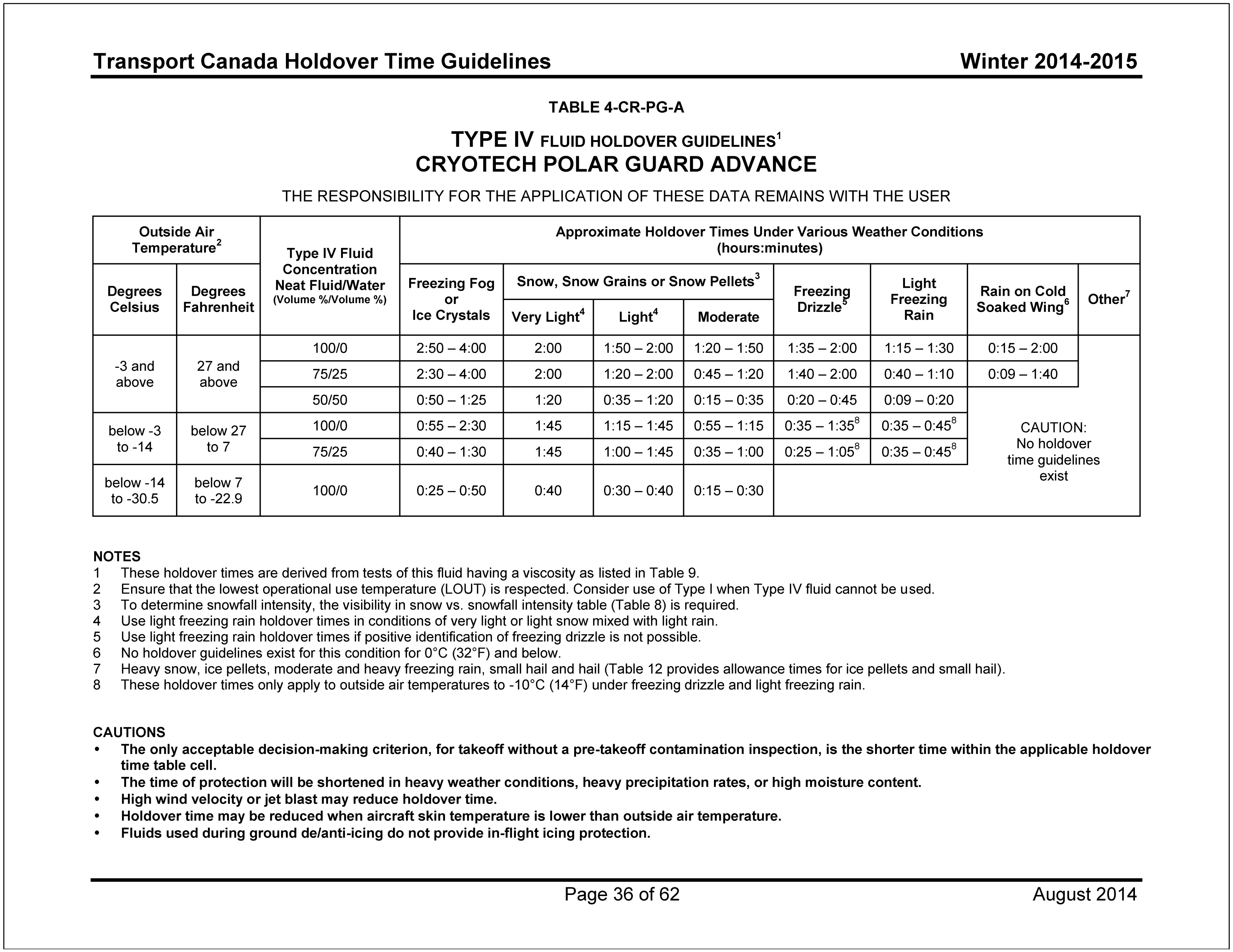


TABLE 4-CR-PG-A

TYPE IV FLUID HOLDOVER GUIDELINES[1]

CRYOTECH POLAR GUARD ADVANCE

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:50 – 2:00	1:20 – 1:50	1:35 – 2:00	1:15 – 1:30	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:30 – 4:00	2:00	1:20 – 2:00	0:45 – 1:20	1:40 – 2:00	0:40 – 1:10	0:09 – 1:40	
		50/50	0:50 – 1:25	1:20	0:35 – 1:20	0:15 – 0:35	0:20 – 0:45	0:09 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:30	1:45	1:15 – 1:45	0:55 – 1:15	0:35 – 1:35[8]	0:35 – 0:45[8]		
		75/25	0:40 – 1:30	1:45	1:00 – 1:45	0:35 – 1:00	0:25 – 1:05[8]	0:35 – 0:45[8]		
below -14 to -30.5	below 7 to -22.9	100/0	0:25 – 0:50	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-D-E106

TYPE IV FLUID HOLDOVER GUIDELINES[1]
DOW CHEMICAL UCAR™ ENDURANCE EG106

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	2:05 – 3:10	2:00	1:20 – 2:00	0:40 – 1:20	1:10 – 2:00	0:50 – 1:15	0:20 – 2:00	
		75/25							CAUTION: No holdover time guidelines exist	
		50/50								
below -3 to -14	below 27 to 7	100/0	1:50 – 3:20	2:00	1:05 – 2:00	0:30 – 1:05	0:55 – 1:50[8]	0:45 – 1:10[8]		
		75/25								
below -14 to -27	below 7 to -16.6	100/0	0:30 – 1:05	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-D-AD-480

TYPE IV FLUID HOLDOVER GUIDELINES[1]
DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:09 – 0:20	0:15 – 0:25	0:09 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[8]	0:15 – 0:30[8]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[8]	0:15 – 0:30[8]		
below -14 to -26	below 7 to -14.8	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

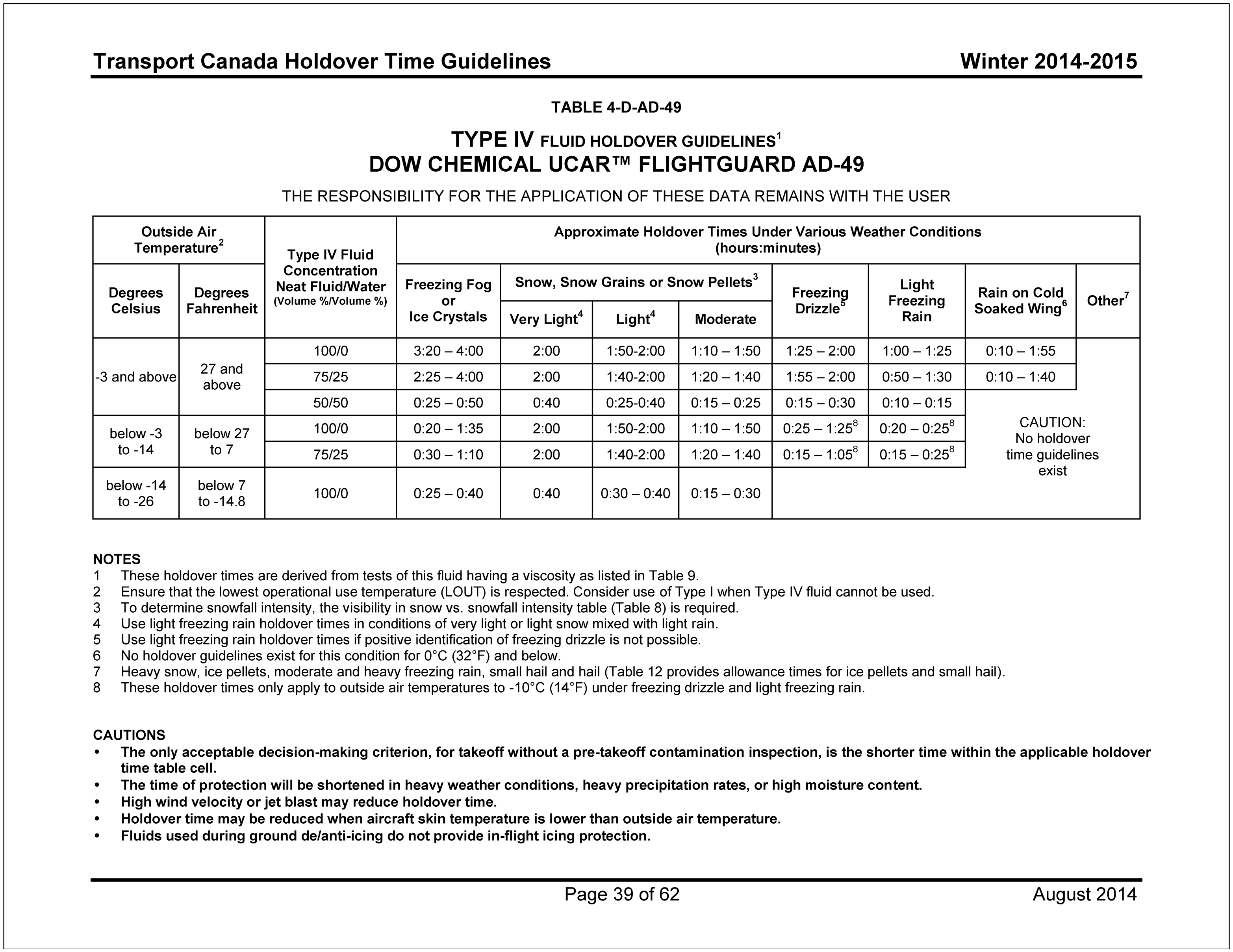


TABLE 4-D-AD-49

TYPE IV FLUID HOLDOVER GUIDELINES[1]
DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	3:20 – 4:00	2:00	1:50-2:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25 – 4:00	2:00	1:40-2:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:40	0:25-0:40	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	2:00	1:50-2:00	1:10 – 1:50	0:25 – 1:25[8]	0:20 – 0:25[8]		
		75/25	0:30 – 1:10	2:00	1:40-2:00	1:20 – 1:40	0:15 – 1:05[8]	0:15 – 0:25[8]		
below -14 to -26	below 7 to -14.8	100/0	0:25 – 0:40	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

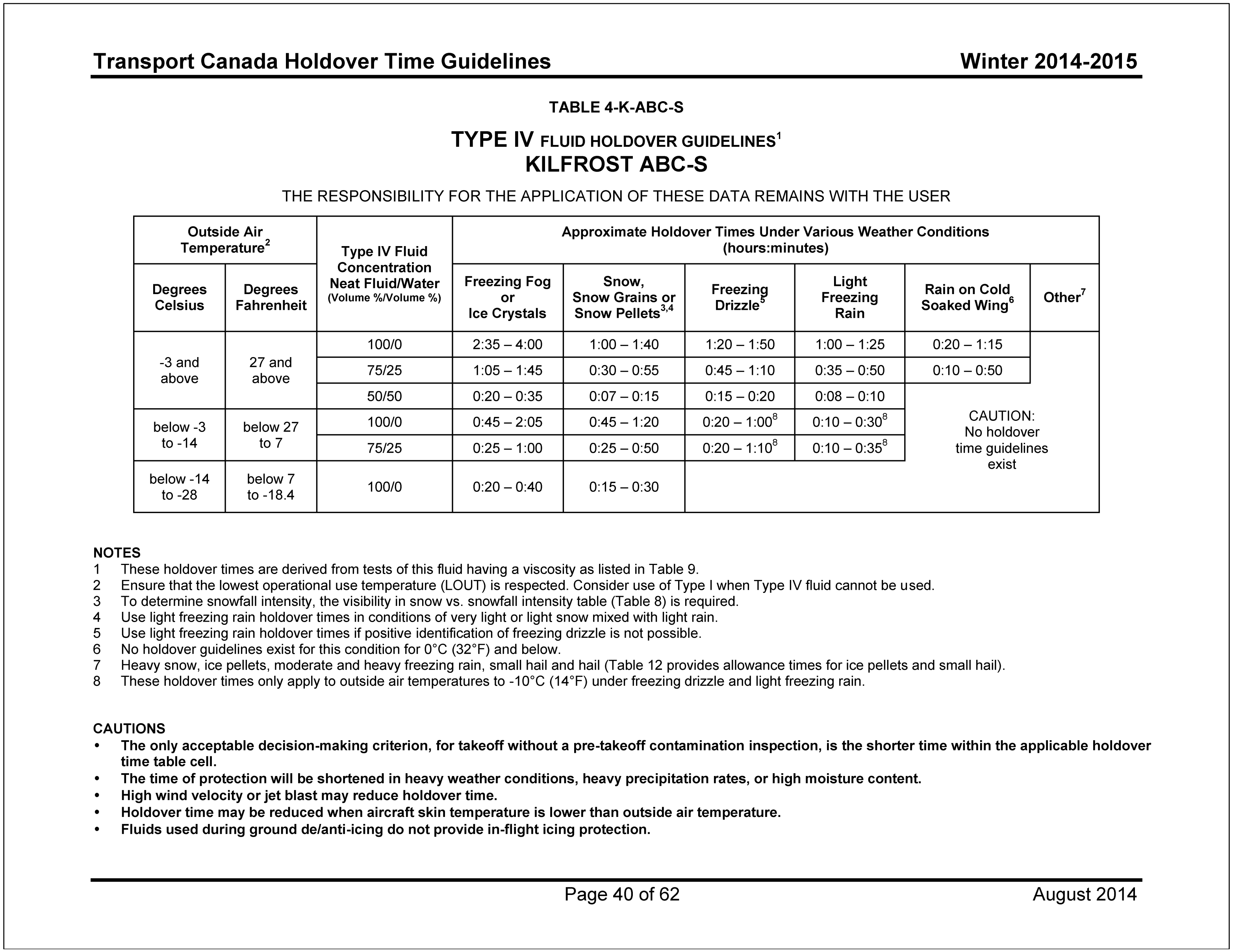


TABLE 4-K-ABC-S

TYPE IV FLUID HOLDOVER GUIDELINES[1]

KILFROST ABC-S

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	2:35 – 4:00	1:00 – 1:40	1:20 – 1:50	1:00 – 1:25	0:20 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:35 – 0:50	0:10 – 0:50	
		50/50	0:20 – 0:35	0:07 – 0:15	0:15 – 0:20	0:08 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:05	0:45 – 1:20	0:20 – 1:00[8]	0:10 – 0:30[8]		
		75/25	0:25 – 1:00	0:25 – 0:50	0:20 – 1:10[8]	0:10 – 0:35[8]		
below -14 to -28	below 7 to -18.4	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-K-ABC-S+

TYPE IV FLUID HOLDOVER GUIDELINES[1]
KILFROST ABC-S PLUS

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	100/0	2:10 – 4:00	2:00	2:00 – 2:00	1:15 – 2:00	1:50 – 2:00	1:05 – 2:00	0:25 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:25 – 2:40	2:00	1:15 – 2:00	0:45 – 1:15	1:00 – 1:20	0:30 – 0:50	0:10 – 1:20	
		50/50	0:30 – 0:55	1:00	0:30 – 1:00	0:15 – 0:30	0:15 – 0:40	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 3:30	2:00	1:45 – 2:00	1:00 – 1:45	0:25 – 1:35[8]	0:20 – 0:30[8]		
		75/25	0:45 – 1:50	1:45	1:00 – 1:45	0:35 – 1:00	0:20 – 1:10[8]	0:15 – 0:25[8]		
below -14 to -28	below 7 to -18.4	100/0	0:40 – 1:00	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-L-E450

TYPE IV FLUID HOLDOVER GUIDELINES[1]
LNT SOLUTIONS E450

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

Outside Air Temperature[2]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3,4]**	**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
-3 and above	27 and above	100/0	1:50 – 2:55	0:35 – 1:10	1:35 – 2:00	0:55 – 1:20	0:25 – 2:00	CAUTION: No holdover time guidelines exist
		75/25						
		50/50						
below -3 to -14	below 27 to 7	100/0	1:30 – 3:55	0:25 – 0:50	1:45 – 2:00[8]	1:05 – 1:40[8]		
		75/25						
below -14 to LOUT	below 7 to LOUT	100/0	0:35 – 1:05	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

TABLE 4-N-F-9311

TYPE IV FLUID HOLDOVER GUIDELINES[1]
NEWAVE AEROCHEMICAL FCY 9311

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

Outside Air Temperature[2]		**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	100/0	1:55 – 4:00	2:00	1:10 – 2:00	0:35 – 1:10	1:10 – 2:00	0:40 – 1:05	0:15–1:25	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:35 – 2:05	1:35	0:50 – 1:35	0:25 – 0:50	0:35 – 1:20[8]	0:20 – 0:35[8]		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:30 – 0:55	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
3 To determine snowfall intensity, the visibility in snow vs. snowfall intensity table (Table 8) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 12 provides allowance times for ice pellets and small hail).
8 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

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

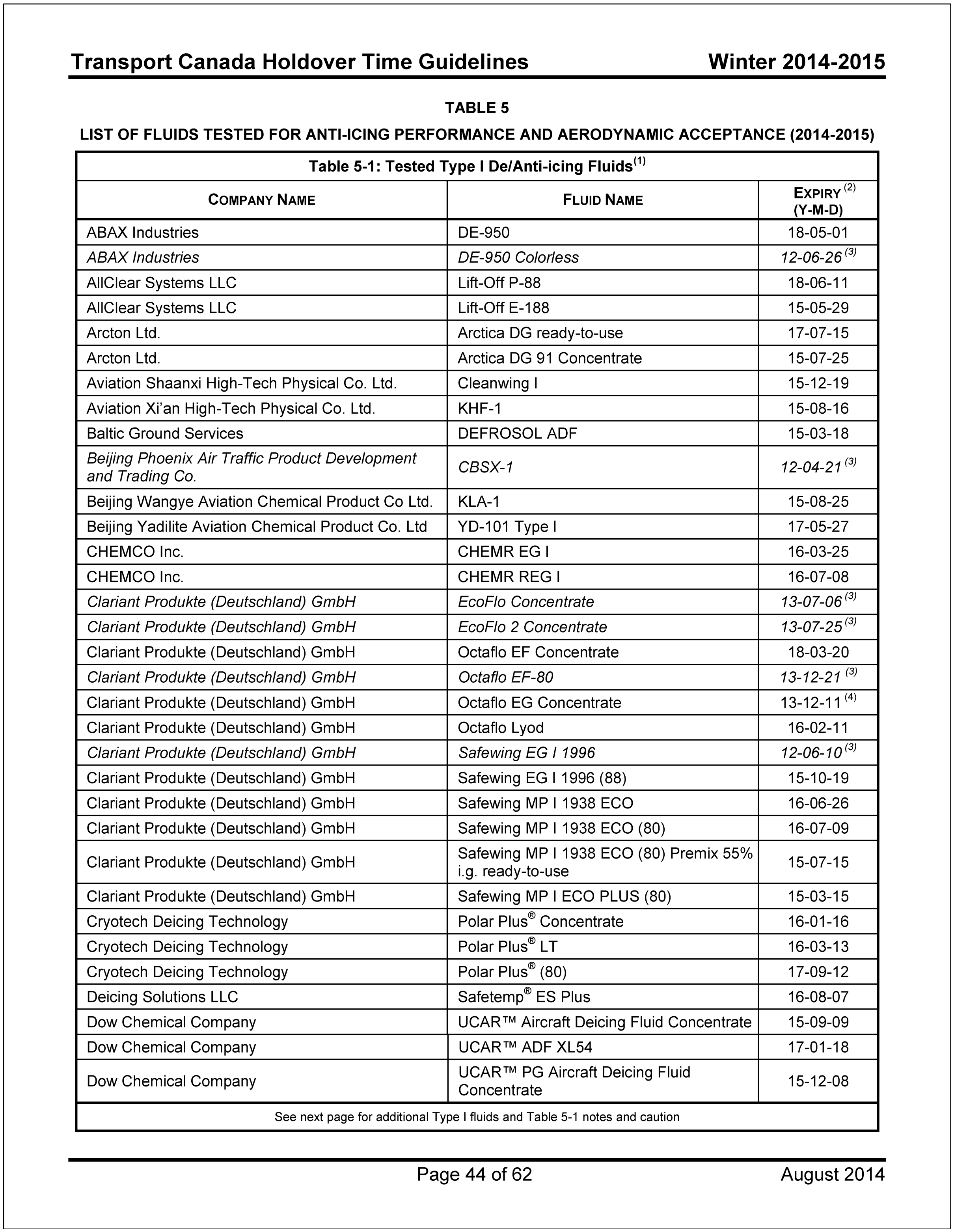


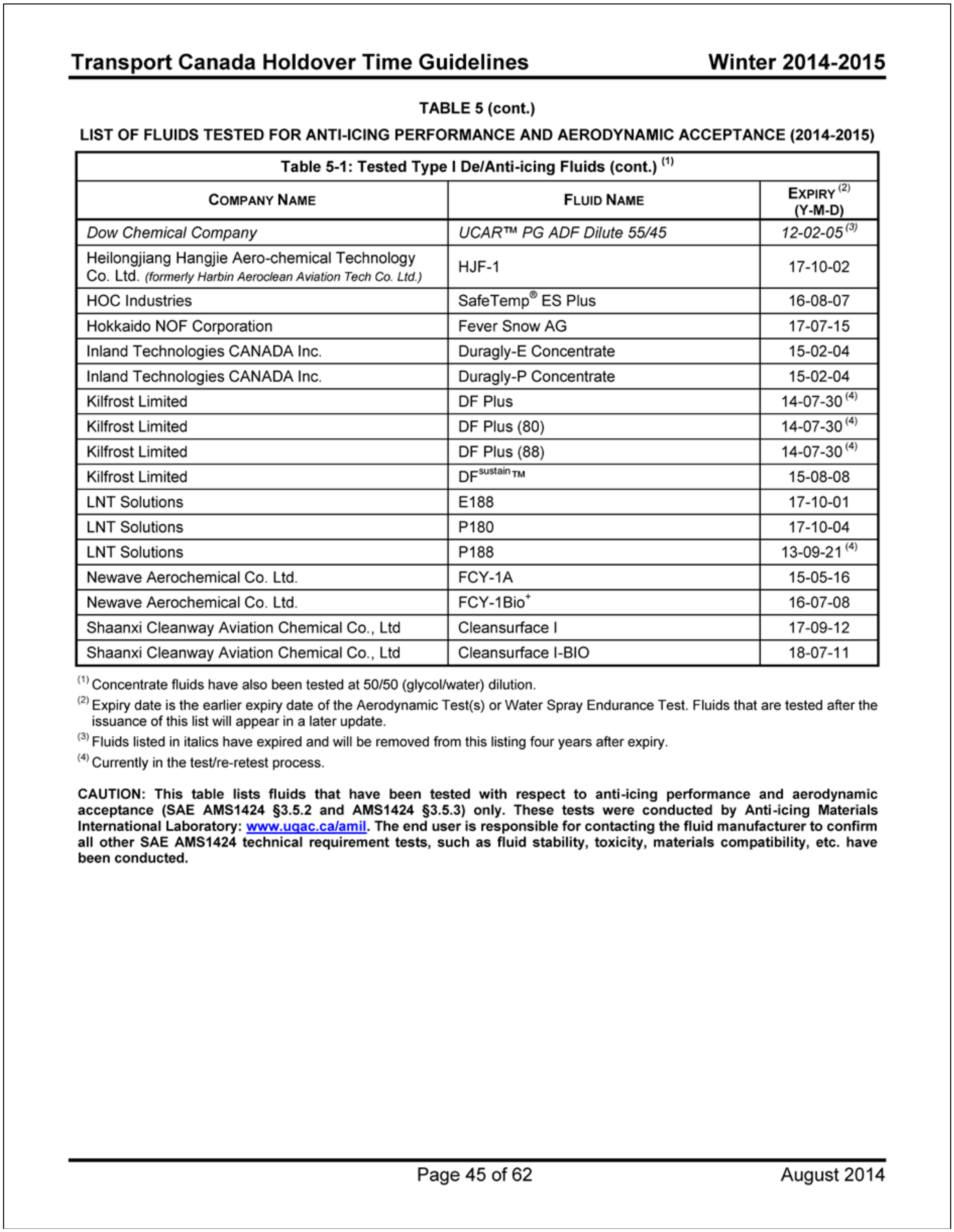
TABLE 5

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2014-2015)

Table 5-1: Tested Type I De/Anti-icing Fluids(1)

COMPANY NAME	FLUID NAME	EXPIRY (2) (Y-M-D)
ABAX Industries	DE-950	18-05-01
ABAX Industries	*DE-950 Colorless*	*12-06-26* (3)
AllClear Systems LLC	Lift-Off P-88	18-06-11
AllClear Systems LLC	Lift-Off E-188	15-05-29
Arcton Ltd.	Arctica DG ready-to-use	17-07-15
Arcton Ltd.	Arctica DG 91 Concentrate	15-07-25
Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I	15-12-19
Aviation Xi'an High-Tech Physical Co. Ltd.	KHF-1	15-08-16
Baltic Ground Services	DEFROSOL ADF	15-03-18
Beijing Phoenix Air Traffic Product Development and Trading Co.	*CBSX-1*	*12-04-21* (3)
Beijing Wangye Aviation Chemical Product Co Ltd.	KLA-1	15-08-25
Beijing Yadilite Aviation Chemical Product Co. Ltd	YD-101 Type I	17-05-27
CHEMCO Inc.	CHEMR EG I	16-03-25
CHEMCO Inc.	CHEMR REG I	16-07-08
Clariant Produkte (Deutschland) GmbH	*EcoFlo Concentrate*	*13-07-06* (3)
Clariant Produkte (Deutschland) GmbH	*EcoFlo 2 Concentrate*	*13-07-25* (3)
Clariant Produkte (Deutschland) GmbH	Octaflo EF Concentrate	18-03-20
Clariant Produkte (Deutschland) GmbH	*Octaflo EF-80*	*13-12-21* (3)
Clariant Produkte (Deutschland) GmbH	Octaflo EG Concentrate	13-12-11 (4)
Clariant Produkte (Deutschland) GmbH	Octaflo Lyod	16-02-11
Clariant Produkte (Deutschland) GmbH	*Safewing EG I 1996*	*12-06-10* (3)
Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	15-10-19
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	16-06-26
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	16-07-09
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use	15-07-15
Clariant Produkte (Deutschland) GmbH	Safewing MP I ECO PLUS (80)	15-03-15
Cryotech Deicing Technology	Polar Plus® Concentrate	16-01-16
Cryotech Deicing Technology	Polar Plus® LT	16-03-13
Cryotech Deicing Technology	Polar Plus® (80)	17-09-12
Deicing Solutions LLC	Safetemp® ES Plus	16-08-07
Dow Chemical Company	UCAR™ Aircraft Deicing Fluid Concentrate	15-09-09
Dow Chemical Company	UCAR™ ADF XL54	17-01-18
Dow Chemical Company	UCAR™ PG Aircraft Deicing Fluid Concentrate	15-12-08

See next page for additional Type I fluids and Table 5-1 notes and caution



Transport Canada Holdover Time Guidelines **Winter 2014-2015**

TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2014-2015)

Table 5-1: Tested Type I De/Anti-icing Fluids (cont.) (1)

COMPANY NAME	FLUID NAME	EXPIRY (2) (Y-M-D)
Dow Chemical Company	*UCAR™ PG ADF Dilute 55/45*	*12-02-05 (3)*
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd. *(formerly Harbin Aeroclean Aviation Tech Co. Ltd.)*	HJF-1	17-10-02
HOC Industries	SafeTemp® ES Plus	16-08-07
Hokkaido NOF Corporation	Fever Snow AG	17-07-15
Inland Technologies CANADA Inc.	Duragly-E Concentrate	15-02-04
Inland Technologies CANADA Inc.	Duragly-P Concentrate	15-02-04
Kilfrost Limited	DF Plus	14-07-30 (4)
Kilfrost Limited	DF Plus (80)	14-07-30 (4)
Kilfrost Limited	DF Plus (88)	14-07-30 (4)
Kilfrost Limited	DF^{sustain}™	15-08-08
LNT Solutions	E188	17-10-01
LNT Solutions	P180	17-10-04
LNT Solutions	P188	13-09-21 (4)
Newave Aerochemical Co. Ltd.	FCY-1A	15-05-16
Newave Aerochemical Co. Ltd.	FCY-1Bio^{+}	16-07-08
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I	17-09-12
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I-BIO	18-07-11

(1) Concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

(2) Expiry date is the earlier expiry date of the Aerodynamic Test(s) or Water Spray Endurance Test. Fluids that are tested after the issuance of this list will appear in a later update.

(3) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(4) Currently in the test/re-retest process.

CAUTION: This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (SAE AMS1424 §3.5.2 and AMS1424 §3.5.3) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1424 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.

Page 45 of 62 August 2014

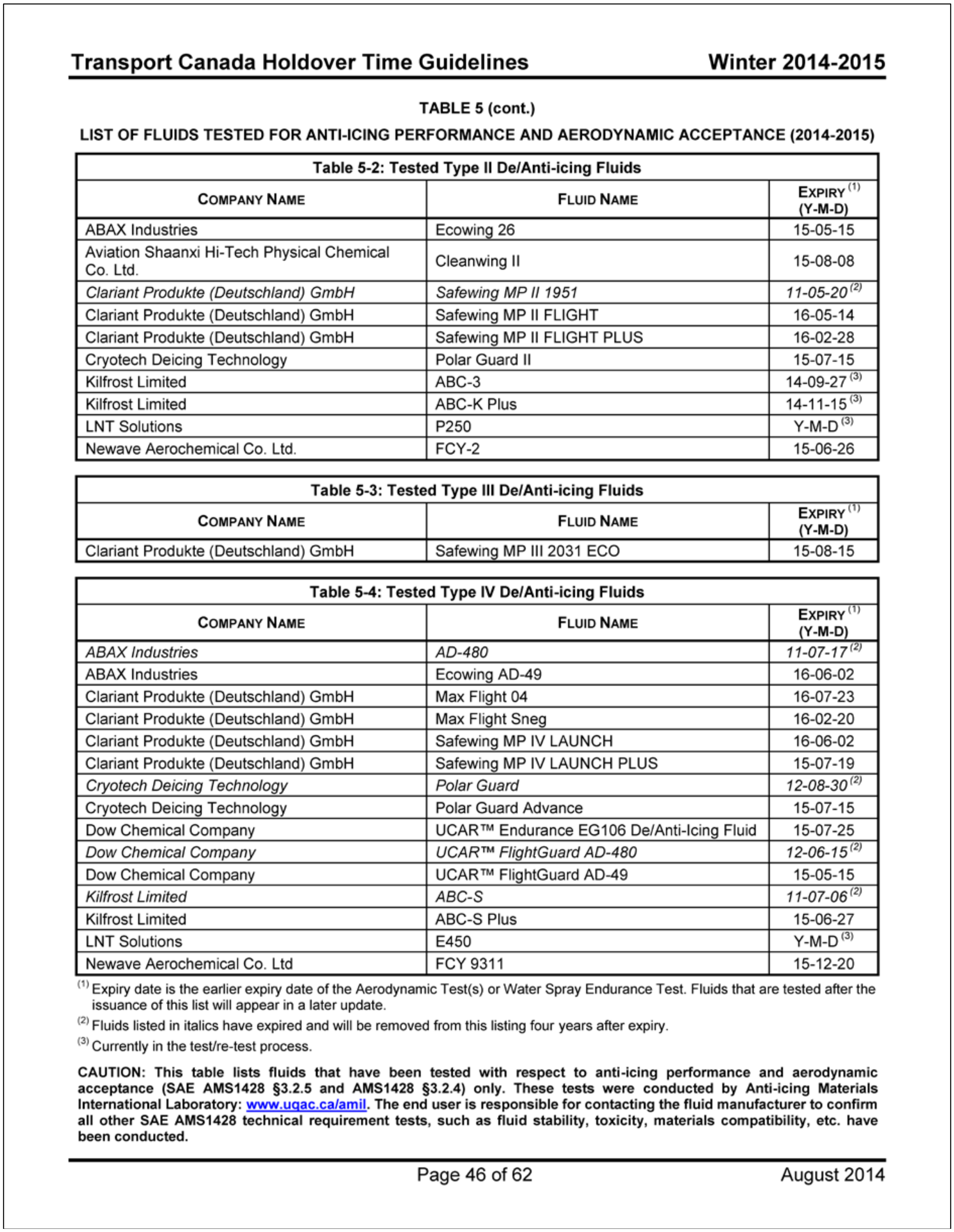


TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2014-2015)

Table 5-2: Tested Type II De/Anti-icing Fluids

COMPANY NAME	FLUID NAME	EXPIRY (1) (Y-M-D)
ABAX Industries	Ecowing 26	15-05-15
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	15-08-08
Clariant Produkte (Deutschland) GmbH	*Safewing MP II 1951*	*11-05-20* (2)
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	16-05-14
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT PLUS	16-02-28
Cryotech Deicing Technology	Polar Guard II	15-07-15
Kilfrost Limited	ABC-3	14-09-27 (3)
Kilfrost Limited	ABC-K Plus	14-11-15 (3)
LNT Solutions	P250	Y-M-D (3)
Newave Aerochemical Co. Ltd.	FCY-2	15-06-26

Table 5-3: Tested Type III De/Anti-icing Fluids

COMPANY NAME	FLUID NAME	EXPIRY (1) (Y-M-D)
Clariant Produkte (Deutschland) GmbH	Safewing MP III 2031 ECO	15-08-15

Table 5-4: Tested Type IV De/Anti-icing Fluids

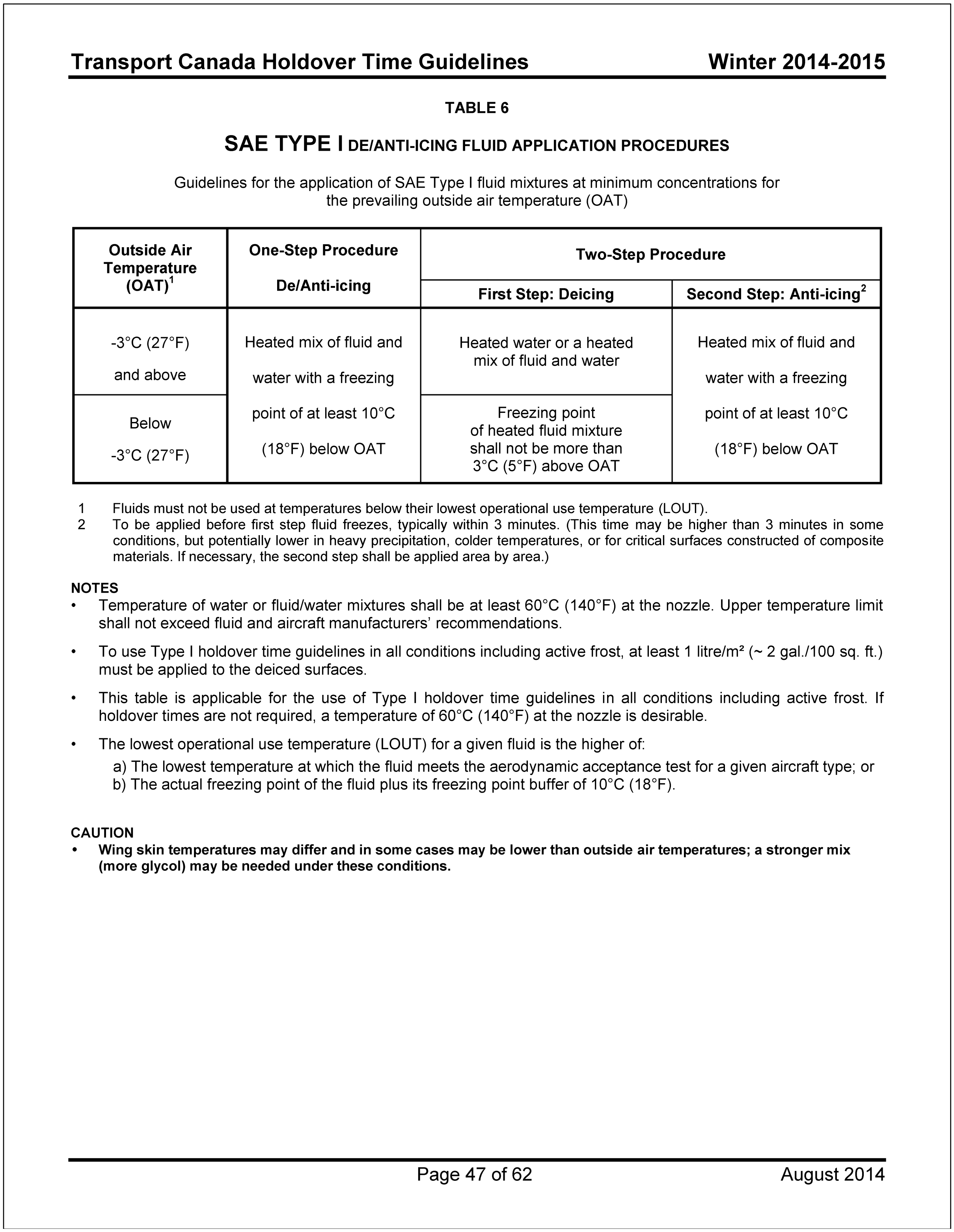
COMPANY NAME	FLUID NAME	EXPIRY (1) (Y-M-D)
ABAX Industries	*AD-480*	*11-07-17* (2)
ABAX Industries	Ecowing AD-49	16-06-02
Clariant Produkte (Deutschland) GmbH	Max Flight 04	16-07-23
Clariant Produkte (Deutschland) GmbH	Max Flight Sneg	16-02-20
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	16-06-02
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	15-07-19
Cryotech Deicing Technology	*Polar Guard*	*12-08-30* (2)
Cryotech Deicing Technology	Polar Guard Advance	15-07-15
Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	15-07-25
Dow Chemical Company	*UCAR™ FlightGuard AD-480*	*12-06-15* (2)
Dow Chemical Company	UCAR™ FlightGuard AD-49	15-05-15
Kilfrost Limited	*ABC-S*	*11-07-06* (2)
Kilfrost Limited	ABC-S Plus	15-06-27
LNT Solutions	E450	Y-M-D (3)
Newave Aerochemical Co. Ltd	FCY 9311	15-12-20

(1) Expiry date is the earlier expiry date of the Aerodynamic Test(s) or Water Spray Endurance Test. Fluids that are tested after the issuance of this list will appear in a later update.

(2) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(3) Currently in the test/re-test process.

CAUTION: This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (SAE AMS1428 §3.2.5 and AMS1428 §3.2.4) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1428 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.



Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 6

SAE TYPE I DE/ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	**Second Step: Anti-icing[2]**
-3°C (27°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

[1] Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).

[2] To be applied before first step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

NOTES

- Temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in all conditions including active frost, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- This table is applicable for the use of Type I holdover time guidelines in all conditions including active frost. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**

TABLE 7

SAE TYPE II, TYPE III and TYPE IV DE/ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type II, III and IV fluid mixtures
(minimum concentrations in % by volume) as a function of outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	50/50 Heated[3] Type II/III/IV	Heated water or a heated mix of Type I, II, III or IV with water	50/50 Type II/III/IV
-14°C (7°F) and above	75/25 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	75/25 Type II/III/IV
-25°C (-13°F) and above	100/0 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	100/0 Type II/III/IV
Below -25°C (-13°F)	Type II/III/IV fluid may be used below -25°C (-13°F) provided that the OAT is at or above the LOUT. Consider the use of Type I when Type II/III/IV fluid cannot be used (see Table 6).		

[1] Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).

[2] To be applied before first step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

[3] Clean aircraft may be anti-iced with unheated fluid.

NOTES

- For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. When the first step is performed using a fluid/water mix with a freezing point above OAT, the temperature at the nozzle shall be at least 60°C and at least 1 litre/m^2 (2 gal./100 sq. ft.) shall be applied to the surfaces to be de-iced.
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- The lowest operational use temperature (LOUT) for a given fluid is the higher of:
  - a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  - b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II, III or IV shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 8

VISIBILITY IN SNOW VS. SNOWFALL INTENSITY[1]

Lighting	Temperature Range		Visibility in Snow in Statute Miles (Metres)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1 (≤1600)	>1 to 2½ (>1600 to 4000)	>2½ to 4 (>4000 to 6400)	>4 (>6400)
	Below -1	Below 30	≤3/4 (≤1200)	>3/4 to 1½ (>1200 to 2400)	>1½ to 3 (>2400 to 4800)	>3 (>4800)
Daylight	-1 and above	30 and above	≤½ (≤800)	>½ to 1½ (>800 to 2400)	>1½ to 3 (>2400 to 4800)	>3 (>4800)
	Below -1	Below 30	≤3/8 (≤600)	>3/8 to 7/8 (>600 to 1400)	>7/8 to 2 (>1400 to 3200)	>2 (>3200)

[1] Based on: *Relationship between Visibility and Snowfall Intensity* (TP 14151E), Transportation Development Centre, Transport Canada, November 2003; and *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (TP 12893E), Transportation Development Centre, Transport Canada, November 1998.

HOW TO READ AND USE THE TABLE

The METAR/SPECI reported visibility or flight crew observed visibility will be used with this visibility table to establish snowfall intensity for Type I, II, III and IV holdover time guidelines, during snow, snow grain, or snow pellet precipitation conditions.

This visibility table will also be used when snow, snow grains or snow pellets are accompanied by blowing or drifting snow in the METAR/SPECI.

RVR values should not be used with this chart.

Example: *CYVO 160200Z 15011G17KT 1SM -SN DRSN OVC009 M06/M08 A2948*

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "visibility in snow vs. snowfall intensity chart", with a visibility of 1 statute mile, in darkness and a temperature of -6°C the snowfall intensity is classified as moderate. The snowfall intensity of moderate - not the METAR reported intensity of light - will be used to determine which holdover time guideline value is appropriate for the fluid in use.

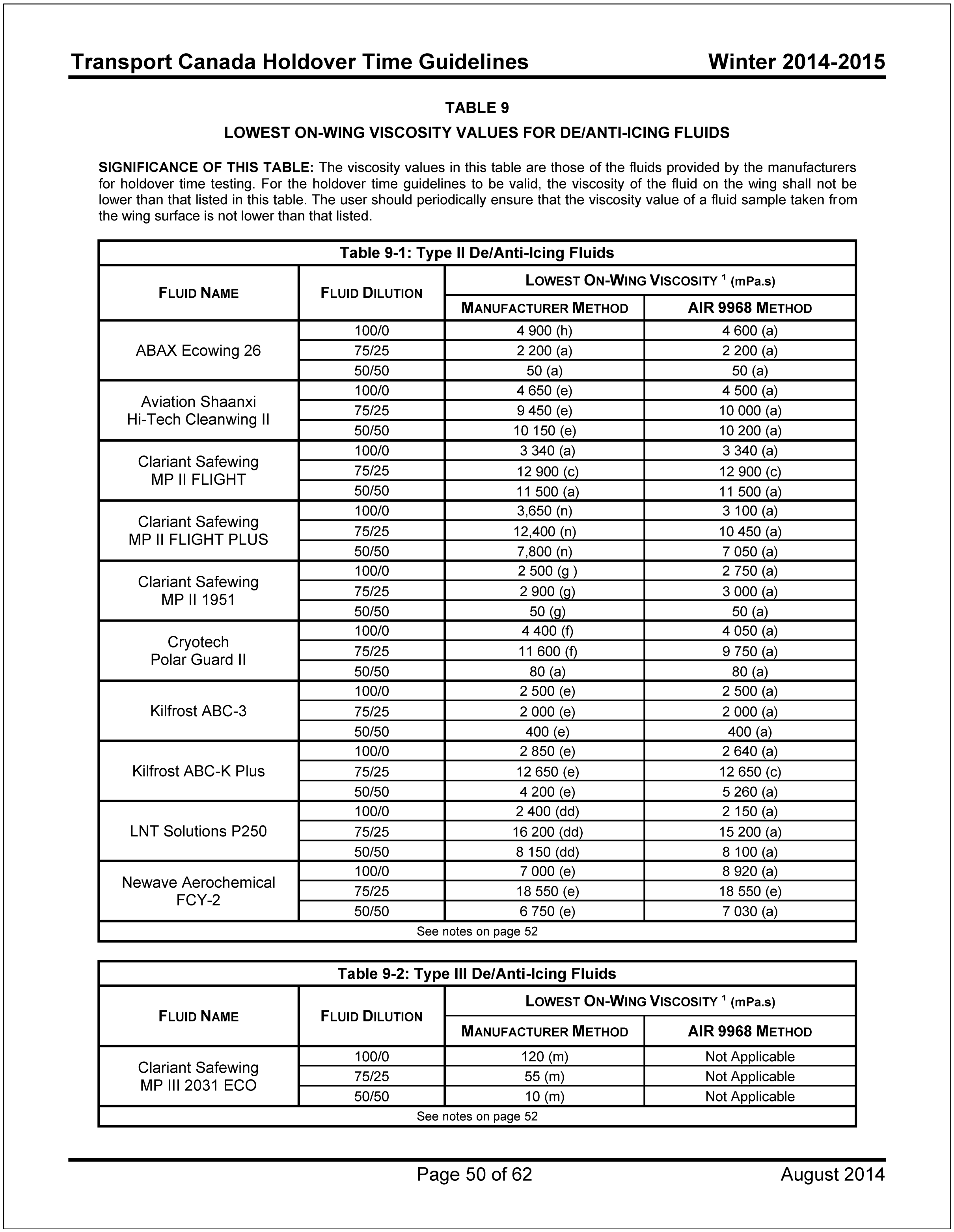


TABLE 9

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS

SIGNIFICANCE OF THIS TABLE: The viscosity values in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing surface is not lower than that listed.

