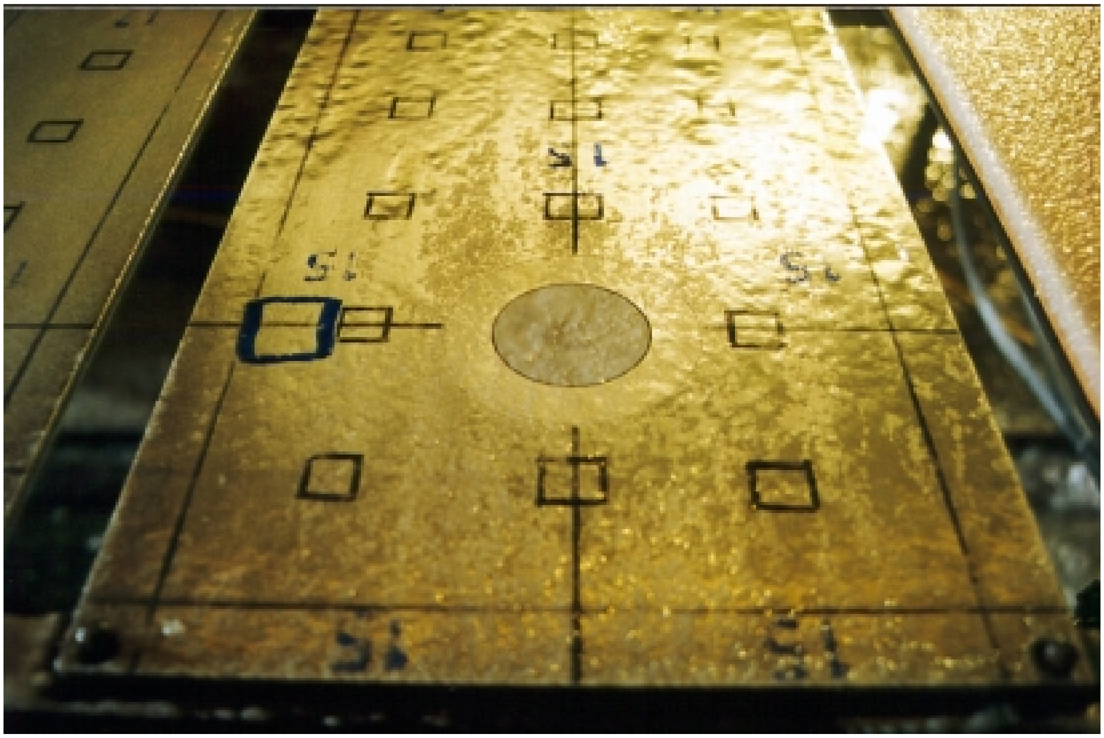
TP 13826E

Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter



Prepared for

Transportation Development Centre
On behalf of
Civil Aviation

Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

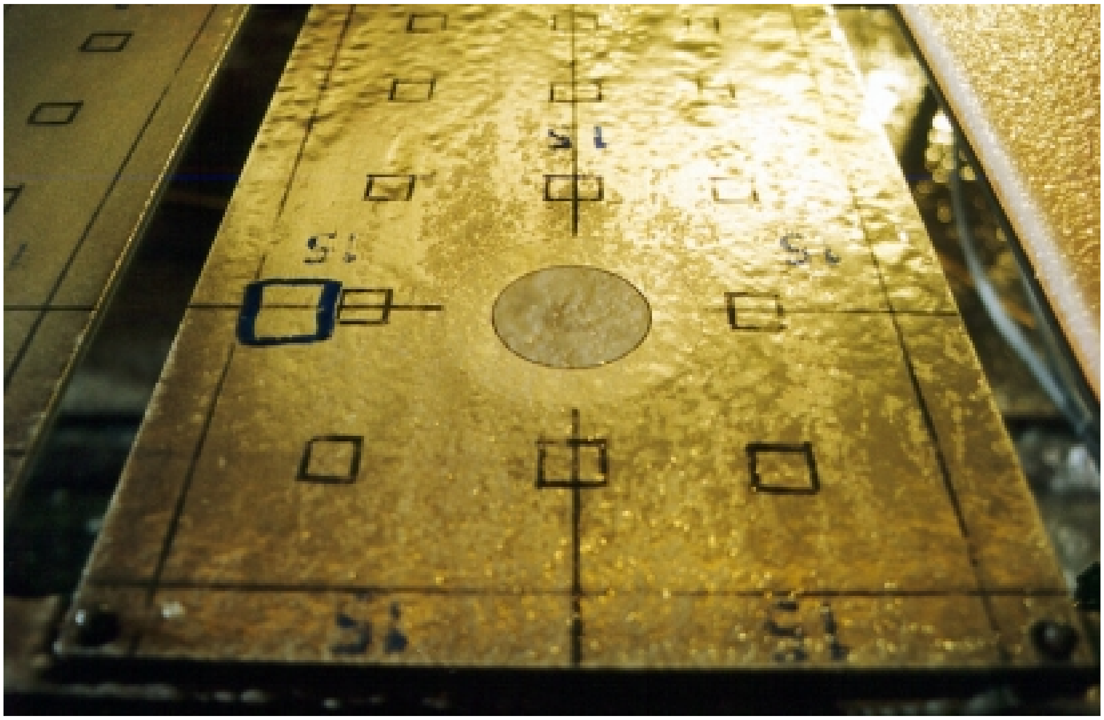
APS AVIATION INC.

December 2001

Final Version 1.0

TP 13826E

Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter



by

Michael Chaput

and

Richard Campbell

APS AVIATION INC.

December 2001

Final Version 1.0

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

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

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:	Michael Chaput Manager, Aircraft Deicing Fluid Testing	Aug 23, 2005 Date
And by:	Richard Campbell, Project Analyst	

Reviewed by: John D'Avirro, Program Manager — Date: Aug 23 2005

Approved by: R.V. Potter, PhD, Vice-President Programs & QA — Date: 23/8/05

Un sommaire français se trouve avant la table des matières.

PREFACE

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

- To develop holdover time data for all newly qualified de/anti-icing fluids;
- To conduct endurance time frost tests for each temperature to substantiate the values in the current SAE holdover time guidelines for Type IV, Type II, and Type I fluids;
- To evaluate weather data from previous winters to establish a range of snow precipitation suitable for the evaluation of holdover time limits;
- To develop a protocol for Type I fluid testing;
- To examine the change in viscosity during the application of Type IV fluids;
- To compare holdover times in natural snow with those in NCAR's artificial snow;
- To prepare the JetStar and Canadair RJ wing for thermodynamic tests;
- To further evaluate the flow of contaminated fluid from the wing of a Falcon 20D aircraft during simulated take-off runs;
- To further evaluate hot water deicing;
- To provide support for tactile tests at Toronto Central Deicing Facility; and
- To investigate the use of ice sensors in the pre-take-off contamination check.

The research activities during the winter of 2000-01 are documented in six reports. The last four objectives listed above have not yet been finalized and are not included in this series of reports. Results will be reported upon study completion. The titles of the documented reports are as follows:

- TP 13826E Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter;
- TP 13827E SAE Type I Fluid Endurance Time Test Protocol;
- TP 13828E Endurance Time Testing in Snow: Reconciliation of Indoor and Outdoor Data;
- TP 13829E Modification of Test Wing to Accommodate Fuel Load Effects for Deicing Research: 2001;
- TP 13830E Winter Weather Data Evaluation: (1995-2001); and
- TP 13831E Endurance Time Tests in Simulated Frost Conditions: 2001.

In addition, an interim report entitled *Viscosity Measurement of Type IV Fluids on Wing Surfaces* will be written.

This report, TP 13826E, documents the project with the following objective:

- To develop holdover time data for all newly qualified de/anti-icing fluids.

This objective was met by conducting holdover time tests on different fluids in simulated freezing precipitation at the NRC Climatic Engineering Facility in Ottawa, and by carrying out tests in natural snow conditions at a test facility operated by APS at Dorval Airport in Montreal.

ACKNOWLEDGEMENTS

This research has been funded by the Civil Aviation Group, Transport Canada, with support from the U.S. Federal Aviation Administration. This program could not have been accomplished without the participation of many organizations. APS would therefore like to thank the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, National Research Council Canada, the Meteorological Service of Canada, and several fluid manufacturers. Special thanks are extended to US Airways Inc., Air Canada, the National Center for Atmospheric Research, AéroMag 2000, Aéroports de Montreal, G. Vestergaard A/S, Hudson General Aviation Services Inc., Union Carbide/Dow, Cryotech, BFGoodrich, Cox and Company Inc., Fortier Transfert Ltée, and MTN Snow Equipment Inc. for provision of personnel and facilities, and for their cooperation with the test program. APS would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data.

The authors gratefully acknowledge the contribution of the APS Aviation Inc. data collection and research team: Nicolas Blais, Tara Newman, Bassem Ghobrial, Derek Flis, Elio Ruggi, Nicoara Moc, Kerri Henry, Philip LeBlanc, Tommy Furino, Marc Mayodon, Jeff Mayhew, Alexander Butler, Dominic Werugia, James Kollmar, Marc Antoni Goulet, Sami Chebil, Shawn Kearns, Alia Alwaid and Yagusha Bodnar.

Special thanks are extended to Frank Eyre and Barry Myers of the Transportation Development Centre for their participation, contribution, and guidance in the preparation of this document.