Table 9-1: Type II De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 METHOD
ABAX Ecowing 26	100/0	4 900 (h)	4 600 (a)
	75/25	2 200 (a)	2 200 (a)
	50/50	50 (a)	50 (a)
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 (e)	4 500 (a)
	75/25	9 450 (e)	10 000 (a)
	50/50	10 150 (e)	10 200 (a)
Clariant Safewing MP II FLIGHT	100/0	3 340 (a)	3 340 (a)
	75/25	12 900 (c)	12 900 (c)
	50/50	11 500 (a)	11 500 (a)
Clariant Safewing MP II FLIGHT PLUS	100/0	3,650 (n)	3 100 (a)
	75/25	12,400 (n)	10 450 (a)
	50/50	7,800 (n)	7 050 (a)
Clariant Safewing MP II 1951	100/0	2 500 (g)	2 750 (a)
	75/25	2 900 (g)	3 000 (a)
	50/50	50 (g)	50 (a)
Cryotech Polar Guard II	100/0	4 400 (f)	4 050 (a)
	75/25	11 600 (f)	9 750 (a)
	50/50	80 (a)	80 (a)
Kilfrost ABC-3	100/0	2 500 (e)	2 500 (a)
	75/25	2 000 (e)	2 000 (a)
	50/50	400 (e)	400 (a)
Kilfrost ABC-K Plus	100/0	2 850 (e)	2 640 (a)
	75/25	12 650 (e)	12 650 (c)
	50/50	4 200 (e)	5 260 (a)
LNT Solutions P250	100/0	2 400 (dd)	2 150 (a)
	75/25	16 200 (dd)	15 200 (a)
	50/50	8 150 (dd)	8 100 (a)
Newave Aerochemical FCY-2	100/0	7 000 (e)	8 920 (a)
	75/25	18 550 (e)	18 550 (e)
	50/50	6 750 (e)	7 030 (a)
See notes on page 52			

Table 9-2: Type III De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 METHOD
Clariant Safewing MP III 2031 ECO	100/0	120 (m)	Not Applicable
	75/25	55 (m)	Not Applicable
	50/50	10 (m)	Not Applicable
See notes on page 52			

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS

Table 9-3: Type IV De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY ^{1} (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 METHOD
ABAX AD-480	100/0	15 200 (h)	12 800 (d)
	75/25	16 000 (h)	12 400 (d)
	50/50	4 000 (h)	3 800 (a)
ABAX Ecowing AD-49	100/0	12 150 (i)	11 000 (a)
	75/25	30 700 (i)	32 350 (c)
	50/50	19 450 (i)	21 150 (c)
Clariant Max Flight 04	100/0	5 540 (b)	5 540 (a)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Clariant Max Flight Sneg	100/0	8 700 (o)	8 050 (a)
	75/25	20 200 (p)	21 800 (c)
	50/50	13 600(p)	15 000 (c)
Clariant Safewing MP IV LAUNCH	100/0	7 550 (a)	7 550 (a)
	75/25	18 000 (a)	18 000 (a)
	50/50	17 800 (a)	17 800 (a)
Clariant Safewing MP IV LAUNCH PLUS	100/0	8,700 (o)	8,450 (a)
	75/25	18,800 (p)	17,200 (c)
	50/50	9,700 (o)	12,150 (a)
Cryotech Polar Guard	100/0	32 100 (k)	36 300 (c)
	75/25	24 200 (k)	27 800 (c)
	50/50	6 200 (k)	7 500 (a)
Cryotech Polar Guard Advance	100/0	4 400 (f)	4 050 (a)
	75/25	11 600 (f)	9 750 (a)
	50/50	80 (a)	80 (a)
Dow UCAR™ Endurance EG106	100/0	24 850 (j)	2 230 (a)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	15 200 (h)	12 800 (d)
	75/25	16 000 (h)	12 400 (d)
	50/50	4 000 (h)	3 800 (a)
Dow UCAR™ FlightGuard AD-49	100/0	12 150 (i)	11 000 (a)
	75/25	30 700 (i)	32 350 (c)
	50/50	19 450 (i)	21 150 (c)
Kilfrost ABC-S	100/0	17 000 (e)	17 000 (c)
	75/25	12 000 (e)	12 000 (c)
	50/50	2 000 (e)	2 000 (a)
Kilfrost ABC-S Plus	100/0	17 900 (e)	17 900 (c)
	75/25	18 300 (e)	18 300 (c)
	50/50	7 500 (e)	7 500 (a)

See next page for additional Type IV fluids and notes

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS

Table 9-3: Type IV De/Anti-Icing Fluids (cont'd)

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 METHOD
LNT Solutions E450	100/0	45 300 (l)	Not Available[2]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Newave Aerochemical FCY 9311	100/0	14 100 (c)	14 100 (c)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
See notes below			

NOTES

1 The Aerospace Information Report (AIR) 9968 viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method. Viscosity measurement methods are indicated as letters (in parentheses) beside each viscosity value. Details of each measurement method are shown in the table below. The exact measurement method (spindle, container, fluid volume, temperature, speed, duration) must be used to compare the viscosity of a sample to a viscosity given in this table.

2 Measurements using the AIR 9968 method do not provide stable, reliable results. Use the manufacturer method to evaluate the viscosity of this fluid.

Method	Brookfield Spindle	Container	Fluid Volume	Temp.	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL*	20°C	0.3 rpm	10 minutes 0 seconds
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL*	20°C	0.3 rpm	33 minutes 20 seconds
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	425 mL*	20°C	0.3 rpm	10 minutes 0 seconds
d	LV2-disc (with guard leg)	250 mL tall form (Berzelius) beaker	200 mL*	20°C	0.3 rpm	10 minutes 0 seconds
dd	LV2-disc (with guard leg)	200 mL tall form (Berzelius) beaker	155 mL*	20°C	0.3 rpm	10 minutes 0 seconds
e	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	135 mL*	20°C	0.3 rpm	10 minutes 0 seconds
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
g	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	15 minutes 0 seconds
h	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30 minutes 0 seconds
i	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
j	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10 minutes 0 seconds
k	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	10 minutes 0 seconds
l	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	10 minutes 0 seconds
m	LV0	UL adapter	16 mL	20°C	0.3 rpm	10 minutes 0 seconds
n	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10 minutes 0 seconds
o	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10 minutes 0 seconds
p	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10 minutes 0 seconds

*If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft

TABLE 10

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2014-2015)

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

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
ABAX DE-950	**-26** for 71/29 dilution	**-31** for 71/29 dilution
ABAX DE-950 Colorless	Not tested[4]	**-24** for 60/40 dilution
AllClear Systems LLC Lift-Off P-88	**-24.5** for 70/30 dilution	**-29.5** for 70/30 dilution
AllClear Systems LLC Lift-Off E-188	**-40** for 70/30 dilution	**-41.5** for 70/30 dilution
Arcton Arctica DG ready-to-use	**-26** as supplied	**-26** as supplied
Arcton Arctica DG 91 Concentrate	**-25** for 75/25 dilution	**-25** for 75/25 dilution
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[4]	**-39.5** for 75/25 dilution
Aviation Xi'an Hi-Tech KHF-1	Not available[3]	**-38.5** for 75/25 dilution
Baltic Ground Services DEFROSOL ADF	**-25** for 65/35 dilution	**-30** for 65/35 dilution
Beijing Phoenix Air Traffic CBSX-1	Not available[3]	Not available[3]
Beijing Wangye Aviation Chemical KLA-1	Not available[3]	**-30.5** for 60/40 dilution
Beijing Yadilite Aviation Chemical Product Co. Ltd YD-101 Type I	Not tested[4]	**-30** for 60/40 dilution
CHEMCO CHEMR EG I	**-30** for 75/25 dilution	**-40** for 75/25 dilution
CHEMCO CHEMR REG I	Not available[3]	**-40.5** for 75/25 dilution
Clariant EcoFlo Concentrate	Not tested[4]	**-30.5** for 65/35 dilution
Clariant EcoFlo 2 Concentrate	Not tested[4]	**-29** for 65/35 dilution
Clariant Octaflo EF Concentrate	**-25** for 65/35 dilution	**-33** for 65/35 dilution
Clariant Octaflo EF-80	**-25** for 70/30 dilution	**-33** for 70/30 dilution
Clariant Octaflo EG Concentrate	**-40.5** for 70/30 dilution	**-44** for 70/30 dilution
Clariant Octaflo Lyod	**-40** for 70/30 dilution	**-45.5** for 70/30 dilution
Clariant Safewing EG I 1996	**-35.5** for 75/25 dilution	**-43** for 75/25 dilution
Clariant Safewing EG I 1996 (88)	**-39.5** for 70/30 dilution	**-41.5** for 70/30 dilution
Clariant Safewing MP I 1938 ECO	**-25.5** for 65/35 dilution	**-32** for 65/35 dilution
Clariant Safewing MP I 1938 ECO (80)	**-25** for 71/29 dilution	**-32.5** for 71/29 dilution
Clariant Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use	Not tested[4]	**-19** as supplied
Clariant Safewing MP I ECO PLUS (80)	**-25** for 71/29 dilution	**-33** for 71/29 dilution
Cryotech Polar Plus® Concentrate	**-27** for 63/37 dilution	**-32** for 63/37 dilution
Cryotech Polar Plus® LT	**-27** for 63/37 dilution	**-33** for 63/37 dilution
Cryotech Polar Plus® (80)	**-24.5** for 70/30 dilution	**-32.5** for 70/30 dilution
Deicing Solutions LLC Safetemp® ES Plus	**-25.5** for 65/35 dilution	**-29** for 65/35 dilution
Dow UCAR™ Aircraft Deicing Fluid Concentrate	**-36.5** for 75/25 dilution	**-45** for 75/25 dilution
Dow UCAR™ ADF XL54	**-33** as supplied	**-33** as supplied
Dow UCAR™ PG Aircraft Deicing Fluid Concentrate	**-25** for 65/35 dilution	**-32** for 65/35 dilution

See next page for additional Type I fluids and Table 10-1 notes and cautions

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2014-2015)

Table 10-1: Type I De/Anti-Icing Fluids (cont.)

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
Dow UCAR™ PG ADF Dilute 55/45	**-24** as supplied	**-25** as supplied
Heilongjiang Hangjie Aero-chemical *(formerly Harbin Aeroclean Aviation)* HJF-1	Not tested[4]	**-42** for 65/35 dilution
HOC SafeTemp® ES Plus	**-25.5** for 65/35 dilution	**-29** for 65/35 dilution
Hokkaido Fever Snow AG	**-21.5** as supplied	**-23** as supplied
Inland Technologies Duragly-E Concentrate	**-26** for 60/40 dilution	**-26** for 60/40 dilution
Inland Technologies Duragly-P Concentrate	**-25** for 60/40 dilution	**-25** for 60/40 dilution
Kilfrost DF Plus	**-25.5** for 69/31 dilution	**-32** for 69/31 dilution
Kilfrost DF Plus (80)	**-26** for 69/31 dilution	**-31.5** for 69/31 dilution
Kilfrost DF Plus (88)	**-26.5** for 63/37 dilution	**-32** for 63/37 dilution
Kilfrost DF$^{\text{sustain}}$™	**-34** for 68/32 dilution	**-41** for 68/32 dilution
LNT Solutions E188	**-30.5** for 70/30 dilution	**-41** for 70/30 dilution
LNT Solutions P180	**-26** for 69/31 dilution	**-32** for 69/31 dilution
LNT Solutions P188	**-24.5** for 70/30 dilution	**-31.5** for 70/30 dilution
Newave FCY-1A	**-40** for 75/25 dilution	**-40** for 75/25 dilution
Newave FCY-1Bio^{+}	Not tested[4]	**-40.5** for 75/25 dilution
Shaanxi Cleanway Cleansurface I	***-32.5*** *for 75/25 dilution*[5]	**-40.5** for 75/25 dilution
Shaanxi Cleanway Cleansurface I-BIO	Not tested[4]	**-37** for 75/25 dilution

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

   The values in this table were determined using pre-production fluid samples when available. In some cases, the fluid manufacturer requested the publication of a more conservative value than the pre-production test value.

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

3 Manufacturer had not provided LOUT information at the time of publication.

4 Manufacturer has indicated fluid was not tested.

5 Fluid was not retested for low speed aerodynamics. This data will be removed four years after the expiry of the last low speed aerodynamics test.

CAUTIONS

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

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2014-2015)

Table 10-2: Type II De/Anti-Icing Fluids

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURE[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
ABAX Ecowing 26	100/0	-25
	75/25	-14
	50/50	-3
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 1951	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II FLIGHT	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II FLIGHT PLUS	100/0	-29
	75/25	-14
	50/50	-3
Cryotech Polar Guard II	100/0	-30.5
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-K Plus	100/0	-29
	75/25	-14
	50/50	-3
LNT Solutions P250	100/0	Not available[3]
	75/25	Not available[3]
	50/50	Not available[3]
Newave Aerochemical FCY-2	100/0	-28
	75/25	-14
	50/50	-3

See page 57 for notes and caution

Transport Canada Holdover Time Guidelines Winter 2014-2015

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2014-2015)

Table 10-3: Type III De/Anti-Icing Fluids

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURE[1] (°C)	
		LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
Clariant Safewing MP III 2031 ECO	100/0	-16.5	-29
	75/25	-9	-10
	50/50	-3	-3
See next page for notes and caution			

Table 10-4: Type IV De/Anti-Icing Fluids

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURE[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
ABAX AD-480	100/0	-26
	75/25	-14
	50/50	-3
ABAX Ecowing AD-49	100/0	-26
	75/25	-14
	50/50	-3
Clariant Max Flight 04	100/0	-23.5
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
Clariant Max Flight Sneg	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP IV LAUNCH	100/0	-28.5
	75/25	-14
	50/50	-3
Clariant Safewing MP IV LAUNCH PLUS	100/0	-29
	75/25	-14
	50/50	-3
Cryotech Polar Guard	100/0	-23.5
	75/25	-5.5
	50/50	-3
Cryotech Polar Guard Advance	100/0	-30.5
	75/25	-14
	50/50	-3
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	100/0	-27
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
See next page for additional Type IV fluids, notes and caution		

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2014-2015)

Table 10-4: Type IV De/Anti-Icing Fluids (cont.)

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
Dow UCAR™ FlightGuard AD-480	100/0	-26
	75/25	-14
	50/50	-3
Dow UCAR™ FlightGuard AD-49	100/0	-26
	75/25	-14
	50/50	-3
Kilfrost ABC-S	100/0	-28
	75/25	-14
	50/50	-3
Kilfrost ABC-S Plus	100/0	-28
	75/25	-14
	50/50	-3
LNT Solutions E450	100/0	Not available[3]
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
Newave Aerochemical FCY 9311	100/0	-29.5
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F).

For the 75/25 and 50/50 dilutions, the holdover time table temperature band limits are posted in the cases where the manufacturer's LOUT is lower than those limits.

The values in this table were determined using pre-production fluid samples when available. In some cases, the fluid manufacturer requested the publication of a more conservative value than the pre-production test value.

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

3 Manufacturer had not provided LOUT information at the time of publication.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data.

ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR WINTER 2014-2015

Comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light or moderate) and light ice pellets mixed with other forms of precipitation.

Results of this research provide the basis for allowance times for operations in ice pellets (light or moderate) and operations in light ice pellets mixed with other forms of precipitation. Allowance times for small hail are also provided, as it has been determined small hail is meteorologically equivalent to moderate ice pellets.

In 2014-15, allowance times were published for undiluted (100/0) Type III fluid applied unheated. Further testing is required to expand allowance times in other conditions, such as temperatures below -10°C.

Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times.

Operational Guidelines

1) Tests have shown that ice pellets generally remain in a frozen state embedded in Type III or Type IV anti-icing fluid and are not dissolved by the fluid in the same manner as other forms of precipitation. Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not dissolved by the fluid (i.e. remaining embedded) is an indication that the fluid has failed. These embedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination inspection procedures.

2) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and light ice pellets mixed with other forms of precipitation in Type III or Type IV fluid will not prevent the fluid from flowing off of the aerodynamic surfaces during takeoff.

3) The allowance times were developed based on this aerodynamic testing and are contained in Table 11 and Table 12.

4) Research has also shown that Type IV propylene glycol (PG) and Type IV ethylene glycol (EG) fluids behave differently under certain temperature and ice pellet precipitation conditions. Currently all Type IV fluids are PG based with the exception of Dow Chemical EG106 and LNT Solutions E450 which are EG based. Higher aircraft rotation speeds are required to effectively remove Type IV PG fluid contaminated with light or moderate ice pellets at temperatures below -10°C. Therefore, there are no allowance times associated with the use of Type IV PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10°C.

5) Research has indicated that Type IV propylene glycol (PG) fluids are removed less effectively when contaminated with moderate ice pellets at temperatures below -16°C; operations in these conditions are not recommended. Therefore, there are no allowance times associated with the use of PG fluids in conditions of moderate ice pellets at temperatures below -16°C, irrespective of aircraft rotation speed.

6) Furthermore, recent research with newer generation type airfoils has shown that the allowance times are shorter when using Type IV PG fluids under certain conditions. Since it is challenging to determine exactly which aircraft may be affected, the allowance time when using Type IV PG fluids at temperatures of -5°C and above is limited to 15 minutes in moderate ice pellets.

7) The ice pellet allowances are contingent on the operator's approved ground icing program being updated to incorporate the ice pellet information contained herein, including the following conditions and restrictions that must be satisfied:

   a) The aircraft critical surfaces must be properly deiced before the application of Type III or Type IV anti-icing fluid;

   b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type III or Type IV fluid;

   c) The Type III allowance times are only applicable for un-heated anti-icing fluid applications;

   d) These allowance times are applicable from the start of the Type III or Type IV anti-icing fluid application;

   e) The allowance time is limited to aircraft with a rotation speed of 100 knots or greater (subject to 4) above);

   f) If the takeoff is not accomplished within the applicable allowance time in Table 11 or 12, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff;

   g) The allowance time cannot be extended by an inspection of the aircraft critical surfaces from either inside or outside the aircraft;

   h) If the temperature decreases below the temperature on which the allowance time was based, where the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit;

   i) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used;

   j) If the precipitation condition stops at, or before, the time limit of the applicable allowance time in Table 11 or 12 and does not restart, the aircraft may take off up to 90 minutes after the start of the application of the Type III or Type IV anti-icing fluid. However, the OAT must remain constant or increase during the 90-minute period under the following conditions:

      - light ice pellets mixed with light or moderate freezing drizzle;
      - light ice pellets mixed with light freezing rain;
      - light ice pellets mixed with light rain; and
      - light ice pellets mixed with moderate rain.

8) Examples:

   a) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50; the aircraft may take off without any further action until 11:30.

   b) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25; however, provided that the OAT remains constant or increases and no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

c) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with light freezing rain falls until 10:10, stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25; however, provided that the OAT remains constant or increases and no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

d) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10, stops and restarts at 10:30, with the allowance time stopping at 10:25, the aircraft may not take off, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

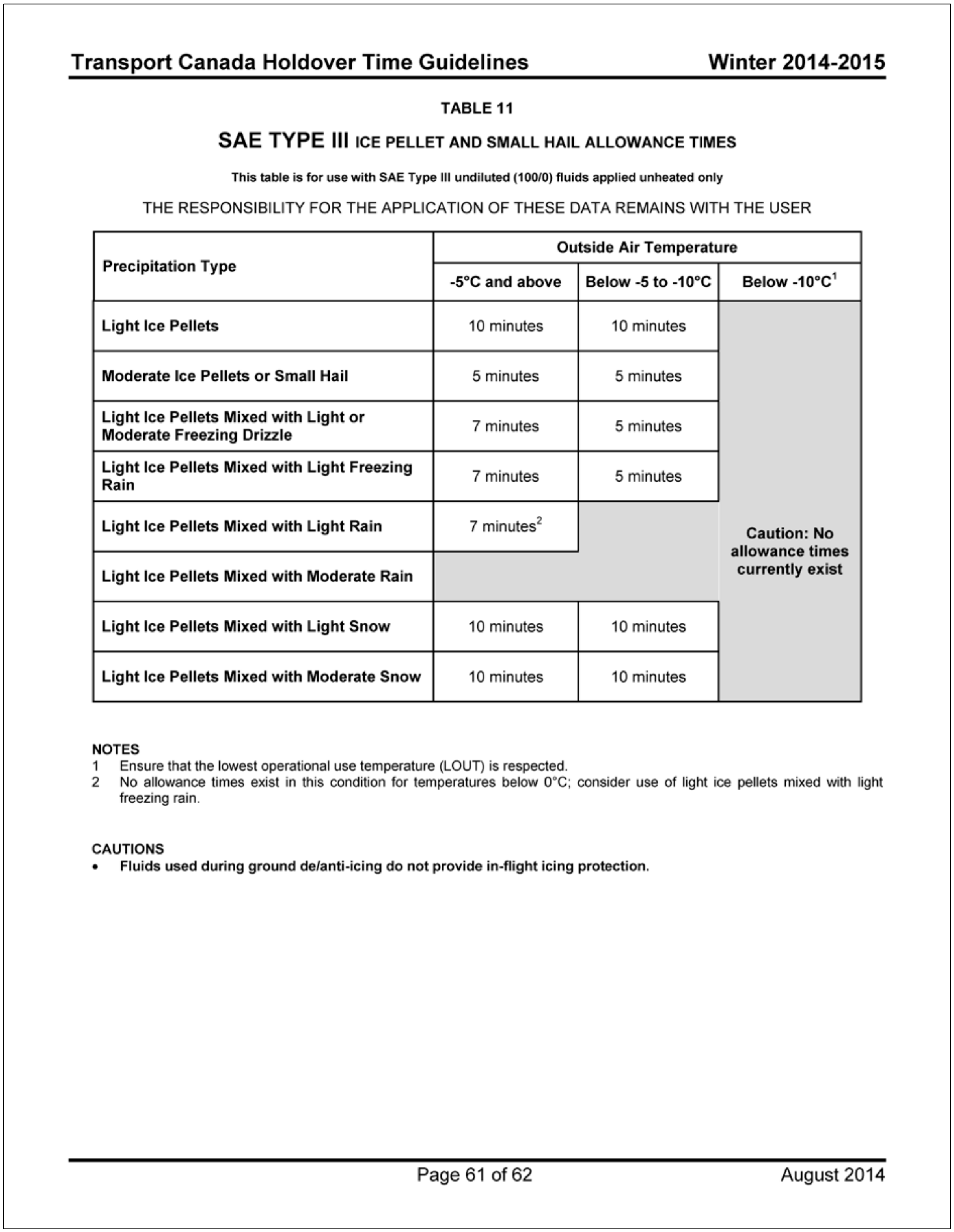


TABLE 11

SAE TYPE III ICE PELLET AND SMALL HAIL ALLOWANCE TIMES

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

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

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[1]
Light Ice Pellets	10 minutes	10 minutes	**Caution: No allowance times currently exist**
Moderate Ice Pellets or Small Hail	5 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	7 minutes[2]		
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Light Snow	10 minutes	10 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	10 minutes	

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.

2 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

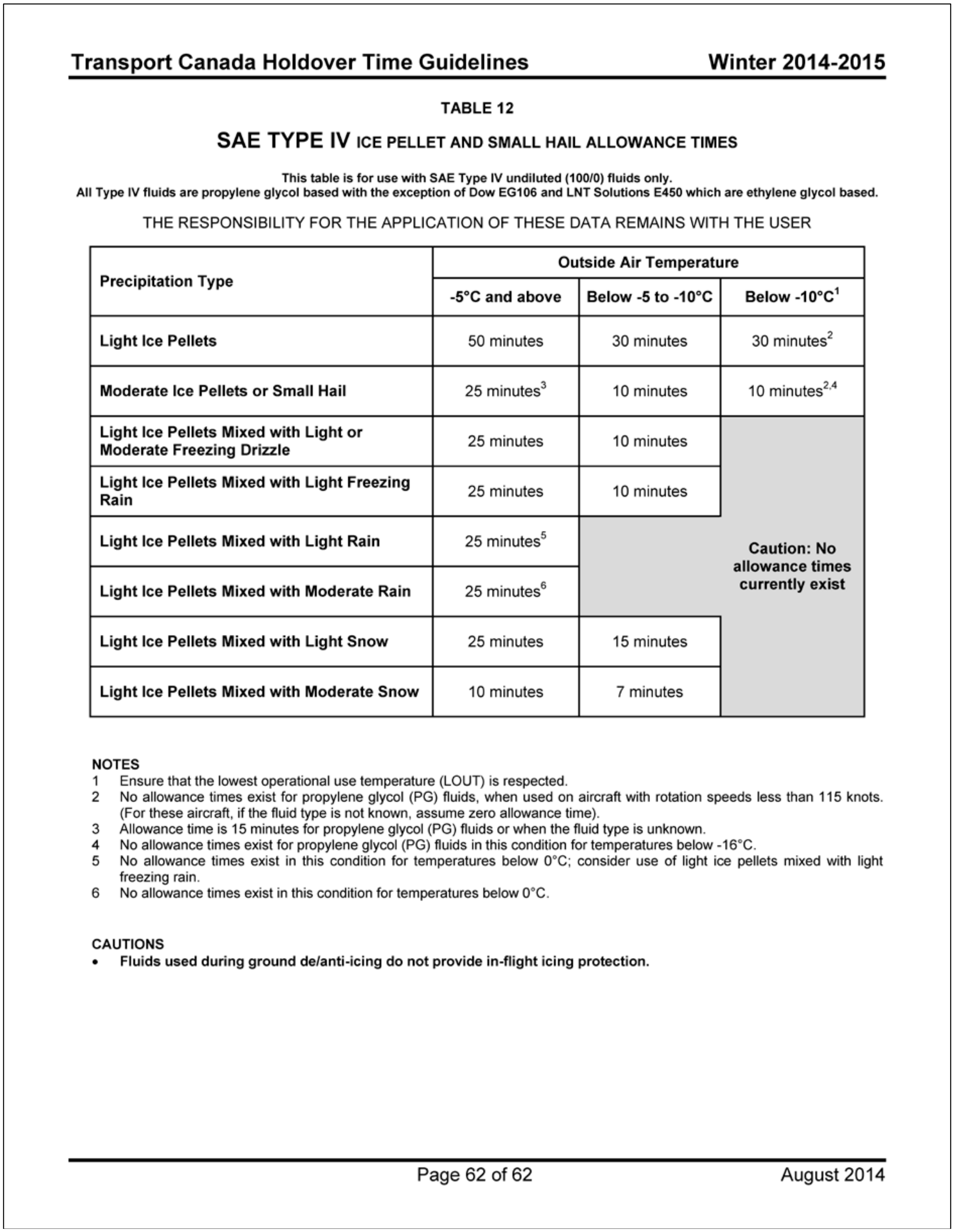


TABLE 12

SAE TYPE IV ICE PELLET AND SMALL HAIL ALLOWANCE TIMES

This table is for use with SAE Type IV undiluted (100/0) fluids only.
All Type IV fluids are propylene glycol based with the exception of Dow EG106 and LNT Solutions E450 which are ethylene glycol based.

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

Precipitation Type	**Outside Air Temperature**		
	-5°C and above	**Below -5 to -10°C**	**Below -10°C**[1]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[2]
Moderate Ice Pellets or Small Hail	25 minutes[3]	10 minutes	10 minutes[2,4]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes[5]		
Light Ice Pellets Mixed with Moderate Rain	25 minutes[6]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	7 minutes	

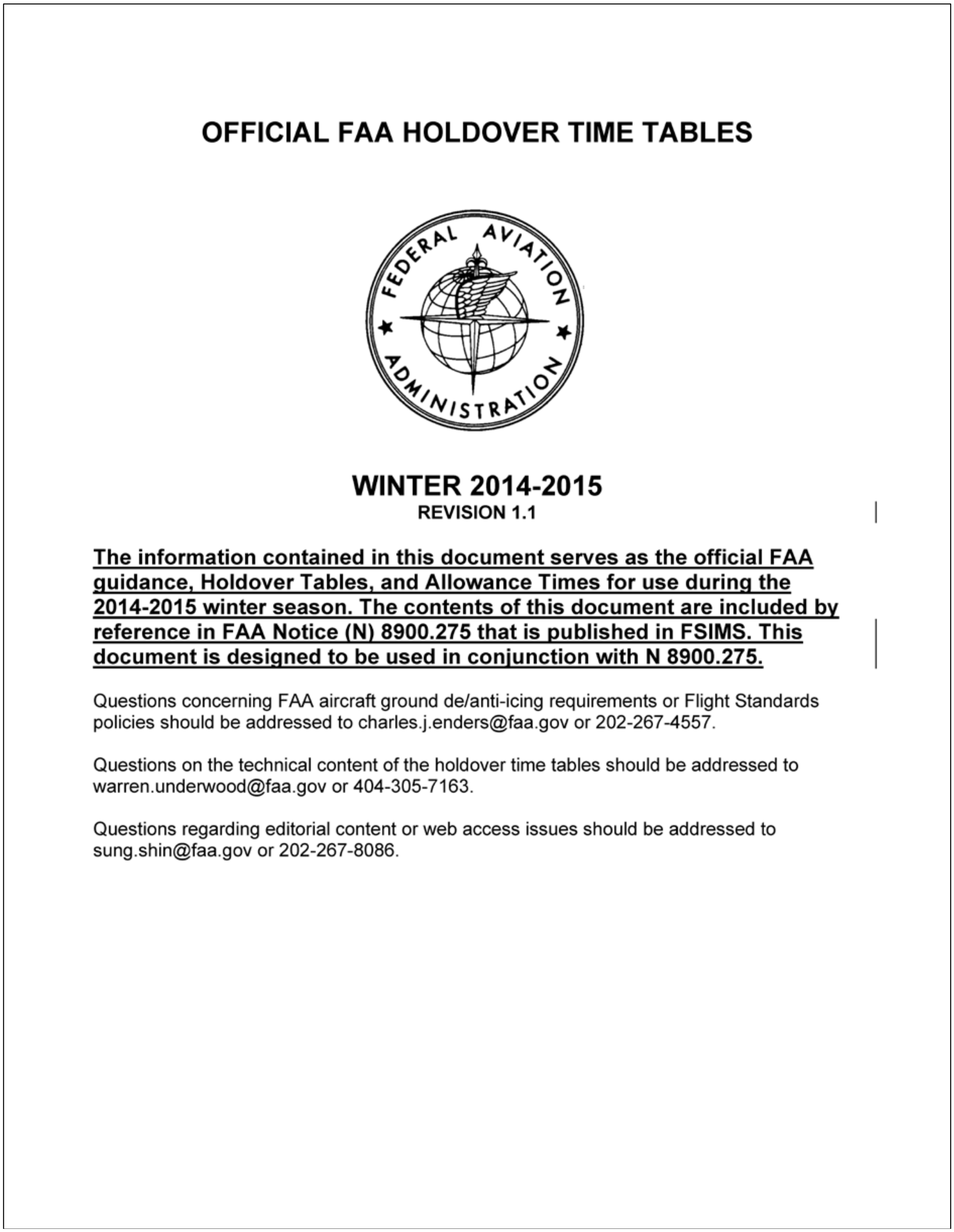
NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.
2 No allowance times exist for propylene glycol (PG) fluids, when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).
3 Allowance time is 15 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
4 No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16°C.
5 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
6 No allowance times exist in this condition for temperatures below 0°C.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

FAA
HOLDOVER TIME GUIDELINES
WINTER 2014-2015



OFFICIAL FAA HOLDOVER TIME TABLES

WINTER 2014-2015

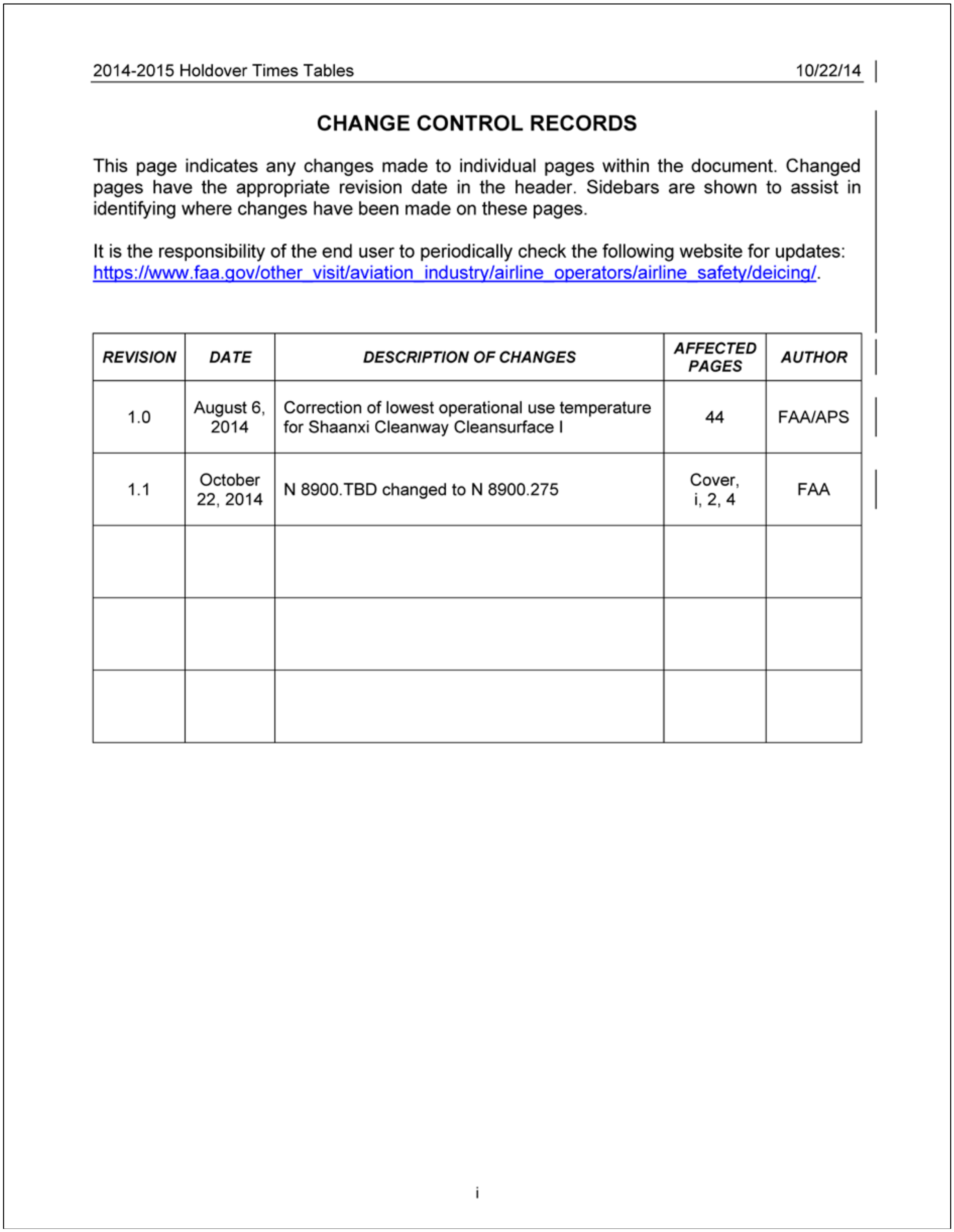
REVISION 1.1

The information contained in this document serves as the official FAA guidance, Holdover Tables, and Allowance Times for use during the 2014-2015 winter season. The contents of this document are included by reference in FAA Notice (N) 8900.275 that is published in FSIMS. This document is designed to be used in conjunction with N 8900.275.

Questions concerning FAA aircraft ground de/anti-icing requirements or Flight Standards policies should be addressed to charles.j.enders@faa.gov or 202-267-4557.

Questions on the technical content of the holdover time tables should be addressed to warren.underwood@faa.gov or 404-305-7163.

Questions regarding editorial content or web access issues should be addressed to sung.shin@faa.gov or 202-267-8086.

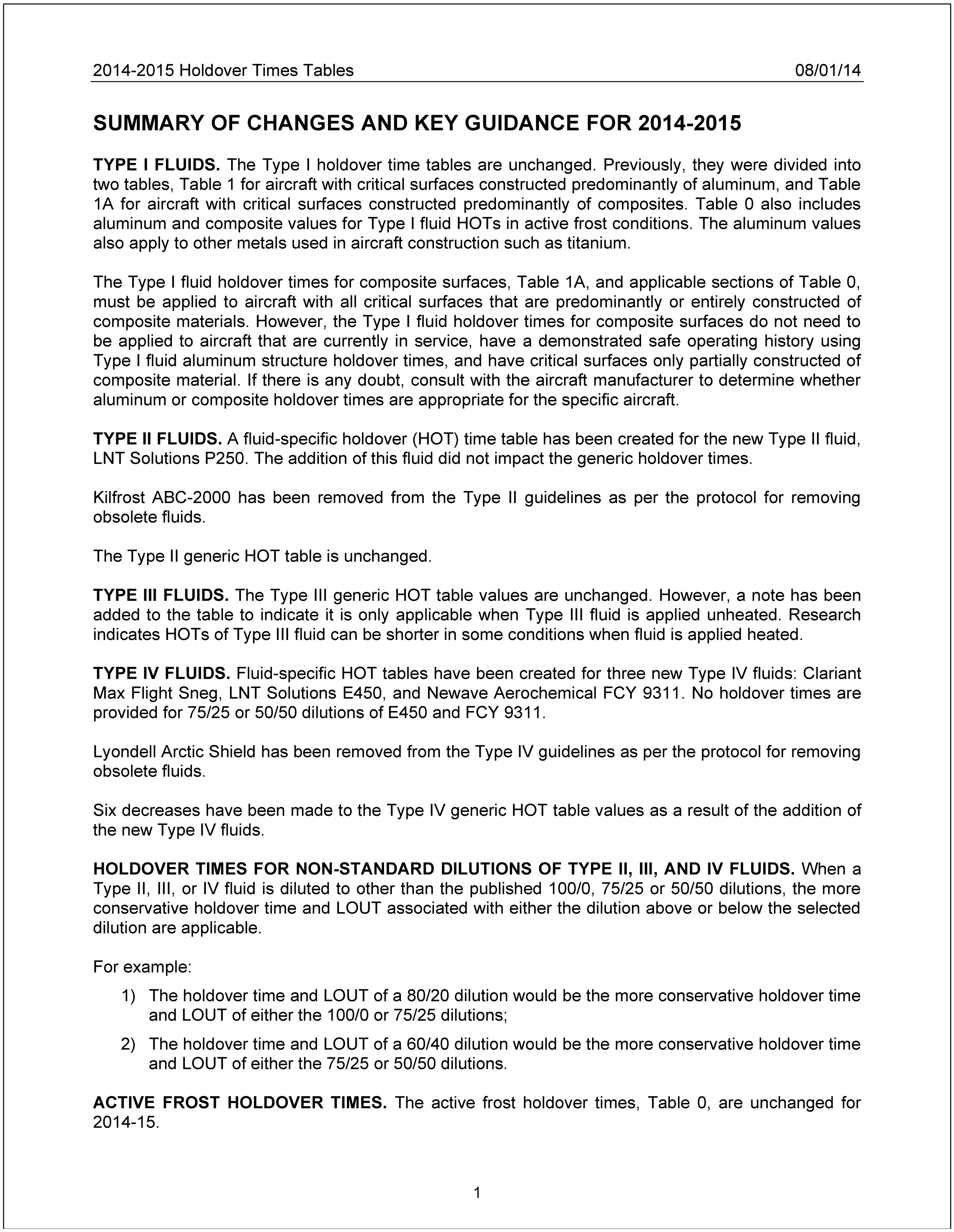


CHANGE CONTROL RECORDS

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

It is the responsibility of the end user to periodically check the following website for updates: https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/.

REVISION	***DATE***	***DESCRIPTION OF CHANGES***	***AFFECTED PAGES***	***AUTHOR***
1.0	August 6, 2014	Correction of lowest operational use temperature for Shaanxi Cleanway Cleansurface I	44	FAA/APS
1.1	October 22, 2014	N 8900.TBD changed to N 8900.275	Cover, i, 2, 4	FAA



SUMMARY OF CHANGES AND KEY GUIDANCE FOR 2014-2015

TYPE I FLUIDS. The Type I holdover time tables are unchanged. Previously, they were divided into two tables, Table 1 for aircraft with critical surfaces constructed predominantly of aluminum, and Table 1A for aircraft with critical surfaces constructed predominantly of composites. Table 0 also includes aluminum and composite values for Type I fluid HOTs in active frost conditions. The aluminum values also apply to other metals used in aircraft construction such as titanium.

The Type I fluid holdover times for composite surfaces, Table 1A, and applicable sections of Table 0, must be applied to aircraft with all critical surfaces that are predominantly or entirely constructed of composite materials. However, the Type I fluid holdover times for composite surfaces do not need to be applied to aircraft that are currently in service, have a demonstrated safe operating history using Type I fluid aluminum structure holdover times, and have critical surfaces only partially constructed of composite material. If there is any doubt, consult with the aircraft manufacturer to determine whether aluminum or composite holdover times are appropriate for the specific aircraft.

TYPE II FLUIDS. A fluid-specific holdover (HOT) time table has been created for the new Type II fluid, LNT Solutions P250. The addition of this fluid did not impact the generic holdover times.

Kilfrost ABC-2000 has been removed from the Type II guidelines as per the protocol for removing obsolete fluids.

The Type II generic HOT table is unchanged.

TYPE III FLUIDS. The Type III generic HOT table values are unchanged. However, a note has been added to the table to indicate it is only applicable when Type III fluid is applied unheated. Research indicates HOTs of Type III fluid can be shorter in some conditions when fluid is applied heated.

TYPE IV FLUIDS. Fluid-specific HOT tables have been created for three new Type IV fluids: Clariant Max Flight Sneg, LNT Solutions E450, and Newave Aerochemical FCY 9311. No holdover times are provided for 75/25 or 50/50 dilutions of E450 and FCY 9311.

Lyondell Arctic Shield has been removed from the Type IV guidelines as per the protocol for removing obsolete fluids.

Six decreases have been made to the Type IV generic HOT table values as a result of the addition of the new Type IV fluids.

HOLDOVER TIMES FOR NON-STANDARD DILUTIONS OF TYPE II, III, AND IV FLUIDS. When a Type II, III, or IV fluid is diluted to other than the published 100/0, 75/25 or 50/50 dilutions, the more conservative holdover time and LOUT associated with either the dilution above or below the selected dilution are applicable.

For example:

1) The holdover time and LOUT of a 80/20 dilution would be the more conservative holdover time and LOUT of either the 100/0 or 75/25 dilutions;
2) The holdover time and LOUT of a 60/40 dilution would be the more conservative holdover time and LOUT of either the 75/25 or 50/50 dilutions.

ACTIVE FROST HOLDOVER TIMES. The active frost holdover times, Table 0, are unchanged for 2014-15.

SNOWFALL VISIBILITY TABLE. Table 1C, Snowfall Intensities as a Function of Prevailing Visibility, is unchanged for 2014-15. For simplification purposes, portions of the table may be included in an air carrier's winter operations plan in non-table format. An example would be: "Since very light snow is being added to some of the Type II and Type IV tables, and since the METAR and the associated ATIS do not report very light snow, a METAR reported visibility of 2.5 miles or higher can be used as an indication that the snowfall intensity is very light." An air carrier certainly would also have the option of providing a more detailed description utilizing lower METAR reported visibilities for specific day/night and temperature conditions.

SURFACE VISIBILITY. Some METARS contain tower visibility as well as surface visibility. Whenever surface visibility is available from an official source, such as a METAR, in either the main body of the METAR or in the Remarks ("RMK") section, the preferred action is to use the surface visibility value.

USE OF RUNWAY VISUAL RANGE (RVR). The use of RVR is not permitted for determining visibility used with the holdover tables.

USE OF ELECTRONIC HAND HELD DEVICES TO DETERMINE HOLDOVER TIMES (eHOT). Electronic devices to determine HOTs may be used as part of an air operator's Title 14 of the Code of Federal Regulations (14 CFR) part 121, § 121.629 winter operations plan submitted to the FAA for approval. If for any reason the device or application fails or if the user has any concern regarding the accuracy of the data being displayed, printed tables sourced from the FAA HOTS must be used as a fall back information source. Questions regarding the use of these devices should be submitted to charles.j.enders@faa.gov, 202-267-4557.

ICE PELLET AND SMALL HAIL ALLOWANCE TIMES. Additional research has been conducted to provide guidance for aircraft operations during ice pellet conditions when operating with Type III undiluted (100/0) fluid applied unheated. A separate ice pellet allowance time table has been developed for Type III fluids (Table 9).