Transport Canada | Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 13826E	2. Project No. 5031-34	3. Recipient's Catalogue No.
4. Title and Subtitle Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter		5. Publication Date December 2001 6. Performing Organization Document No. CM1680.001
7. Author(s) Michael Chaput and Richard Campbell		8. Transport Canada File No. ZCD2450-B-14
9. Performing Organization Name and Address APS Aviation Inc. 1100 René Lévesque Blvd. West Suite 1340 Montreal, Quebec H3B 4N4		10. PWGSC File No. MTB-0-02254 11. PWGSC or Transport Canada Contract No. T8200-000556/001/MTB
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) 800 René Lévesque Blvd. West Suite 600 Montreal, Quebec H3B 1X9		13. Type of Publication and Period Covered Final 14. Project Officer Barry B. Myers

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

Research reports produced on behalf of Transport Canada for testing during previous winters are available from the Transportation Development Centre (TDC). Six reports (including this one) were produced as part of this winter's research program. Their subject matter is outlined in the preface.

16. Abstract

The objective of the 2000-01 holdover time test program was to evaluate the performance of newly and previously qualified deicing and anti-icing fluids over the entire range of conditions encompassed by the holdover time guidelines. These tests involved using fluid samples selected by the various manufacturers according to the sample selection procedures specified in proposed Aerospace Standard 5485.

The endurance time test procedure consisted of pouring fluids onto clean aluminium test surfaces inclined at 10º. The onset of failure was recorded as a function of time in natural snow and artificial conditions including simulated freezing fog, freezing drizzle, light freezing rain, and rain on a cold-soaked wing. Type II and Type IV fluids were supplied by Clariant, Octagon, UCAR/Dow, and SPCA, and were tested in neat and diluted forms. Type I fluids were supplied by Clariant, Lyondell, and Newave Aerochemical. A total of 812 endurance time tests were performed either at the APS Dorval Airport test facility or at National Research Council Canada's Climatic Engineering Facility in Ottawa.

De/anti-icing fluid holdover times were determined using a multi-variable regression analysis, resulting in seven reductions to the generic Type IV fluid table. In addition to the seven reductions, eight increases were made to the generic Type IV table due to the elimination of obsolete data. No changes were made to the Type I or Type II tables. Transport Canada and the U.S. Federal Aviation Administration (FAA) will continue to endorse the Type I fluid table that existed prior to the changes made at the SAE G-12 meetings in Toulouse, France, in May 2000. The SAE no longer endorses or publishes generic holdover time guidelines. These guidelines will continue to be published by Transport Canada and the FAA.

17. Key Words Anti-icing, deicing, deicing fluid, holdover times, precipitation	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	—	xxvi, 250, apps	Shipping/ Handling

CDT/TDC 79-005
Rev. 96

Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada TP 13826E	2. N° de l'étude 5031-34	3. N° de catalogue du destinataire
4. Titre et sous-titre Aircraft Ground De/Anti-icing Fluid Holdover Time Development Program for the 2000-01 Winter		5. Date de la publication Décembre 2001
		6. N° de document de l'organisme exécutant CM1680.001
7. Auteur(s) Michael Chaput et Richard Campbell		8. N° de dossier - Transports Canada ZCD2450-B-14
9. Nom et adresse de l'organisme exécutant APS Aviation Inc. 1100, boul. René-Lévesque Ouest Bureau 1340 Montréal (Québec) H3B 4N4		10. N° de dossier - TPSGC MTB-0-02254
		11. N° de contrat - TPSGC ou Transports Canada T8200-000556/001/MTB
12. Nom et adresse de l'organisme parrain Centre de développement des transports (CDT) 800, boul. René-Lévesque Ouest Bureau 600 Montréal (Québec) H3B 1X9		13. Genre de publication et période visée Final
		14. Agent de projet Barry B. Myers

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

Les rapports de recherche produits au nom de Transports Canada sur les essais réalisés au cours des hivers antérieurs peuvent être obtenus auprès du Centre de développement des transports (CDT). Le programme de la saison hivernale a donné lieu à six rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports.

16. Résumé

L'objectif du programme d'essais de durée d'efficacité de l'hiver 2000-2001 était d'évaluer la performance de liquides de dégivrage/antigivre déjà ou nouvellement homologués, dans toute la gamme des conditions météorologiques couvertes par le guide sur les durées d'efficacité. Les essais ont été réalisés à l'aide d'échantillons de liquides sélectionnés par les divers fabricants conformément à la procédure d'échantillonnage indiquée dans le projet de norme Aerospace Standard 5485.

Les essais d'endurance consistaient à verser les liquides sur des surfaces en aluminium propres, inclinées à 10°. On notait ensuite l'amorce de la perte d'efficacité en fonction du temps, sous la neige naturelle et dans des conditions artificielles simulant de la bruine verglaçante, du brouillard verglaçant, de la pluie légère verglaçante et de la pluie sur une aile imprégnée de froid. Les liquides de type II et de type IV, fournis par Clariant, Octagon, UCAR/Dow et SPCA, ont été essayés purs et dilués. Les liquides de type I provenaient de Clariant, Lyondell et Newave Aerochemical. Un total de 812 essais ont été réalisés au site d'essai d'APS à l'Aéroport de Dorval et à l'Installation de génie climatique du Conseil national de recherches du Canada (CNRC) à Ottawa.