Small hail has been added to the allowance time tables as it has been determined to be meteorologically equivalent to moderate ice pellets. It has also been added to the titles of the allowance time guidance section and allowance time tables.

Research has indicated that Type IV propylene glycol (PG) fluids are removed less effectively during take-off when contaminated with moderate ice pellets at temperatures below -16 °C. Therefore operations in these conditions are not recommended and no allowance times exist for PG fluids in conditions of moderate ice pellets at temperatures below -16 °C, irrespective of aircraft rotation speed.

Research has provided data to support a new Type IV allowance time of 7 minutes for light ice pellets mixed with moderate snow at temperatures below -5 to -10 °C.

EARLY FLUID FAILURE ON EXTENDED SLATS AND FLAPS. Research has determined that fluid degradation is accelerated by the steeper angles of the flaps/slats in the takeoff configuration. The degree of potential degradation is significantly affected by the specific aircraft design. For the winter of 2014-2015, holdover time and allowance time tables have been published which include 90% adjusted holdover / allowance times. The 90% adjusted times were obtained by multiplying the standard holdover / allowance times by 90% and rounding the result to the nearest minute. (Note: times of 5 minutes and less do not change as the 10% reduction is less than required to reduce the time by one minute. Additionally, the 90% adjustment was applied to the uncapped snow holdover times. In some cases, this leads to adjusted snow holdover times which are longer than 90% of the standard (capped) holdover time.)

The 90% adjusted tables provide holdover / allowance times that must be used when flaps and slats are deployed prior to de/anti-icing. Standard holdover / allowance times can be used if flaps and slats are deployed as close to departure as safety allows. Additional guidance is provided in N 8900.275.

LOWEST OPERATIONAL USE TEMPERATURE (LOUT) TABLE. Lowest Operational Use Temperature (LOUT) information for Types I, II, III and IV fluids has been updated with revised values for some fluids. Information has also been added for new fluids and deleted for obsolete fluids. This information has been derived by the FAA based on data provided by the fluid manufacturers. The LOUT information can be found in Tables 7-1 for Type I fluids and Tables 7-2, 7-3, and 7-4 for Types II, III, and IV fluids respectively Tables 7-2, and 7-4 now include data for dilutions of Type II and Type IV fluids. Contact the fluid manufacturer if further clarification with respect to the information in these tables is required.

The Lowest Operational Use Temperature, or LOUT, is the lowest temperature at which a de/anti-icing fluid will adequately flow off aircraft critical surfaces and maintain the required anti-icing freezing point buffer which is 7 °C (13 °F) below outside air temperature (OAT) for SAE Type II, Type III, and Type IV fluids and 10 °C (18 °F) below (OAT) for SAE Type I fluids.

For example, if a Type IV fluid has been aerodynamically tested and demonstrated adequate flow-off capability down to -30 °C (-22 °F), and the freezing point of this fluid is -35 °C (-31 °F), the LOUT would be -28 °C (-18.4 °F) to account for the required 7 °C (13 °F) freezing point buffer. In this case, the freezing point buffer requirement is the LOUT limiting factor.

Similarly if a Type I fluid has been found to adequately flow off down to -29 °C (-20.2 °F), and the freezing point is -40 °C (-40 °F) , the LOUT would be -29 °C (-20.2 °F) to account for the lowest temperature at which the fluid adequately flows off the aircraft. Here, in this example, the fluid aerodynamic flow-off capability limits the LOUT.

There are two aerodynamic fluid flow-off test protocols for fluids; the low speed test is for aircraft with rotation speeds less than 100 knots and the high speed test for aircraft with rotation speeds greater than 100 knots. Type II, and Type IV fluids generally do not pass the low speed test. Therefore in order for these fluids to be used on a low rotation speed aircraft (rotation speed of 100 knots or less), the aircraft manufacturer must conduct testing to determine if these fluids can be safely applied on these aircraft and to identify operational procedures that must be implemented to insure the safe operation when these fluids have been applied.

The LOUTs for Type I fluids provided in Table 7-1 also include the manufacturer specified fluid/water concentration used to establish the LOUT for each fluid. This concentration should not be exceeded.

As previously stated, in the cases of Types II, III, and IV fluids, there can be multiple LOUTs to account for the undiluted fluid (100/0) and the 50/50 and 75/25 dilutions. In addition to being provided in Tables 7-2, 7-3, and 7-4, the LOUTs are also listed in their brand-specific holdover tables, but not Table 0, the frost holdover table. For this table, refer to Tables 7-2, 7-3, or 7-4, or the Type II, III, or IV HOTs to determine if the LOUT of the fluid being applied is warmer than -25 °C (-13 °F) and restrict use to -25 °C or the LOUT, whichever is warmer. Type I fluid LOUTs are only found in Table 7-1, and are allowed to be used at temperatures down to their actual LOUT.

FLIGHT CREW AWARENESS OF CONDITIONS AFFECTING THE AIRCRAFT ANTI-ICING TREATMENT FOLLOWING DEICING AND ANTI-ICING OPERATIONS. The operator's deicing plan must provide a process that informs the captain of the time of the deicing/anti-icing treatment and conditions that have affected the aircraft anti-icing treatment since that time. If the flight crew is not present at the time of the deicing/anti-icing application, the crew will review this information before calculating the holdover time.

STANDARDIZED INTERNATIONAL AIRCRAFT GROUND DEICING PROGRAM (SIAGDP). For those air carriers participating in the SIAGDP one change was agreed upon after the 2010-2011 winter revisions were made to the SIAGDP. This change was included in the 2011-2012 revision. This change addresses a concern that the air carriers have expressed over the completion of the annual audits within the anniversary month. In addition to the scheduling difficulties that this has generated, it has also necessitated that many of the audits be conducted in late summer and early fall prior to the service providers being in a full operational mode. In many cases this has limited the auditor's effectiveness and has not been conducive to the high quality audit that is fundamental to the success of the SIAGDP. Therefore it was agreed upon by the member air carriers participating in the SIAGDP and the FAA policy office that the grace month concept that is currently applied to the training/qualification annual requirements under the SIAGDP will be also applied to the annual audit requirements. This allows a three month period in which the audit can be conducted and credited as though it was conducted in the month it was originally due. For example if the audit in 2009 was completed in September the next audit would be due in September 2010. The 2010 audit could be completed in either August, September or October 2010 and credited as completed in its original due month of September 2010. The next audit would be due in September 2011 regardless of which of the three months the audit was completed in 2010. The same grace month rational will apply for the 2011 audit as well. If the recurring audit is not completed in the three month applicable period then the service provider would be considered as a new service provider under the SIAGDP and an initial detailed qualification audit would need to be completed prior to any SIAGDP participating air carrier utilizing their services under the SIAGDP. Policy development is continuing in 2014-15.

GUIDANCE ON HAIL AND SMALL HAIL. The meteorological conditions "hail" and "small hail" are not equivalent. No holdover times exist for either of these conditions; however, it has been determined that small hail is meteorologically equivalent to moderate ice pellets and therefore moderate ice pellet allowance times can be used in small hail conditions. The following changes have been made to provide clearer guidance on the use of holdover times and allowance times in hail and small hail conditions:

a) Small hail has been added to the list of "other" weather conditions for which holdover times do not exist. This list is provided as a note in each of the Type I, II, III and IV HOT tables.

b) Additional text has been added to the "other" weather conditions note in the Type III and IV HOT tables to guide users to the allowance time tables in ice pellet and small hail conditions.

c) Small hail has been added to the allowance time tables (Table 9 and Table 10).

d) A section on hail and small hail has been added to N 8900.275.

INTERPRETATION OF METAR CODE GS. The World Meteorological Organization (WMO) states METAR code GS is used for two meteorological conditions: "snow pellets" and "small hail." However, investigation has determined that not all countries follow these guidelines. The use of the reported GS code can potentially lead to difficulties in determining which condition (snow pellets or small hail) is occurring and therefore in establishing the appropriate holdover time/allowance time. Consequently, a new section has been added to N 8900.275 to provide guidance for determining which holdover times/allowance times should be used with METAR code GS.

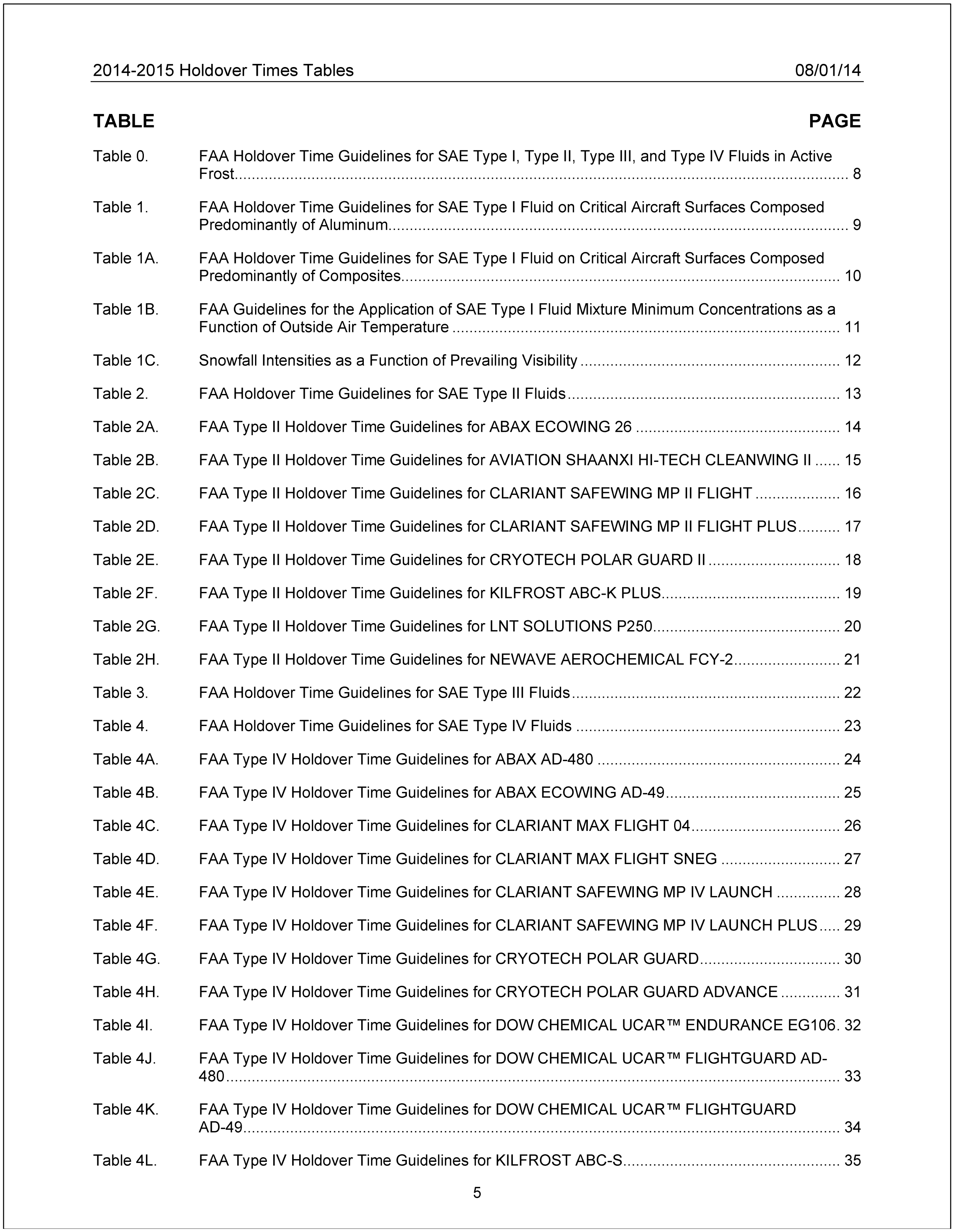


TABLE		PAGE
Table 0.	FAA Holdover Time Guidelines for SAE Type I, Type II, Type III, and Type IV Fluids in Active Frost	8
Table 1.	FAA Holdover Time Guidelines for SAE Type I Fluid on Critical Aircraft Surfaces Composed Predominantly of Aluminum	9
Table 1A.	FAA Holdover Time Guidelines for SAE Type I Fluid on Critical Aircraft Surfaces Composed Predominantly of Composites	10
Table 1B.	FAA Guidelines for the Application of SAE Type I Fluid Mixture Minimum Concentrations as a Function of Outside Air Temperature	11
Table 1C.	Snowfall Intensities as a Function of Prevailing Visibility	12
Table 2.	FAA Holdover Time Guidelines for SAE Type II Fluids	13
Table 2A.	FAA Type II Holdover Time Guidelines for ABAX ECOWING 26	14
Table 2B.	FAA Type II Holdover Time Guidelines for AVIATION SHAANXI HI-TECH CLEANWING II	15
Table 2C.	FAA Type II Holdover Time Guidelines for CLARIANT SAFEWING MP II FLIGHT	16
Table 2D.	FAA Type II Holdover Time Guidelines for CLARIANT SAFEWING MP II FLIGHT PLUS	17
Table 2E.	FAA Type II Holdover Time Guidelines for CRYOTECH POLAR GUARD II	18
Table 2F.	FAA Type II Holdover Time Guidelines for KILFROST ABC-K PLUS	19
Table 2G.	FAA Type II Holdover Time Guidelines for LNT SOLUTIONS P250	20
Table 2H.	FAA Type II Holdover Time Guidelines for NEWAVE AEROCHEMICAL FCY-2	21
Table 3.	FAA Holdover Time Guidelines for SAE Type III Fluids	22
Table 4.	FAA Holdover Time Guidelines for SAE Type IV Fluids	23
Table 4A.	FAA Type IV Holdover Time Guidelines for ABAX AD-480	24
Table 4B.	FAA Type IV Holdover Time Guidelines for ABAX ECOWING AD-49	25
Table 4C.	FAA Type IV Holdover Time Guidelines for CLARIANT MAX FLIGHT 04	26
Table 4D.	FAA Type IV Holdover Time Guidelines for CLARIANT MAX FLIGHT SNEG	27
Table 4E.	FAA Type IV Holdover Time Guidelines for CLARIANT SAFEWING MP IV LAUNCH	28
Table 4F.	FAA Type IV Holdover Time Guidelines for CLARIANT SAFEWING MP IV LAUNCH PLUS	29
Table 4G.	FAA Type IV Holdover Time Guidelines for CRYOTECH POLAR GUARD	30
Table 4H.	FAA Type IV Holdover Time Guidelines for CRYOTECH POLAR GUARD ADVANCE	31
Table 4I.	FAA Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ ENDURANCE EG106.	32
Table 4J.	FAA Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480	33
Table 4K.	FAA Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49	34
Table 4L.	FAA Type IV Holdover Time Guidelines for KILFROST ABC-S	35

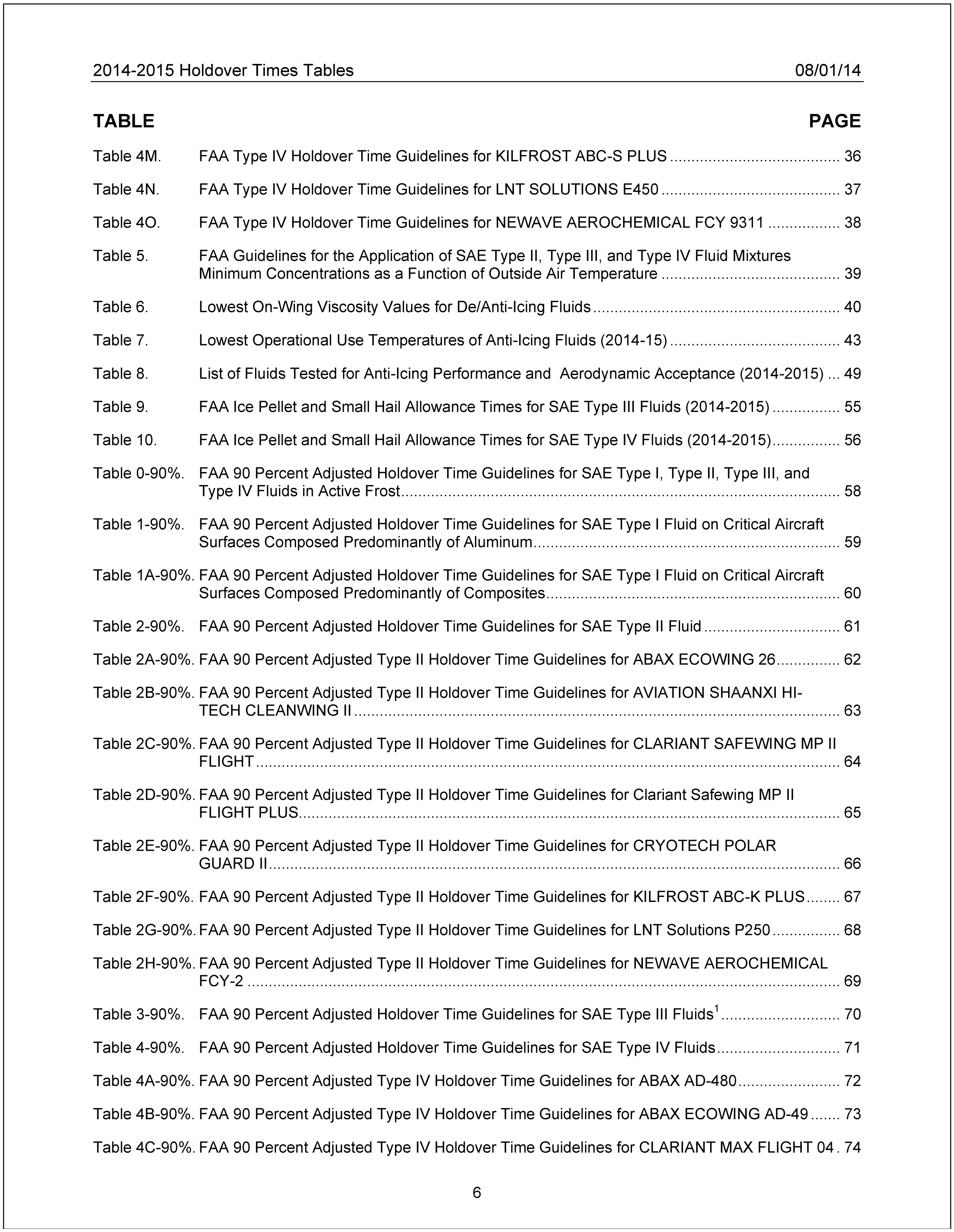


TABLE **PAGE**

Table 4M. FAA Type IV Holdover Time Guidelines for KILFROST ABC-S PLUS 36

Table 4N. FAA Type IV Holdover Time Guidelines for LNT SOLUTIONS E450 37

Table 4O. FAA Type IV Holdover Time Guidelines for NEWAVE AEROCHEMICAL FCY 9311 38

Table 5. FAA Guidelines for the Application of SAE Type II, Type III, and Type IV Fluid Mixtures Minimum Concentrations as a Function of Outside Air Temperature 39

Table 6. Lowest On-Wing Viscosity Values for De/Anti-Icing Fluids 40

Table 7. Lowest Operational Use Temperatures of Anti-Icing Fluids (2014-15) 43

Table 8. List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance (2014-2015) ... 49

Table 9. FAA Ice Pellet and Small Hail Allowance Times for SAE Type III Fluids (2014-2015) 55

Table 10. FAA Ice Pellet and Small Hail Allowance Times for SAE Type IV Fluids (2014-2015) 56

Table 0-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type I, Type II, Type III, and Type IV Fluids in Active Frost 58

Table 1-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type I Fluid on Critical Aircraft Surfaces Composed Predominantly of Aluminum 59

Table 1A-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type I Fluid on Critical Aircraft Surfaces Composed Predominantly of Composites 60

Table 2-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type II Fluid 61

Table 2A-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for ABAX ECOWING 26 62

Table 2B-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for AVIATION SHAANXI HI-TECH CLEANWING II 63

Table 2C-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for CLARIANT SAFEWING MP II FLIGHT 64

Table 2D-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for Clariant Safewing MP II FLIGHT PLUS 65

Table 2E-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for CRYOTECH POLAR GUARD II 66

Table 2F-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for KILFROST ABC-K PLUS 67

Table 2G-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for LNT Solutions P250 68

Table 2H-90%. FAA 90 Percent Adjusted Type II Holdover Time Guidelines for NEWAVE AEROCHEMICAL FCY-2 69

Table 3-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type III Fluids[1] 70

Table 4-90%. FAA 90 Percent Adjusted Holdover Time Guidelines for SAE Type IV Fluids 71

Table 4A-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for ABAX AD-480 72

Table 4B-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for ABAX ECOWING AD-49 73

Table 4C-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CLARIANT MAX FLIGHT 04 . 74

TABLE **PAGE**

Table 4D-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CLARIANT MAX FLIGHT SNEG ... 75

Table 4E-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CLARIANT SAFEWING MP IV LAUNCH ... 76

Table 4F-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CLARIANT SAFEWING MP IV LAUNCH PLUS ... 77

Table 4G-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CRYOTECH POLAR GUARD ... 78

Table 4H-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for CRYOTECH POLAR GUARD ADVANCE ... 79

Table 4I-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ ENDURANCE EG106 ... 80

Table 4J-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480 ... 81

Table 4K-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49 ... 82

Table 4L-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for KILFROST ABC-S ... 83

Table 4M-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for KILFROST ABC-S PLUS ... 84

Table 4N-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for LNT SOLUTIONS E450 ... 85

Table 4O-90%. FAA 90 Percent Adjusted Type IV Holdover Time Guidelines for NEWAVE AEROCHEMICAL FCY 9311 ... 86

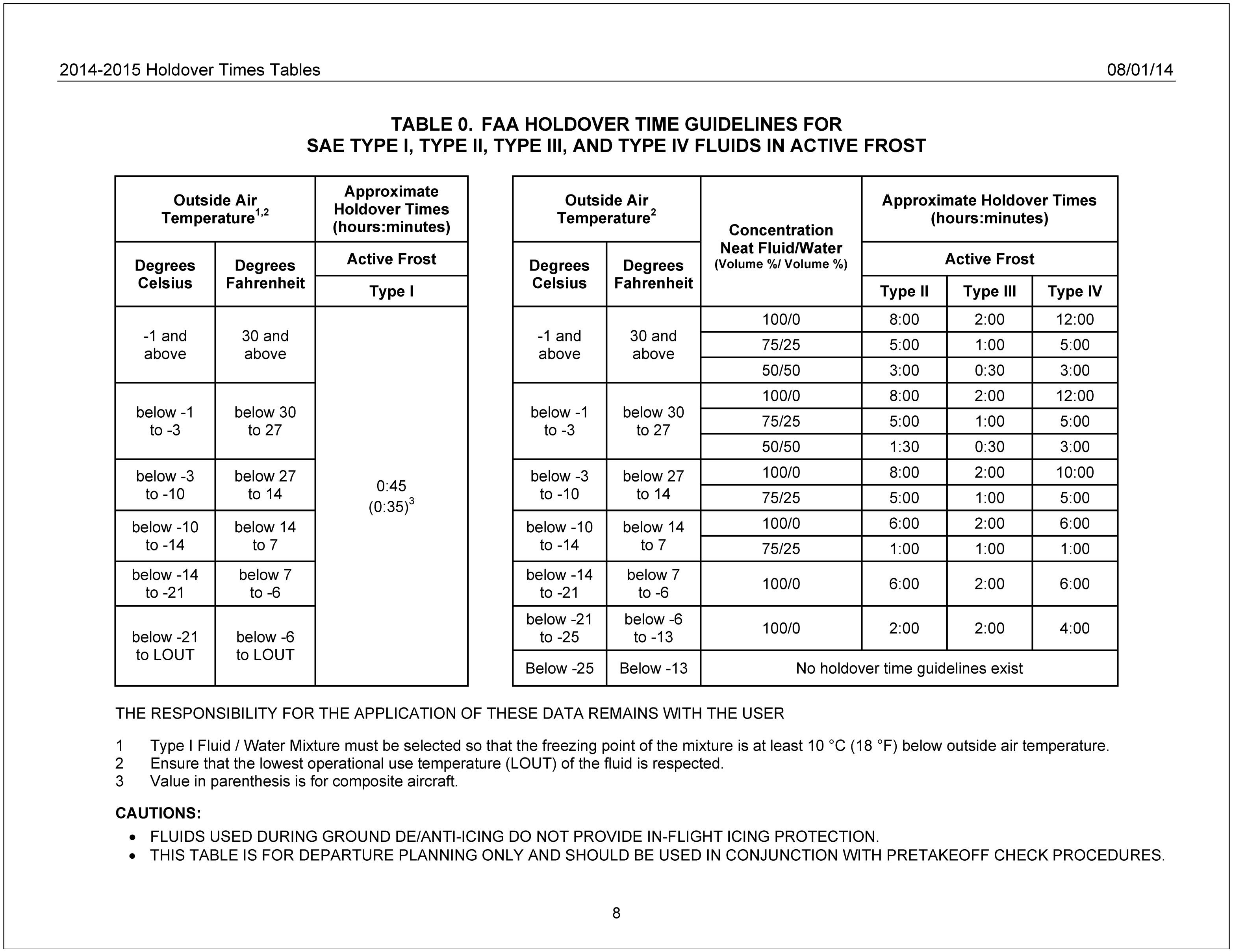
Table 9-90%. FAA Ice Pellet and Small Hail 90 Percent Adjusted Allowance Times for SAE Type III Fluids (2014-2015) ... 87

Table 10-90%. FAA Ice Pellet and Small Hail 90 Percent Adjusted Allowance Times for SAE Type IV Fluids (2014-2015) ... 88

GUIDANCE/INFORMATION **PAGE**

Ice Pellet and Small Hail Allowance Times 2014-2015 ... 52

Operations in Heavy Snow 2014-2015 ... 57



2014-2015 Holdover Times Tables 08/01/14

TABLE 0. FAA HOLDOVER TIME GUIDELINES FOR SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS IN ACTIVE FROST

Outside Air Temperature[1,2]		**Approximate Holdover Times (hours:minutes)**
Degrees Celsius	**Degrees Fahrenheit**	**Active Frost**
		Type I
-1 and above	30 and above	0:45 (0:35)[3]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2]		**Concentration Neat Fluid/Water** (Volume %/ Volume %)	**Approximate Holdover Times (hours:minutes)**		
Degrees Celsius	**Degrees Fahrenheit**		**Active Frost**		
			Type II	**Type III**	**Type IV**
-1 and above	30 and above	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0	8:00	2:00	10:00
		75/25	5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0	6:00	2:00	6:00
		75/25	1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0	6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0	2:00	2:00	4:00
Below -25	Below -13	No holdover time guidelines exist			

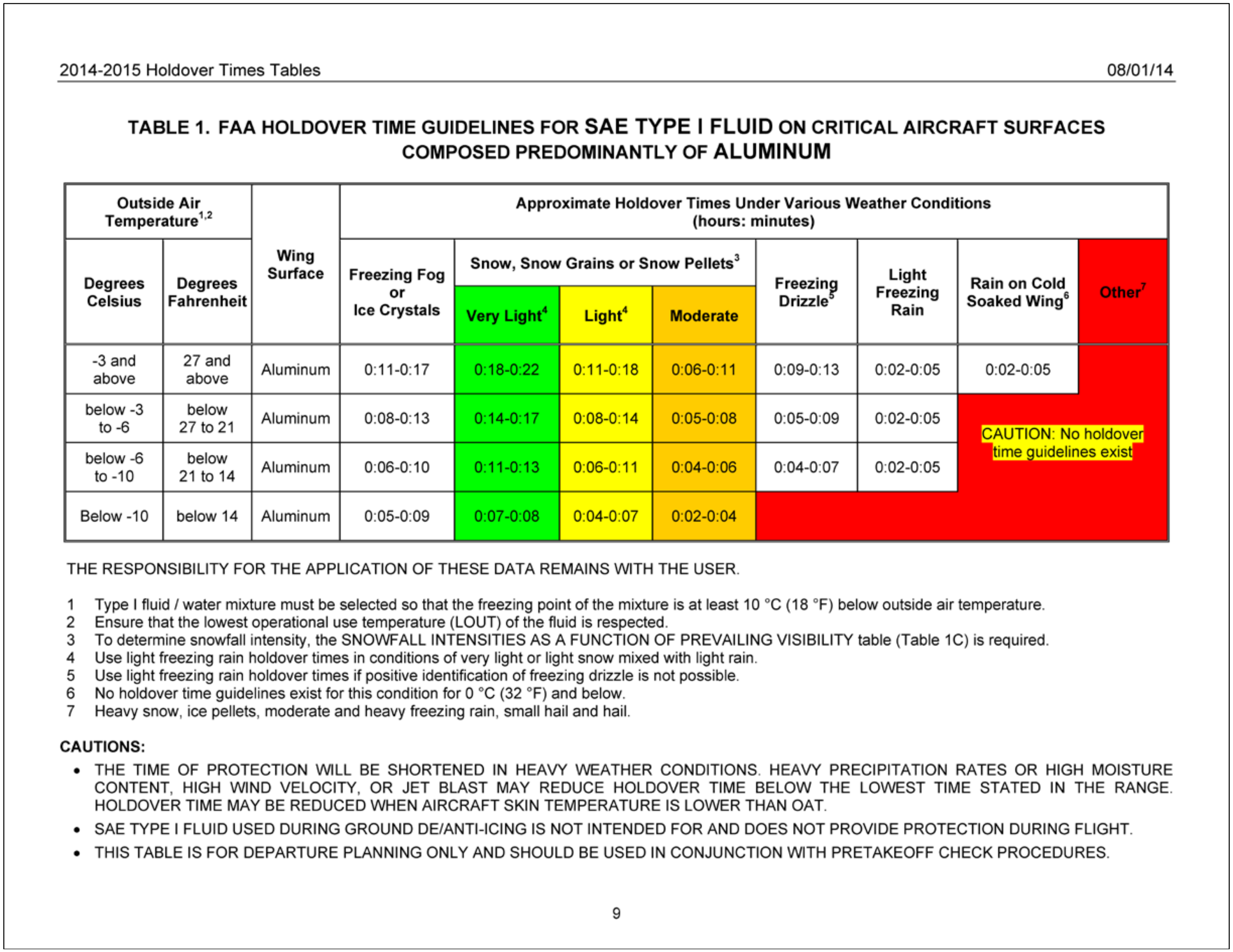
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 Value in parenthesis is for composite aircraft.

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

8



2014-2015 Holdover Times Tables 08/01/14

TABLE 1. FAA HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

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

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE I FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

9

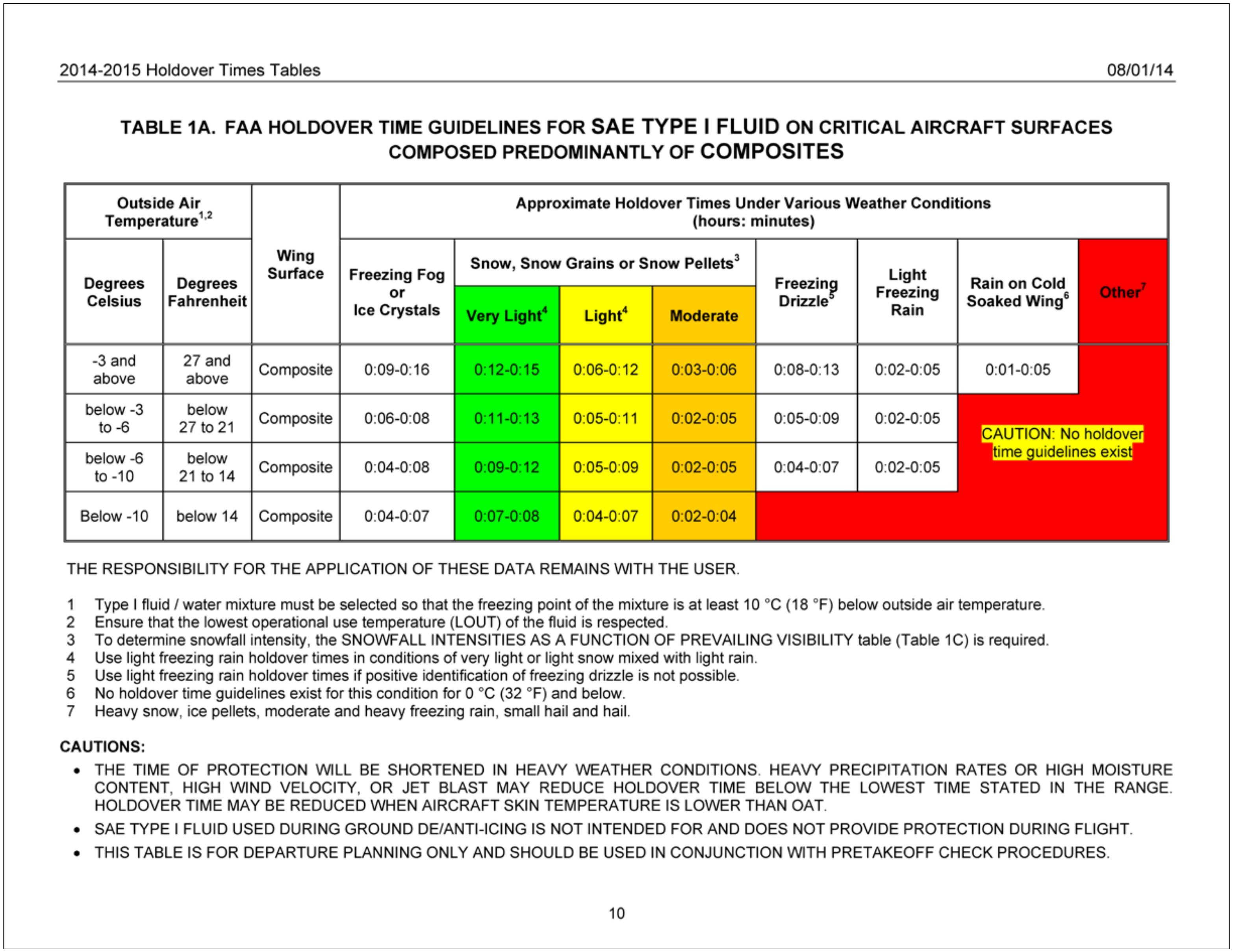


TABLE 1A. FAA HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-0:06	0:08-0:13	0:02-0:05	0:01-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04				

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

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE I FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TABLE 1B. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID MIXTURE MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

Outside Air Temperature (OAT)	**One-step Procedure Deicing/Anti-icing**[1]	**Two-step Procedure**	
		First step: Deicing	**Second step: Anti-icing**[1,2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

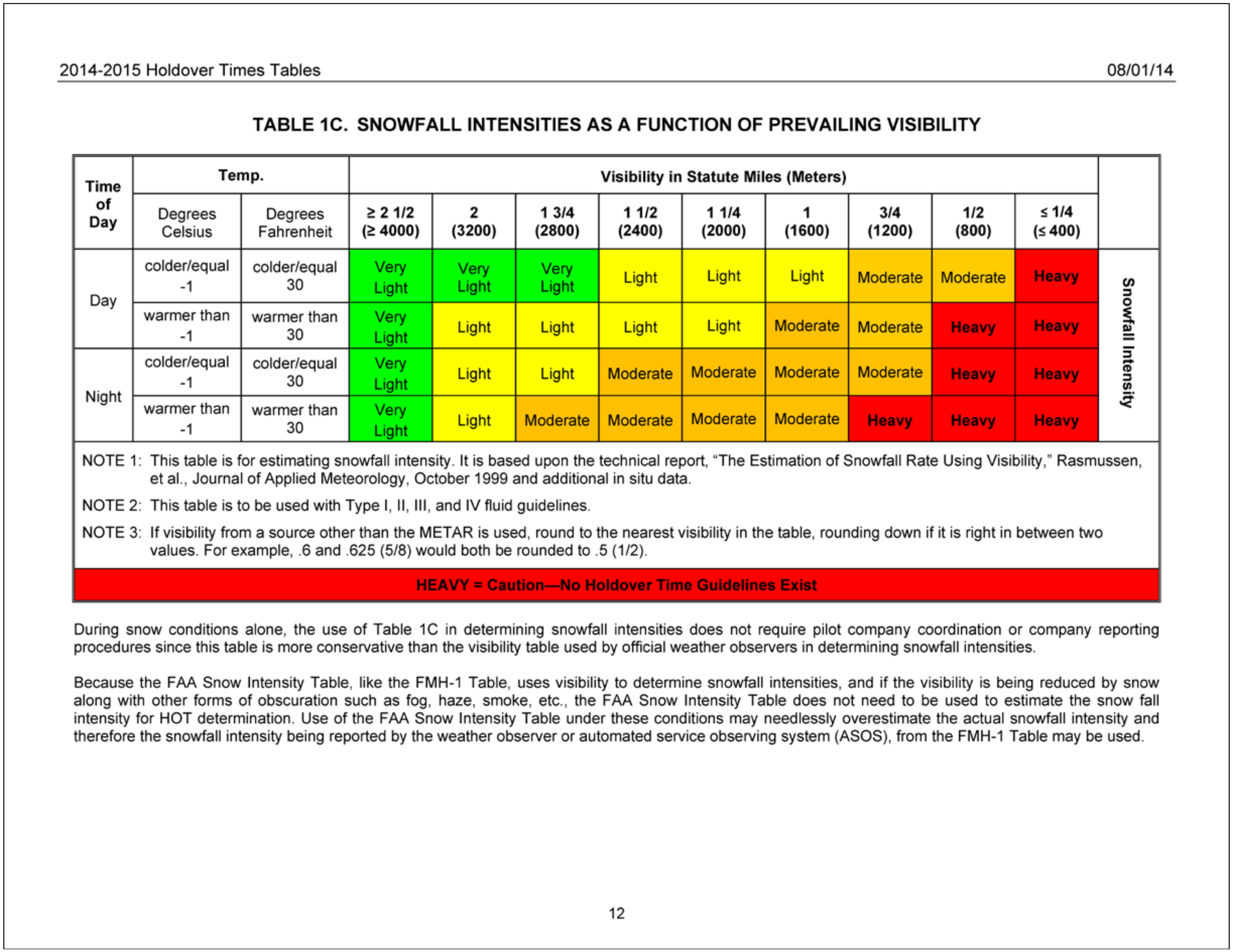
1 Fluids must only be used at temperatures above their lowest operational use temperature (LOUT).

2 To be applied before first-step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

Notes:

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in all conditions including active frost, at least 1 liter per square meter (~2 gal. per 100 square feet) fluid must be applied to the deiced surfaces.
- This table is applicable for the use of Type I Holdover Time Guidelines in all conditions, including active frost. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- The lowest operational use temperature (LOUT) for a given Type I fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  b) The actual freezing point of the fluid plus a freezing point buffer of 10 °C (18 °F).

Caution: WING SKIN TEMPERATURES MAY DIFFER AND, IN SOME CASES, BE LOWER THAN OAT. A STRONGER MIX (MORE GLYCOL) MAY BE NEEDED UNDER THESE CONDITIONS.



2014-2015 Holdover Times Tables 08/01/14

TABLE 1C. SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY

Time of Day	**Temp.**		**Visibility in Statute Miles (Meters)**									
	Degrees Celsius	Degrees Fahrenheit	**≥ 2 1/2 (≥ 4000)**	**2 (3200)**	**1 3/4 (2800)**	**1 1/2 (2400)**	**1 1/4 (2000)**	**1 (1600)**	**3/4 (1200)**	**1/2 (800)**	**≤ 1/4 (≤ 400)**	
Day	colder/equal -1	colder/equal 30	Very Light	Very Light	Very Light	Light	Light	Light	Moderate	Moderate	**Heavy**	**Snowfall Intensity**
	warmer than -1	warmer than 30	Very Light	Light	Light	Light	Light	Moderate	Moderate	**Heavy**	**Heavy**	
Night	colder/equal -1	colder/equal 30	Very Light	Light	Light	Moderate	Moderate	Moderate	Moderate	**Heavy**	**Heavy**	
	warmer than -1	warmer than 30	Very Light	Light	Moderate	Moderate	Moderate	Moderate	**Heavy**	**Heavy**	**Heavy**	

NOTE 1: This table is for estimating snowfall intensity. It is based upon the technical report, "The Estimation of Snowfall Rate Using Visibility," Rasmussen, et al., Journal of Applied Meteorology, October 1999 and additional in situ data.

NOTE 2: This table is to be used with Type I, II, III, and IV fluid guidelines.

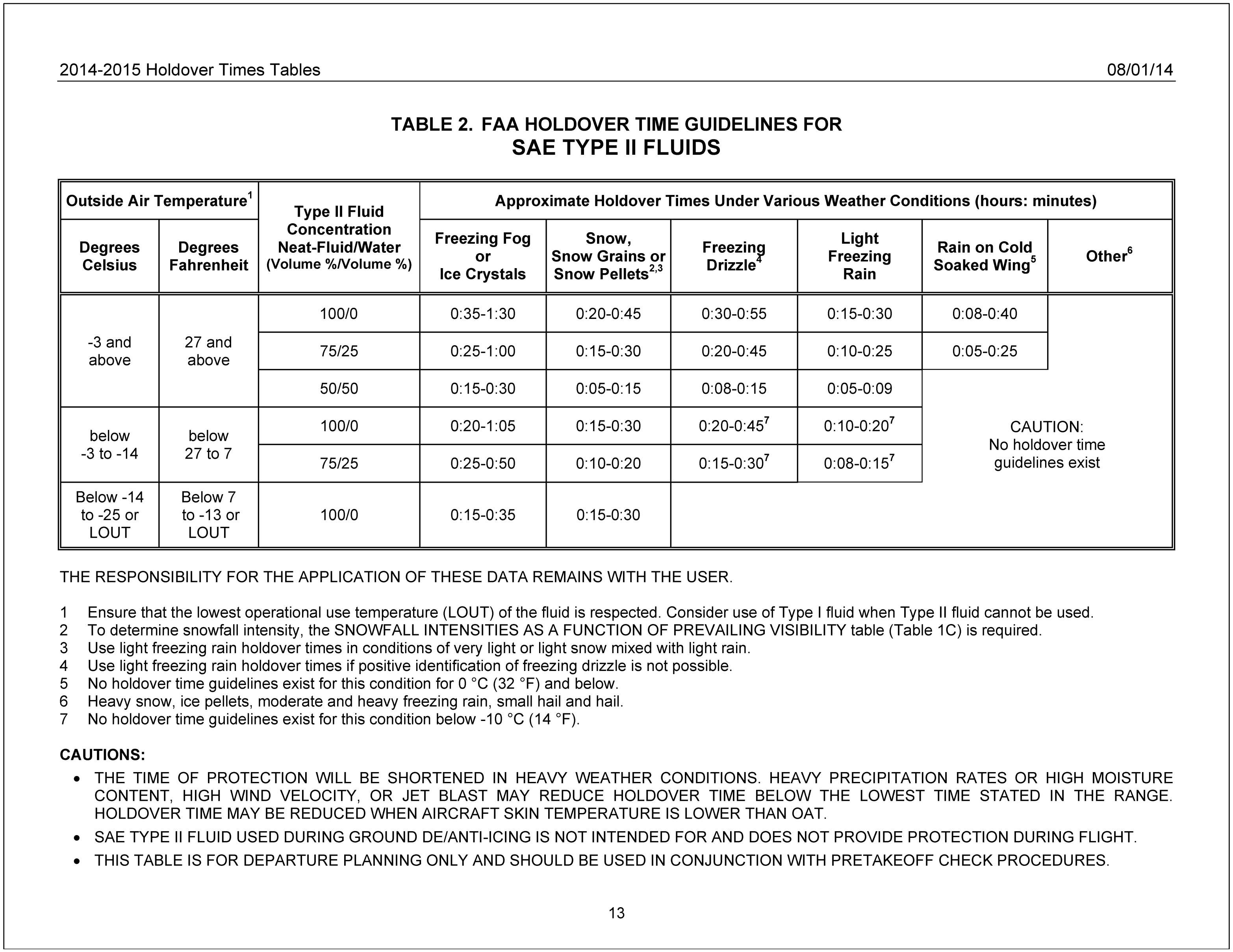
NOTE 3: If visibility from a source other than the METAR is used, round to the nearest visibility in the table, rounding down if it is right in between two values. For example, .6 and .625 (5/8) would both be rounded to .5 (1/2).

HEAVY = Caution—No Holdover Time Guidelines Exist

During snow conditions alone, the use of Table 1C in determining snowfall intensities does not require pilot company coordination or company reporting procedures since this table is more conservative than the visibility table used by official weather observers in determining snowfall intensities.

Because the FAA Snow Intensity Table, like the FMH-1 Table, uses visibility to determine snowfall intensities, and if the visibility is being reduced by snow along with other forms of obscuration such as fog, haze, smoke, etc., the FAA Snow Intensity Table does not need to be used to estimate the snow fall intensity for HOT determination. Use of the FAA Snow Intensity Table under these conditions may needlessly overestimate the actual snowfall intensity and therefore the snowfall intensity being reported by the weather observer or automated service observing system (ASOS), from the FMH-1 Table may be used.

12



2014-2015 Holdover Times Tables 08/01/14

TABLE 2. FAA HOLDOVER TIME GUIDELINES FOR
SAE TYPE II FLUIDS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:08-0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	0:15-0:30	0:05-0:15	0:08-0:15	0:05-0:09		
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	0:20-0:45[7]	0:10-0:20[7]		
		75/25	0:25-0:50	0:10-0:20	0:15-0:30[7]	0:08-0:15[7]		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:15-0:35	0:15-0:30				

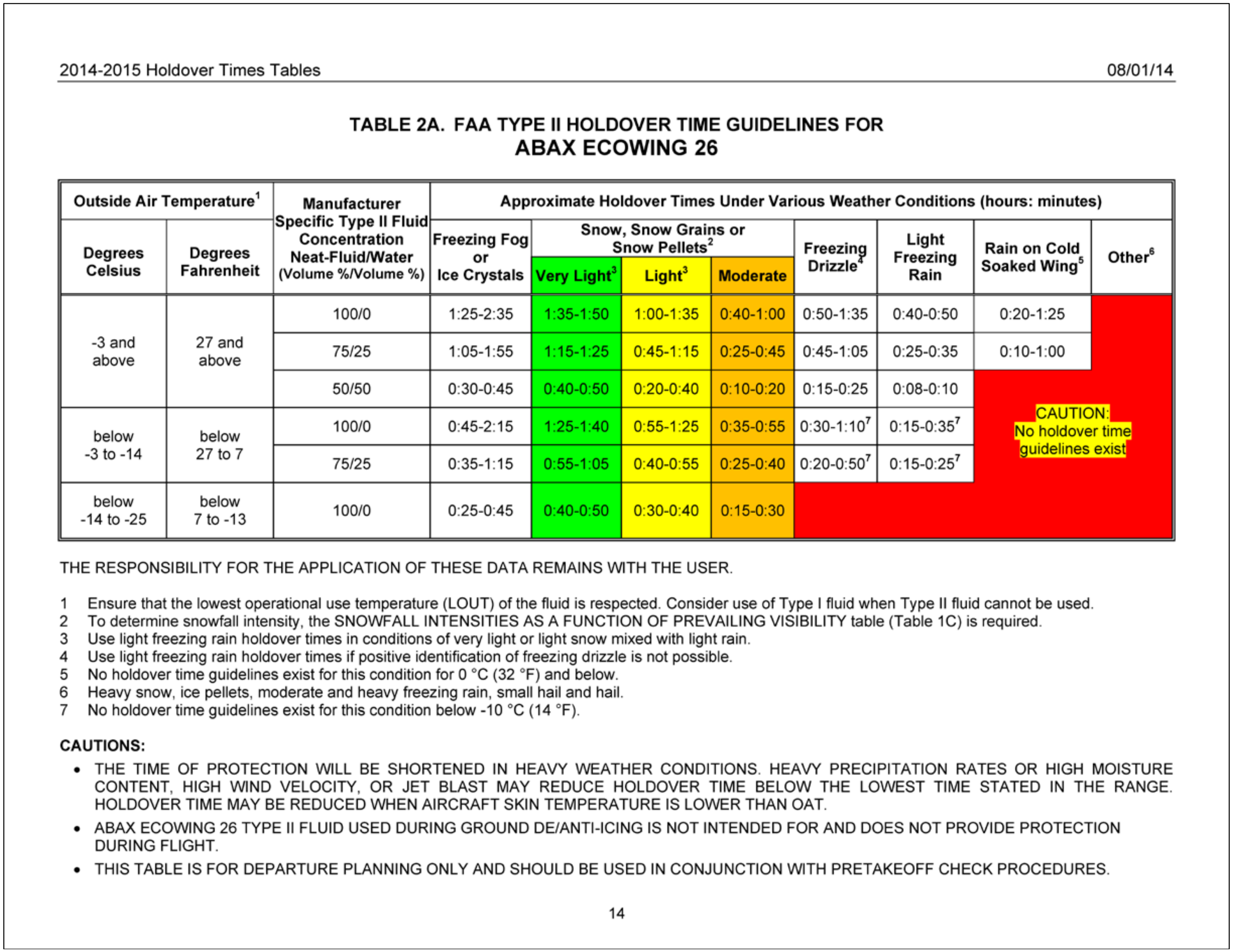
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

13



2014-2015 Holdover Times Tables 08/01/14

TABLE 2A. FAA TYPE II HOLDOVER TIME GUIDELINES FOR
ABAX ECOWING 26

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:25-2:35	1:35-1:50	1:00-1:35	0:40-1:00	0:50-1:35	0:40-0:50	0:20-1:25	CAUTION: No holdover time guidelines exist
		75/25	1:05-1:55	1:15-1:25	0:45-1:15	0:25-0:45	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	0:30-0:45	0:40-0:50	0:20-0:40	0:10-0:20	0:15-0:25	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-2:15	1:25-1:40	0:55-1:25	0:35-0:55	0:30-1:10[7]	0:15-0:35[7]		
		75/25	0:35-1:15	0:55-1:05	0:40-0:55	0:25-0:40	0:20-0:50[7]	0:15-0:25[7]		
below -14 to -25	below 7 to -13	100/0	0:25-0:45	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX ECOWING 26 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

14

TABLE 2B. FAA TYPE II HOLDOVER TIME GUIDELINES FOR AVIATION SHAANXI HI-TECH CLEANWING II

Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets**[2,3]	**Freezing Drizzle**[4]	**Light Freezing Rain**	**Rain on Cold Soaked Wing**[5]	**Other**[6]
-3 and above	27 and above	100/0	0:55-1:50	0:30-0:55	0:35-1:05	0:25-0:35	0:10-0:55	CAUTION: No holdover time guidelines exist
		75/25	0:50-1:20	0:25-0:45	0:35-1:00	0:20-0:30	0:07-0:50	
		50/50	0:35-1:00	0:15-0:30	0:20-0:40	0:10-0:20		
below -3 to -14	below 27 to 7	100/0	0:45-1:50	0:30-0:55	0:30-0:55[7]	0:20-0:25[7]		
		75/25	0:40-1:45	0:25-0:45	0:35-0:40[7]	0:20-0:25[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- AVIATION SHAANXI HI-TECH CLEANWING II TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

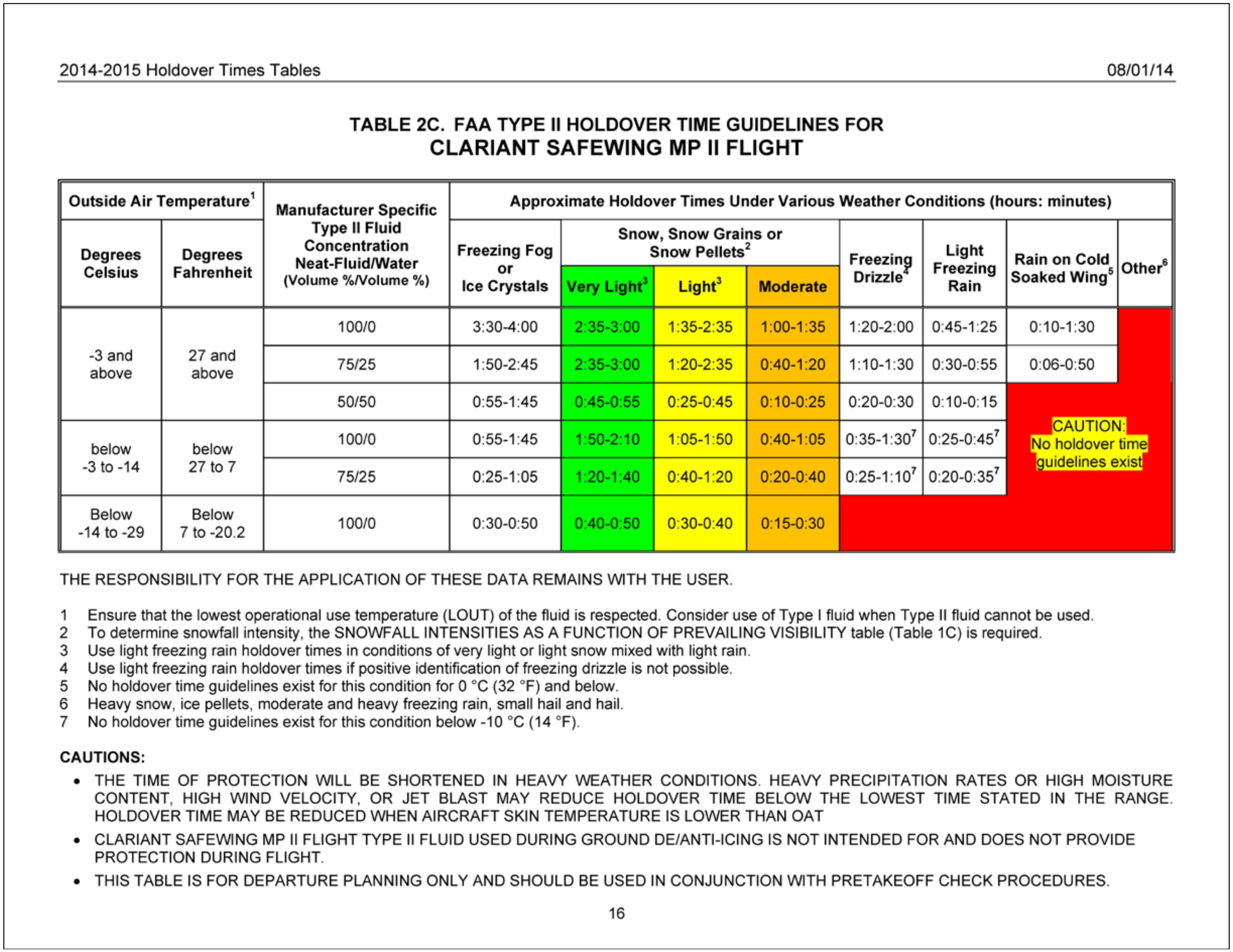


TABLE 2C. FAA TYPE II HOLDOVER TIME GUIDELINES FOR
CLARIANT SAFEWING MP II FLIGHT

Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)**	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	3:30-4:00	2:35-3:00	1:35-2:35	1:00-1:35	1:20-2:00	0:45-1:25	0:10-1:30	CAUTION: No holdover time guidelines exist
		75/25	1:50-2:45	2:35-3:00	1:20-2:35	0:40-1:20	1:10-1:30	0:30-0:55	0:06-0:50	
		50/50	0:55-1:45	0:45-0:55	0:25-0:45	0:10-0:25	0:20-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:55-1:45	1:50-2:10	1:05-1:50	0:40-1:05	0:35-1:30[7]	0:25-0:45[7]		
		75/25	0:25-1:05	1:20-1:40	0:40-1:20	0:20-0:40	0:25-1:10[7]	0:20-0:35[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:30-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CLARIANT SAFEWING MP II FLIGHT TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TABLE 2D. FAA TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT PLUS

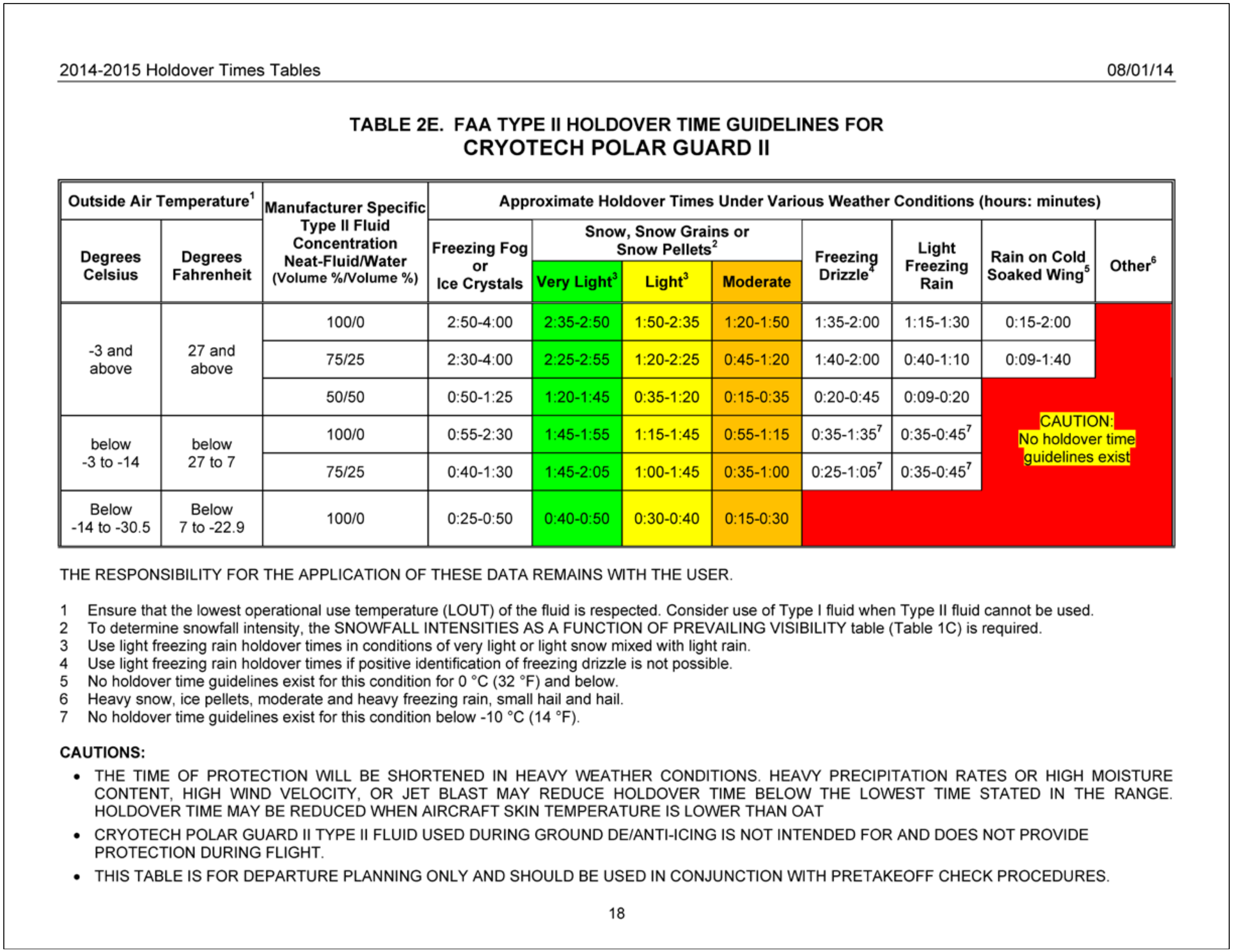
Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:40-4:00	0:50-1:50	1:25-2:00	0:45-1:00	0:15-2:00	CAUTION: No holdover time guidelines exist
		75/25	2:35-4:00	1:00-1:45	1:35-2:00	0:50-1:15	0:15-1:15	
		50/50	1:05-2:20	0:15-0:25	0:30-1:05	0:15-0:20		
below -3 to -14	below 27 to 7	100/0	0:40-2:20	0:35-1:15	0:35-1:25[7]	0:35-0:55[7]		
		75/25	0:30-1:45	0:55-1:40	0:25-1:10[7]	0:30-0:45[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:20-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CLARIANT SAFEWING MP II FLIGHT PLUS TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 2E. FAA TYPE II HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD II

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50-4:00	2:35-2:50	1:50-2:35	1:20-1:50	1:35-2:00	1:15-1:30	0:15-2:00	CAUTION: No holdover time guidelines exist
		75/25	2:30-4:00	2:25-2:55	1:20-2:25	0:45-1:20	1:40-2:00	0:40-1:10	0:09-1:40	
		50/50	0:50-1:25	1:20-1:45	0:35-1:20	0:15-0:35	0:20-0:45	0:09-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-2:30	1:45-1:55	1:15-1:45	0:55-1:15	0:35-1:35[7]	0:35-0:45[7]		
		75/25	0:40-1:30	1:45-2:05	1:00-1:45	0:35-1:00	0:25-1:05[7]	0:35-0:45[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CRYOTECH POLAR GUARD II TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

18

TABLE 2F. FAA TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-K PLUS

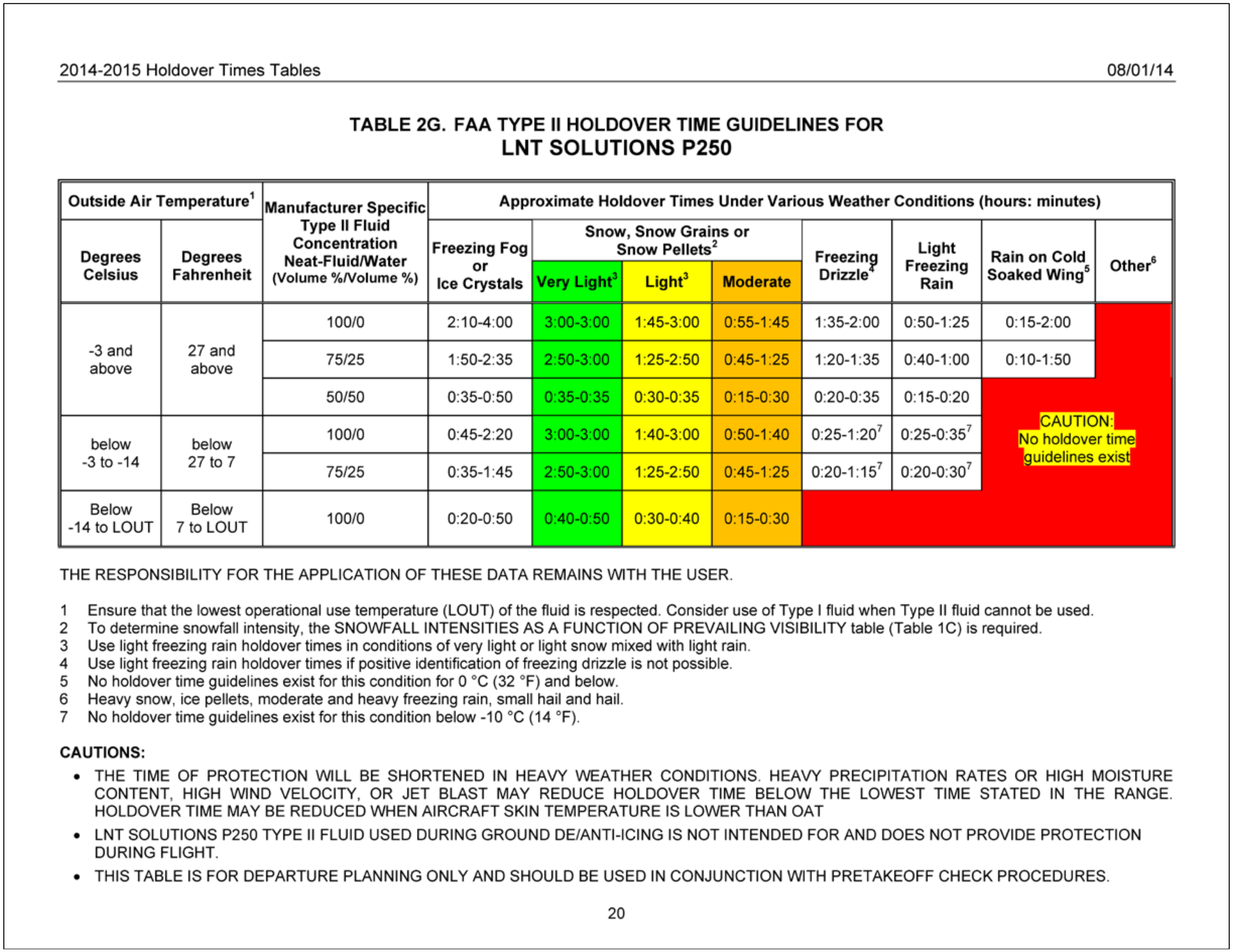
Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:15-3:45	1:00-1:40	1:50-2:00	1:00-1:25	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	1:40-2:30	0:35-1:10	1:25-2:00	0:50-1:10	0:15-2:00	
		50/50	0:35-1:05	0:07-0:15	0:20-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:30-1:05	0:50-1:25	0:25-1:00[7]	0:15-0:35[7]		
		75/25	0:25-1:25	0:35-1:05	0:20-0:55[7]	0:09-0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:30-0:55	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-K PLUS TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 2G. FAA TYPE II HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS P250

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

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- LNT SOLUTIONS P250 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

20

TABLE 2H. FAA TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:15-2:25	0:30-0:55	0:35-1:05	0:25-0:35	0:08-0:45	CAUTION: No holdover time guidelines exist
		75/25	0:50-1:30	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:25	
		50/50	0:25-0:35	0:15-0:25	0:10-0:20	0:07-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-1:30	0:15-0:30	0:20-0:45[7]	0:15-0:20[7]		
		75/25	0:30-1:05	0:10-0:20	0:15-0:30[7]	0:08-0:15[7]		
below -14 to -28	below 7 to -18.4	100/0	0:25-0:35	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY-2 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

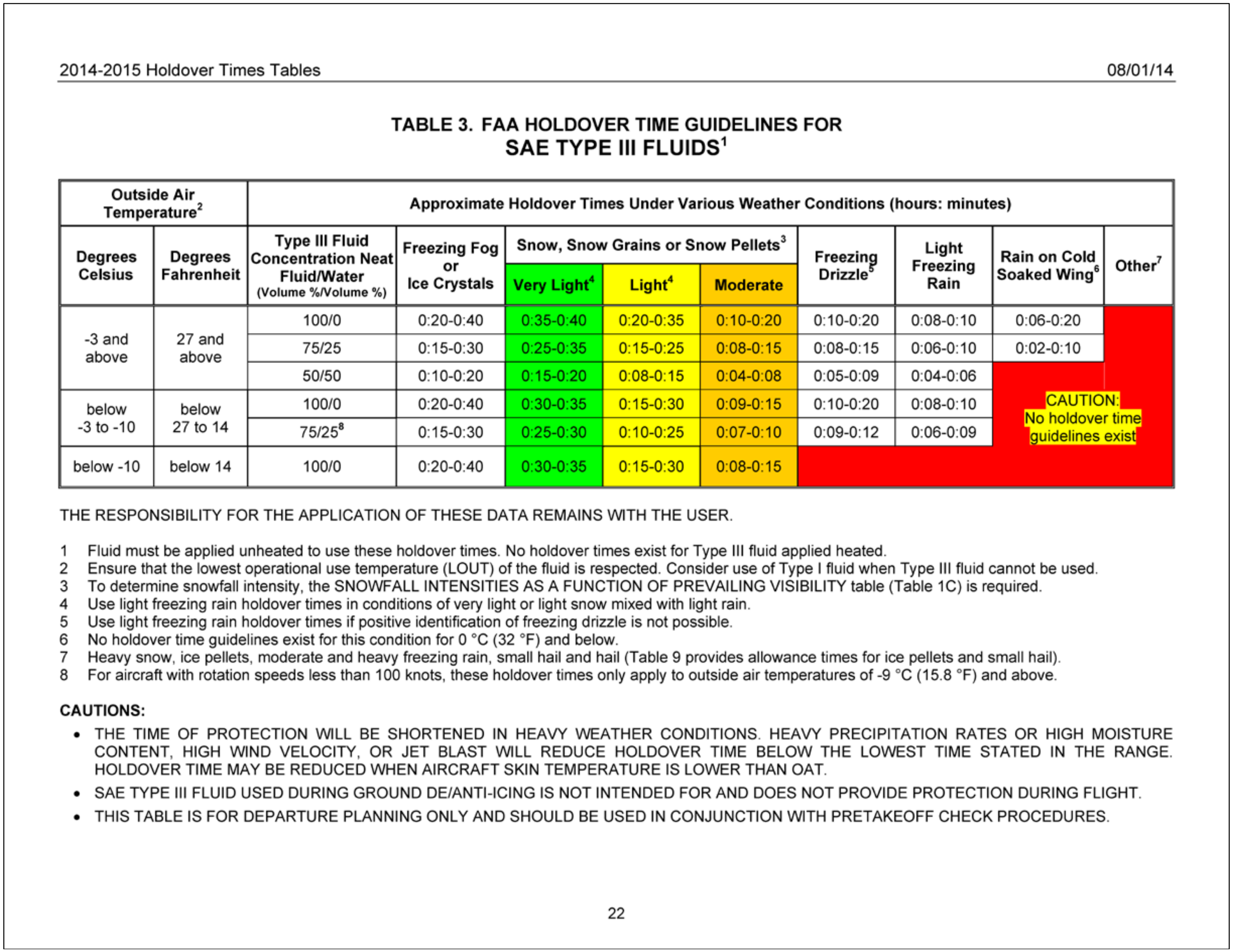


TABLE 3. FAA HOLDOVER TIME GUIDELINES FOR
SAE TYPE III FLUIDS[1]

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:20-0:40	0:35-0:40	0:20-0:35	0:10-0:20	0:10-0:20	0:08-0:10	0:06-0:20	CAUTION: No holdover time guidelines exist
		75/25	0:15-0:30	0:25-0:35	0:15-0:25	0:08-0:15	0:08-0:15	0:06-0:10	0:02-0:10	
		50/50	0:10-0:20	0:15-0:20	0:08-0:15	0:04-0:08	0:05-0:09	0:04-0:06		
below -3 to -10	below 27 to 14	100/0	0:20-0:40	0:30-0:35	0:15-0:30	0:09-0:15	0:10-0:20	0:08-0:10		
		75/25[8]	0:15-0:30	0:25-0:30	0:10-0:25	0:07-0:10	0:09-0:12	0:06-0:09		
below -10	below 14	100/0	0:20-0:40	0:30-0:35	0:15-0:30	0:08-0:15				

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

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for Type III fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 9 provides allowance times for ice pellets and small hail).
8 For aircraft with rotation speeds less than 100 knots, these holdover times only apply to outside air temperatures of -9 °C (15.8 °F) and above.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST WILL REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE III FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TABLE 4. FAA HOLDOVER TIME GUIDELINES FOR SAE TYPE IV FLUIDS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:50-2:55	0:35-1:10	0:50-1:30	0:35-0:55	0:10-1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05-1:45	0:30-0:55	0:45-1:10	0:30-0:45	0:09-0:50	
		50/50	0:20-0:35	0:07-0:15	0:15-0:20	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:25-0:50	0:20-1:00[7]	0:10-0:25[7]		
		75/25[8]	0:25-0:50	0:20-0:40	0:15-1:05[7]	0:10-0:25[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0[9]	0:15-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 For Cryotech Polar Guard temperature is limited to -5.5 °C (22 °F).
9 For Cryotech Polar Guard and Clariant Max Flight 04, temperature is limited to -23.5 °C (-10.3 °F). If the fluid specific brand is unknown, all of the temperature limitations in this and the preceding note apply.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TABLE 4A. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
ABAX AD-480

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	0:30-0:45	0:09-0:20	0:15-0:25	0:09-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	0:25-1:20[7]	0:15-0:30[7]		
		75/25	0:25-0:50	0:20-0:45	0:25-1:05[7]	0:15-0:30[7]		
below -14 to -26	below 7 to -14.8	100/0	0:15-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX AD-480 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

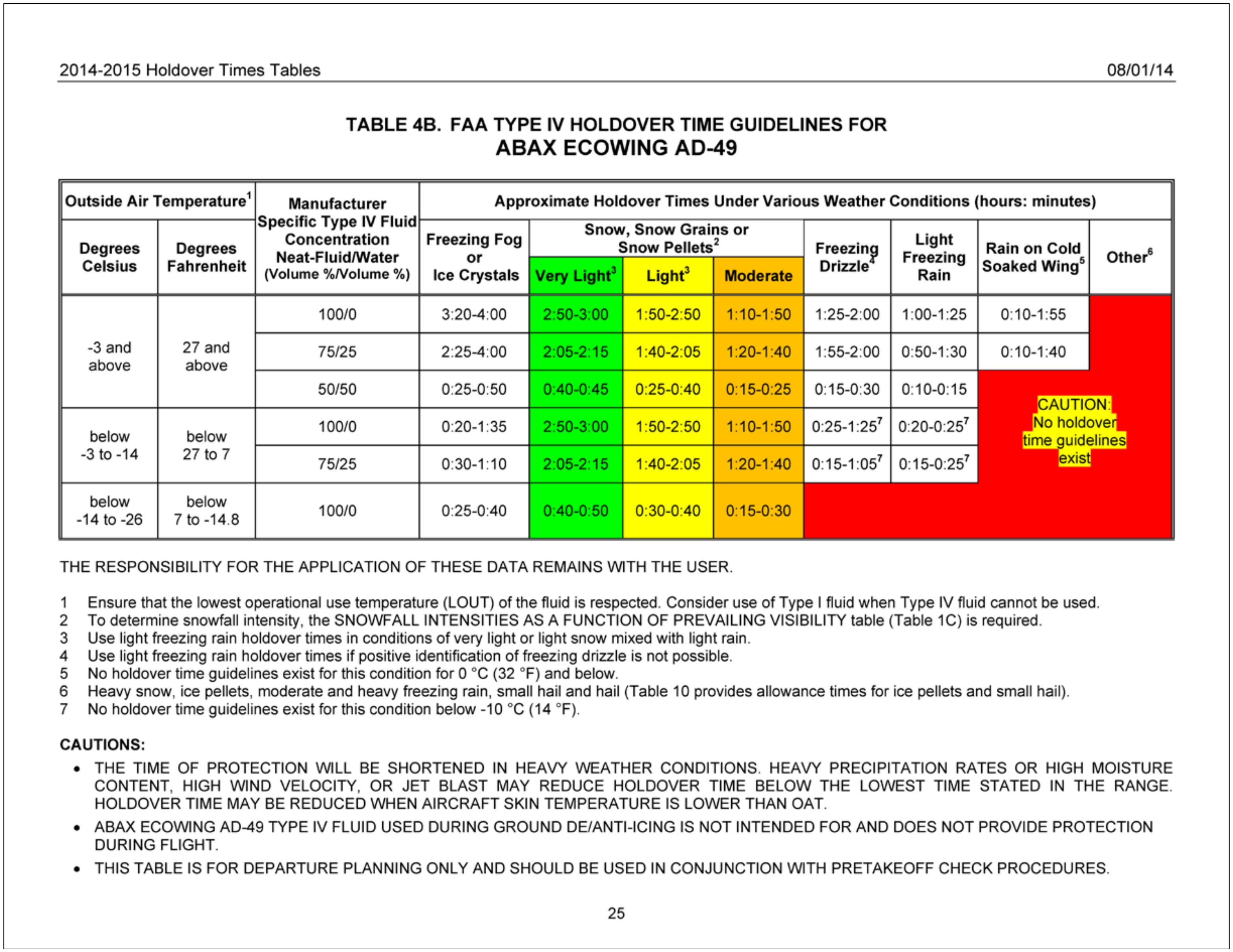


TABLE 4B. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
ABAX ECOWING AD-49

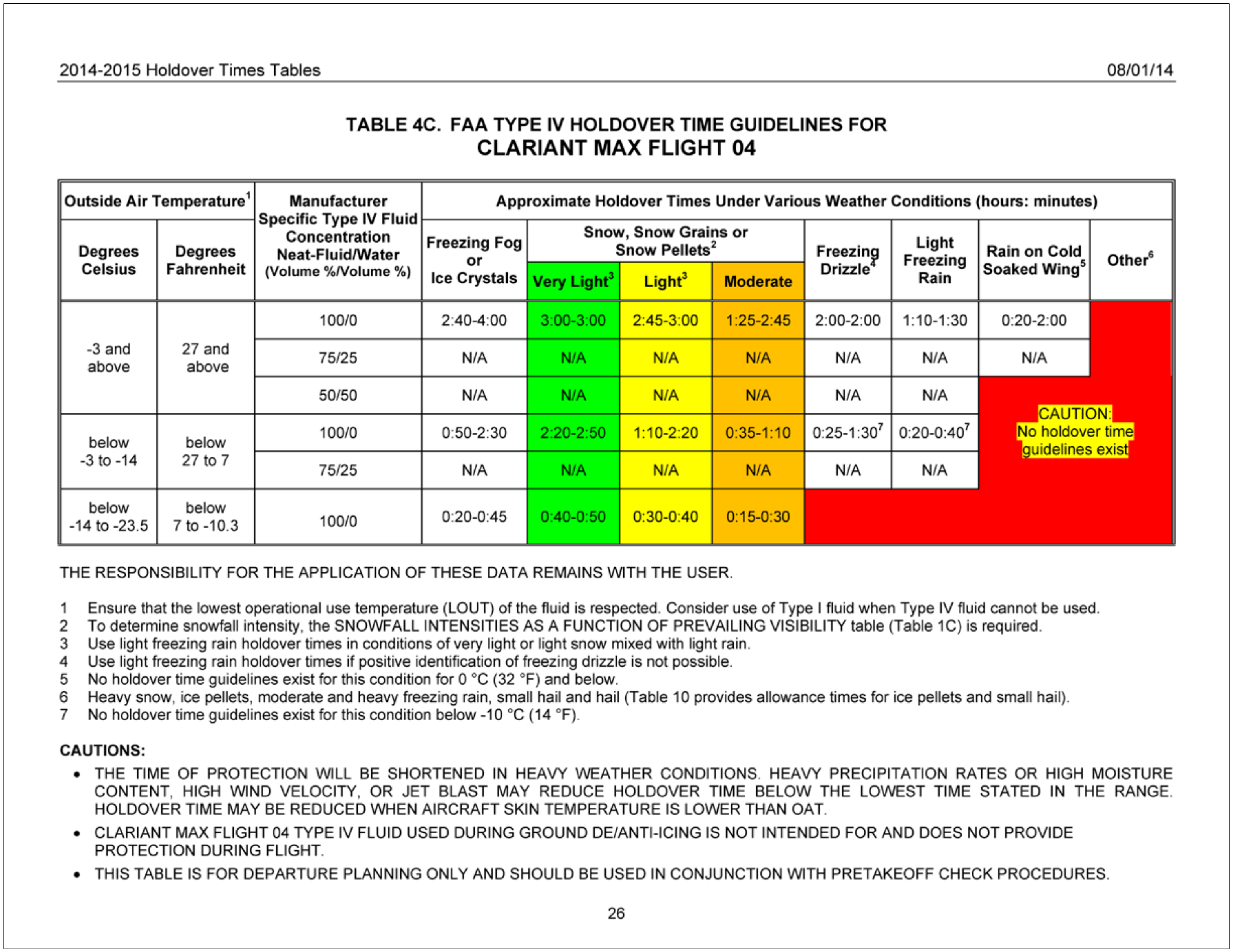
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:20-4:00	2:50-3:00	1:50-2:50	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25-4:00	2:05-2:15	1:40-2:05	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:40-0:45	0:25-0:40	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	2:50-3:00	1:50-2:50	1:10-1:50	0:25-1:25[7]	0:20-0:25[7]		
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-1:05[7]	0:15-0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX ECOWING AD-49 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 4C. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT MAX FLIGHT 04

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	2:40-4:00	3:00-3:00	2:45-3:00	1:25-2:45	2:00-2:00	1:10-1:30	0:20-2:00	
		75/25	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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-2:30	2:20-2:50	1:10-2:20	0:35-1:10	0:25-1:30[7]	0:20-0:40[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -23.5	below 7 to -10.3	100/0	0:20-0:45	0:40-0:50	0:30-0:40	0:15-0:30				

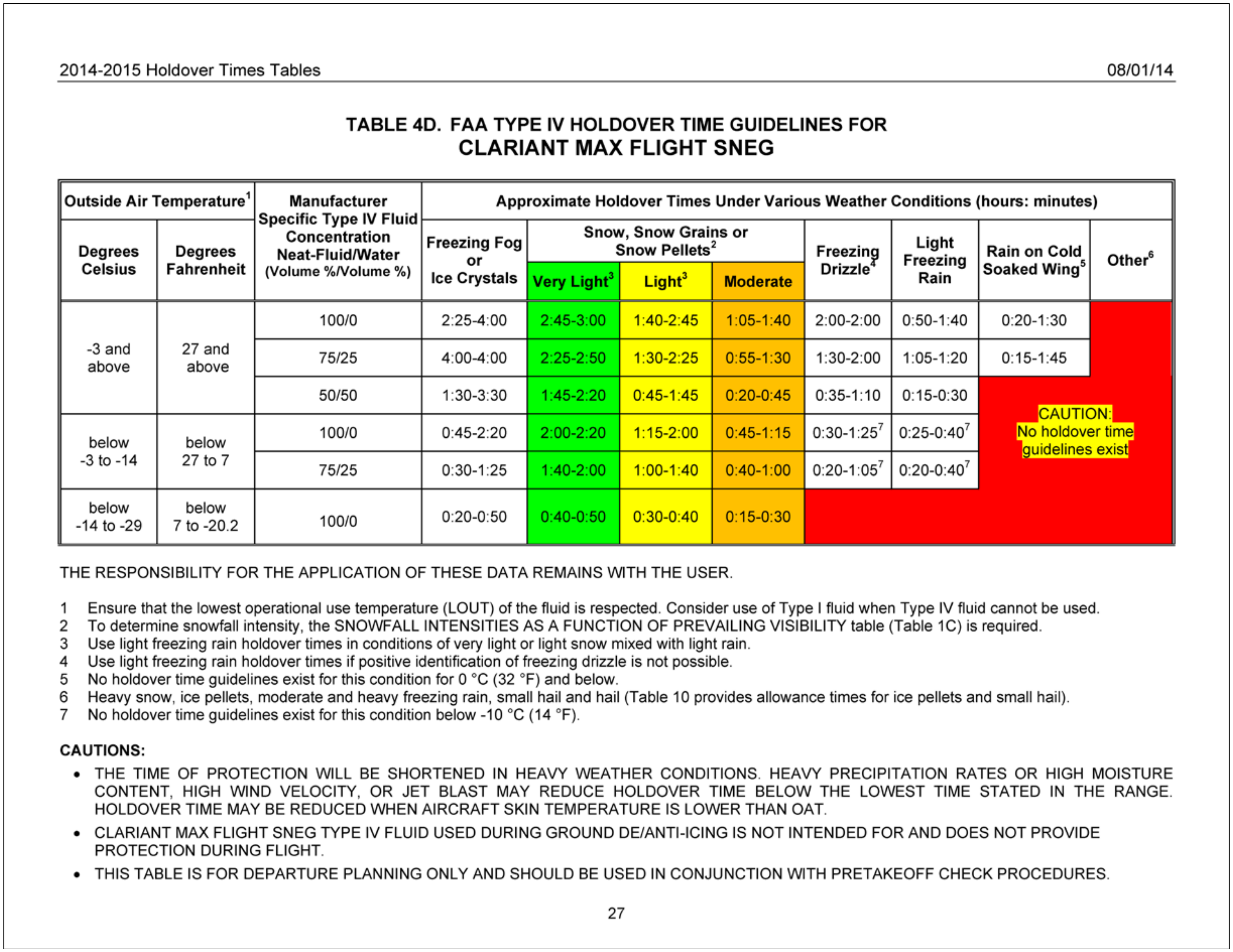
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT MAX FLIGHT 04 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

26



2014-2015 Holdover Times Tables 08/01/14

TABLE 4D. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT SNEG

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:25-4:00	2:45-3:00	1:40-2:45	1:05-1:40	2:00-2:00	0:50-1:40	0:20-1:30	CAUTION: No holdover time guidelines exist
		75/25	4:00-4:00	2:25-2:50	1:30-2:25	0:55-1:30	1:30-2:00	1:05-1:20	0:15-1:45	
		50/50	1:30-3:30	1:45-2:20	0:45-1:45	0:20-0:45	0:35-1:10	0:15-0:30		
below -3 to -14	below 27 to 7	100/0	0:45-2:20	2:00-2:20	1:15-2:00	0:45-1:15	0:30-1:25[7]	0:25-0:40[7]		
		75/25	0:30-1:25	1:40-2:00	1:00-1:40	0:40-1:00	0:20-1:05[7]	0:20-0:40[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT MAX FLIGHT SNEG TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

27

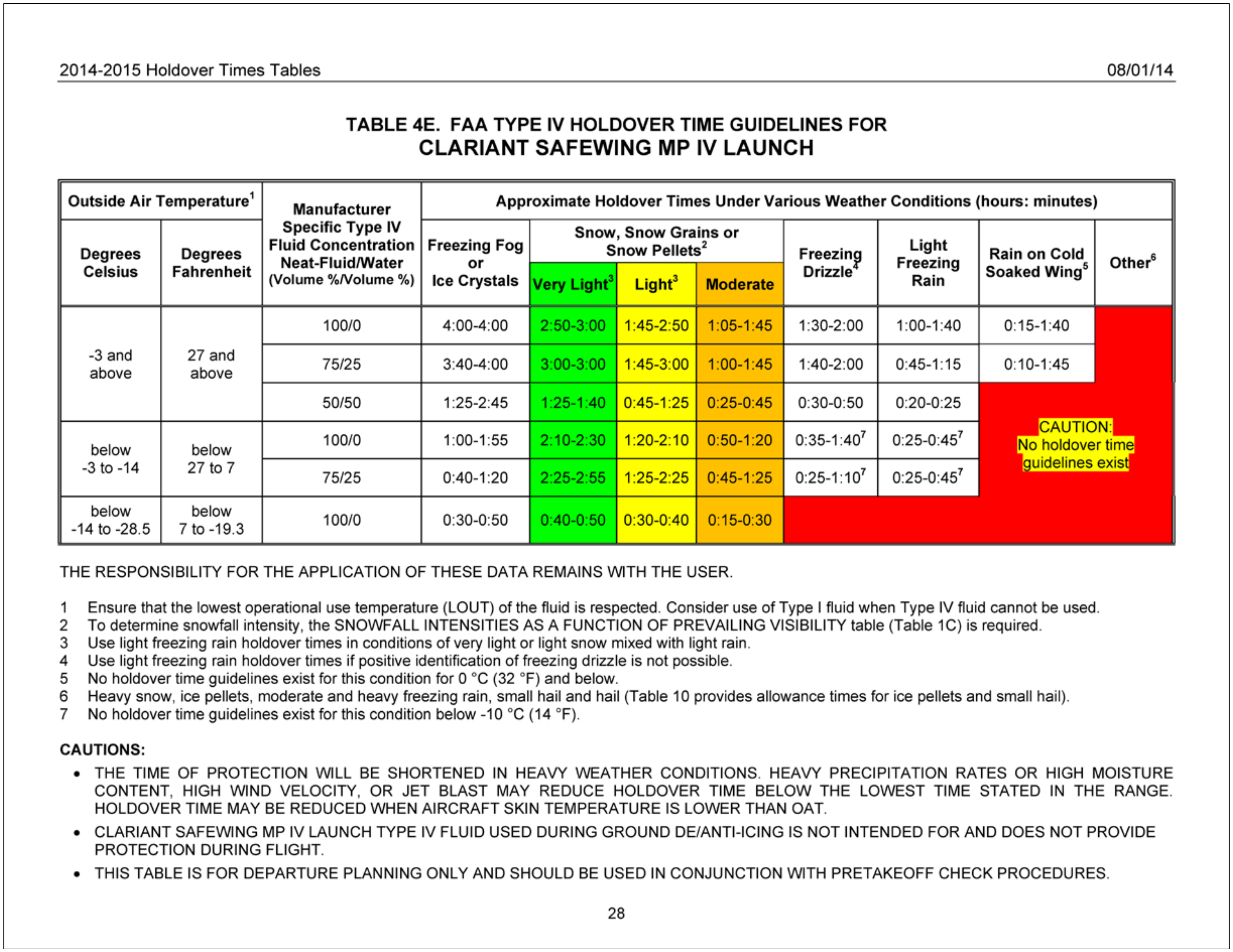


TABLE 4E. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH

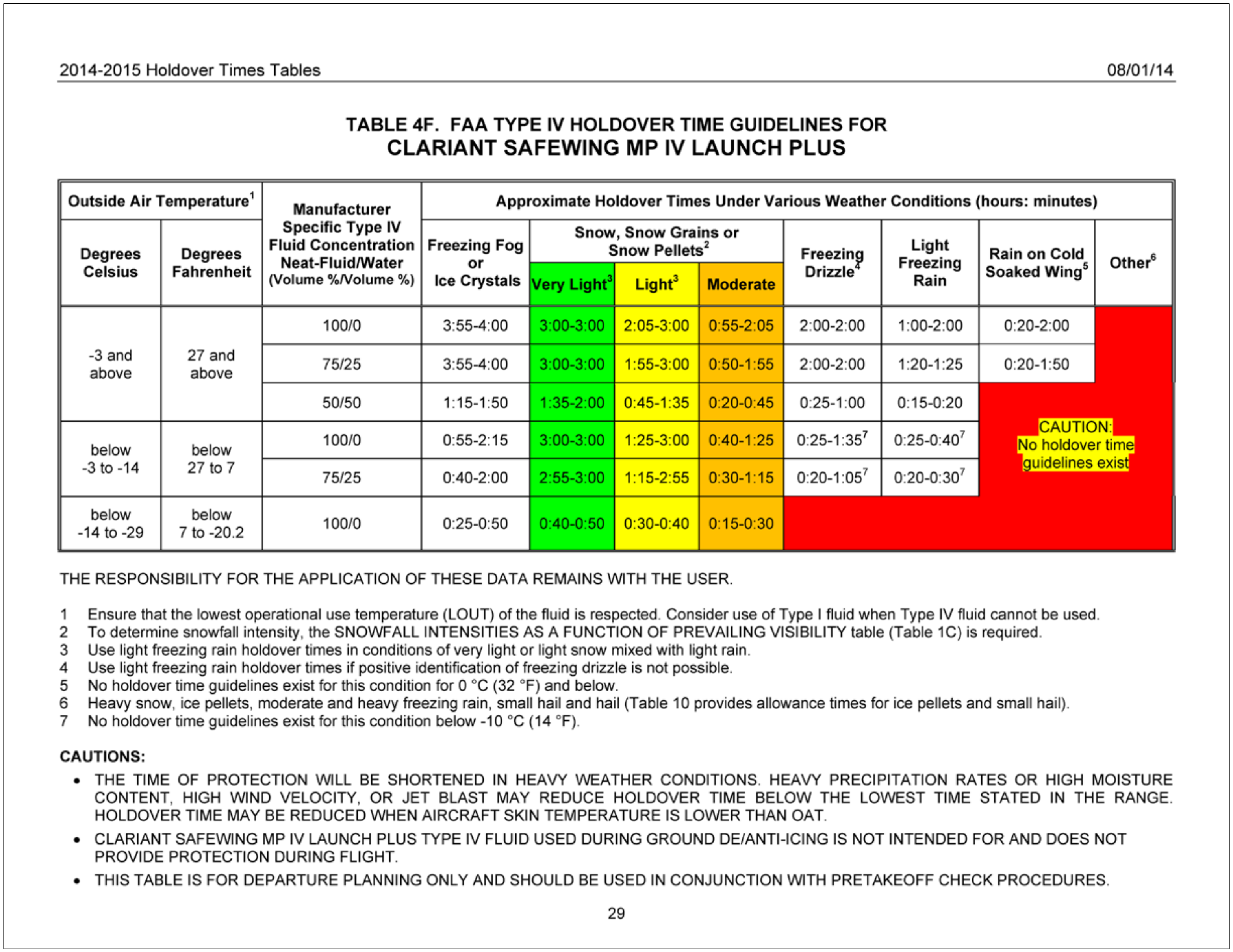
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	4:00-4:00	2:50-3:00	1:45-2:50	1:05-1:45	1:30-2:00	1:00-1:40	0:15-1:40	🟥
		75/25	3:40-4:00	3:00-3:00	1:45-3:00	1:00-1:45	1:40-2:00	0:45-1:15	0:10-1:45	🟥
		50/50	1:25-2:45	1:25-1:40	0:45-1:25	0:25-0:45	0:30-0:50	0:20-0:25	🟥	🟥
below -3 to -14	below 27 to 7	100/0	1:00-1:55	2:10-2:30	1:20-2:10	0:50-1:20	0:35-1:40[7]	0:25-0:45[7]	CAUTION: No holdover time guidelines exist	🟥
		75/25	0:40-1:20	2:25-2:55	1:25-2:25	0:45-1:25	0:25-1:10[7]	0:25-0:45[7]	🟥	🟥
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	0:40-0:50	0:30-0:40	0:15-0:30	🟥	🟥	🟥	🟥