Les durées d'efficacité, déterminées par une analyse de régression multi-dimensionnelle, ont mené à la diminution de sept valeurs du tableau générique des durées d'efficacité des liquides de type IV. De plus, huit valeurs de ce même tableau ont été augmentées, par suite de l'élimination de données périmées. Par contre, aucun changement n'a été apporté aux tableaux concernant les liquides de type I ou de type II. Transports Canada et la Federal Aviation Administration (FAA) des États-Unis entendent continuer de reconnaître le tableau des durées d'efficacité des liquides de type I tel qu'il existait avant que des changements y soient apportés lors des réunions des sous-comités G-12 de la SAE tenues en mai 2000 à Toulouse, en France. La SAE ne reconnaît plus les guides génériques sur les durées d'efficacité et n'en publie plus. Mais Transports Canada et la FAA continueront de publier ces guides.

17. Mots clés Antigivrage, dégivrage, liquide de dégivrage, durées d'efficacité, précipitation	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xxvi, 250, ann.	Port et manutention

EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre of Transport Canada and co-sponsored by the Federal Aviation Administration, APS Aviation Inc. (APS) has undertaken a test and evaluation program to further advance aircraft pre-flight de/anti-icing technology. While a number of objectives of the test program are documented in a series of related reports, the primary objectives specifically addressed in this document were to develop holdover time tables for new de/anti-icing fluids and to validate generic tables.

The project involved the participation of several de/anti-icing fluid manufacturers, the Transportation Development Centre of Transport Canada, National Research Council Canada (NRC), the U.S. Federal Aviation Administration (FAA), and the Meteorological Service of Canada (MSC).

Holdover time tests consisted of pouring freezing point depressant fluids onto clean, inclined (10°), standard flat aluminum plates. The plates were mounted on a test stand and systematically exposed to an array of natural or artificially produced icing conditions. For every plate, the elapsed time required to reach a predefined end condition was recorded. Test conditions, test parameters, and test bed specifications were determined based on the Society of Automotive Engineers (SAE) G-12 Holdover Time Subcommittee guidelines.

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

Data Collection

During the 2000-01 test season, data were collected for tests conducted during natural precipitation events at the APS Dorval airport test site. Data were also collected for artificial precipitation tests in the following simulated conditions: freezing drizzle, light freezing rain, freezing fog, snow, and rain on cold-soaked surfaces. The artificial precipitation tests were performed indoors at NRC's Climatic Engineering Facility in Ottawa. Tests in frost conditions had not been conducted in the past. In 2000-01, a series of frost tests were conducted by APS in an attempt to substantiate the holdover time values of SAE fluids (see Transport Canada report TP 13831E, *Endurance Time Tests in Simulated Frost Conditions*).

A total of 812 tests were conducted. The distribution of tests is listed Table 1 according to precipitation condition and fluid type. The majority of tests were carried out using Type IV fluids in natural snow conditions.

TABLE 1
Summary of Tests Conducted

	CONDITION					
Fluid Type	**Natural Snow**	**Freezing Drizzle**	**Light Freezing Rain**	**Freezing Fog**	**Cold Soak**	**Total**
Type I (10° buffer)	86	8	8	16	8	**126**
Type II (Neat)	30	7	8	12	4	**61**
Type II (75/25)	23	8	8	8	4	**51**
Type II (50/50)	27	5	4	4	-	**40**
Type IV (Neat)	96	32	24	38	16	**213**
Type IV (75/25)	94	27	28	27	17	**193**
Type IV (50/50)	89	18	12	16	-	**135**
Total	**445**	**105**	**92**	**121**	**49**	**812**

Meteorological Considerations

With the cooperation of MSC, APS was able to obtain detailed meteorological information for the tests at the Dorval site. The data provided by MSC instruments were automated and afforded minute-by-minute information such as total precipitation, wind speed, wind direction, visibility, and temperature. Precipitation was also collected at the Dorval site using plate pans. Data on rates of precipitation for natural snowfall versus temperature were also collected to assist in the evaluation of precipitation rate limits (see Transport Canada report TP 13830E, *Winter Weather Data Evaluation: 1995-2001*).

Holdover Time Tests

Five Type I fluids, one Type II fluid, and four Type IV fluids were tested by APS in 2000-01. A holdover time table was developed for one new SAE-qualified Type IV fluid. In addition, one previously certified Type IV fluid was retested. From the tests conducted in 2000-01, one generic holdover time guideline was assembled to reflect the holdover times of the worst performing fluid. In the fluid-specific holdover time tables, holdover times were determined using the regression analysis of the data collected for each specific fluid and for all categories of precipitation and temperature ranges.