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT SAFEWING MP IV LAUNCH TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 4F. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT SAFEWING MP IV LAUNCH PLUS

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow, Snow Grains or Snow Pellets[2]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:55-4:00	3:00-3:00	2:05-3:00	0:55-2:05	2:00-2:00	1:00-2:00	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	3:55-4:00	3:00-3:00	1:55-3:00	0:50-1:55	2:00-2:00	1:20-1:25	0:20-1:50	
		50/50	1:15-1:50	1:35-2:00	0:45-1:35	0:20-0:45	0:25-1:00	0:15-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-2:15	3:00-3:00	1:25-3:00	0:40-1:25	0:25-1:35[7]	0:25-0:40[7]		
		75/25	0:40-2:00	2:55-3:00	1:15-2:55	0:30-1:15	0:20-1:05[7]	0:20-0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:25-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

29

TABLE 4G. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD

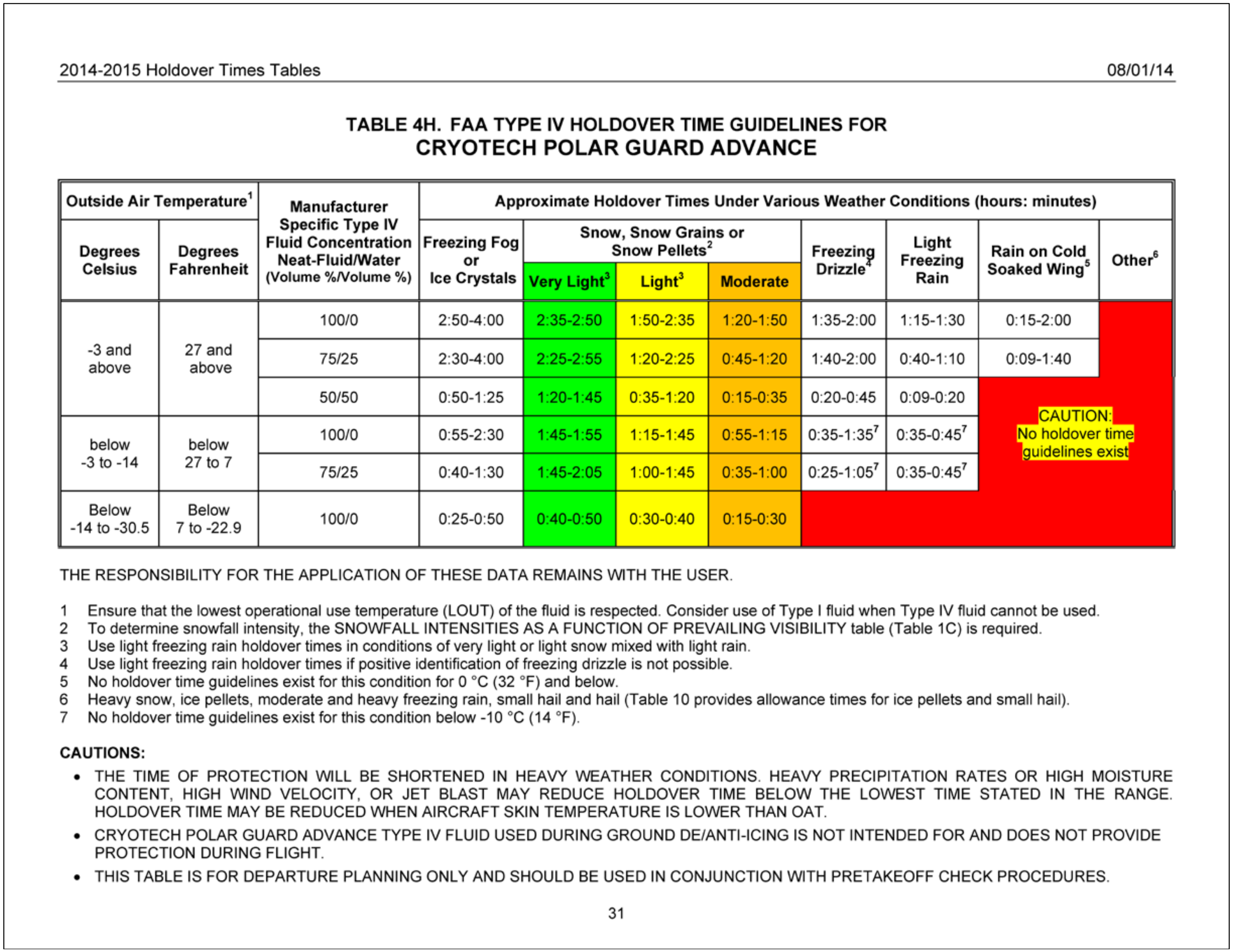
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:15-3:30	0:50-1:30	1:15-2:00	0:50-1:15	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	1:40-2:40	0:35-1:10	1:05-1:25	0:35-1:00	0:10-1:15	
		50/50	0:25-0:40	0:10-0:15	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:45-1:45	0:30-0:55	0:25-1:10[7]	0:15-0:35[7]		
		75/25[8]	0:35-1:30[8]	0:20-0:40[8]	0:25-1:05[8]	0:20-0:30[8]		
Below -14 to -23.5	Below 7 to -10.3	100/0	0:20-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Temperature is limited to -5.5 °C (22 °F) when using 75/25 dilution of this fluid.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CRYOTECH POLAR GUARD TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 4H. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD ADVANCE

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50-4:00	2:35-2:50	1:50-2:35	1:20-1:50	1:35-2:00	1:15-1:30	0:15-2:00	
		75/25	2:30-4:00	2:25-2:55	1:20-2:25	0:45-1:20	1:40-2:00	0:40-1:10	0:09-1:40	
		50/50	0:50-1:25	1:20-1:45	0:35-1:20	0:15-0:35	0:20-0:45	0:09-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55-2:30	1:45-1:55	1:15-1:45	0:55-1:15	0:35-1:35[7]	0:35-0:45[7]		
		75/25	0:40-1:30	1:45-2:05	1:00-1:45	0:35-1:00	0:25-1:05[7]	0:35-0:45[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CRYOTECH POLAR GUARD ADVANCE TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

31

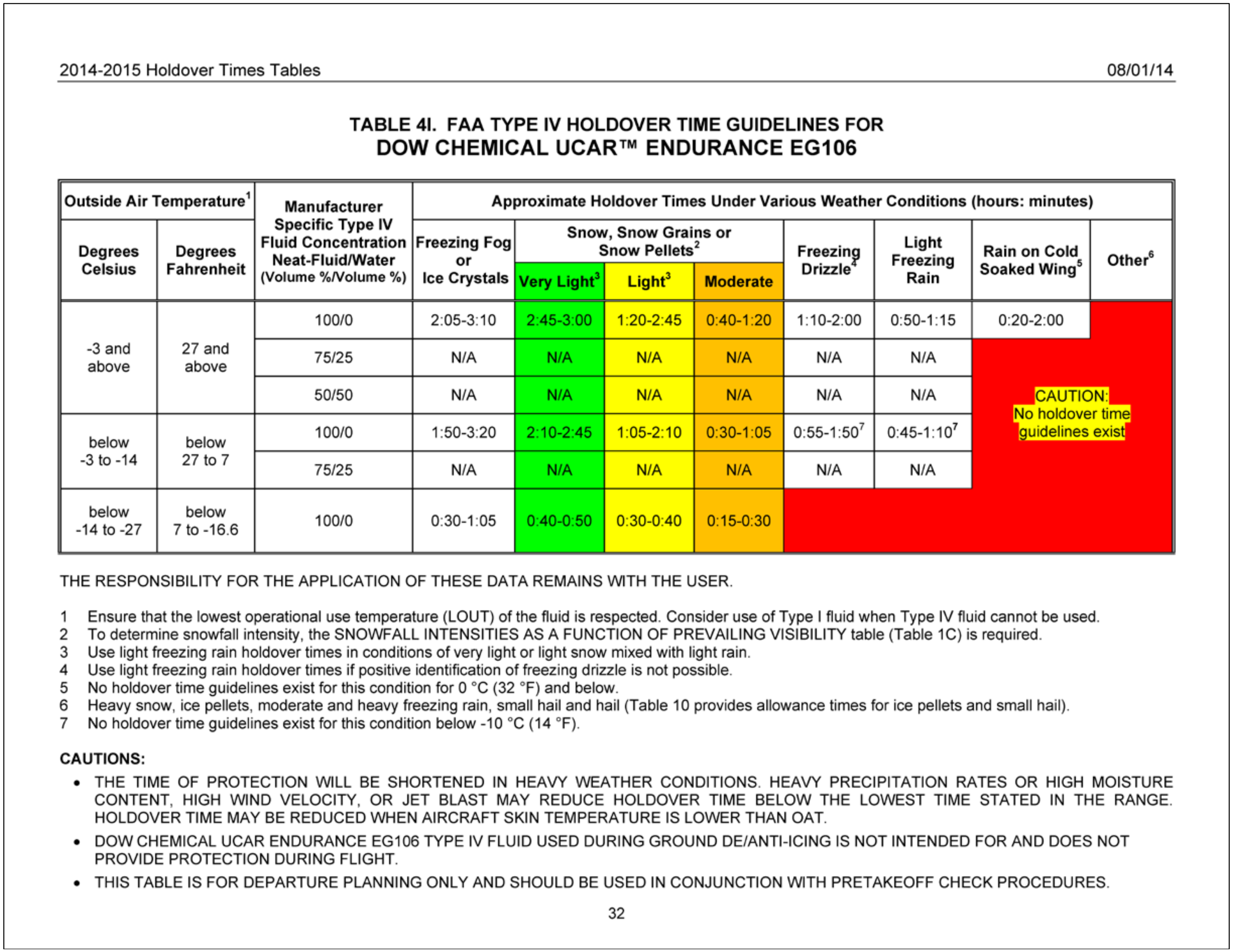


TABLE 4I. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
DOW CHEMICAL UCAR™ ENDURANCE EG106

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:05-3:10	2:45-3:00	1:20-2:45	0:40-1:20	1:10-2:00	0:50-1:15	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	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		
below -3 to -14	below 27 to 7	100/0	1:50-3:20	2:10-2:45	1:05-2:10	0:30-1:05	0:55-1:50[7]	0:45-1:10[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -27	below 7 to -16.6	100/0	0:30-1:05	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR ENDURANCE EG106 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TABLE 4J. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480

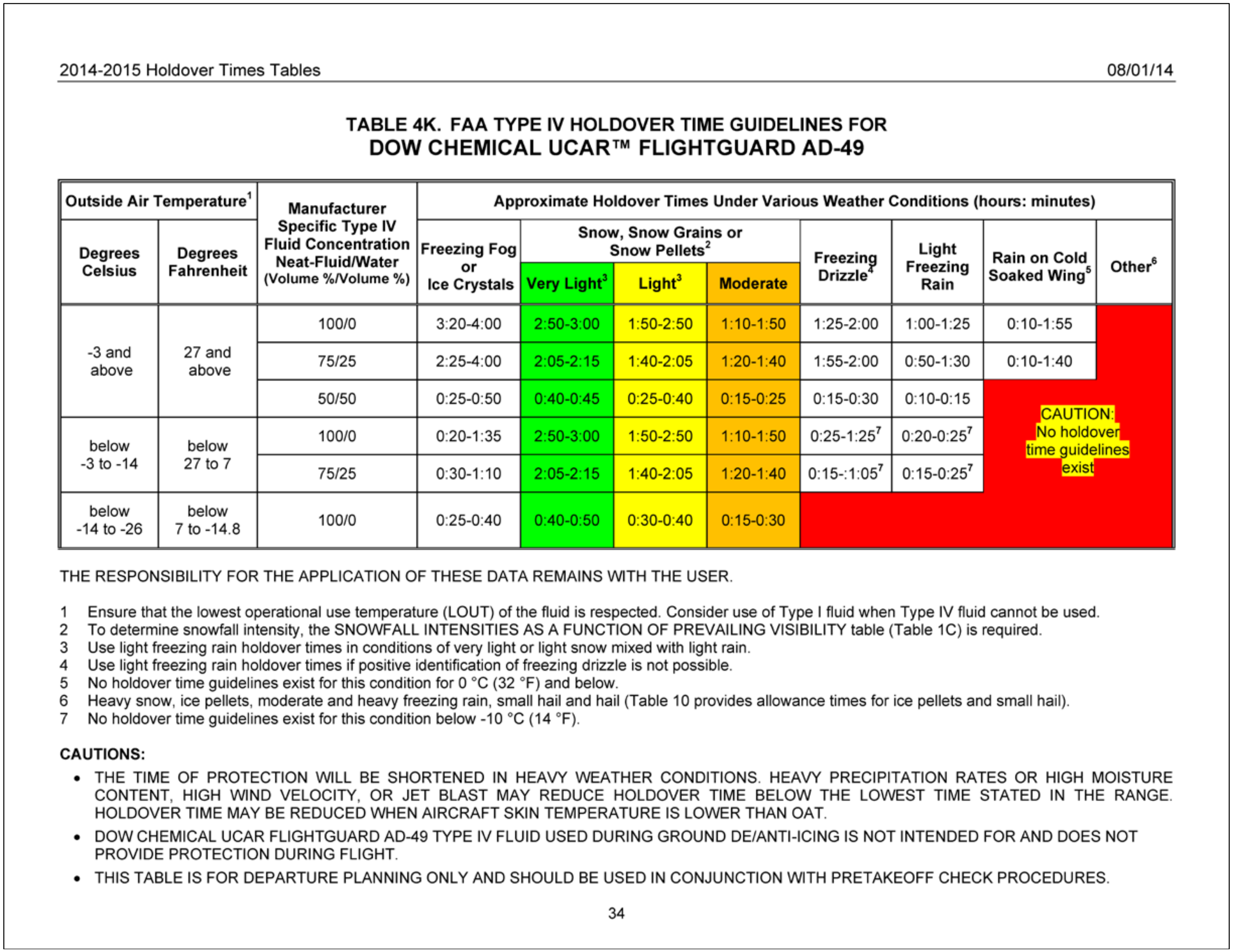
Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets**[2,3]	**Freezing Drizzle**[4]	**Light Freezing Rain**	**Rain on Cold Soaked Wing**[5]	**Other**[6]
-3 and above	27 and above	100/0	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	0:30-0:45	0:09-0:20	0:15-0:25	0:09-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	0:25-1:20[7]	0:15-0:30[7]		
		75/25	0:25-0:50	0:20-0:45	0:25-1:05[7]	0:15-0:30[7]		
below -14 to -26	below 7 to -14.8	100/0	0:15-0:40	0:15-0:30				

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

[1] Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
[2] To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
[3] Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
[4] Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
[5] No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
[6] Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
[7] No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR FLIGHTGUARD AD-480 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 4K. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:20-4:00	2:50-3:00	1:50-2:50	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25-4:00	2:05-2:15	1:40-2:05	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:40-0:45	0:25-0:40	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	2:50-3:00	1:50-2:50	1:10-1:50	0:25-1:25[7]	0:20-0:25[7]		
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-:1:05[7]	0:15-0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR FLIGHTGUARD AD-49 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

34

TABLE 4L. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
KILFROST ABC-S

Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25	0:20-1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	0:20-0:35	0:07-0:15	0:15-0:20	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-2:05	0:45-1:20	0:20-1:00[7]	0:10-0:30[7]		
		75/25	0:25-1:00	0:25-0:50	0:20-1:10[7]	0:10-0:35[7]		
below -14 to -28	below 7 to -18.4	100/0	0:20-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-S TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

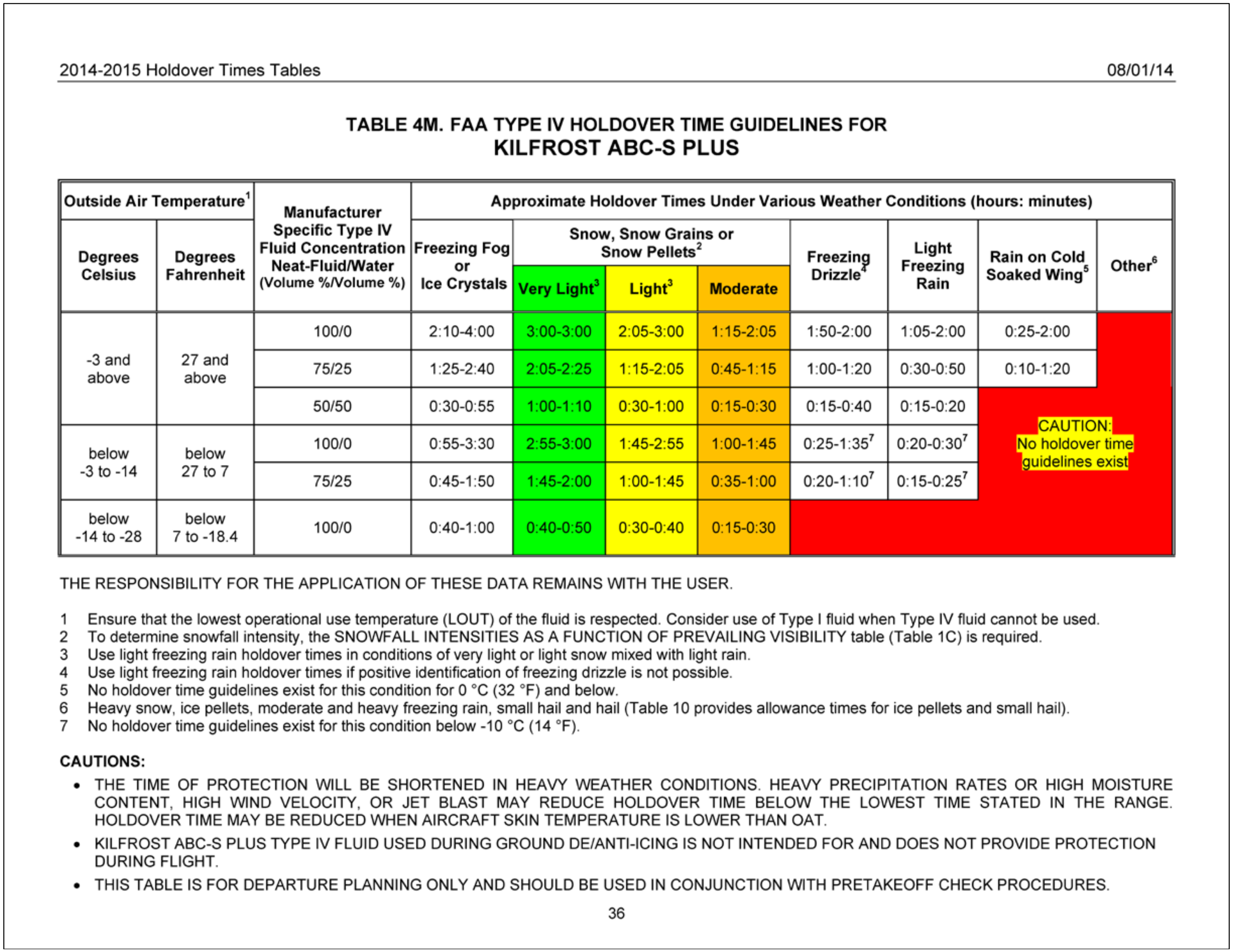


TABLE 4M. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
KILFROST ABC-S PLUS

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:10-4:00	3:00-3:00	2:05-3:00	1:15-2:05	1:50-2:00	1:05-2:00	0:25-2:00	CAUTION: No holdover time guidelines exist
		75/25	1:25-2:40	2:05-2:25	1:15-2:05	0:45-1:15	1:00-1:20	0:30-0:50	0:10-1:20	
		50/50	0:30-0:55	1:00-1:10	0:30-1:00	0:15-0:30	0:15-0:40	0:15-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-3:30	2:55-3:00	1:45-2:55	1:00-1:45	0:25-1:35[7]	0:20-0:30[7]		
		75/25	0:45-1:50	1:45-2:00	1:00-1:45	0:35-1:00	0:20-1:10[7]	0:15-0:25[7]		
below -14 to -28	below 7 to -18.4	100/0	0:40-1:00	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-S PLUS TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

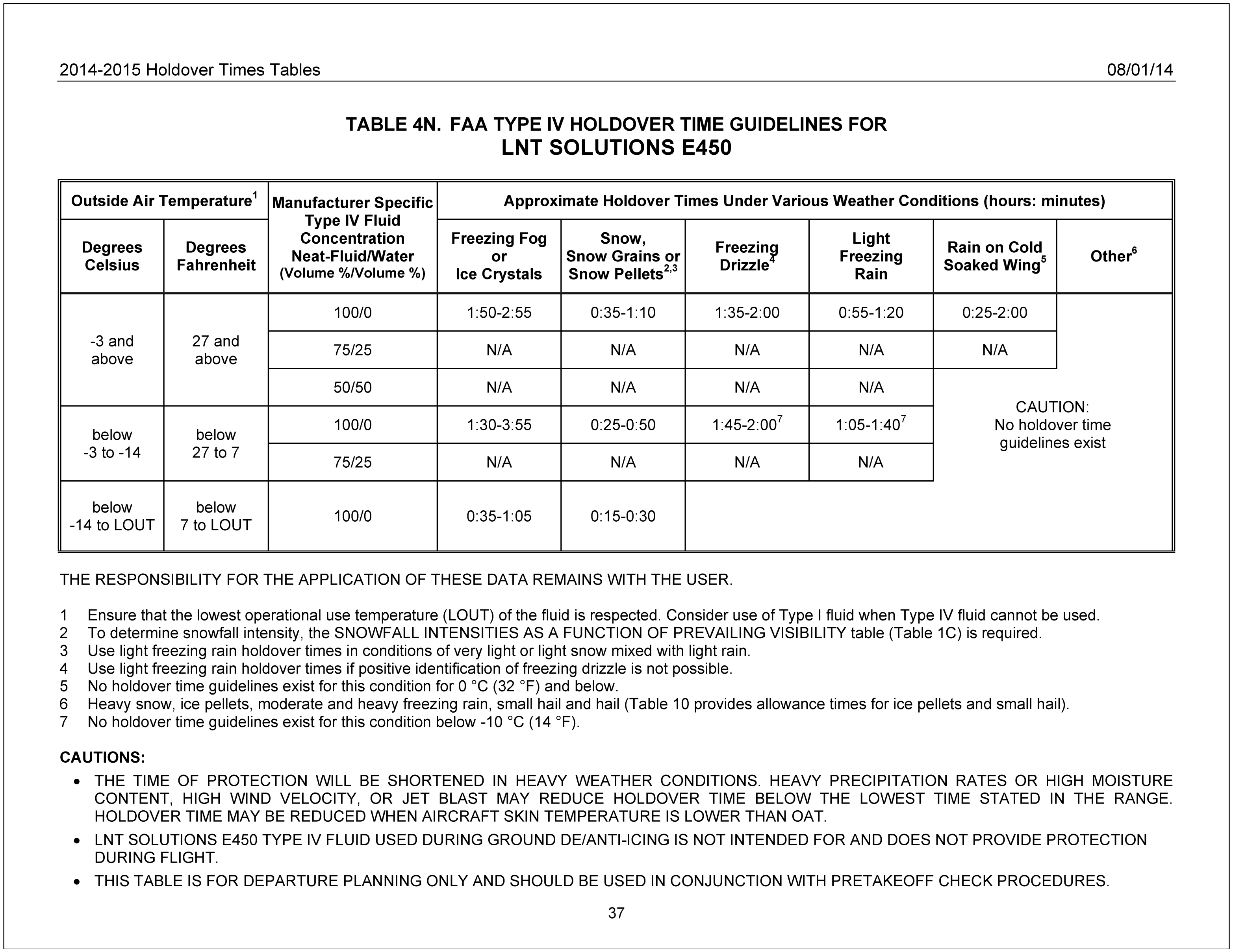


TABLE 4N. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR
LNT SOLUTIONS E450

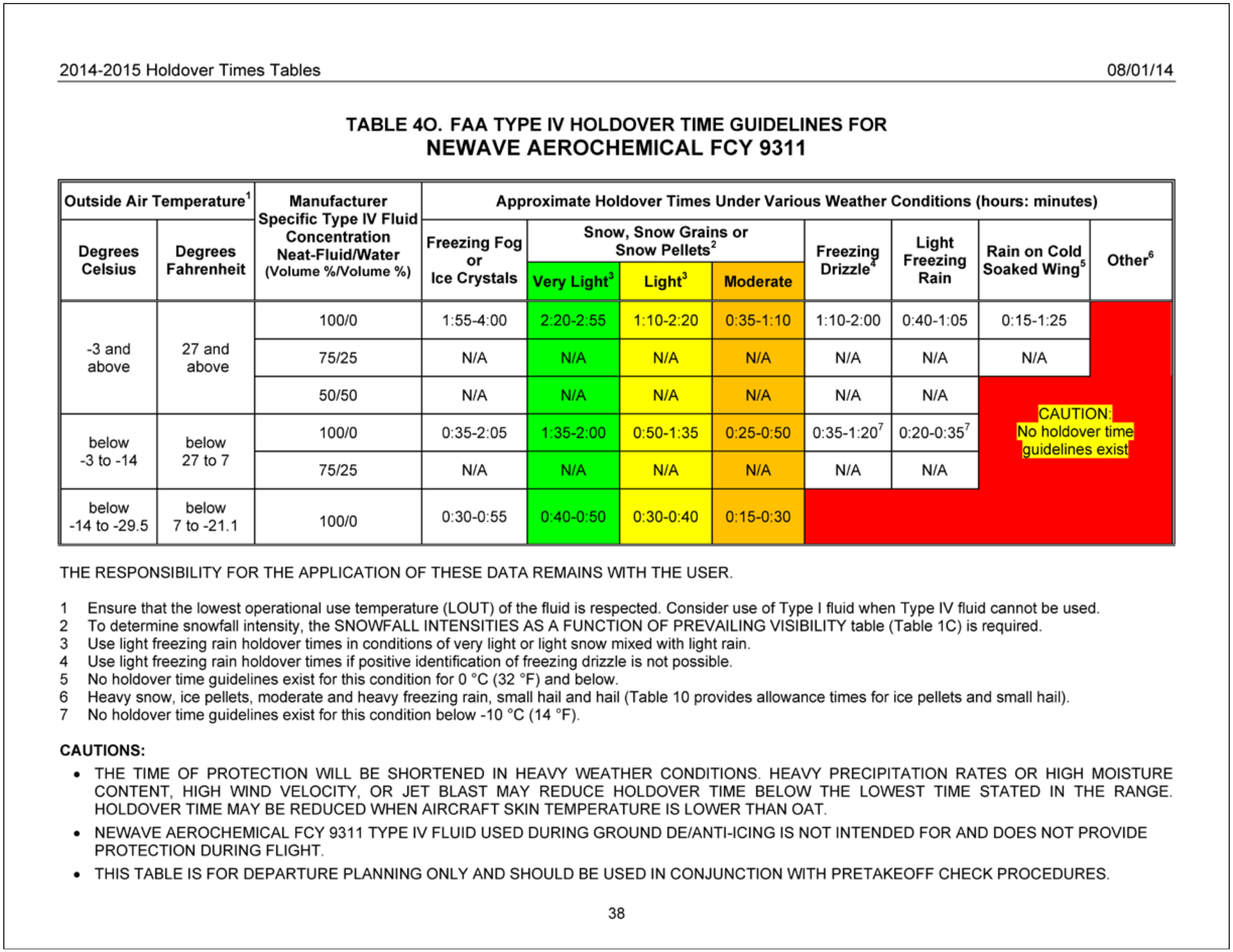
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]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

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- LNT SOLUTIONS E450 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

TABLE 4O. FAA TYPE IV HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY 9311

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	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		
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20[7]	0:20-0:35[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:40-0:50	0:30-0:40	0:15-0:30				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY 9311 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

38

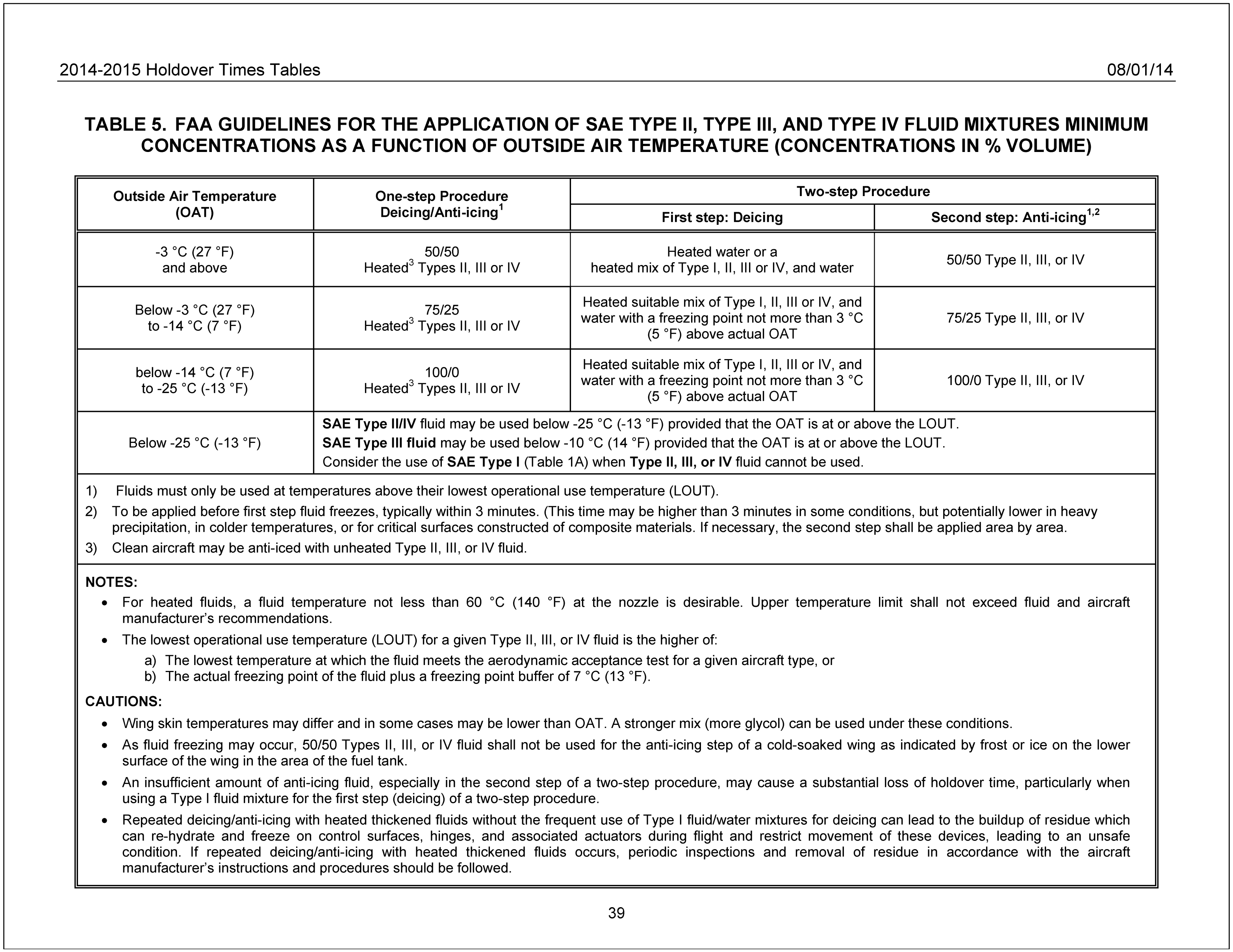


TABLE 5. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE II, TYPE III, AND TYPE IV FLUID MIXTURES MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE (CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	**Second step: Anti-icing[1,2]**
-3 °C (27 °F) and above	50/50 Heated[3] Types II, III or IV	Heated water or a heated mix of Type I, II, III or IV, and water	50/50 Type II, III, or IV
Below -3 °C (27 °F) to -14 °C (7 °F)	75/25 Heated[3] Types II, III or IV	Heated suitable mix of Type I, II, III or IV, and water with a freezing point not more than 3 °C (5 °F) above actual OAT	75/25 Type II, III, or IV
below -14 °C (7 °F) to -25 °C (-13 °F)	100/0 Heated[3] Types II, III or IV	Heated suitable mix of Type I, II, III or IV, and water with a freezing point not more than 3 °C (5 °F) above actual OAT	100/0 Type II, III, or IV
Below -25 °C (-13 °F)	**SAE Type II/IV** fluid may be used below -25 °C (-13 °F) provided that the OAT is at or above the LOUT. **SAE Type III fluid** may be used below -10 °C (14 °F) provided that the OAT is at or above the LOUT. Consider the use of **SAE Type I** (Table 1A) when **Type II, III, or IV** fluid cannot be used.		

1) Fluids must only be used at temperatures above their lowest operational use temperature (LOUT).
2) To be applied before first step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.
3) Clean aircraft may be anti-iced with unheated Type II, III, or IV fluid.

NOTES:

- For heated fluids, a fluid temperature not less than 60 °C (140 °F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturer's recommendations.
- The lowest operational use temperature (LOUT) for a given Type II, III, or IV fluid is the higher of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  b) The actual freezing point of the fluid plus a freezing point buffer of 7 °C (13 °F).

CAUTIONS:

- Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more glycol) can be used under these conditions.
- As fluid freezing may occur, 50/50 Types II, III, or IV fluid shall not be used for the anti-icing step of a cold-soaked wing as indicated by frost or ice on the lower surface of the wing in the area of the fuel tank.
- An insufficient amount of anti-icing fluid, especially in the second step of a two-step procedure, may cause a substantial loss of holdover time, particularly when using a Type I fluid mixture for the first step (deicing) of a two-step procedure.
- Repeated deicing/anti-icing with heated thickened fluids without the frequent use of Type I fluid/water mixtures for deicing can lead to the buildup of residue which can re-hydrate and freeze on control surfaces, hinges, and associated actuators during flight and restrict movement of these devices, leading to an unsafe condition. If repeated deicing/anti-icing with heated thickened fluids occurs, periodic inspections and removal of residue in accordance with the aircraft manufacturer's instructions and procedures should be followed.

TABLE 6. LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS

(See Page 42 for Table 6 Notes)

FLUID NAME	**FLUID DILUTION**	**LOWEST ON-WING VISCOSITY[1,2] (mPa.s)**	
		MANUFACTURER METHOD	**AIR 9968 METHOD**
Type II De/Anti-Icing Fluids			
ABAX Ecowing 26	100/0	4 900 (h)	4 600 (a)
	75/25	2 200 (a)	2 200 (a)
	50/50	50 (a)	50 (a)
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 (e)	4 500 (a)
	75/25	9 450 (e)	10 000 (a)
	50/50	10 150 (e)	10 200 (a)
Clariant Safewing MP II FLIGHT	100/0	3 340 (a)	3 340 (a)
	75/25	12 900 (c)	12 900 (c)
	50/50	11 500 (a)	11 500 (a)
Clariant Safewing MP II FLIGHT PLUS	100/0	3,650 (n)	3 100 (a)
	75/25	12,400 (n)	10 450 (a)
	50/50	7,800 (n)	7 050 (a)
Clariant Safewing MP II 1951	100/0	2 500 (g)	2 750 (a)
	75/25	2 900 (g)	3 000 (a)
	50/50	50 (g)	50 (a)
Cryotech Polar Guard II	100/0	4 400 (f)	4 050 (a)
	75/25	11 600 (f)	9 750 (a)
	50/50	80 (a)	80 (a)
Kilfrost ABC-3	100/0	2 500 (e)	2 500 (a)
	75/25	2 000 (e)	2 000 (a)
	50/50	400 (e)	400 (a)
Kilfrost ABC-K Plus	100/0	2 850 (e)	2 640 (a)
	75/25	12 650 (e)	12 650 (c)
	50/50	4 200 (e)	5 260 (a)
LNT Solutions P250	100/0	2 400 (dd)	2 150 (a)
	75/25	16 200 (dd)	15 200 (a)
	50/50	8 150 (dd)	8 100 (a)
Newave Aerochemical FCY-2	100/0	7 000 (e)	8 920 (a)
	75/25	18 550 (e)	18 550 (e)
	50/50	6 750 (e)	7 030 (a)
Type III De/Anti-Icing Fluids			
Clariant Safewing MP III 2031 ECO	100/0	120 (m)	Not Applicable
	75/25	55 (m)	Not Applicable
	50/50	10 (m)	Not Applicable
Type IV De/Anti-Icing Fluids			
ABAX AD-480	100/0	15 200 (h)	12 800 (d)
	75/25	16 000 (h)	12 400 (d)
	50/50	4 000 (h)	3 800 (a)
ABAX Ecowing AD-49	100/0	12 150 (i)	11 000 (a)
	75/25	30 700 (i)	32 350 (c)
	50/50	19 450 (i)	21 150 (c)
See next page for additional Type IV Fluids			

TABLE 6. LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS (CONT'D)

(See Page 42 for Table 6 Notes)

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY[1,2] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 METHOD
Type IV De/Anti-Icing Fluids (cont'd)			
Clariant Max Flight 04	100/0	5 540 (b)	5 540 (a)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Clariant Max Flight Sneg	100/0	8 700 (o)	8 050 (a)
	75/25	20 200 (p)	21 800 (c)
	50/50	13 600(p)	15 000 (c)
Clariant Safewing MP IV LAUNCH	100/0	7 550 (a)	7 550 (a)
	75/25	18 000 (a)	18 000 (a)
	50/50	17 800 (a)	17 800 (a)
Clariant Safewing MP IV LAUNCH PLUS	100/0	8,700 (o)	8,450 (a)
	75/25	18,800 (p)	17,200 (c)
	50/50	9,700 (o)	12,150 (a)
Cryotech Polar Guard	100/0	32 100 (k)	36 300 (c)
	75/25	24 200 (k)	27 800 (c)
	50/50	6 200 (k)	7 500 (a)
Cryotech Polar Guard Advance	100/0	4 400 (f)	4 050 (a)
	75/25	11 600 (f)	9 750 (a)
	50/50	80 (a)	80 (a)
Dow UCAR™ Endurance EG106	100/0	24 850 (j)	2 230 (a)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	15 200 (h)	12 800 (d)
	75/25	16 000 (h)	12 400 (d)
	50/50	4 000 (h)	3 800 (a)
Dow UCAR™ FlightGuard AD-49	100/0	12 150 (i)	11 000 (a)
	75/25	30 700 (i)	32 350 (c)
	50/50	19 450 (i)	21 150 (c)
Kilfrost ABC-S	100/0	17 000 (e)	17 000 (c)
	75/25	12 000 (e)	12 000 (c)
	50/50	2 000 (e)	2 000 (a)
Kilfrost ABC-S Plus	100/0	17 900 (e)	17 900 (c)
	75/25	18 300 (e)	18 300 (c)
	50/50	7 500 (e)	7 500 (a)
LNT Solutions E450	100/0	45 300 (l)	Not Available[3]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Newave Aerochemical FCY 9311	100/0	14 100 (c)	14 100 (c)
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable

TABLE 6. LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS (CONT'D)

(Table 6 Notes)

NOTES

1 Significance of this Table: The viscosity values in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing surface is not lower than that listed.

2 The Aerospace Information Report (AIR) 9968 viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method. Viscosity measurement methods are indicated as letters (in parentheses) beside each viscosity value. Details of each measurement method are shown in the table below. The exact measurement method (spindle, container, fluid volume, temperature, speed, duration) must be used to compare the viscosity of a sample to a viscosity given in this table.

3 Measurements using the AIR 9968 method do not provide stable, reliable results. Use the manufacturer method to evaluate the viscosity of this fluid.

Method	Brookfield Spindle	Container	Fluid Volume	Temp.	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL*	20°C	0.3 rpm	10 minutes 0 seconds
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL*	20°C	0.3 rpm	33 minutes 20 seconds
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	425 mL*	20°C	0.3 rpm	10 minutes 0 seconds
d	LV2-disc (with guard leg)	250 mL tall form (Berzelius) beaker	200 mL*	20°C	0.3 rpm	10 minutes 0 seconds
dd	LV2-disc (with guard leg)	200 mL tall form (Berzelius) beaker	155 mL*	20°C	0.3 rpm	10 minutes 0 seconds
e	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	135 mL*	20°C	0.3 rpm	10 minutes 0 seconds
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
g	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	15 minutes 0 seconds
h	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30 minutes 0 seconds
i	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
j	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10 minutes 0 seconds
k	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	10 minutes 0 seconds
l	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	10 minutes 0 seconds
m	LV0	UL adapter	16 mL	20°C	0.3 rpm	10 minutes 0 seconds
n	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10 minutes 0 seconds
o	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10 minutes 0 seconds
p	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10 minutes 0 seconds

*If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (2014-15)

(See Page 48 for Table 7 Notes and Cautions)

Table 7-1: Type I Anti-Icing Fluids

Fluid Name	Lowest Operational Use Temperatures with Dilution Per Cent Fluid/Water at LOUT in Parenthesis[1]			
	Low Speed Aerodynamic Test[2]		High Speed Aerodynamic Test[2]	
	Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit
ABAX DE-950	-26 (71/29)	-14.8 (71/29)	-31 (71/29)	-23.8(71/29)
ABAX DE-950 Colorless	Not tested[4]	Not tested[4]	-24 (60/40)	-11.2 (60/40)
AllClear Systems LLC Lift-Off P-88	-24.5 (70/30)	-12.1 (70/30)	-29.5 (70/30)	-21.1 for 70/30
AllClear Systems LLC Lift-Off E-188	-40 (70/30)	-40 (70/30)	-41.5 (70/30)	-42.7 (70/30)
Arcton Arctica DG ready-to-use	-26 as supplied	-14.8 as supplied	-26 as supplied	-14.8 as supplied
Arcton Arctica DG 91 Concentrate	-25 (75/25)	-13 (75/25)	-25 (75/25)	-13 (75/25)
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[4]	Not tested[4]	-39.5 (75/25)	-39.1 (75/25)
Aviation Xi'an Hi-Tech KHF-1	Not available[3]	Not available[3]	-38.5 (75/25)	-37.3 (75/25)
Baltic Ground Services DEFROSOL ADF	-25 (65/35)	-13 (65/35)	-30 (65/35	-22 (65/35)
Beijing Phoenix Air Traffic CBSX-1	Not available[3]	Not available[3]	Not available[3]	Not available[3]
Beijing Wangye Aviation Chemical KLA-1	Not available[3]	Not available[3]	-30.5 (60/40)	-22.9 (60/40)
Beijing Yadilite Aviation Chemical Product Co. Ltd YD-101 Type I	Not tested[4]	Not tested[4]	-30 (60/40)	-22 (60/40)
CHEMCO CHEMR EG I	-30 (75/25)	-22 (75/25)	-40 (75/25)	-40 (75/25)
CHEMCO CHEMR REG I	Not available[3]	Not available[3]	-40.5 (75/25)	-40.9 (75/25
Clariant EcoFlo Concentrate	Not tested[4]	Not tested[4]	-30.5 (65/35)	-22.9 (65/35)
Clariant EcoFlo 2 Concentrate	Not tested[4]	Not tested[4]	-29 (65/35)	-20.2 (65/35)
Clariant Octaflo EF Concentrate	-25 (65/35)	-13 (65/35)	-33 (65/35)	-27.4 (65/35)
Clariant Octaflo EF-80	-25 (70/30)	-13 (70/30)	-33 (70/30)	-27.4 (70/30)
Clariant Octaflo EG Concentrate	-40.5 (70/30)	-40.9 (70/30)	-44 (70/30)	-47.2 (70/30)
Clariant Octaflo Loyd	-40 (70/30)	-40 (70/30)	-45.5 (70/30)	-49.9 (70/30)
Clariant Safewing EG I 1996	-35.5 (75/25)	-31.9 (75/25)	-43 (75/25)	-45.4 (75/25)
Clariant Safewing EG I 1996 (88)	-39.5 (70/30)	-39.1 (70/30)	-41.5 (70/30)	-42.7 (70/30)
Clariant Safewing MP I 1938 ECO	-25.5 (65/35)	-13.9 (65/35)	-32 (65/35)	-25.6 (65/35)
Clariant Safewing MP I 1938 ECO (80)	-25 (71/29)	-13 (71/29)	-32.5 (71/29)	-26.5 (71/29)
Clariant Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use	Not tested[4]	Not tested[4]	-19 as supplied	-2.2 as supplied
Clariant Safewing MP I ECO PLUS (80)	-25 (71/29)	-13 (71/29)	-33 (71/29)	-27.4 (71/29)

See next page for additional Type I Fluids

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (CONT'D)

(See Page 48 for Table 7 Notes and Cautions)

Table 7-1: Type I Anti-Icing Fluids (continued)

Fluid Name	Lowest Operational Use Temperatures with Dilution Per Cent Fluid/Water at LOUT in Parenthesis[1]			
	Low Speed Aerodynamic Test[2]		High Speed Aerodynamic Test[2]	
	Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit
Cryotech Polar Plus® Concentrate	-27 (63/37)	-16.6 (63/37)	-32 (63/37)	-25.6 (63/37)
Cryotech Polar Plus® LT	-27 (63/37)	-16.6 (63/37)	-33 (63/37)	-27.4 (63/37)
Cryotech Polar Plus® (80)	-24.5 (70/30)	-12.1 (70/30)	-32.5 (70/30)	-26.5 (70/30)
Deicing Solutions LLC Safetemp® ES Plus	-25.5 (65/35)	-13.9 (65/35)	-29 (65/35)	-20.2 (65/35)
Dow UCAR™ ADF XL54	-33 as supplied	-27.4 as supplied	-33 as supplied	-27.4 as supplied
Dow UCAR™ Aircraft Deicing Fluid Concentrate	-36.5 (75/25)	-33.7 (75/25)	-45 (75/25)	-49 (75/25)
Dow UCAR™ PG ADF Dilute 55/45	-24 as supplied	-11.2 as supplied	-25 as supplied	-13 as supplied
Dow UCAR™ PG Aircraft Deicing Fluid Concentrate	-25 (65/35)	-13 (65/35)	-32 (65/35)	-25.6 (65/35)
Heilongjiang Hangjie Aero-chemical *(formerly Harbin Aeroclean Aviation)* HJF-1	Not tested[4]	Not tested[4]	-42 (65/35)	-43.6 (65/35)
HOC SafeTemp® ES Plus	-25.5 (65/35)	-13.9 (65/35)	-29 (65/35)	-20.2 (65/35)
Hokkaido Fever Snow AG	-21.5 as supplied	-6.7 as supplied	-23 as supplied	-9.4 as supplied
Inland Technologies Duragly-E Concentrate	-26 (60/40)	-14.8 (60/40)	-26 (60/40)	-14.8 (60/40)
Inland Technologies Duragly-P Concentrate	-25 (60/40)	-13 (60/40)	-25 (60/40)	-13 (60/40)
Kilfrost DF Plus	-25.5 (69/31)	-13.9 (69/31)	-32 (69/31)	-25.6 (69/31)
Kilfrost DF Plus (80)	-26 (69/31)	-14.8 (69/31)	-31.5 (69/31)	-24.7 (69/31)
Kilfrost DF Plus (88)	-26.5 (69/31)	-15.7 (69/31)	-32 (63/37)	-25.6 (63/37)
Kilfrost DF$^{\text{sustain}}$™	-34 (68/32)	-29.2 (68/32)	-41 (68/32)	-43 (68/32)
LNT Solutions E188	-30.5 (70/30)	-22.9 (70/30)	-41 (70/30)	-41.8 (70/30)
LNT Solutions P180	-26 (69/31)	-14.8 (69/31)	-32 (69/31)	-25.6 (70/30)
LNT Solutions P188	-24.5 (70/30)	-12.1 (70/30)	-31.5 (70/30)	-24.7 (70/30)
Newave FCY-1A	-40 (75/25)	-40 (75/25)	-40 (75/25)	-40 (75/25)
Newave FCY-1Bio^{+}	Not tested[4]	Not tested[4]	-40.5 (75/25)	-40.9 (75/25
Shanxi Cleanway Cleansurface I	-32.5 (75/25)[5]	-26.5 (75/25)[5]	-40.5 (75/25)	-40.9 (75/25)
Shanxi Cleanway Cleansurface I-BIO	Not tested[4]	Not tested[4]	-37 (75/25)	-34.6 (75/25)

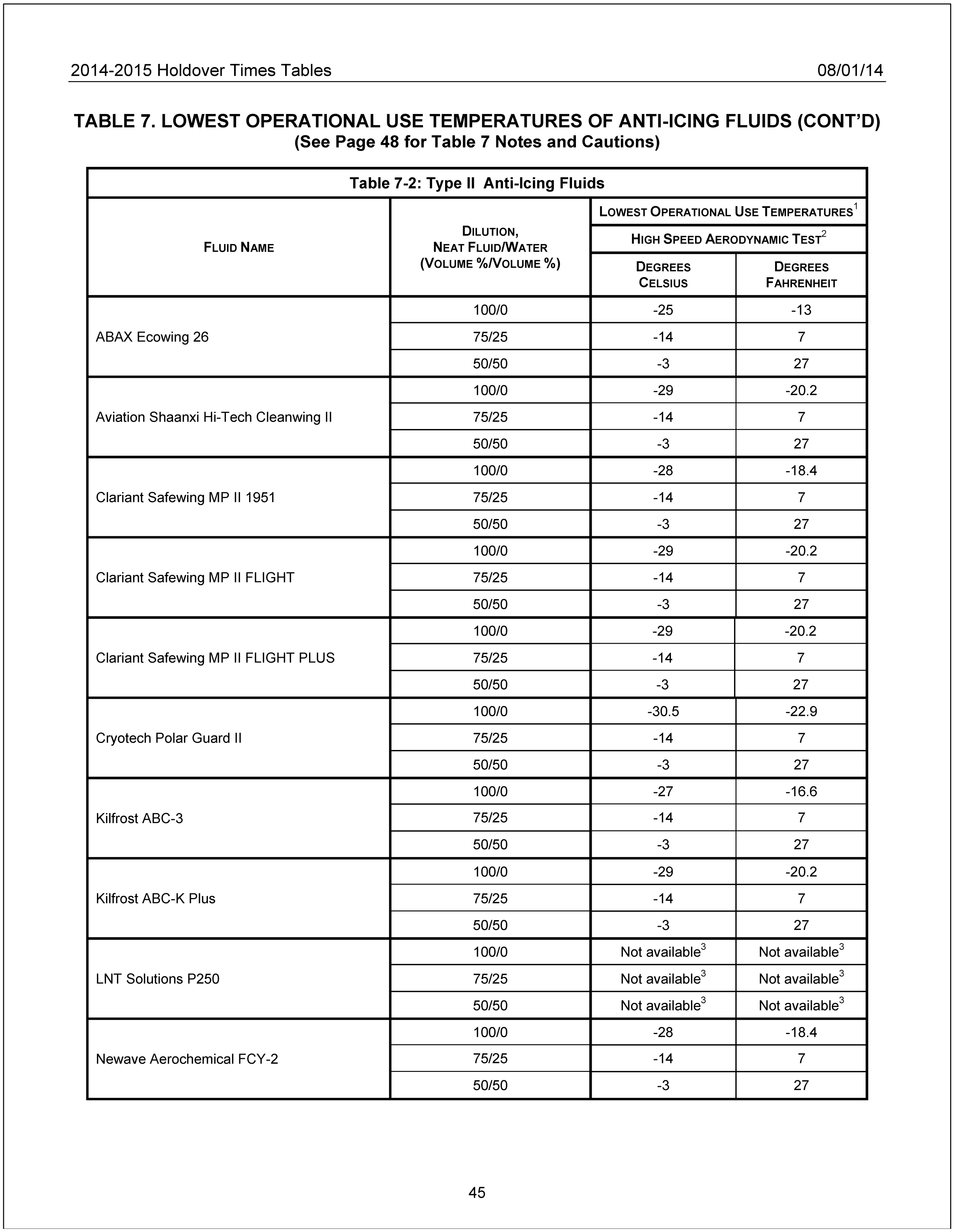


TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (CONT'D)

(See Page 48 for Table 7 Notes and Cautions)

Table 7-2: Type II Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures[1]	
		High Speed Aerodynamic Test[2]	
		Degrees Celsius	Degrees Fahrenheit
ABAX Ecowing 26	100/0	-25	-13
	75/25	-14	7
	50/50	-3	27
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II 1951	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II FLIGHT	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II FLIGHT PLUS	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Cryotech Polar Guard II	100/0	-30.5	-22.9
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-3	100/0	-27	-16.6
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-K Plus	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
LNT Solutions P250	100/0	Not available[3]	Not available[3]
	75/25	Not available[3]	Not available[3]
	50/50	Not available[3]	Not available[3]
Newave Aerochemical FCY-2	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (CONT'D)

(See Page 48 for Table 7 Notes and Cautions)

Table 7-3: Type III Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures[1]			
		Low Speed Aerodynamic Test		High Speed Aerodynamic Test[2]	
		Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit
Clariant Safewing MP III 2031 ECO	100/0	-16.5	2.3	-29	-20.2
	75/25	-9	15.8	-10	14
	50/50	-3	27	-3	27

Table 7-4: Type IV (100/0) Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures[1]	
		High Speed Aerodynamic Test[2]	
		Degrees Celsius	Degrees Fahrenheit
ABAX AD-480	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
ABAX Ecowing AD-49	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
Clariant Max Flight 04	100/0	-23.5	-10.3
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	
Clariant Max Flight Sneg	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP IV LAUNCH	100/0	-28.5	-19.3
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP IV LAUNCH PLUS	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Cryotech Polar Guard	100/0	-23.5	-10.3
	75/25	-5.5	22.1
	50/50	-3	27

See next page for additional Type IV Fluids

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (CONT'D)

(See Page 48 for Table 7 Notes and Cautions)

Table 7-4: Type IV (100/0) Anti-Icing Fluids (continued)

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1]	
		HIGH SPEED AERODYNAMIC TEST[2]	
		DEGREES CELSIUS	DEGREES FAHRENHEIT
Cryotech Polar Guard Advance	100/0	-30.5	-22.9
	75/25	-14	7
	50/50	-3	27
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	100/0	-27	-16.6
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	
Dow UCAR™ FlightGuard AD-480	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
Dow UCAR™ FlightGuard AD-49	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-S	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-S PLUS	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
LNT Solutions E450	100/0	Not available[3]	Not available[3]
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	
Newave Aerochemical FCY 9311	100/0	-29.5	-21.1
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES OF ANTI-ICING FLUIDS (CONT'D)

(Table 7 Notes and Cautions)

NOTES

1. The lowest operational use temperature (LOUT) for a given fluid is the warmer of:

   a) The lowest temperature at which the fluid meets the low and/or high speed aerodynamic acceptance test; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10 °C (18 °F).

   The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available. In some cases, the fluid manufacturer requested the publication of a more conservative value than the pre-production test value.
2. If uncertain whether the aircraft to be treated conforms to the low speed or the high speed aerodynamic test, consult the aircraft manufacturer. The aerodynamic test is defined in SAE AS 5900 (latest version).
3. Manufacturer had not provided LOUT information at the time of this publication.
4. Manufacturer has indicated fluid not tested.
5. Fluid was not retested for low speed aerodynamics. This data will be removed four years after the expiry of the last low speed aerodynamics test.

CAUTIONS:

- LOUT data provided in this table is based on the manufacturer's data.
- Type I fluids supplied in concentrated form must not be used in that form and must be diluted.
- For Type I fluids that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest operational use temperature. For other dilutions, determine the freezing point of the fluid and add a 10 °C (18 °F) freezing point buffer, as this will usually yield a higher (warmer) and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use of a diluted fluid.

TABLE 8. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2014-2015)

(See Page 51 for Table 8 Notes)

Type I Deicing/Anti-Icing Fluids[1]

Company Name	**Fluid Name**
ABAX Industries	DE-950
ABAX Industries	DE-950 Colorless
AllClear Systems LLC	Lift-Off P-88
AllClear Systems LLC	Lift-Off E-188
Arcton Ltd.	Arctica DG Ready to Use
Arcton Ltd.	Arctica DG 91 Concentrate
Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I
Aviation Xi'an High-Tech	KHF-1
Baltic Ground Services	DEFROSOL ADF
Beijing Phoenix Air Traffic Product Development and Trading Co.	CBSX-1
Beijing Wangye Aviation Chem. Prod. Co.	KLA-1
Beijing Yadilite Aviation Chemical Product Co. Ltd	YD-101 Type I
CHEMCO Inc.	CHEMR EG I
CHEMCO Inc.	CHEMR REG I
Clariant GmbH	EcoFlo Concentrate
Clariant GmbH	EcoFlo 2 Concentrate
Clariant GmbH	Octaflo EF Concentrate
Clariant GmbH	Octaflo EF 80
Clariant GmbH	Octaflo EG Concentrate
Clariant GmbH	Octaflo Lyod
Clariant GmbH	Safewing MP I 1938 ECO (80)
Clariant GmbH	Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use
Clariant GmbH	Safewing MP I 1938 ECO
Clariant GmbH	Safewing EG I 1996
Clariant GmbH	Safewing EG I 1996 (88)
Clariant GmbH	Safewing MP I ECO PLUS (80)
Cryotech Deicing Technology	Polar Plus® Concentrate
Cryotech Deicing Technology	Polar Plus® LT
Cryotech Deicing Technology	Polar Plus® (80)
Deicing Solutions LLC	Safetemp® ES Plus
Dow Chemical Company	UCAR™ ADF Concentrate
Dow Chemical Company	UCAR™ ADF XL-54
Dow Chemical Company	UCAR™ PG ADF Concentrate
Dow Chemical Company	UCAR™ PG ADF Dilute 55/45
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd. *(formerly Harbin Aeroclean Aviation Tech Co. Ltd.)*	HJF-1
HOC Industries	SafeTemp® ES Plus
Hokkaido NOF Corporation	Fever Snow AG
Inland Technologies	Duragly-E Concentrate
Inland Technologies	Duragly-P Concentrate
Kilfrost	Kilfrost DF PLUS
Kilfrost	Kilfrost DF PLUS (80)
Kilfrost	Kilfrost DF PLUS (88)

TABLE 8. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (CONT'D)

(See Page 51 for Table 8 Notes)

Type I Deicing/Anti-Icing Fluids[1] (continued)

Company Name	Fluid Name
Kilfrost	Kilfrost DF^{sustain}™
LNT Solutions	E188
LNT Solutions	P180
LNT Solutions	P188
Newave Aerochemical Co. Ltd.	FCY-1A
Newave Aerochemical Co. Ltd.	FCY-1Bio^{+}
Shanxi Cleanway Aviation Chemical Co., Ltd.	Cleansurface I
Shanxi Cleanway Aviation Chemical Co., Ltd.	Cleansurface I-BIO

Type II Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
ABAX Industries	Ecowing 26
Aviation Shaanxi Hi-Tech Physical Chemical Co., Ltd.	Cleanwing II
Clariant GmbH	Safewing MP II 1951
Clariant GmbH	Safewing MP II FLIGHT
Clariant GmbH	Safewing MP II FLIGHT PLUS
Cryotech Deicing Technology	Polar Guard II
Kilfrost	ABC-3
Kilfrost	ABC-K PLUS
LNT Solutions	P250
Newave Aerochemical Co Ltd.	FCY-2

Type III Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
Clariant GmbH	Safewing MP III 2031 ECO

Type IV Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
ABAX Industries	AD-480
ABAX Industries	Ecowing AD-49
Clariant GmbH	Max Flight 04
Clariant GmbH	Max Flight Sneg
Clariant GmbH	Safewing MP IV LAUNCH
Clariant GmbH	Safewing MP IV LAUNCH PLUS
Cryotech Deicing Technology	Polar Guard
Cryotech Deicing Technology	Polar Guard Advance
Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-icing Fluid
Dow Chemical Company	UCAR™ FlightGuard AD-480
Dow Chemical Company	UCAR™ FlightGuard AD-49
Kilfrost	ABC-S
Kilfrost	ABC-S Plus
LNT Solutions	E450
Newave Aerochemical	FCY 9311

TABLE 8. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (CONT'D)

(Table 8 Notes)

NOTES

1. This table lists fluids that have been tested with respect to anti-icing performance requirements according to SAE AMS 1424, Paragraph 3.5.2 and aerodynamic performance according to SAE AMS 1424, Paragraph 3.5.3 only by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, web site: www.uqac.ca/amil. The end user is responsible for confirming that other SAE AMS 1424 technical requirement tests, such as materials compatibility, and stability, etc, have been performed by contacting the fluid manufacturer.
2. This table lists Types II, III, or IV fluids that have been tested with respect to anti-icing performance requirements according to SAE AMS 1428, Paragraph 3.2.4 and aerodynamic performance according to SAE AMS 1428, Paragraph 3.2.5 only by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, web site: www.uqac.ca/amil. The end user is responsible for confirming that other SAE AMS 1428 technical requirement tests, such as materials compatibility, and stability, etc, have been performed by contacting the fluid manufacturer.

Ice Pellet and Small Hail Allowance Times 2014-2015

1. Background

During the winter of 2006-2007, operations in ice pellets were approved for "light ice pellets" with an allowance time of 25 minutes. That time was based on limited research conducted late in the winter of 2005-2006 at the request of various industry groups. Additional and more comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada during the 2007-2008 winter season.

This research consisted of extensive climatic chamber and wind tunnel testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times. Results of this research provide the basis for extended allowance times for operations in light ice pellets, as well as allowance times for operations in moderate ice pellets and light ice pellets mixed with other forms of precipitation. Additional ice pellet research was conducted during the winter season of 2008-2009 which further expanded the ice pellet allowance times under specified conditions. Guidance was also provided for Type IV anti-icing fluid with embedded ice pellets "aged" beyond its allowance time when the precipitation stops at or prior to the expiration of the allowance time.

During the winter of 2009-2010, wind tunnel research conducted with a newer generation type airfoil showed that Propylene Glycol (PG) and Ethylene Glycol (EG) fluids behave differently under certain temperature and ice pellet conditions. Specifically, higher aircraft rotation speeds are required to effectively remove PG fluid contaminated with light or moderate ice pellets at temperatures less than -10 °C. Therefore, there are no allowance times associated with the use of PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10 °C.

Furthermore, research with this newer generation type airfoil has shown that the allowance times are shorter when using PG fluids under certain conditions for all aircraft regardless of the rotation speed. This research resulted in the allowance time when using PG fluids at temperatures of -5 °C and above being limited to 15 minutes in moderate ice pellets. Currently all Type IV fluids are PG based with the exception of Dow EG106 and LNT Solutions E450 which are EG based.

Research has indicated that Type IV PG fluids are removed less effectively when contaminated with moderate ice pellets at temperatures below -16°C; operations in these conditions are not recommended. Therefore, there are no allowance times associated with the use of PG fluids in conditions of moderate ice pellets at temperatures below -16°C, irrespective of aircraft rotation speed.

In 2014-15, allowance times were published for undiluted (100/0) Type III fluid applied unheated in select conditions. Further testing is required to expand Type III allowance times in other conditions, such as temperatures below -10°C. Allowance times for small hail were also added, as it was determined small hail is meteorologically equivalent to moderate ice pellets.

2. Operations in Light and Moderate Ice Pellets and Light Ice Pellets mixed with other forms of precipitation.

A. Tests have shown that ice pellets generally remain in the frozen state imbedded in Type III and Type IV anti-icing fluid, and are not absorbed by the fluid in the same manner as other forms of precipitation. Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not absorbed by the fluid (remaining imbedded) would be an indication that the fluid has failed. These imbedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination check procedures. Therefore, a visual pre-takeoff contamination check in ice pellet conditions may not be of value and is not required.

B. The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and ice pellets mixed with other forms of precipitation in Type III or Type IV fluid will not prevent the fluid from flowing off the aerodynamic surfaces during takeoff except as noted above. This flow-off due to the shearing forces occurs with rotation speeds consistent with Type III or Type IV anti-icing fluid recommended applications, and up to the applicable allowance time listed in Table 9 and Table 10 below. These allowance times are from the start of the Type III/IV anti-icing fluid application. Additionally, if the ice pellet condition stops, and the allowance time has not been exceeded, the operator is permitted to consider the Type III or Type IV anti-icing fluid effective without any further action up to 90 minutes after the start of the application time of the Type III or Type IV anti icing fluid, however, the OAT must remain constant or increase during the 90 minute period under the following conditions:

- light ice pellets mixed with light or moderate freezing drizzle;
- light ice pellets mixed with light freezing rain;
- light ice pellets mixed with light rain; and
- light ice pellets mixed with moderate rain.

Examples:

1) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50 the aircraft may takeoff without any further action up to 11:30.
2) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:15 and stops at 10:20. The allowance time stops at 10:25, however provided that the OAT remains constant or increases and that no precipitation restarts after the allowance time of 10:25, the aircraft may takeoff without any further action up to 11:30.
3) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets mixed with light freezing rain falls until 10:10, stops and restarts at 10:15, and stops at 10:20. The allowance time stops at 10:25; however, provided that the OAT remains constant or increases and no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.
4) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:30 with the allowance time stopping at 10:25 the aircraft may not takeoff, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

C. Operators with a deicing program approved in accordance with Title 14 of the Code of Federal Regulations 14 CFR part 121, § 121.629, will be allowed, in the specified ice pellet and small hail conditions listed in Tables 9 and 10, up to the specific allowance time, to commence the takeoff with the following restrictions:

1) The aircraft critical surfaces must be free of contaminants before applying Type III or Type IV anti-icing fluid. If not, the aircraft must be properly deiced and checked to be free of contaminants before the application of Type III or Type IV anti-icing fluid.
2) The allowance time is valid only if the aircraft is anti-iced with undiluted Type III or Type IV fluid.
3) The Type III allowance times are only applicable for un-heated anti-icing fluid applications.
4) Due to the shearing qualities of Type III and Type IV fluids with imbedded ice pellets, this allowance is limited to aircraft with a rotation speed of 100 knots or greater or 115 knots as indicated in the Ice Pellet Allowance Table below.

5) If the takeoff is not accomplished within the applicable allowance time in Table 9 or Table 10, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff. If the precipitation stops at or before the time limits of the applicable allowance time and does not restart, the aircraft may takeoff up to 90 minutes after the start of the application of the Type III or Type IV anti-icing fluid, subject to the restrictions in 2. B. on the previous page.

6) A pre-takeoff contamination check is not required. The allowance time cannot be extended by an internal or external check of the aircraft critical surfaces.

7) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used.

8) If the temperature decreases below the temperature on which the allowance time was based,

    a) and the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit.

    b) and the allowance time has expired (within the 90 minute post anti-icing window if the precipitation has stopped within the allowance time), the aircraft may not takeoff and must be completely deiced and, if applicable, anti-iced before a subsequent takeoff.

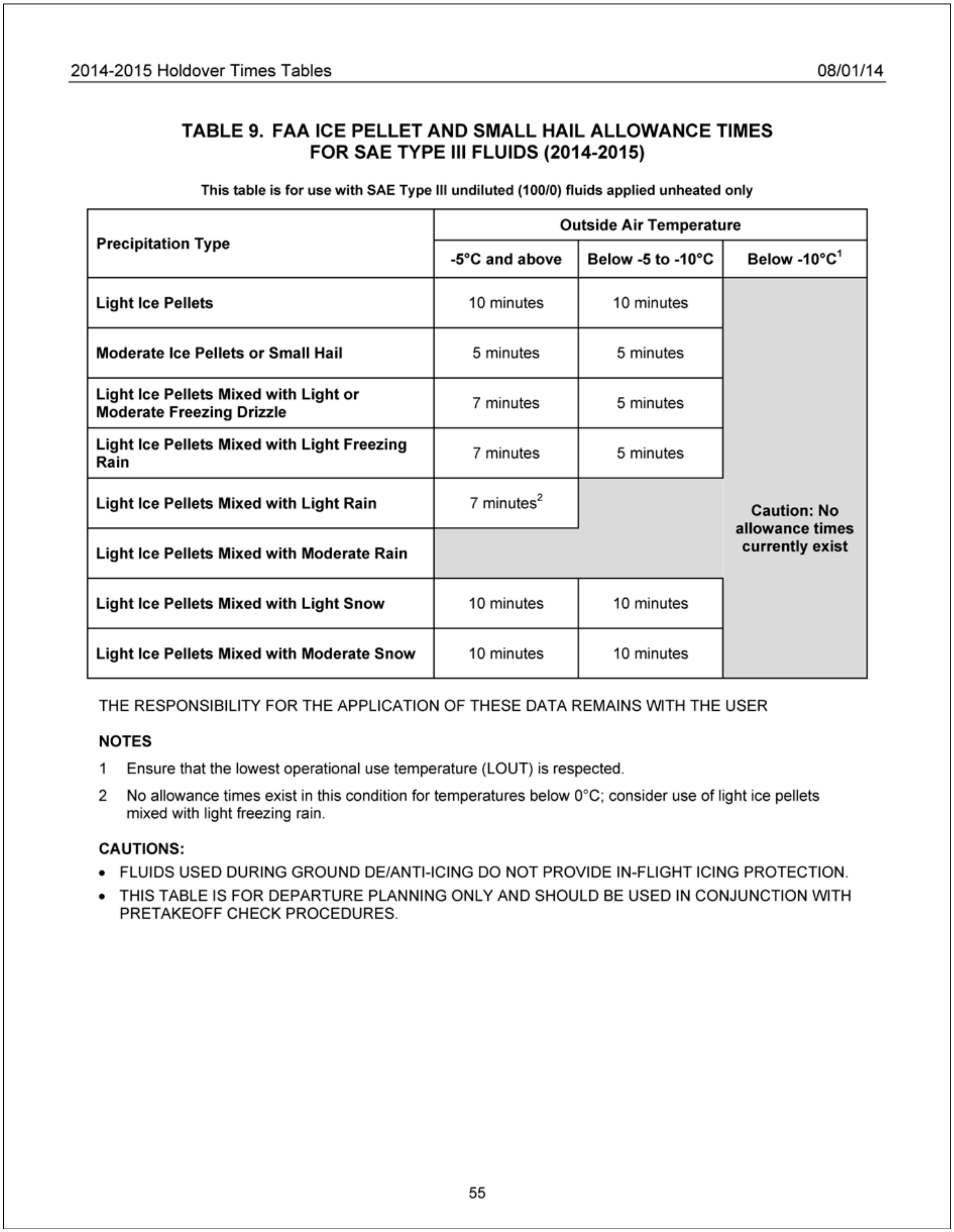


TABLE 9. FAA ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE III FLUIDS (2014-2015)

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

Precipitation Type	**Outside Air Temperature**		
	-5°C and above	**Below -5 to -10°C**	**Below -10°C**[1]
Light Ice Pellets	10 minutes	10 minutes	**Caution: No allowance times currently exist**
Moderate Ice Pellets or Small Hail	5 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	7 minutes[2]		
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Light Snow	10 minutes	10 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	10 minutes	

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

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.

2 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

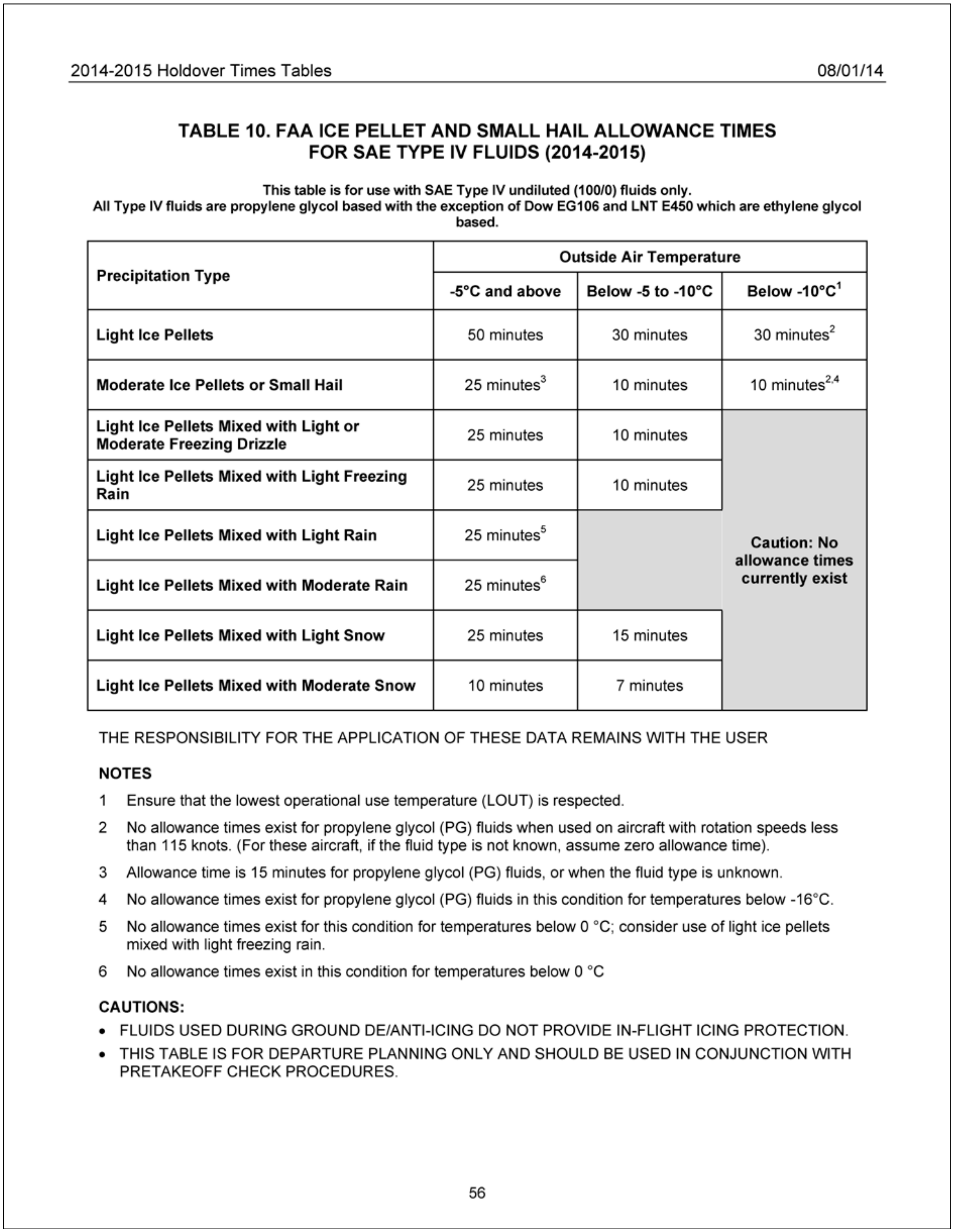


TABLE 10. FAA ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE IV FLUIDS (2014-2015)

This table is for use with SAE Type IV undiluted (100/0) fluids only.
All Type IV fluids are propylene glycol based with the exception of Dow EG106 and LNT E450 which are ethylene glycol based.

Precipitation Type	**Outside Air Temperature**		
	-5°C and above	**Below -5 to -10°C**	**Below -10°C[1]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[2]
Moderate Ice Pellets or Small Hail	25 minutes[3]	10 minutes	10 minutes[2,4]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes[5]		
Light Ice Pellets Mixed with Moderate Rain	25 minutes[6]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	7 minutes	

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

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.

2 No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).

3 Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

4 No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16°C.

5 No allowance times exist for this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.

6 No allowance times exist in this condition for temperatures below 0 °C

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Operations in Heavy Snow 2014-2015

(No Change from 2013-2014 Guidance)

1. **Tactile and Visual Checks of Aircraft.** No holdover times (HOT) exist for heavy snow conditions in the current HOT tables. Review of existing data from past testing has indicated takeoffs may be safely conducted with proper tactile and/or visual checks, as appropriate for the aircraft, and a determination that the fluid has not failed. A tactile and/or visual check in heavy snow conditions must be accomplished in a manner that provides an assessment that can be accurately accomplished. It is imperative that the tactile and/or visual check procedures to determine if the anti-icing fluid has failed in heavy snow conditions be at least as comprehensive as the authorized procedures for the operator's pretakeoff contamination check (when HOTs have been exceeded) for those precipitation conditions for which HOTs exist. Anti-icing fluids dissolve the snow and absorb the resulting moisture into the fluid. When the fluid begins to fail it starts to change in appearance (e.g., less glossy and more opaque) and the snow starts to accumulate on and in the fluid. At this stage, the fluid has failed and takeoff is not authorized. If the operator's procedure to accomplish this check is different from the operator's approved pretakeoff contamination check procedures for other precipitation conditions, this check procedure must be verified and approved by the operator's Principal Operations Inspector (POI).

2. **Takeoff in Heavy Snow Conditions.** Operators with a deicing program approved in accordance with 14 CFR part 121, § 121.629, will be allowed to takeoff in heavy snow conditions subject to the following restrictions:

   1) The aircraft must be anti-iced with undiluted Type IV fluid.

   2) The aircraft critical surfaces must be free of contaminants, or the aircraft must be properly deiced before the application of the anti-icing fluid.

   3) When appropriate, the operator must accomplish an approved tactile and/or visual check of the aircraft critical surfaces within 5 minutes of takeoff.

   4) If this check is accomplished visually from within the aircraft, the view must be such that it is not obscured by de/anti-icing fluid, dirt, or fogging. If the critical surfaces cannot be seen due to snowfall, distance from the viewing position, or inadequate lighting, or for any other reason, the check must be a visual or tactile check conducted from outside the aircraft.

   5) If a definitive fluid failure determination cannot be made using the checks prescribed, takeoff is not authorized. The aircraft must be completely deiced, and if precipitation is still present, anti-iced again before a subsequent takeoff.

   Note: Current aircraft certification standards only require testing of flight instrument sensing devices and engine anti-icing systems in moderate snow levels. Ground operations in heavy snow conditions may exceed the capabilities or limitations of these systems and devices to adequately provide anti-icing.

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 0-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS IN ACTIVE FROST

Outside Air Temperature[1,2]		**Approximate Holdover Times (hours:minutes)**
		Active Frost
Degrees Celsius	**Degrees Fahrenheit**	**Type I**
-1 and above	30 and above	0:41 (0:32)[3]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

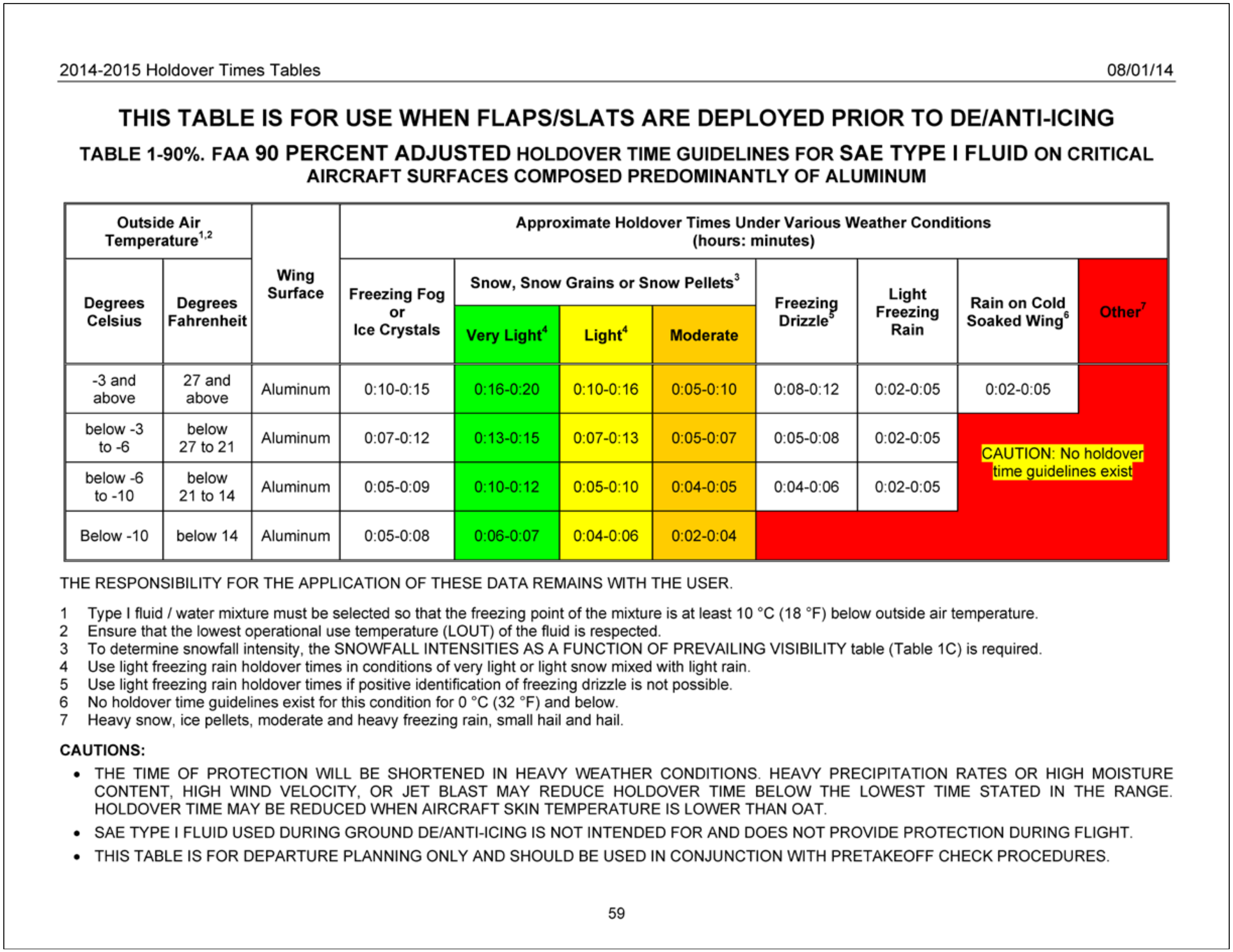
Outside Air Temperature[2]		**Concentration Neat Fluid/Water** (Volume %/ Volume %)	**Approximate Holdover Times (hours:minutes)**		
			Active Frost		
Degrees Celsius	**Degrees Fahrenheit**		**Type II**	**Type III**	**Type IV**
-1 and above	30 and above	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	2:42	0:27	2:42
below -1 to -3	below 30 to 27	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	1:21	0:27	2:42
below -3 to -10	below 27 to 14	100/0	7:12	1:48	9:00
		75/25	4:30	0:54	4:30
below -10 to -14	below 14 to 7	100/0	5:24	1:48	5:24
		75/25	0:54	0:54	0:54
below -14 to -21	below 7 to -6	100/0	5:24	1:48	5:24
below -21 to -25	below -6 to -13	100/0	1:48	1:48	3:36
Below -25	Below -13	No holdover time guidelines exist			

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

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 Value in parenthesis is for composite aircraft.