Seven reductions were made to the generic Type IV table based on the results of Type IV fluid tests in 2000-01: five in the Freezing Drizzle column, and two in the category of Light Freezing Rain.

In addition to the seven reductions, eight generic holdover time values – four in each of the Snow and Freezing Drizzle columns of the generic Type IV table – were increased due to the elimination of data from obsolete fluids tested in 1996-97.

One change was made to the generic Type II table for use in 2001-02 winter operations. In the Light Freezing Rain column for Neat Type II fluid between -3 and -10°C, the upper generic value was reduced by five minutes based on the results of Type IV fluid tests from 2000-01. No changes to the Type II table were made as a result of the most recent Type II fluid tests.

No Type III fluids were available during the past season; therefore, no Type III tests were performed. A Type III holdover time table exists; however, the values need to be substantiated since the table was generated using a fluid that is no longer commercially available.

In general, the Type I holdover time results from tests conducted in 2000-01 agreed with the reduced generic Type I holdover time guidelines agreed upon at the SAE G-12 meetings in Toulouse, France, and no changes were made to the generic Type I table.

In addition to the endurance time testing of new fluids, APS evaluated the endurance time performance of a degraded viscosity sample of a certified Type IV fluid. The research team also conducted tests using certified Type IV fluids to determine differences between the results obtained at NRC and other facilities in conditions of light freezing rain and freezing drizzle.

Recommendations

It is recommended that:

- Any new Type I, Type II or Type IV fluids be evaluated over the entire range of conditions of the holdover time tables;
- The holdover time table for Type III fluids be re-evaluated if new Type III fluids become available for testing in the 2001-02 test season;
- Type II fluid-specific tables be generated for previously certified Type II fluids; and
- A new endurance time test procedure aimed at simulating a real-world Type I application to a wing be developed for Type I fluids.

SOMMAIRE

En vertu d'un contrat avec le Centre de développement des transports de Transports Canada, et avec le coparrainage de la Federal Aviation Administration, APS Aviation Inc. a entrepris un programme d'essai et d'évaluation qui vise à faire progresser la technologie de dégivrage/antigivrage des avions au sol. Plusieurs des objectifs assignés à ce programme sont traités dans une série de rapports déjà publiés. Les grands objectifs de la présente recherche étaient de mettre au point des tableaux de durées d'efficacité pour de nouveaux liquides de dégivrage/antigivre et de valider les tableaux génériques.

Ont participé au programme plusieurs fabricants de liquides dégivrants/antigivre, le Centre de développement des transports de Transports Canada, le Conseil national de recherches du Canada (CNRC), la Federal Aviation Administration des États-Unis et le Service météorologique du Canada (SMC).

Les essais de durée d'efficacité consistaient à verser des liquides abaisseurs du point de congélation sur des plaques standard en aluminium propres, inclinées (à 10°). Les plaques étaient montées sur un support et systématiquement exposées à une gamme de conditions verglaçantes, naturelles et simulées. Pour chaque plaque, on notait le temps nécessaire pour qu'une condition prédéterminée, indicatrice de la «perte d'efficacité» du liquide, soit remplie. Les conditions d'essai, les paramètres d'essai et les spécifications relatives au banc d'essai ont été déterminés en fonction des lignes directrices du sous-comité sur les durées d'efficacité G-12 de la SAE (Society of Automotive Engineers).

Les variables mesurées comprenaient le temps couru jusqu'à la perte d'efficacité, le type de précipitation, le taux de précipitation, la quantité totale de précipitation, la visibilité, la vitesse du vent, la direction du vent, la température ambiante, la température des surfaces d'essai, la marque du liquide, le type de liquide et la concentration du liquide.

Collecte des données

Pendant la campagne 2000-2001, des données ont été colligées au cours d'essais menés sous des précipitations naturelles au site d'essai de APS à l'Aéroport de Dorval. Des données ont aussi été colligées sous des précipitations artificielles de bruine verglaçante, de pluie légère verglaçante, de brouillard verglaçant, de neige et de pluie sur des surfaces imprégnées de froid. Ces derniers essais ont eu lieu à l'intérieur, à l'Installation de génie climatique du CNRC, à Ottawa. C'était la première fois qu'étaient menés des essais dans des conditions de givre. Ceux-ci avaient pour but d'étayer les valeurs de durée

d'efficacité des liquides de la SAE (voir le rapport TP 13831E de Transports Canada intitulé *Endurance Time Tests in Simulated Frost Conditions: 2001*).

Un total de 812 essais ont été réalisés. Le tableau 1 donne la ventilation de ces essais selon la précipitation et le type de liquide. La majorité mettaient en jeu des liquides de type IV dans des conditions de neige naturelle.