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Aluminum	0:10-0:15	0:16-0:20	0:10-0:16	0:05-0:10	0:08-0:12	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Aluminum	0:07-0:12	0:13-0:15	0:07-0:13	0:05-0:07	0:05-0:08	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:05-0:09	0:10-0:12	0:05-0:10	0:04-0:05	0:04-0:06	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:08	0:06-0:07	0:04-0:06	0:02-0:04				

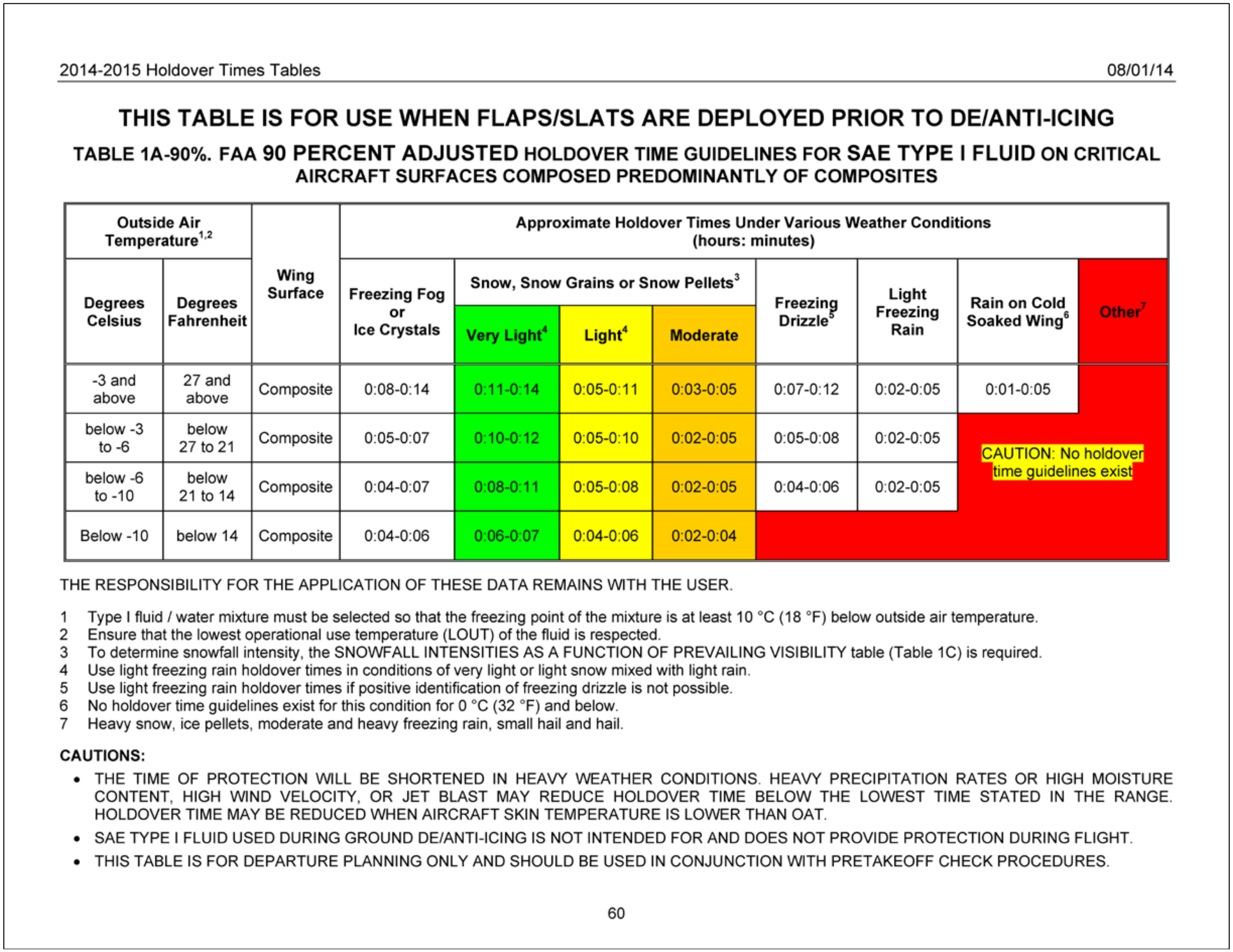
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE I FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

59



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1A-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES

Outside Air Temperature[1,2]		**Wing Surface**	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[3]**			**Freezing Drizzle[5]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[6]**	**Other[7]**
				Very Light[4]	**Light[4]**	**Moderate**				
-3 and above	27 and above	Composite	0:08-0:14	0:11-0:14	0:05-0:11	0:03-0:05	0:07-0:12	0:02-0:05	0:01-0:05	
below -3 to -6	below 27 to 21	Composite	0:05-0:07	0:10-0:12	0:05-0:10	0:02-0:05	0:05-0:08	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	Composite	0:04-0:07	0:08-0:11	0:05-0:08	0:02-0:05	0:04-0:06	0:02-0:05		
Below -10	below 14	Composite	0:04-0:06	0:06-0:07	0:04-0:06	0:02-0:04				

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

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected.
3 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE I FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

60

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE II FLUID

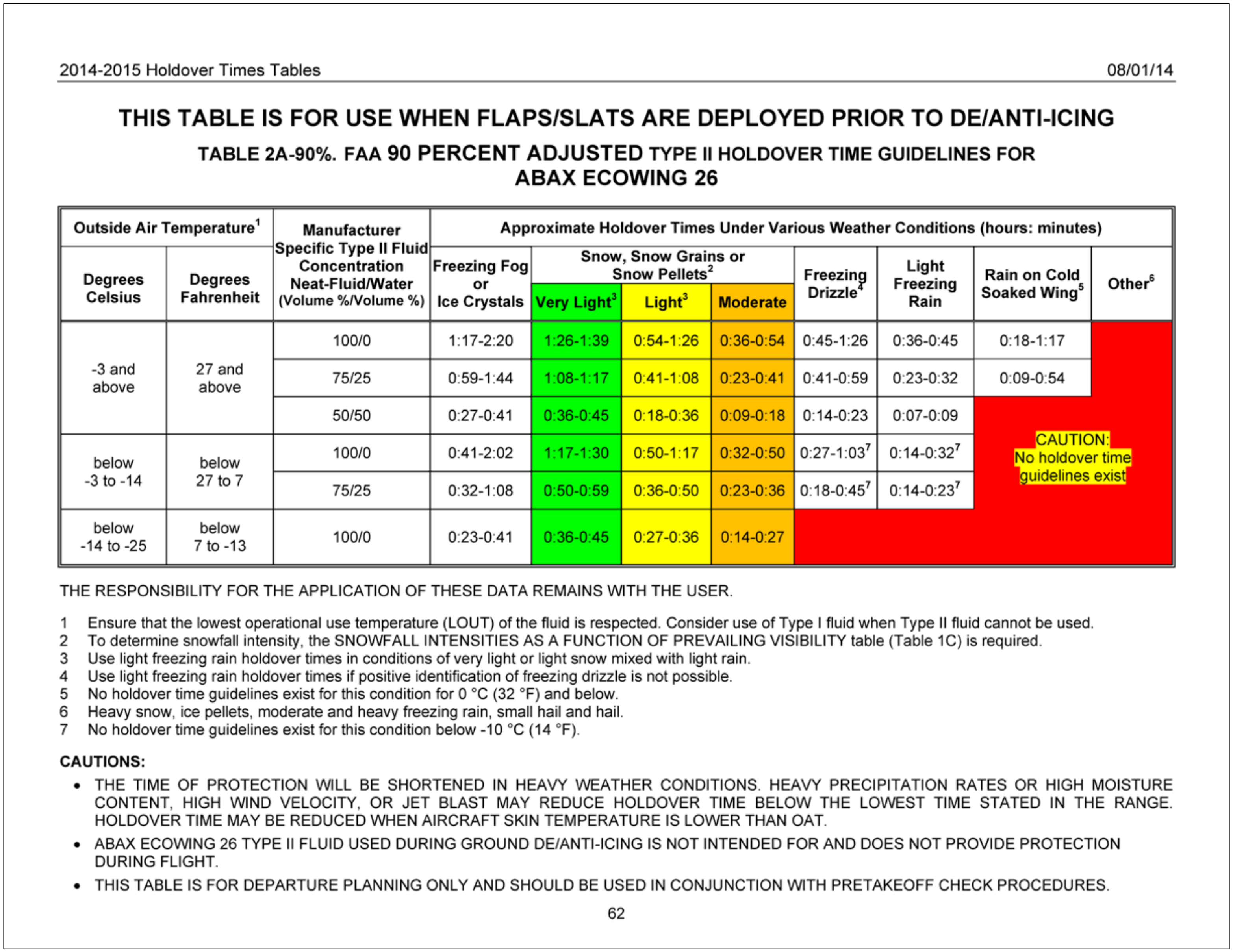
Outside Air Temperature[1]		**Type II Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets**[2,3]	**Freezing Drizzle**[4]	**Light Freezing Rain**	**Rain on Cold Soaked Wing**[5]	**Other**[6]
-3 and above	27 and above	100/0	0:32-1:21	0:18-0:41	0:27-0:50	0:14-0:27	0:07-0:36	CAUTION: No holdover time guidelines exist
		75/25	0:23-0:54	0:14-0:27	0:18-0:41	0:09-0:23	0:05-0:23	
		50/50	0:14-0:27	0:05-0:14	0:07-0:14	0:05-0:08		
below -3 to -14	below 27 to 7	100/0	0:18-0:59	0:14-0:27	0:18-0:41[7]	0:09-0:18[7]		
		75/25	0:23-0:45	0:09-0:18	0:14-0:27[7]	0:07-0:14[7]		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:14-0:32	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2A-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR ABAX ECOWING 26

Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)**	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	1:17-2:20	1:26-1:39	0:54-1:26	0:36-0:54	0:45-1:26	0:36-0:45	0:18-1:17	CAUTION: No holdover time guidelines exist
		75/25	0:59-1:44	1:08-1:17	0:41-1:08	0:23-0:41	0:41-0:59	0:23-0:32	0:09-0:54	
		50/50	0:27-0:41	0:36-0:45	0:18-0:36	0:09-0:18	0:14-0:23	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:41-2:02	1:17-1:30	0:50-1:17	0:32-0:50	0:27-1:03[7]	0:14-0:32[7]		
		75/25	0:32-1:08	0:50-0:59	0:36-0:50	0:23-0:36	0:18-0:45[7]	0:14-0:23[7]		
below -14 to -25	below 7 to -13	100/0	0:23-0:41	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX ECOWING 26 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

62

2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2B-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR AVIATION SHAANXI HI-TECH CLEANWING II

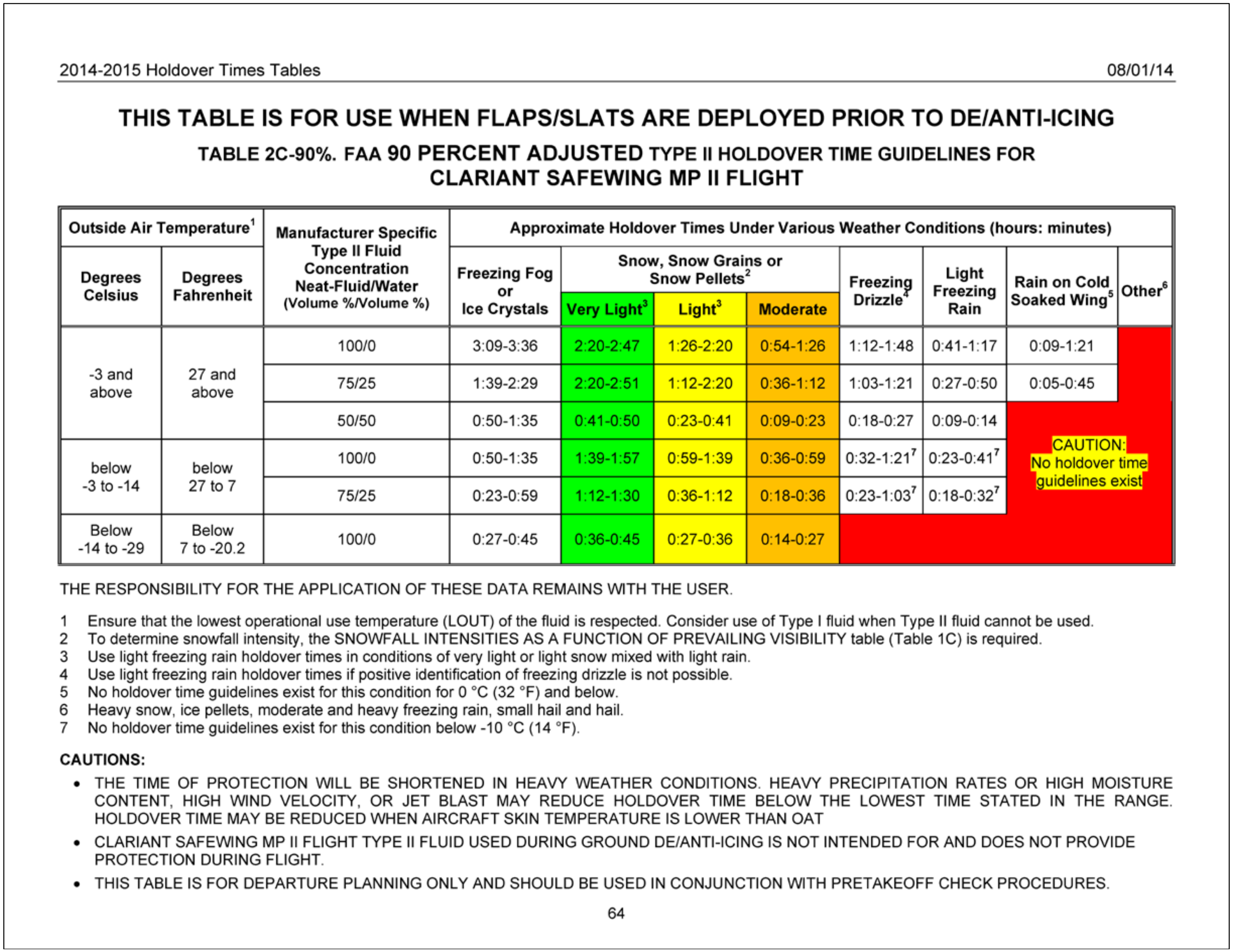
Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	0:50-1:39	0:27-0:50	0:32-0:59	0:23-0:32	0:09-0:50	CAUTION: No holdover time guidelines exist
		75/25	0:45-1:12	0:23-0:41	0:32-0:54	0:18-0:27	0:06-0:45	
		50/50	0:32-0:54	0:14-0:27	0:18-0:36	0:09-0:18		
below -3 to -14	below 27 to 7	100/0	0:41-1:39	0:27-0:50	0:27-0:50^7	0:18-0:23^7		
		75/25	0:36-1:35	0:23-0:41	0:32-0:36^7	0:18-0:23^7		
below -14 to -29	below 7 to -20.2	100/0	0:18-0:45	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- AVIATION SHAANXI HI-TECH CLEANWING II TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2C-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:09-3:36	2:20-2:47	1:26-2:20	0:54-1:26	1:12-1:48	0:41-1:17	0:09-1:21	CAUTION: No holdover time guidelines exist
		75/25	1:39-2:29	2:20-2:51	1:12-2:20	0:36-1:12	1:03-1:21	0:27-0:50	0:05-0:45	
		50/50	0:50-1:35	0:41-0:50	0:23-0:41	0:09-0:23	0:18-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:50-1:35	1:39-1:57	0:59-1:39	0:36-0:59	0:32-1:21[7]	0:23-0:41[7]		
		75/25	0:23-0:59	1:12-1:30	0:36-1:12	0:18-0:36	0:23-1:03[7]	0:18-0:32[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:27-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CLARIANT SAFEWING MP II FLIGHT TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

64

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2D-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT PLUS

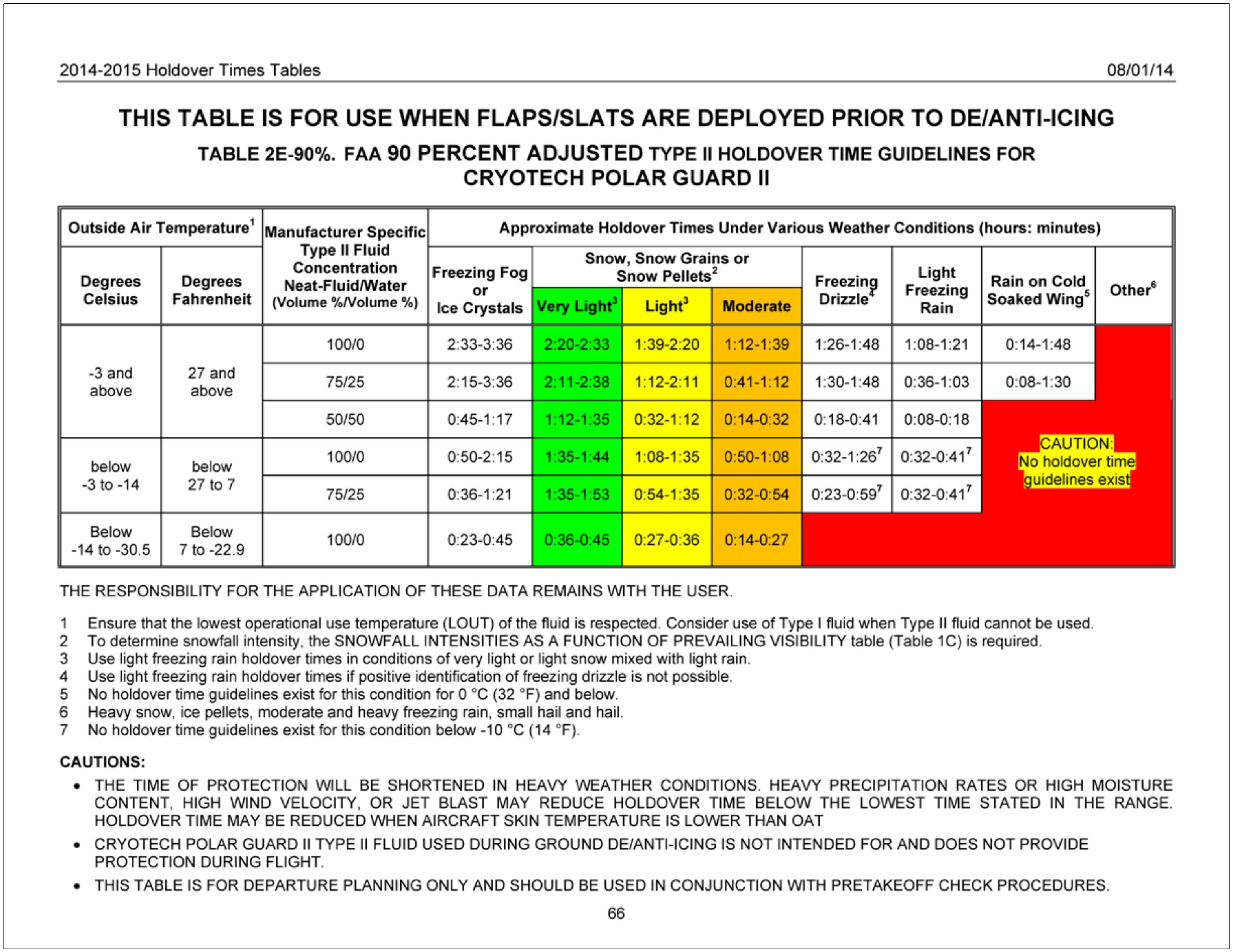
Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets**[2,3]	**Freezing Drizzle**[4]	**Light Freezing Rain**	**Rain on Cold Soaked Wing**[5]	**Other**[6]
-3 and above	27 and above	100/0	2:24-3:36	0:45-1:39	1:17-1:48	0:41-0:54	0:14-1:48	CAUTION: No holdover time guidelines exist
		75/25	2:20-3:36	0:54-1:35	1:26-1:48	0:45-1:08	0:14-1:08	
		50/50	0:59-2:06	0:14-0:23	0:27-0:59	0:14-0:18		
below -3 to -14	below 27 to 7	100/0	0:36-2:06	0:32-1:08	0:32-1:17[7]	0:32-0:50[7]		
		75/25	0:27-1:35	0:50-1:30	0:23-1:03[7]	0:27-0:41[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:18-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CLARIANT SAFEWING MP II FLIGHT PLUS TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2E-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD II

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:33-3:36	2:20-2:33	1:39-2:20	1:12-1:39	1:26-1:48	1:08-1:21	0:14-1:48	CAUTION: No holdover time guidelines exist
		75/25	2:15-3:36	2:11-2:38	1:12-2:11	0:41-1:12	1:30-1:48	0:36-1:03	0:08-1:30	
		50/50	0:45-1:17	1:12-1:35	0:32-1:12	0:14-0:32	0:18-0:41	0:08-0:18		
below -3 to -14	below 27 to 7	100/0	0:50-2:15	1:35-1:44	1:08-1:35	0:50-1:08	0:32-1:26[7]	0:32-0:41[7]		
		75/25	0:36-1:21	1:35-1:53	0:54-1:35	0:32-0:54	0:23-0:59[7]	0:32-0:41[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:23-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- CRYOTECH POLAR GUARD II TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

66

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2F-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-K PLUS

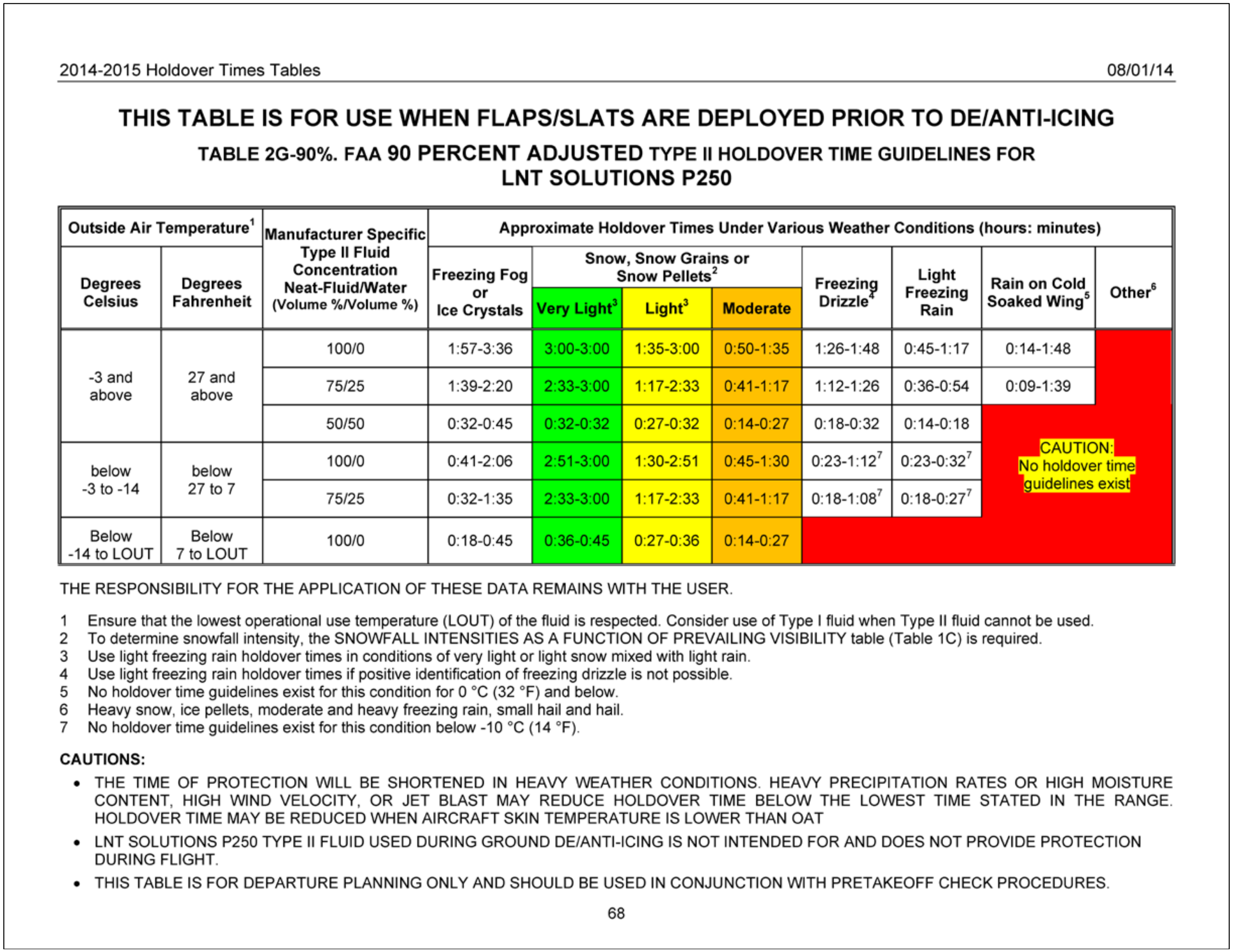
Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:02-3:23	0:54-1:30	1:39-1:48	0:54-1:17	0:18-1:48	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:15	0:32-1:03	1:17-1:48	0:45-1:03	0:14-1:48	
		50/50	0:32-0:59	0:06-0:14	0:18-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:27-0:59	0:45-1:17	0:23-0:54[7]	0:14-0:32[7]		
		75/25	0:23-1:17	0:32-0:59	0:18-0:50[7]	0:08-0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:27-0:50	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-K PLUS TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2G-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS P250

Outside Air Temperature[1]		Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:57-3:36	3:00-3:00	1:35-3:00	0:50-1:35	1:26-1:48	0:45-1:17	0:14-1:48	
		75/25	1:39-2:20	2:33-3:00	1:17-2:33	0:41-1:17	1:12-1:26	0:36-0:54	0:09-1:39	
		50/50	0:32-0:45	0:32-0:32	0:27-0:32	0:14-0:27	0:18-0:32	0:14-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:41-2:06	2:51-3:00	1:30-2:51	0:45-1:30	0:23-1:12[7]	0:23-0:32[7]		
		75/25	0:32-1:35	2:33-3:00	1:17-2:33	0:41-1:17	0:18-1:08[7]	0:18-0:27[7]		
Below -14 to LOUT	Below 7 to LOUT	100/0	0:18-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT
- LNT SOLUTIONS P250 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2H-90%. FAA 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2

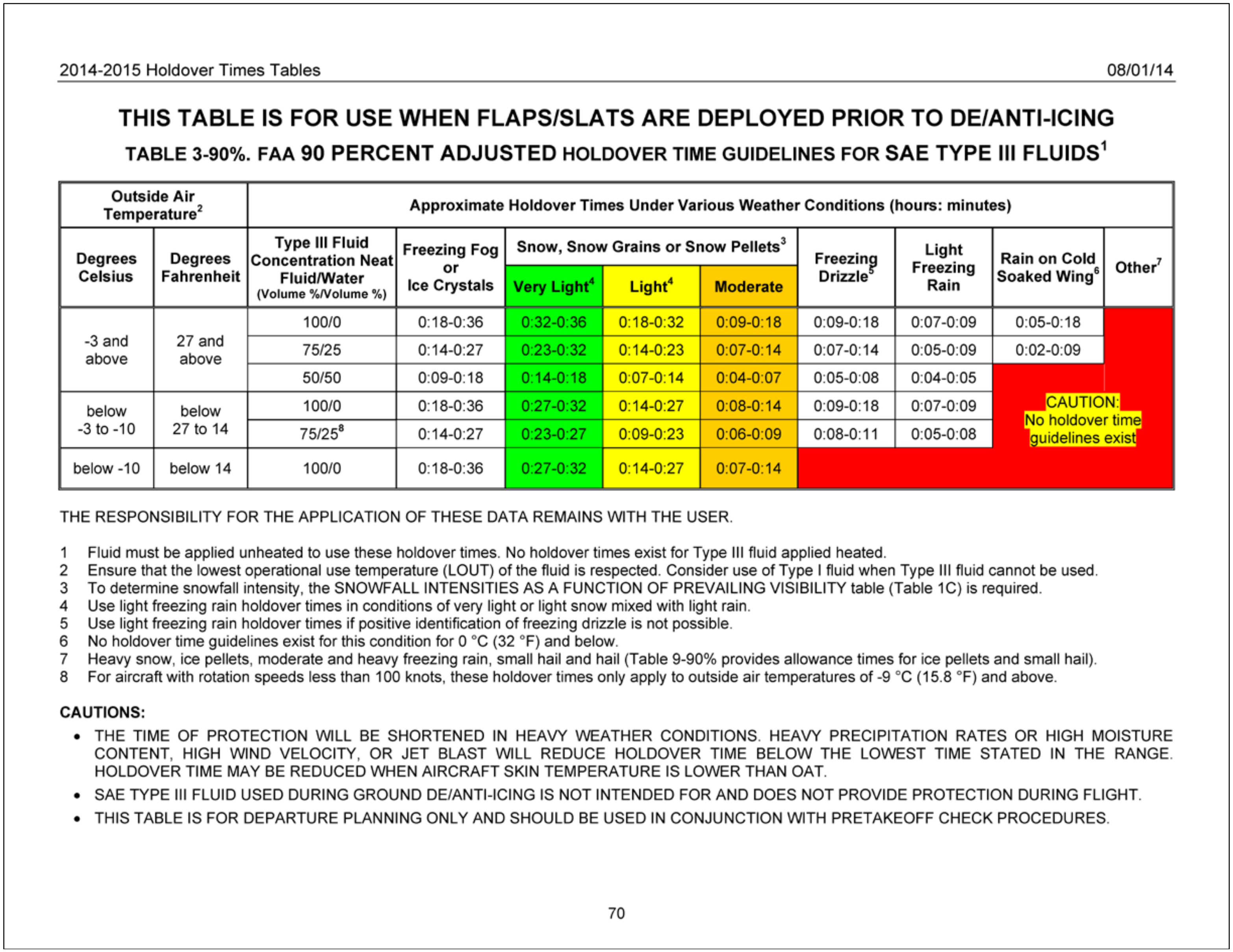
Outside Air Temperature[1]		**Manufacturer Specific Type II Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:08-2:11	0:27-0:50	0:32-0:59	0:23-0:32	0:07-0:41	CAUTION: No holdover time guidelines exist
		75/25	0:45-1:21	0:18-0:36	0:23-0:41	0:14-0:23	0:05-0:23	
		50/50	0:23-0:32	0:14-0:23	0:09-0:18	0:06-0:09		
below -3 to -14	below 27 to 7	100/0	0:41-1:21	0:14-0:27	0:18-0:41[7]	0:14-0:18[7]		
		75/25	0:27-0:59	0:09-0:18	0:14-0:27[7]	0:07-0:14[7]		
below -14 to -28	below 7 to -18.4	100/0	0:23-0:32	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY-2 TYPE II FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE III FLUIDS[1]

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:18-0:36	0:32-0:36	0:18-0:32	0:09-0:18	0:09-0:18	0:07-0:09	0:05-0:18	CAUTION: No holdover time guidelines exist
		75/25	0:14-0:27	0:23-0:32	0:14-0:23	0:07-0:14	0:07-0:14	0:05-0:09	0:02-0:09	
		50/50	0:09-0:18	0:14-0:18	0:07-0:14	0:04-0:07	0:05-0:08	0:04-0:05		
below -3 to -10	below 27 to 14	100/0	0:18-0:36	0:27-0:32	0:14-0:27	0:08-0:14	0:09-0:18	0:07-0:09		
		75/25[8]	0:14-0:27	0:23-0:27	0:09-0:23	0:06-0:09	0:08-0:11	0:05-0:08		
below -10	below 14	100/0	0:18-0:36	0:27-0:32	0:14-0:27	0:07-0:14				

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

[1] Fluid must be applied unheated to use these holdover times. No holdover times exist for Type III fluid applied heated.
[2] Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type III fluid cannot be used.
[3] To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
[4] Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
[5] Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
[6] No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
[7] Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 9-90% provides allowance times for ice pellets and small hail).
[8] For aircraft with rotation speeds less than 100 knots, these holdover times only apply to outside air temperatures of -9 °C (15.8 °F) and above.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST WILL REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE III FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%. FAA 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE IV FLUIDS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:39-2:38	0:32-1:03	0:45-1:21	0:32-0:50	0:09-1:08	CAUTION: No holdover time guidelines exist
		75/25	0:59-1:35	0:27-0:50	0:41-1:03	0:27-0:41	0:08-0:45	
		50/50	0:18-0:32	0:06-0:14	0:14-0:18	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:18-1:12	0:23-0:45	0:18-0:54[7]	0:09-0:23[7]		
		75/25[8]	0:23-0:45	0:18-0:36	0:14-0:59[7]	0:09-0:23[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0[9]	0:14-0:36	0:14-0:27				

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

[1] Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
[2] To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
[3] Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
[4] Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
[5] No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
[6] Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
[7] No holdover time guidelines exist for this condition below -10 °C (14 °F).
[8] For Cryotech Polar Guard temperature is limited to -5.5 °C (22 °F).
[9] For Cryotech Polar Guard and Clariant Max Flight 04, temperature is limited to -23.5 °C (-10.3 °F). If the fluid specific brand is unknown, all of the temperature limitations in this and the preceding note apply.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- SAE TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4A-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR ABAX AD-480

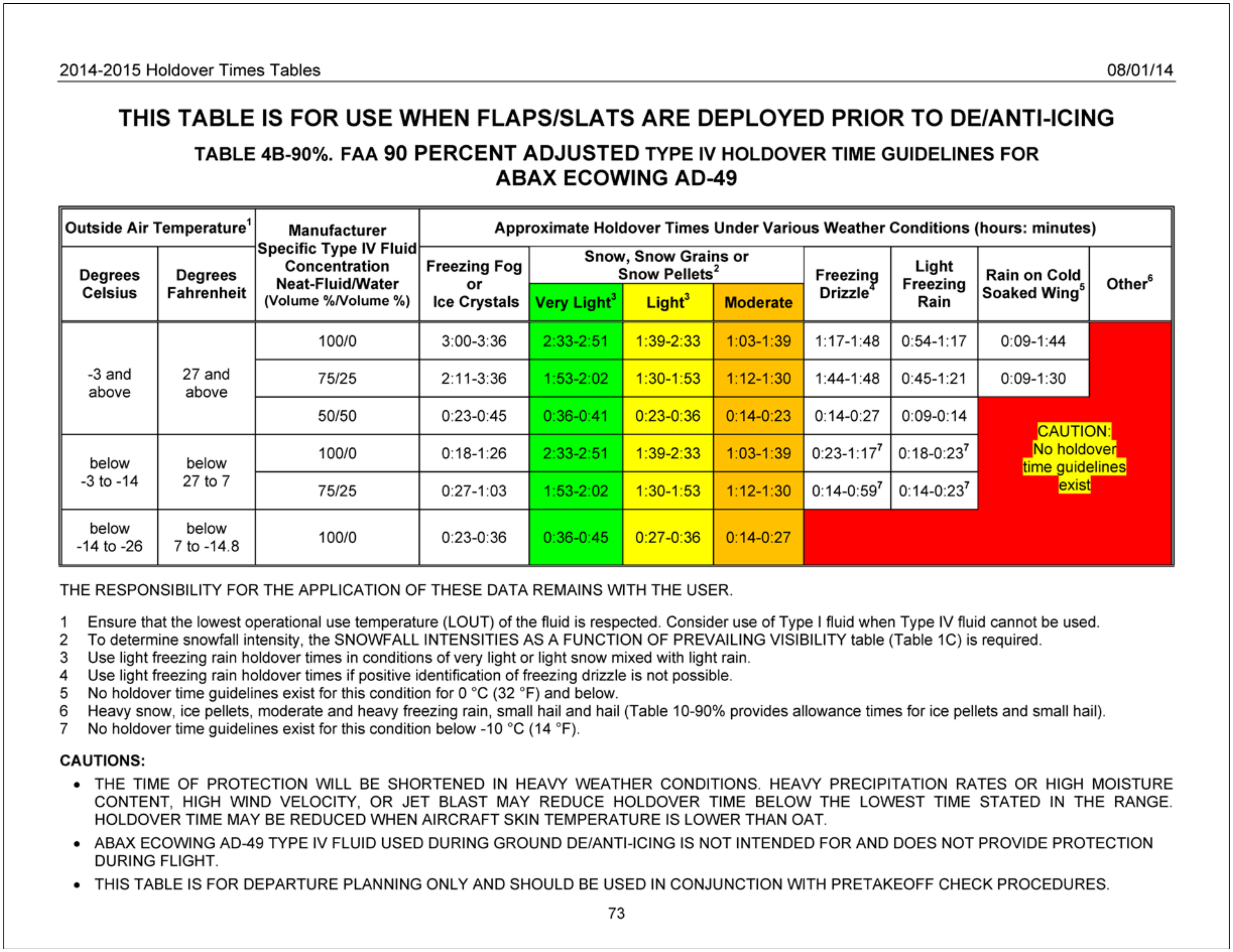
Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:48-3:09	0:36-1:12	0:45-1:21	0:32-0:50	0:14-1:26	CAUTION: No holdover time guidelines exist
		75/25	1:21-2:29	0:27-0:59	0:45-1:08	0:27-0:41	0:09-1:08	
		50/50	0:27-0:41	0:08-0:18	0:14-0:23	0:08-0:14		
below -3 to -14	below 27 to 7	100/0	0:18-1:12	0:27-0:50	0:23-1:12[7]	0:14-0:27[7]		
		75/25	0:23-0:45	0:18-0:41	0:23-0:59[7]	0:14-0:27[7]		
below -14 to -26	below 7 to -14.8	100/0	0:14-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX AD-480 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4B-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR ABAX ECOWING AD-49

Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	3:00-3:36	2:33-2:51	1:39-2:33	1:03-1:39	1:17-1:48	0:54-1:17	0:09-1:44	CAUTION: No holdover time guidelines exist
		75/25	2:11-3:36	1:53-2:02	1:30-1:53	1:12-1:30	1:44-1:48	0:45-1:21	0:09-1:30	
		50/50	0:23-0:45	0:36-0:41	0:23-0:36	0:14-0:23	0:14-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:18-1:26	2:33-2:51	1:39-2:33	1:03-1:39	0:23-1:17[7]	0:18-0:23[7]		
		75/25	0:27-1:03	1:53-2:02	1:30-1:53	1:12-1:30	0:14-0:59[7]	0:14-0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23-0:36	0:36-0:45	0:27-0:36	0:14-0:27				

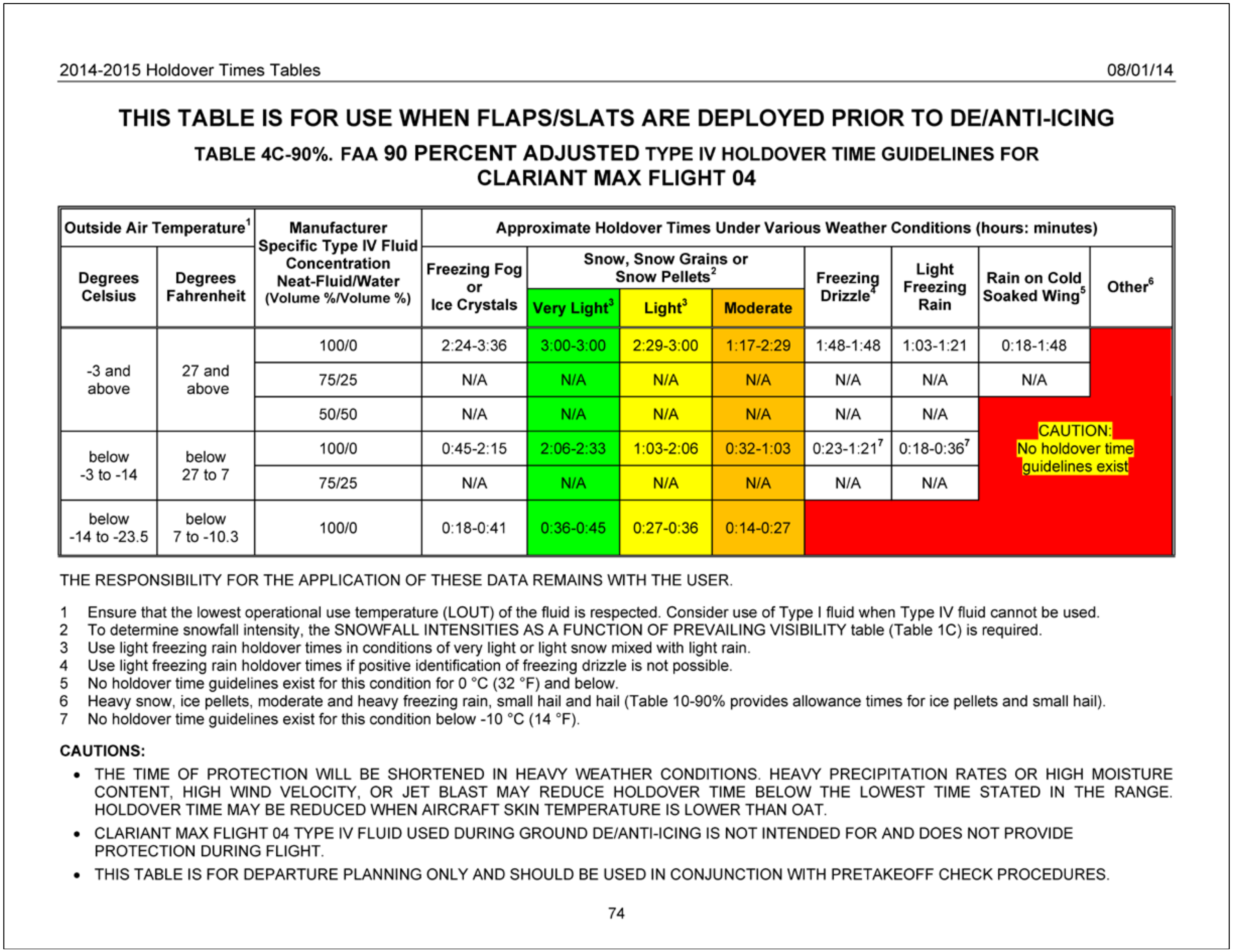
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

[1] Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
[2] To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
[3] Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
[4] Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
[5] No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
[6] Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
[7] No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- ABAX ECOWING AD-49 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

73



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4C-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT 04

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:24-3:36	3:00-3:00	2:29-3:00	1:17-2:29	1:48-1:48	1:03-1:21	0:18-1:48	
		75/25	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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-2:15	2:06-2:33	1:03-2:06	0:32-1:03	0:23-1:21[7]	0:18-0:36[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -23.5	below 7 to -10.3	100/0	0:18-0:41	0:36-0:45	0:27-0:36	0:14-0:27				

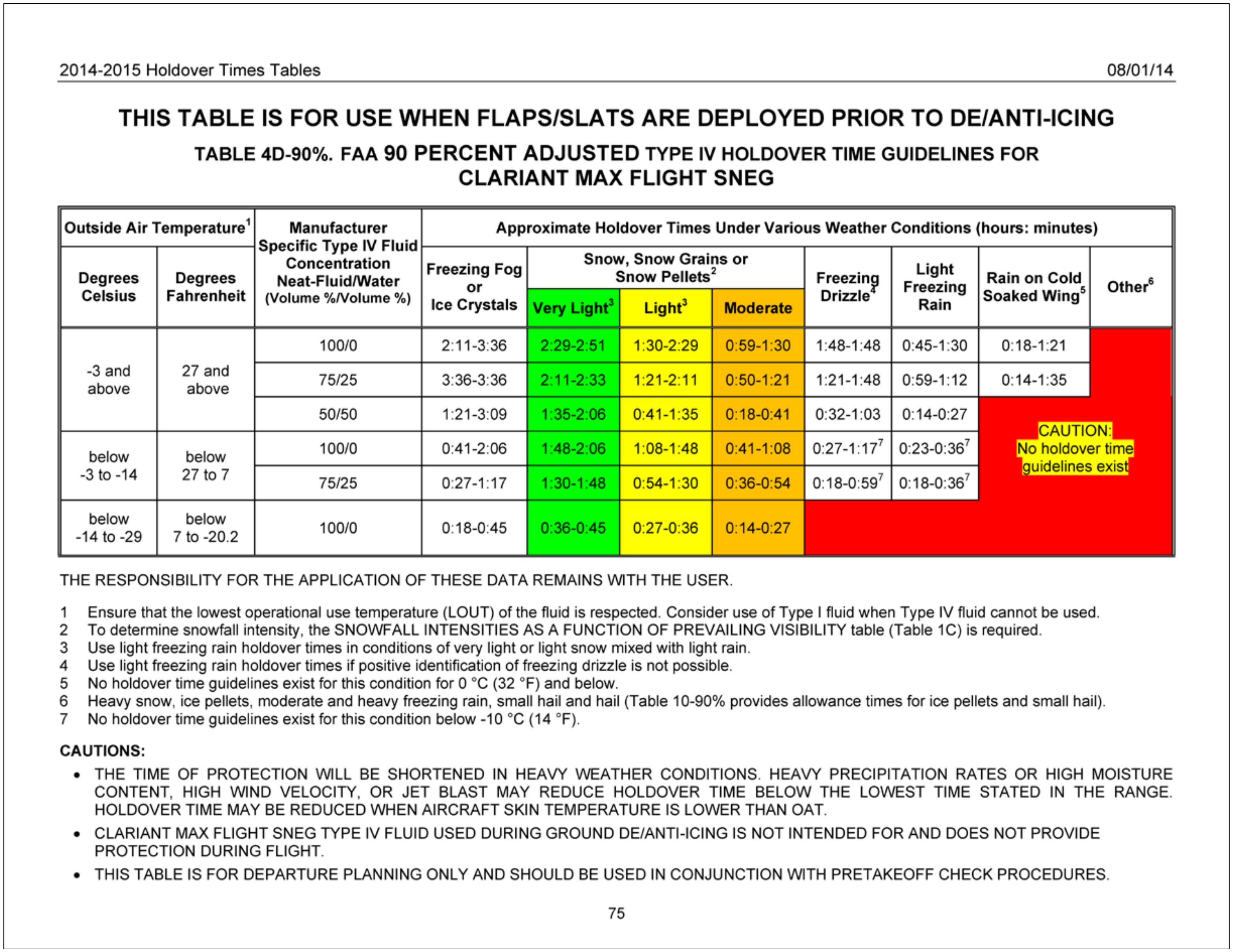
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT MAX FLIGHT 04 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

74



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4D-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT SNEG

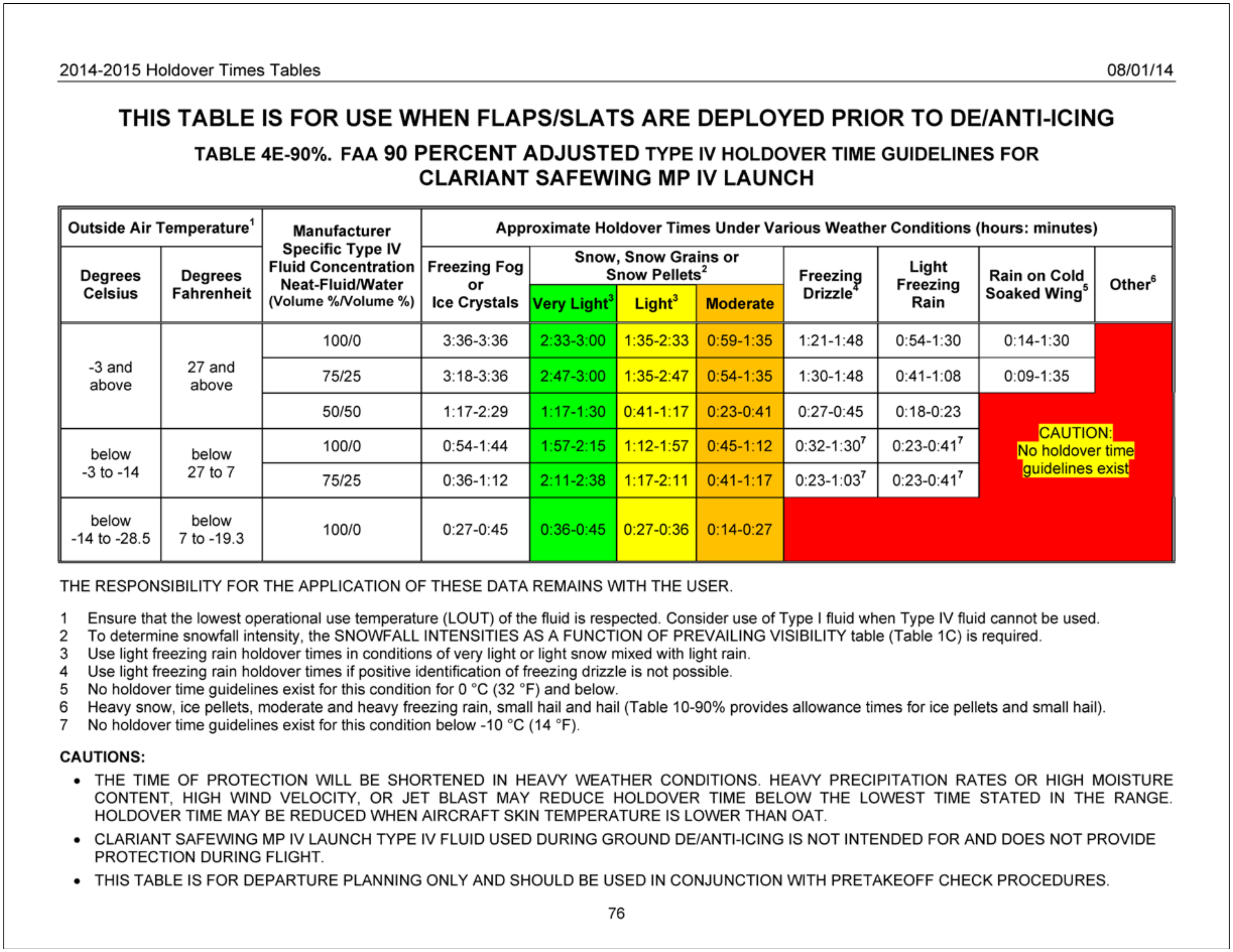
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:11-3:36	2:29-2:51	1:30-2:29	0:59-1:30	1:48-1:48	0:45-1:30	0:18-1:21	CAUTION: No holdover time guidelines exist
		75/25	3:36-3:36	2:11-2:33	1:21-2:11	0:50-1:21	1:21-1:48	0:59-1:12	0:14-1:35	
		50/50	1:21-3:09	1:35-2:06	0:41-1:35	0:18-0:41	0:32-1:03	0:14-0:27		
below -3 to -14	below 27 to 7	100/0	0:41-2:06	1:48-2:06	1:08-1:48	0:41-1:08	0:27-1:17[7]	0:23-0:36[7]		
		75/25	0:27-1:17	1:30-1:48	0:54-1:30	0:36-0:54	0:18-0:59[7]	0:18-0:36[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT MAX FLIGHT SNEG TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4E-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	3:36-3:36	2:33-3:00	1:35-2:33	0:59-1:35	1:21-1:48	0:54-1:30	0:14-1:30	
		75/25	3:18-3:36	2:47-3:00	1:35-2:47	0:54-1:35	1:30-1:48	0:41-1:08	0:09-1:35	
		50/50	1:17-2:29	1:17-1:30	0:41-1:17	0:23-0:41	0:27-0:45	0:18-0:23	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:54-1:44	1:57-2:15	1:12-1:57	0:45-1:12	0:32-1:30[7]	0:23-0:41[7]		
		75/25	0:36-1:12	2:11-2:38	1:17-2:11	0:41-1:17	0:23-1:03[7]	0:23-0:41[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:27-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

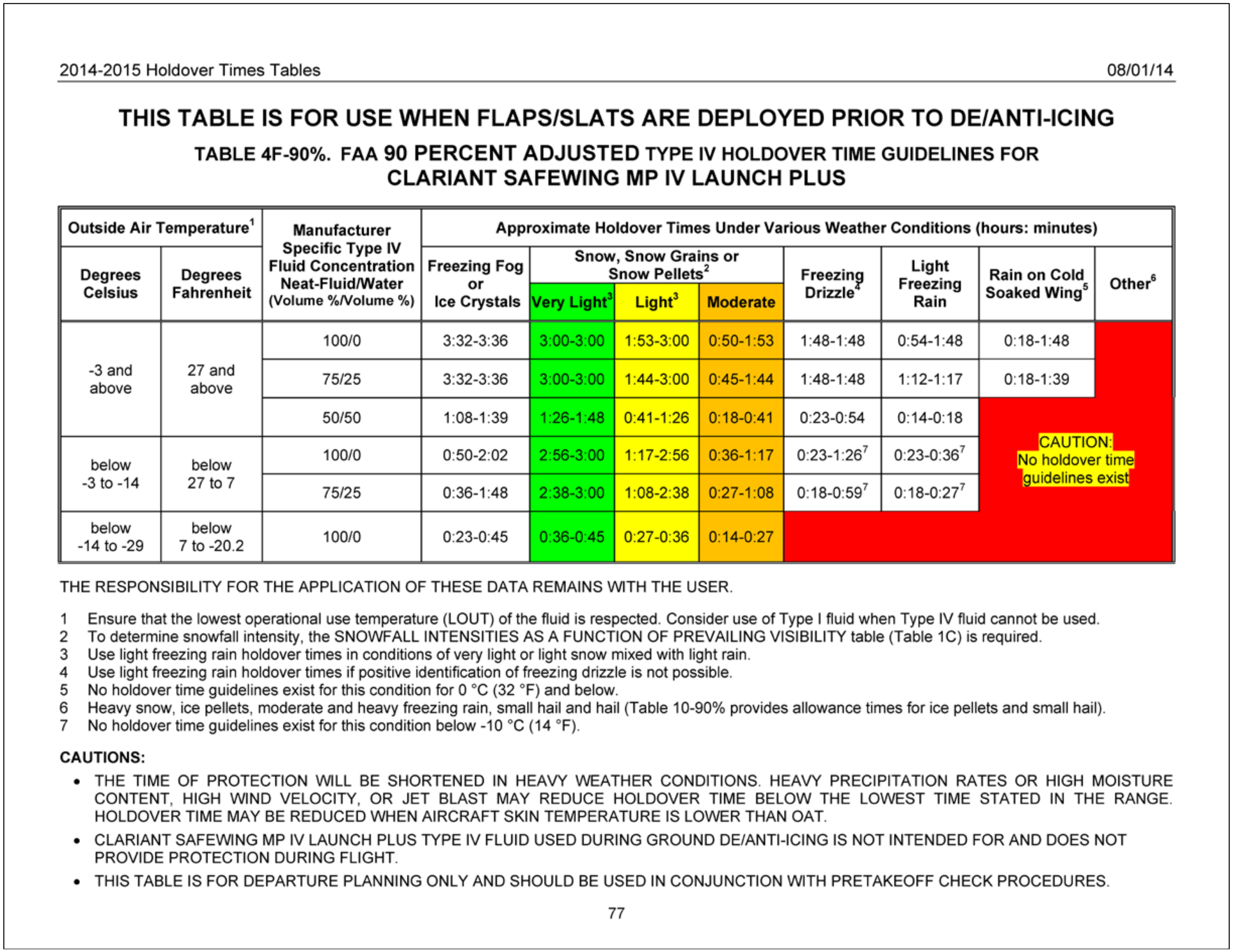
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT SAFEWING MP IV LAUNCH TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

76



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4F-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH PLUS

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	3:32-3:36	3:00-3:00	1:53-3:00	0:50-1:53	1:48-1:48	0:54-1:48	0:18-1:48	CAUTION: No holdover time guidelines exist
		75/25	3:32-3:36	3:00-3:00	1:44-3:00	0:45-1:44	1:48-1:48	1:12-1:17	0:18-1:39	
		50/50	1:08-1:39	1:26-1:48	0:41-1:26	0:18-0:41	0:23-0:54	0:14-0:18		
below -3 to -14	below 27 to 7	100/0	0:50-2:02	2:56-3:00	1:17-2:56	0:36-1:17	0:23-1:26[7]	0:23-0:36[7]		
		75/25	0:36-1:48	2:38-3:00	1:08-2:38	0:27-1:08	0:18-0:59[7]	0:18-0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:23-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

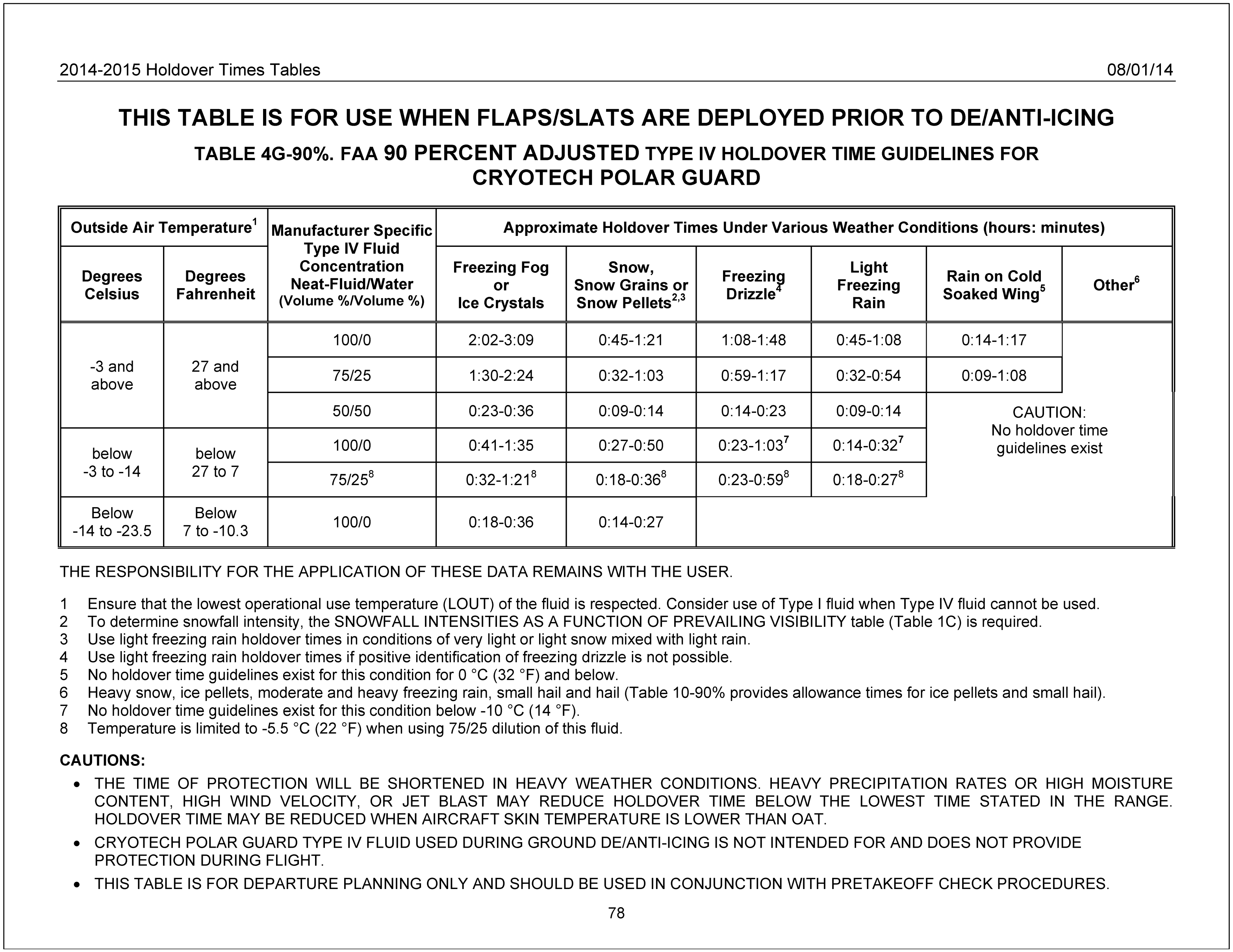
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

77



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4G-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD

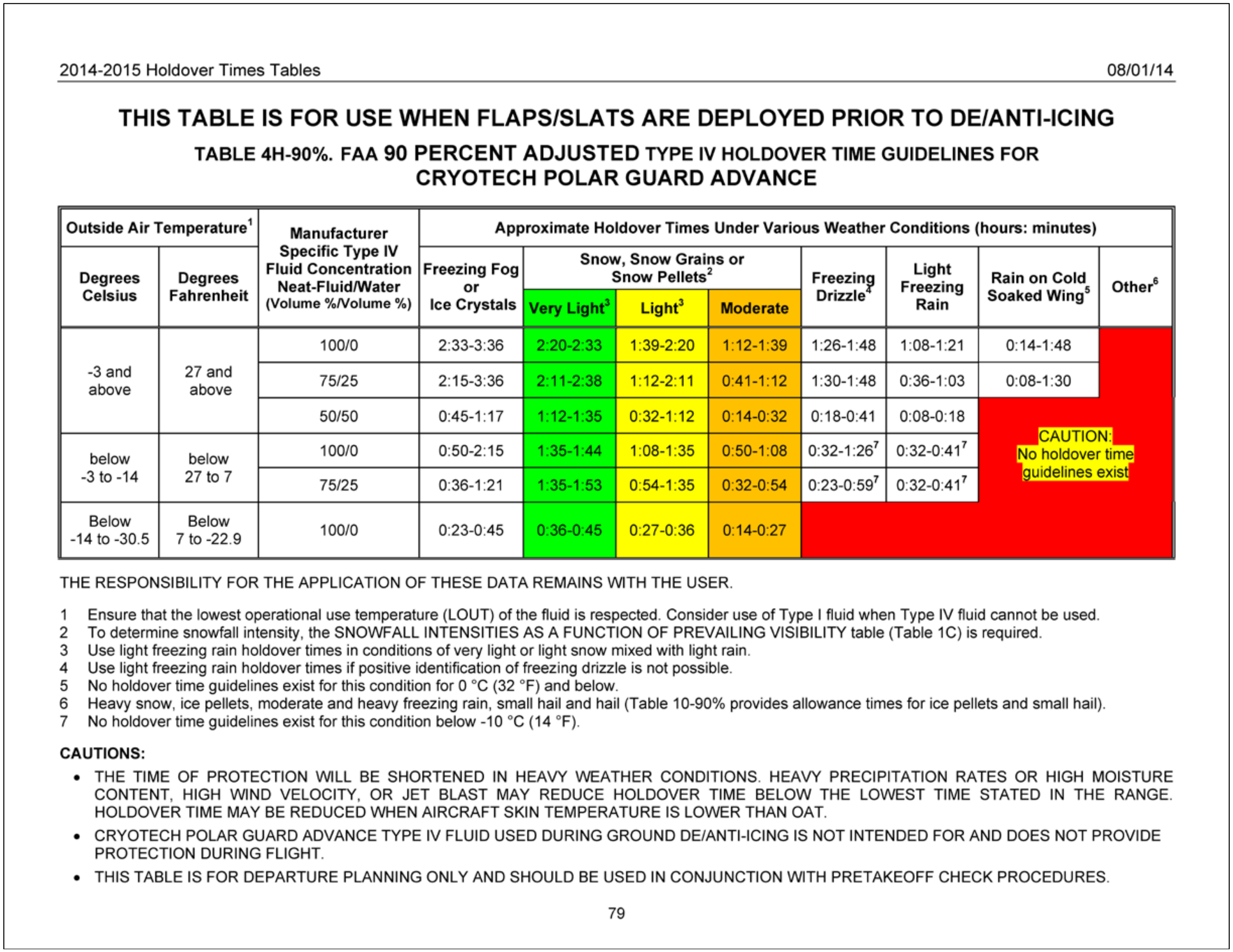
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:02-3:09	0:45-1:21	1:08-1:48	0:45-1:08	0:14-1:17	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:24	0:32-1:03	0:59-1:17	0:32-0:54	0:09-1:08	
		50/50	0:23-0:36	0:09-0:14	0:14-0:23	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:41-1:35	0:27-0:50	0:23-1:03[7]	0:14-0:32[7]		
		75/25[8]	0:32-1:21[8]	0:18-0:36[8]	0:23-0:59[8]	0:18-0:27[8]		
Below -14 to -23.5	Below 7 to -10.3	100/0	0:18-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Temperature is limited to -5.5 °C (22 °F) when using 75/25 dilution of this fluid.

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CRYOTECH POLAR GUARD TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4H-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD ADVANCE

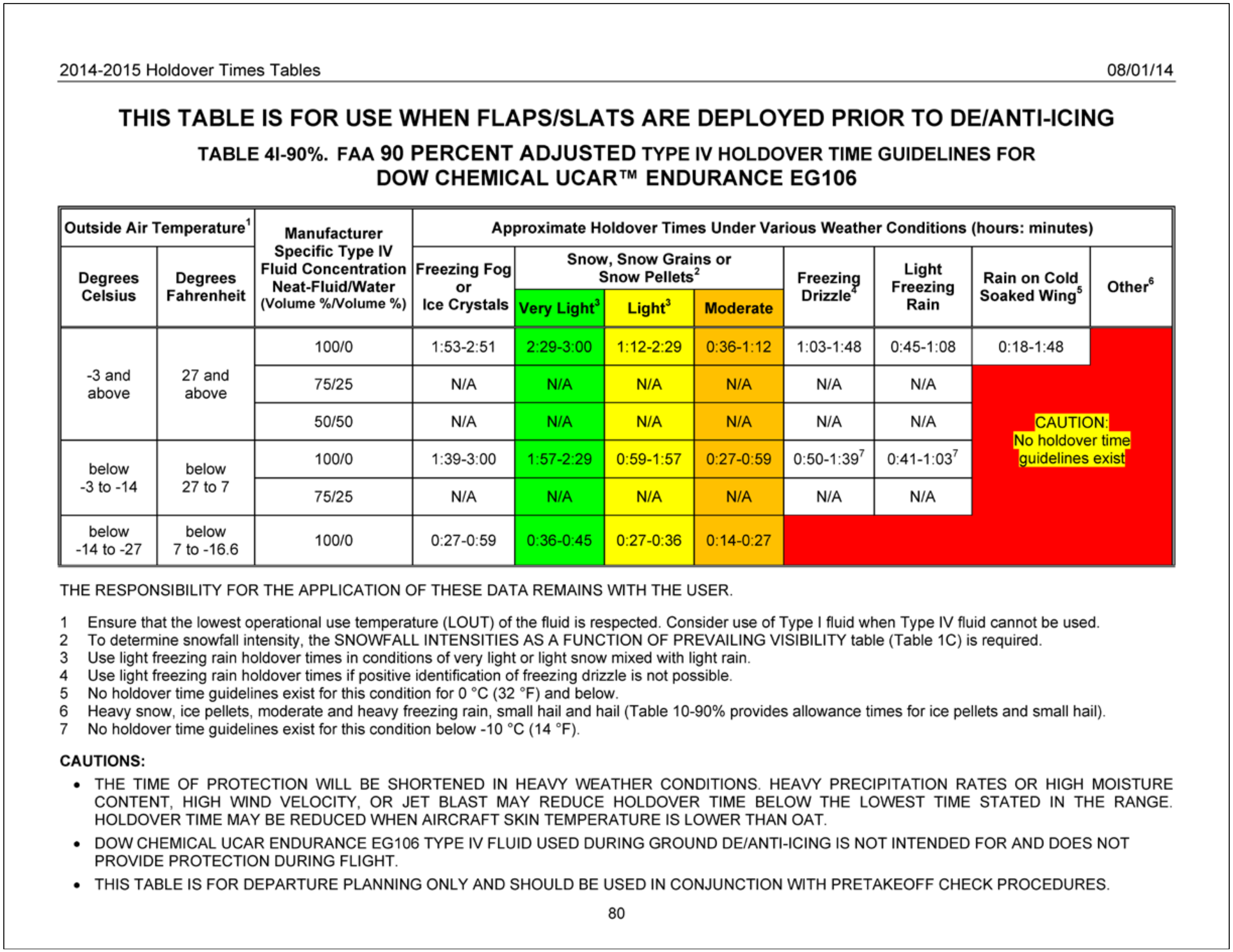
Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	2:33-3:36	2:20-2:33	1:39-2:20	1:12-1:39	1:26-1:48	1:08-1:21	0:14-1:48	
		75/25	2:15-3:36	2:11-2:38	1:12-2:11	0:41-1:12	1:30-1:48	0:36-1:03	0:08-1:30	
		50/50	0:45-1:17	1:12-1:35	0:32-1:12	0:14-0:32	0:18-0:41	0:08-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-2:15	1:35-1:44	1:08-1:35	0:50-1:08	0:32-1:26[7]	0:32-0:41[7]		
		75/25	0:36-1:21	1:35-1:53	0:54-1:35	0:32-0:54	0:23-0:59[7]	0:32-0:41[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:23-0:45	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- CRYOTECH POLAR GUARD ADVANCE TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4I-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ ENDURANCE EG106

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:53-2:51	2:29-3:00	1:12-2:29	0:36-1:12	1:03-1:48	0:45-1:08	0:18-1:48	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:39-3:00	1:57-2:29	0:59-1:57	0:27-0:59	0:50-1:39[7]	0:41-1:03[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -27	below 7 to -16.6	100/0	0:27-0:59	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR ENDURANCE EG106 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4J-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480

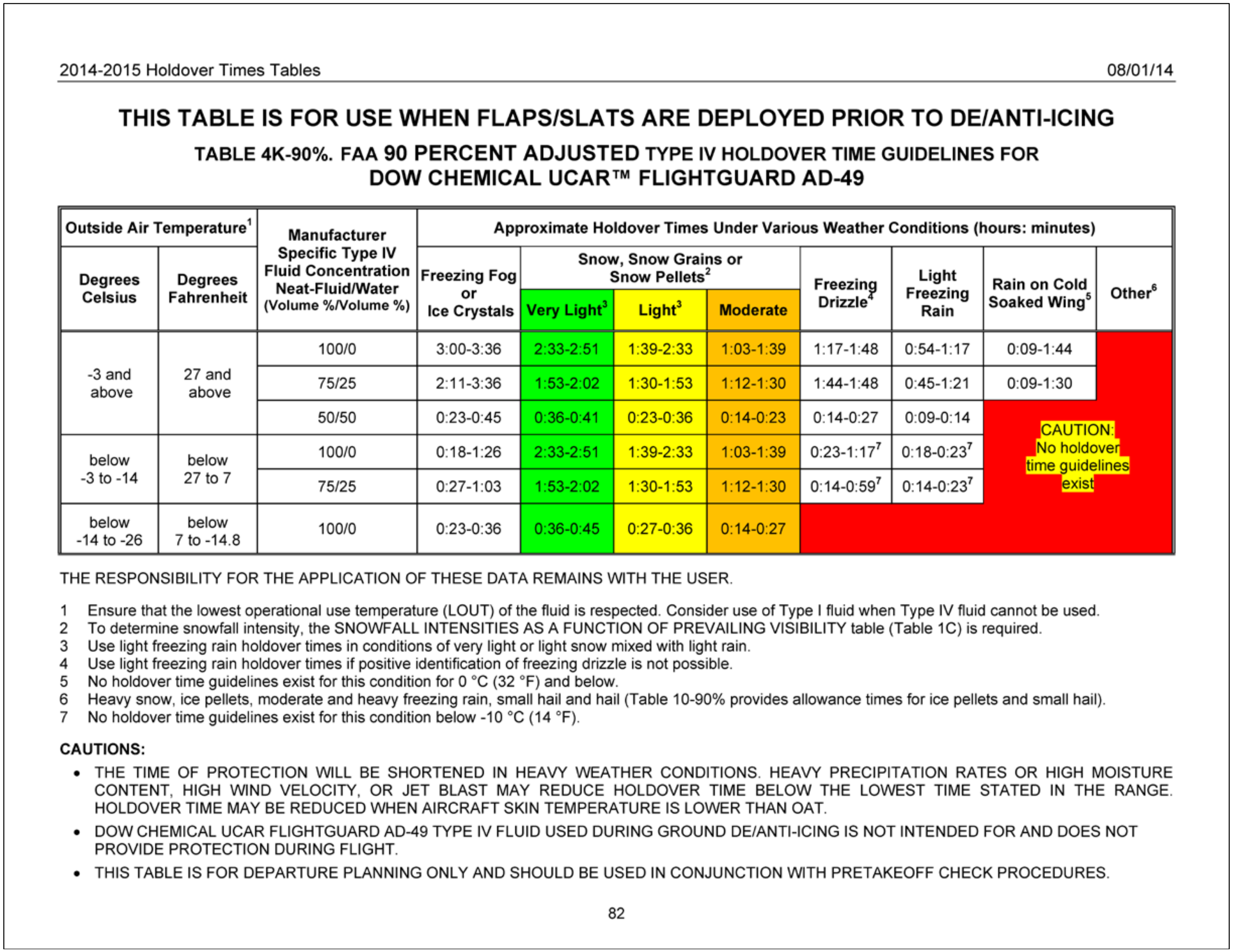
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:48-3:09	0:36-1:12	0:45-1:21	0:32-0:50	0:14-1:26	CAUTION: No holdover time guidelines exist
		75/25	1:21-2:29	0:27-0:59	0:45-1:08	0:27-0:41	0:09-1:08	
		50/50	0:27-0:41	0:08-0:18	0:14-0:23	0:08-0:14		
below -3 to -14	below 27 to 7	100/0	0:18-1:12	0:27-0:50	0:23-1:12[7]	0:14-0:27[7]		
		75/25	0:23-0:45	0:18-0:41	0:23-0:59[7]	0:14-0:27[7]		
below -14 to -26	below 7 to -14.8	100/0	0:14-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR FLIGHTGUARD AD-480 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4K-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow, Snow Grains or Snow Pellets[2]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:00-3:36	2:33-2:51	1:39-2:33	1:03-1:39	1:17-1:48	0:54-1:17	0:09-1:44	CAUTION: No holdover time guidelines exist
		75/25	2:11-3:36	1:53-2:02	1:30-1:53	1:12-1:30	1:44-1:48	0:45-1:21	0:09-1:30	
		50/50	0:23-0:45	0:36-0:41	0:23-0:36	0:14-0:23	0:14-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:18-1:26	2:33-2:51	1:39-2:33	1:03-1:39	0:23-1:17[7]	0:18-0:23[7]		
		75/25	0:27-1:03	1:53-2:02	1:30-1:53	1:12-1:30	0:14-0:59[7]	0:14-0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23-0:36	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- DOW CHEMICAL UCAR FLIGHTGUARD AD-49 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4L-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR KILFROST ABC-S

Outside Air Temperature[1]		**Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:20-3:36	0:54-1:30	1:12-1:39	0:54-1:17	0:18-1:08	CAUTION: No holdover time guidelines exist
		75/25	0:59-1:35	0:27-0:50	0:41-1:03	0:32-0:45	0:09-0:45	
		50/50	0:18-0:32	0:06-0:14	0:14-0:18	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:41-1:53	0:41-1:12	0:18-0:54[7]	0:09-0:27[7]		
		75/25	0:23-0:54	0:23-0:45	0:18-1:03[7]	0:09-0:32[7]		
below -14 to -28	below 7 to -18.4	100/0	0:18-0:36	0:14-0:27				

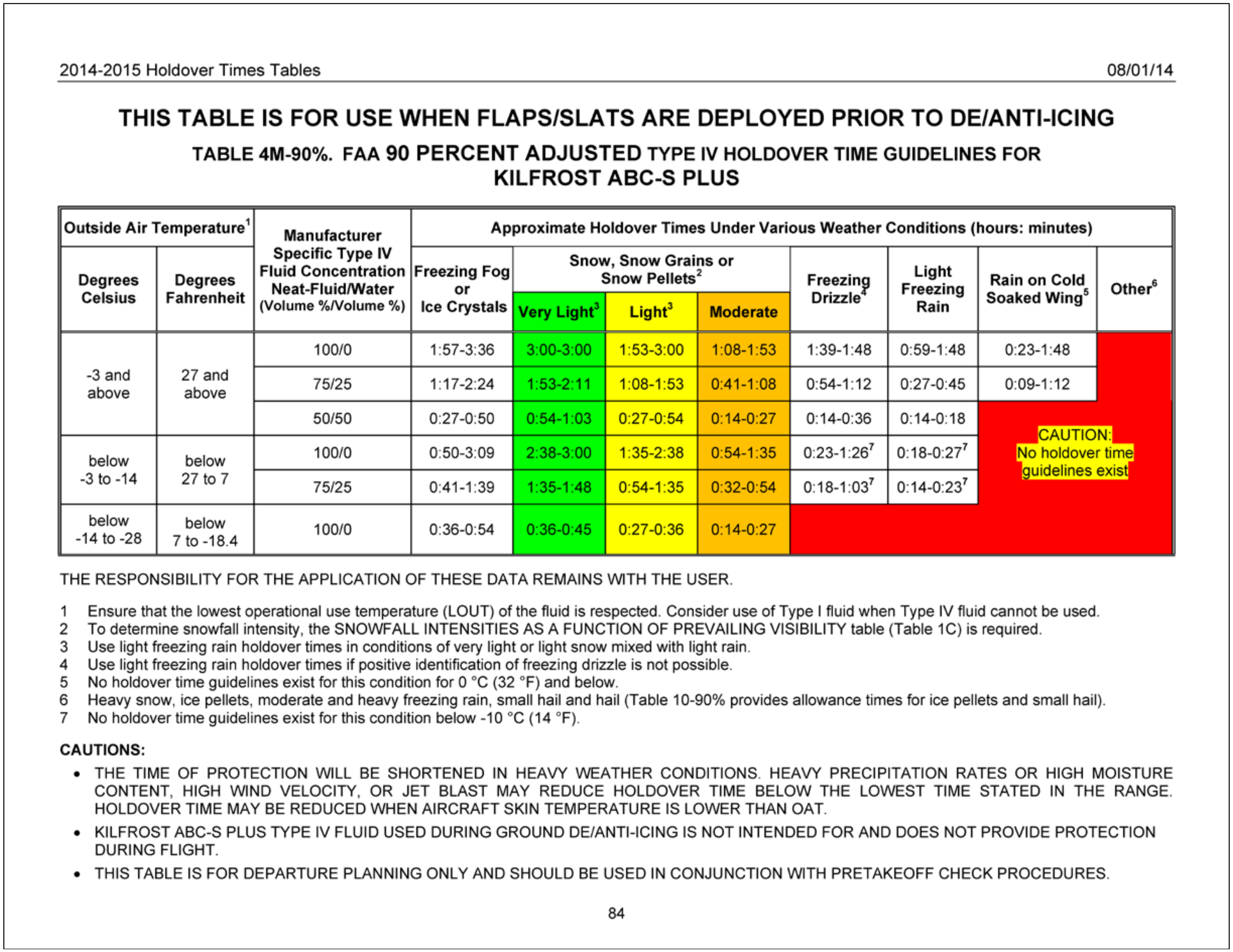
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-S TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

83



2014-2015 Holdover Times Tables 08/01/14

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4M-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR KILFROST ABC-S PLUS

Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:57-3:36	3:00-3:00	1:53-3:00	1:08-1:53	1:39-1:48	0:59-1:48	0:23-1:48	CAUTION: No holdover time guidelines exist
		75/25	1:17-2:24	1:53-2:11	1:08-1:53	0:41-1:08	0:54-1:12	0:27-0:45	0:09-1:12	
		50/50	0:27-0:50	0:54-1:03	0:27-0:54	0:14-0:27	0:14-0:36	0:14-0:18		
below -3 to -14	below 27 to 7	100/0	0:50-3:09	2:38-3:00	1:35-2:38	0:54-1:35	0:23-1:26[7]	0:18-0:27[7]		
		75/25	0:41-1:39	1:35-1:48	0:54-1:35	0:32-0:54	0:18-1:03[7]	0:14-0:23[7]		
below -14 to -28	below 7 to -18.4	100/0	0:36-0:54	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- KILFROST ABC-S PLUS TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

84

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4N-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS E450

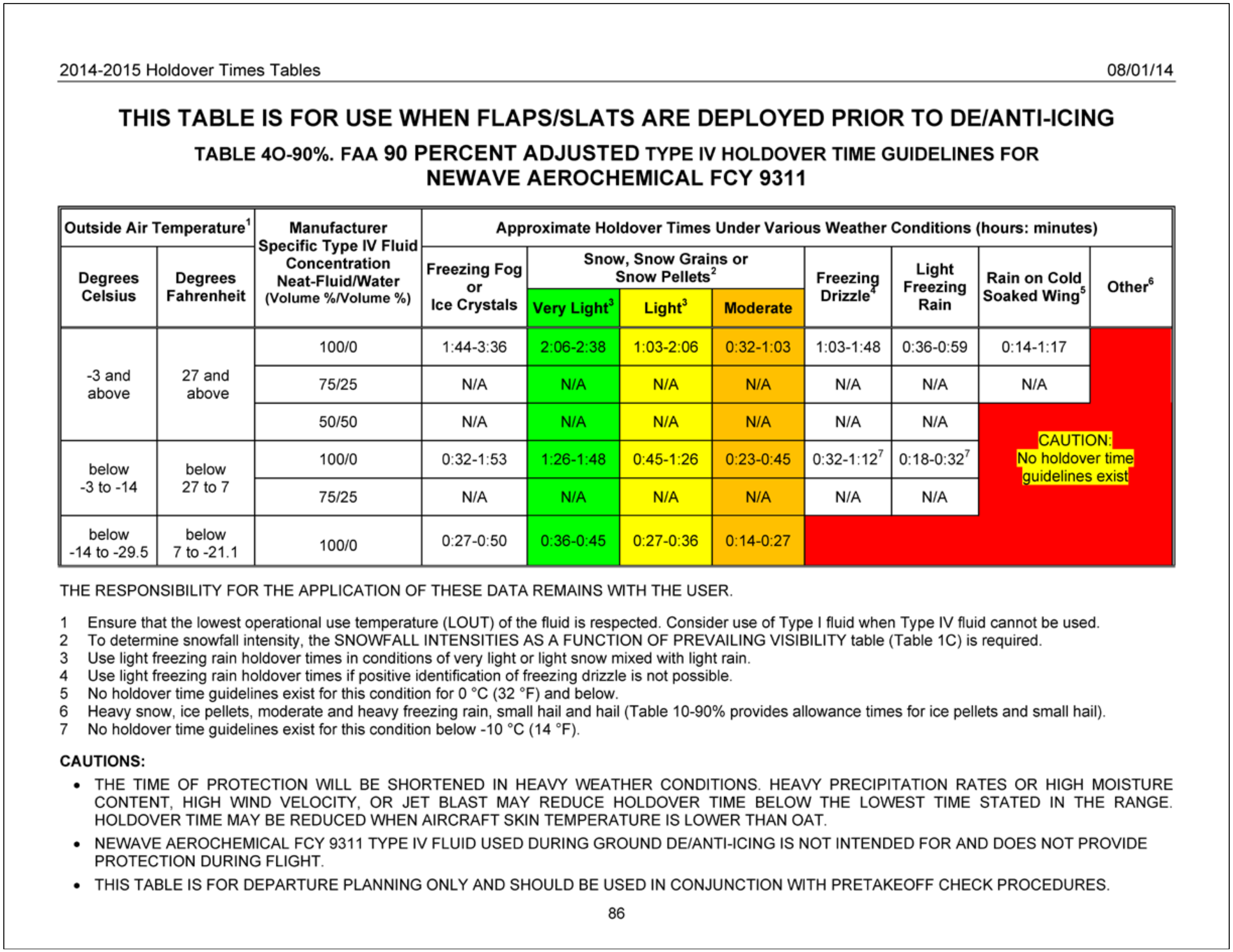
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:39-2:38	0:32-1:03	1:26-1:48	0:50-1:12	0:23-1:48	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:21-3:32	0:23-0:45	1:35-1:48[7]	0:59-1:30[7]		
		75/25	N/A	N/A	N/A	N/A		
below -14 to LOUT	below 7 to LOUT	100/0	0:32-0:59	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- LNT SOLUTIONS E450 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4O-90%. FAA 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY 9311

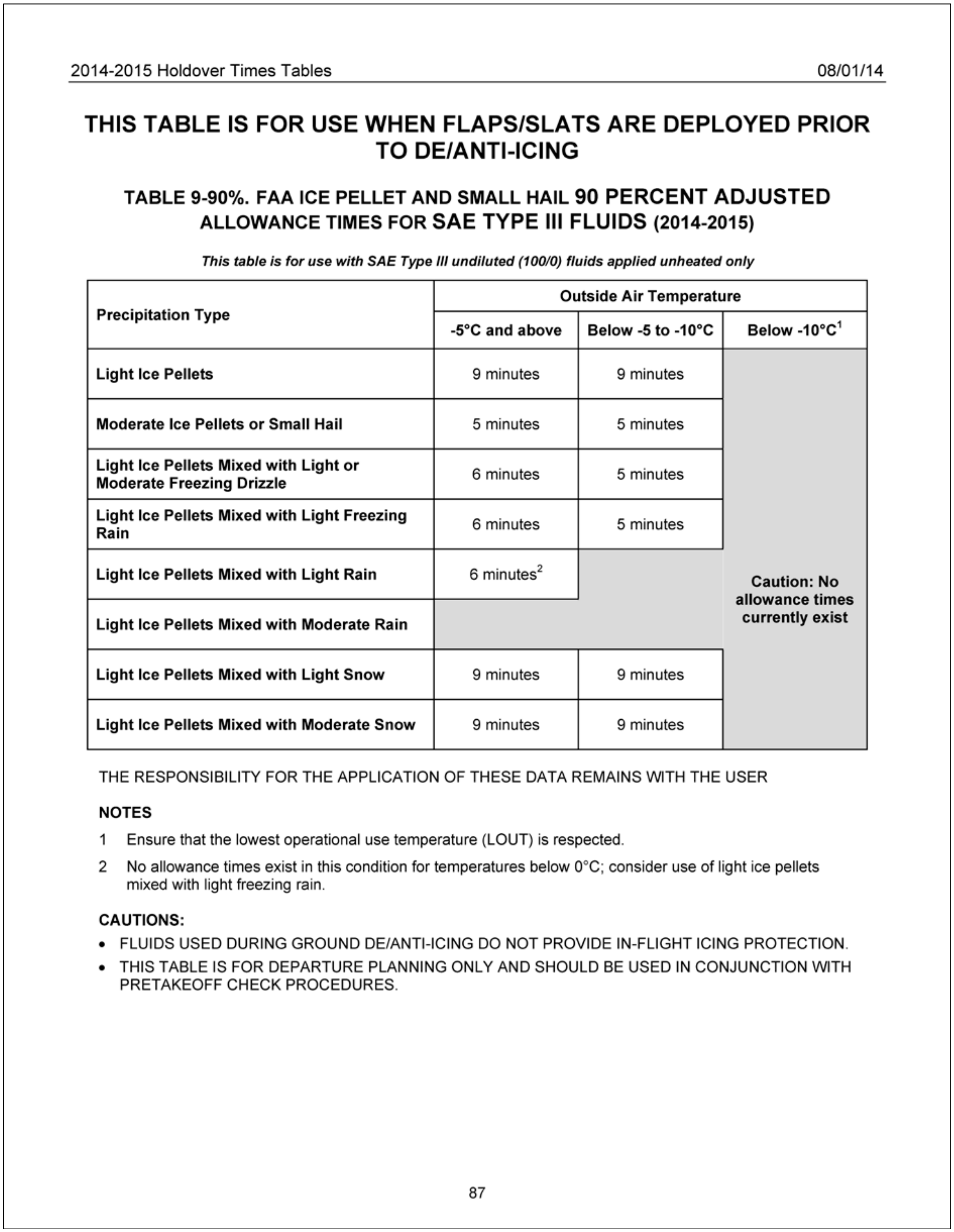
Outside Air Temperature[1]		Manufacturer Specific Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
				Snow, Snow Grains or Snow Pellets[2]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:44-3:36	2:06-2:38	1:03-2:06	0:32-1:03	1:03-1:48	0:36-0:59	0:14-1:17	
		75/25	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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:32-1:53	1:26-1:48	0:45-1:26	0:23-0:45	0:32-1:12[7]	0:18-0:32[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:27-0:50	0:36-0:45	0:27-0:36	0:14-0:27				

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

1 Ensure that the lowest operational use temperature (LOUT) of the fluid is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY table (Table 1C) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 10-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY, OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.
- NEWAVE AEROCHEMICAL FCY 9311 TYPE IV FLUID USED DURING GROUND DE/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 9-90%. FAA ICE PELLET AND SMALL HAIL 90 PERCENT ADJUSTED ALLOWANCE TIMES FOR SAE TYPE III FLUIDS (2014-2015)

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[1]
Light Ice Pellets	9 minutes	9 minutes	Caution: No allowance times currently exist
Moderate Ice Pellets or Small Hail	5 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	6 minutes[2]		
Light Ice Pellets Mixed with Moderate Rain			
Light Ice Pellets Mixed with Light Snow	9 minutes	9 minutes	
Light Ice Pellets Mixed with Moderate Snow	9 minutes	9 minutes	

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

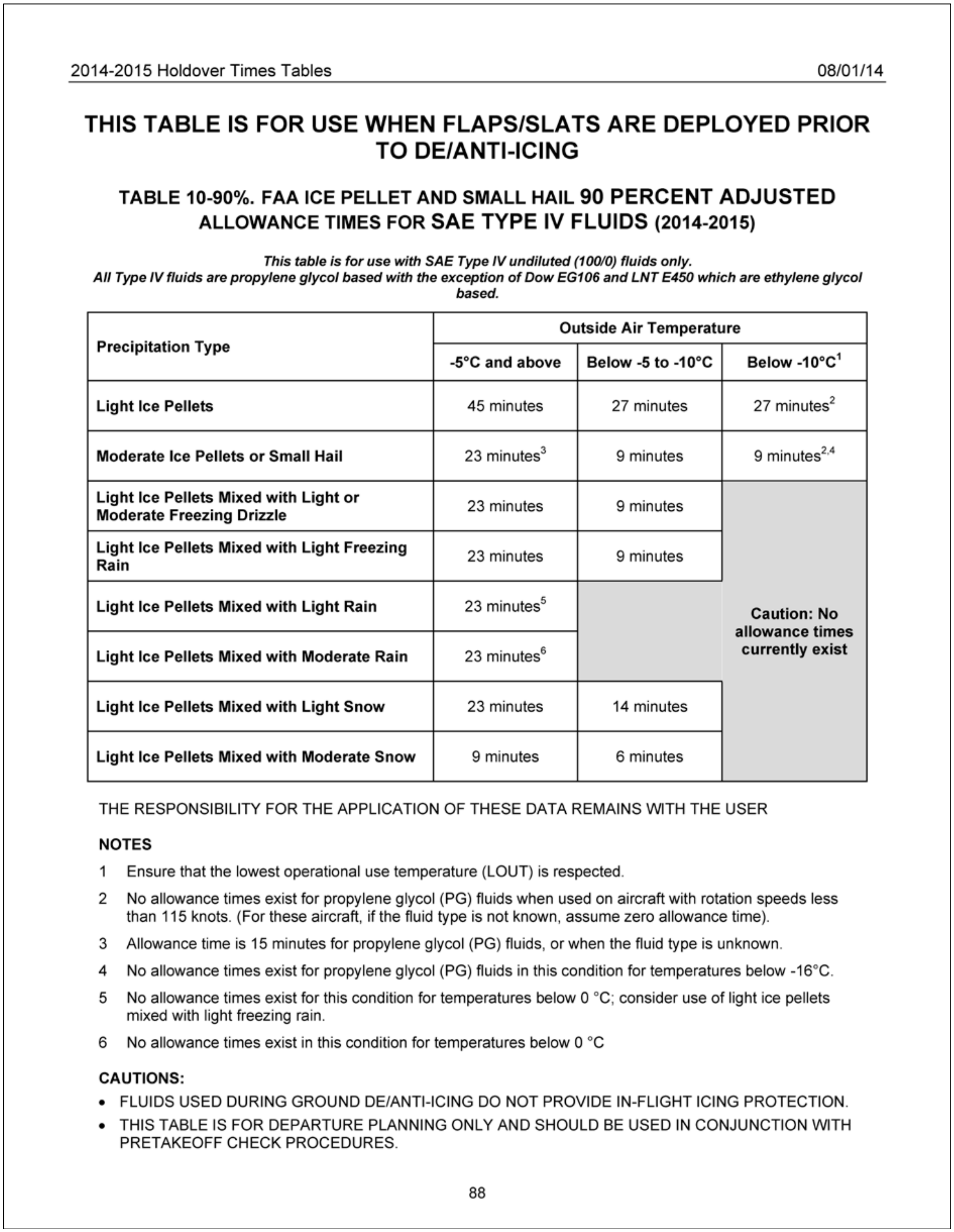
NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.

2 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.



THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 10-90%. FAA ICE PELLET AND SMALL HAIL 90 PERCENT ADJUSTED ALLOWANCE TIMES FOR SAE TYPE IV FLUIDS (2014-2015)

This table is for use with SAE Type IV undiluted (100/0) fluids only.
All Type IV fluids are propylene glycol based with the exception of Dow EG106 and LNT E450 which are ethylene glycol based.

Precipitation Type	**Outside Air Temperature**		
	-5°C and above	**Below -5 to -10°C**	**Below -10°C[1]**
Light Ice Pellets	45 minutes	27 minutes	27 minutes[2]
Moderate Ice Pellets or Small Hail	23 minutes[3]	9 minutes	9 minutes[2,4]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	23 minutes	9 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	23 minutes	9 minutes	
Light Ice Pellets Mixed with Light Rain	23 minutes[5]		
Light Ice Pellets Mixed with Moderate Rain	23 minutes[6]		
Light Ice Pellets Mixed with Light Snow	23 minutes	14 minutes	
Light Ice Pellets Mixed with Moderate Snow	9 minutes	6 minutes	

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

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected.

2 No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time).

3 Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.

4 No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16°C.

5 No allowance times exist for this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.

6 No allowance times exist in this condition for temperatures below 0 °C

CAUTIONS:

- FLUIDS USED DURING GROUND DE/ANTI-ICING DO NOT PROVIDE IN-FLIGHT ICING PROTECTION.
- THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.