TABLEAU 1
Sommaire des essais

	PRÉCIPITATION					
Type de liquide	**Neige naturelle**	**Bruine vergl.**	**Pluie légère vergl.**	**Brouillard vergl.**	**Pluie sur surface imprégnée de froid**	**Total**
Type I (marge de sécurité de 10°)	86	8	8	16	8	**126**
Type II (pur)	30	7	8	12	4	**61**
Type II (75/25)	23	8	8	8	4	**51**
Type II (50/50)	27	5	4	4	-	**40**
Type IV (pur)	96	32	24	38	16	**213**
Type IV (75/25)	94	27	28	27	17	**193**
Type IV (50/50)	89	18	12	16	-	**135**
Total	**445**	**105**	**92**	**121**	**49**	**812**

Considérations météorologiques

Grâce à la collaboration du SMC, APS a pu obtenir des données météorologiques détaillées pour ses essais au site de Dorval. Les instruments du SEA transmettaient automatiquement, de minute en minute, l'information concernant la quantité totale de précipitation, la vitesse et la direction du vent, la visibilité et la température. À Dorval, les précipitations étaient également recueillies dans des bacs. Les données sur les taux de précipitation de neige naturelle en fonction de la température ont aussi été colligées; elles seront utiles pour déterminer les taux de précipitation limites (voir le rapport TP 13830E de Transports Canada, *Winter Weather Data Evaluation: 1995-2001*).

Essais de durée d'efficacité

Cinq liquides de type I, un liquide de type II et quatre liquides de type IV ont été testés par APS en 2000-2001. Un tableau des durées d'efficacité a été élaboré pour un nouveau liquide de type IV homologué par la SAE. De plus, un liquide de type IV certifié précédemment a été remis à l'essai. Les essais de 2000-2001 ont mené à la constitution d'un tableau générique des durées d'efficacité, dans lequel figurent les durées d'efficacité du liquide le moins performant. Quant aux durées d'efficacité qui figurent sur les tableaux dits spécifiques, elles ont été établies au terme de l'analyse de régression des résultats d'essai de chacun des liquides, pour toutes les catégories de précipitations et plages de températures.

Sept valeurs du tableau générique des liquides de type IV ont été réduites, à la lumière des résultats des essais des liquides de type IV menés en 2000-2001 : cinq dans la colonne *Brouillard verglaçant*, et deux dans la colonne *Pluie légère verglaçante*.

Outre ces sept réductions, huit valeurs de durée d'efficacité – quatre dans chacune des colonnes *Neige naturelle* et *Brouillard verglaçant* du tableau générique des liquides de type IV – ont été augmentées, par suite de l'élimination de données concernant des liquides essayés en 1996-1997 et retirés du marché depuis.

Un seul changement a été apporté au tableau générique des liquides de type II devant être publié pour la saison hivernale 2001-2002. À la colonne *Pluie légère verglaçante* correspondant au liquide de type II pur appliqué à une plage de températures allant de -3 °C à -10 °C, la valeur générique maximale a été réduite de cinq minutes, d'après les résultats des essais de liquides de type IV menés en 2000-2001. Aucun changement n'a été apporté au tableau des liquides de type II par suite des derniers essais portant sur ces liquides.

Il n'existait sur le marché aucun liquide de type III cette dernière saison; aucun liquide de ce type n'a donc été essayé. Il existe bien un tableau des durées d'efficacité des liquides de type III; mais ces valeurs doivent être validées car le tableau a été produit à l'aide d'un liquide disparu du marché.

De façon générale, les résultats des essais de durée d'efficacité des liquides de type I menés en 2000-2001 concordaient avec les valeurs réduites du tableau générique concernant les liquides de type I, accepté aux réunions des sous-comités G-12 de la SAE tenues à Toulouse, en France. Aucun changement n'a donc été apporté à ce tableau.

Outre l'endurance de nouveaux liquides, APS a évalué celle d'un échantillon de liquide de type IV déjà homologué, à viscosité réduite. L'équipe de recherche a également mené des essais à l'aide de liquides de type IV homologués afin de mettre en lumière les différences entre les résultats obtenus au CNRC et à d'autres installations, dans des conditions de pluie légère verglaçante et de brouillard verglaçant.

Recommandations

Il est recommandé ce qui suit :

- que tout nouveau liquide de type I, de type II ou de type IV soit évalué dans toute la gamme des conditions couvertes par les tableaux de durées d'efficacité;
- que le tableau des durées d'efficacité des liquides de type III soit revu si de nouveaux liquides de type III deviennent disponibles pour des essais au cours de la saison 2001-2002;
- que des tableaux spécifiques soient produits pour les liquides de type II déjà homologués;
- qu'une nouvelle procédure d'essai d'endurance simulant les conditions réelles d'application d'un liquide de type I sur une aile soit mise au point.

CONTENTS

LIST OF APPENDICES

This page intentionally left blank.

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF PHOTOS

Page

GLOSSARY

AMIL	Anti-icing Materials International Laboratory
APS	APS Aviation Inc.
AS	Aerospace Standard (Proposed)
C/FIMS	Contaminant/Fluid Integrity Monitoring System
CEF	Climatic Engineering Facility
cP	Centipoise
DEG	Diethylene Glycol
EG	Ethylene Glycol
FAA	Federal Aviation Administration
GPM	Gallons Per Minute
HHET	High Humidity Endurance Time
HSS	Biral UK (acquired the HSS technology)
IREQ	Institut de Recherche d'Hydro-Québec
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LWC	Liquid Water Content
MSC	Meteorological Service of Canada (as of 2000), formerly known as Atmospheric Environmental Services (AES).
MVD	Median Volume Diameter
NCAR	National Center for Atmospheric Research
NRC Canada	National Research Council Canada
OAT	Outside Air Temperature
PG	Propylene Glycol
POSS	Precipitation Occurrence Sensing System
READAC	Remote Environmental Automatic Data Acquisition Concept
ROCSW	Rain on a Cold-Soaked Wing
RPM	Revolutions Per Minute
SAE	Society of Automotive Engineers
TDC	Transportation Development Centre
UCAR	Union Carbide Corporation
WSET	Water Spray Endurance Time

This page intentionally left blank.

1. INTRODUCTION

Under contract to the Transportation Development Centre (TDC) of Transport Canada and co-sponsored by the U.S. Federal Aviation Administration (FAA), APS Aviation Inc. (APS) has undertaken a research project to further advance ground aircraft de/anti-icing technology. This project involved the participation of TDC, Transport Canada, National Research Council Canada (NRC), the FAA, the Meteorological Service of Canada (MSC), and several de/anti-icing fluid manufacturers.

Aircraft ground de/anti-icing has been the subject of concentrated industry attention over the past decade due the occurrence of several fatal icing-related aircraft accidents. Recent attention has been focused on the enhancement of anti-icing fluids 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 guidelines for use by aircraft operators and accepted by regulatory authorities. 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. More recently, fluid manufacturers have reformulated fluids in an effort to reduce environmental concerns and to improve characteristics such as fluid stability.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop and substantiate fluid holdover time guidelines for current fluids and new formulations. Test procedures to measure the duration of fluid protection against ice formation have evolved into a refined standard approach that has been followed by APS and others at a number of locations in previous years. The tests provide endurance times using a visual fluid failure criterion and are then converted to holdover times based on correlations between the visual fluid failures on flat plates and similar fluid failures on wing surfaces.

Aircraft are deiced using heated Type I fluids. These fluids are excellent for the removal of existing contamination on aircraft wings; however, they provide limited protection against further ice accumulation. Anti-icing fluids are applied following aircraft deicing. Type II fluids are thicker and more viscous than Type I deicing fluids. They form a thicker layer on application and provide a longer duration of protection against further contamination. Type III is an anti-icing fluid developed with shear and flow properties designed for aircraft with slower rotation speeds. Type IV fluids are the latest generation of anti-icing fluids and are designed to provide the best holdover time protection. The results of tests conducted during the 2000-01 winter season with Type I, Type II, and Type IV fluids constitute the major focus of this report. No Type III fluids were tested. All Type II and Type IV anti-icing fluid tests were conducted using pre-sheared fluid samples selected by the manufacturers according to new sample selection procedures, which are outlined in Proposed SAE Aerospace Standard 5485 [1]. Type I fluids were diluted to a 10°C buffer prior to testing.

Testing of these fluids has resulted in the generation of holdover time tables. These tables provide guidelines for use in departure planning in adverse winter weather conditions. They provide the holdover time ranges for aircraft treated with any particular qualified deicing or anti-icing fluid.

A new data analysis protocol was developed in 1996-97. In each cell of the holdover time tables, the failure data for each fluid brand were subjected to a multi-variable regression analysis. The new Type II and Type IV fluid holdover times, obtained during the 2000-01 test season, were determined using this method, resulting in the generation of one *generic* fluid table for Type II and Type IV, three *fluid-specific* Type II tables, and eight *fluid-specific* Type IV tables. These tables are presented in Section 4.

The generic holdover time guidelines for Type I, Type II, and Type IV fluids have traditionally been published by the Society of Automotive Engineers (SAE). Prior to the SAE G-12 meetings in New Orleans in May 2001, SAE informed the industry that it would no longer publish this information. The generic and fluid-specific guidelines are now published by the regulatory agencies.

Over the past few years, APS has completed considerable testing on behalf of Transport Canada. These tests have related to the determination of fluid holdover times and the substantiation of holdover time tables, as well as general research and development of deicing technology. A summary of the research related to fluid holdover times is provided in Table 1.1.

1.1 Holdover Time Tables

The holdover time guidelines provided to operators for use during the 2000-01 winter season are shown in Tables 1.2 to 1.4. Table 1.2 gives the holdover times for Type I fluids, Table 1.3 provides the generic or SAE table for Type II fluids, and Table 1.4 displays the generic or SAE table for Type IV fluids. These generic tables were also the last published by SAE for the industry.

All holdover time tables are composed of cells. Each cell contains a holdover time range for a specific fluid type and dilution, temperature range, and category of precipitation. The time range in each cell is defined by a "lower" time and an "upper" time; these values represent the average failure time of the fluid at upper and lower precipitation rate limits, respectively. These limits are defined in Subsection 2.9 for all categories of precipitation.

TABLE 1.1

SUMMARY OF APS HOLDOVER TIME TESTING ACTIVITIES

Year	Transport Canada Publication #	Conditions Tested	Primary Fluids Tested	Location of Testing
1990-91	TP 11206E	• Natural Precipitation (mostly snow)	Type II (100%)	Mostly Dorval, worldwide
1991-92	TP 11454E	• Natural Precipitation (mostly snow)	Type III	Mostly Dorval, St. John's
1992-93	TP 11836E	• Natural Precipitation (snow) • Simulated Freezing Drizzle (preliminary) • Simulated Freezing Fog (outdoor)	Type I (Standard)	Dorval and Ottawa (NRC)
1993-94	TP 12915E Will soon be published	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (outdoor)	Type II (75/25, 50/50)	Dorval and Ottawa (NRC)
1994-95	TP 12654E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface (preliminary)	• Type I (Diluted for 10ºC buffer) • Type IV (Preliminary)	Dorval and Ottawa (NRC)
1995-96	TP 12896E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	Type IV	Dorval and Ottawa (NRC)
1996/97	TP 13131E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• New Type IVs • Type III	Dorval and Ottawa (NRC)
1997-98	TP 13318E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• New Type IVs	Dorval and Ottawa (NRC)
1998-99	TP 13477E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Simulated Snow	• Low Viscosity Type IVs • Type II • Type I	Dorval and Ottawa (NRC)
1999-2000	TP 13659E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Simulated Snow • Preliminary Frost	• Type IV • Type II • Type I	Dorval and Ottawa (NRC) Varennes (IREQ)
2000-01	TP 13826E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Simulated Snow • Preliminary Frost	• Type IV • Type II • Type I	Dorval and Ottawa (NRC) Varennes (IREQ)

TABLE 1.2

SAE TYPE I FLUID HOLDOVER TIME GUIDELINES

For Use in 2000-01

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	**°F**	***FROST**	**FREEZING FOG**	**SNOW ①**	****FREEZING DRIZZLE**	**LIGHT FRZ RAIN**	**RAIN ON COLD SOAKED WING**	**OTHER*****
above 0°	**above 32°**	0:45	0:12-0:30	0:07-0:12	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	**32 to 14**	0:45	0:06-0:11	0:03-0:06	0:05-0:08	0:02-0:05	**CAUTION No holdover time guidelines exist**	
below -10	**below 14**	0:45	0:06-0:09	0:02-0:04				

* During conditions that apply to aircraft protection for ACTIVE FROST.

** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

*** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.3

SAE TYPE II FLUID HOLDOVER TIME GUIDELINES

For Use in 2000-01

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	12:00	0:35-1:30	0:20-0:55	0:30-0:55	0:15-0:30	0:05-0:40	CAUTION No holdover time guidelines exist
		75/25	6:00	0:25-1:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.4

SAE TYPE IV FLUID HOLDOVER TIME GUIDELINES

For Use in 2000-01

OAT °C	OAT °F	Type IV Fluid Concentration Neat Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
			Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
above 0º	above 32º	**100/0**	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	
		75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
0 to -3	32 to 27	**100/0**	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:20-1:20	0:20-0:40	**0:20-0:55	**0:10-0:30		
		75/25	5:00	0:25-0:50	0:15-0:25	**0:20-0:50	**0:10-0:25		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:15-0:40	0:15-0:30				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

The holdover time guidelines shown in this section are shown in the 1999-2000 Transport Canada report, TP 13659E (2). Analysis of the Type IV data from the 1996-97 test season revealed a need to develop fluid-specific holdover time tables in addition to a generic or worst-case SAE fluid holdover time table, due to wide variations in the performance of the different Type IV fluids tested. Results of subsequent testing with Type II and Type IV fluids also indicated a requirement for generic and fluid-specific holdover time tables. The generic table encompasses the performance behaviour of all qualified fluids.

The fluid-specific holdover time tables were generated for two Type II fluids, Kilfrost ABC-II Plus and Clariant MPII 1951, and seven Type IV fluids, Clariant MPIV 1957, Clariant MPIV 2001, Clariant Safewing Four, Kilfrost ABC-S, Octagon Max-Flight, SPCA AD-480, and Union Carbide Ultra+. These for fluid-specific holdover times are given in Tables 1.5 to 1.13 at the end of this section.

The primary effort of the 2000-01 winter study was directed toward the comprehensive testing of new Type I, Type II, and Type IV fluids in various natural and artificial conditions and locations. Extensive testing in natural snow was conducted by APS Aviation at the Dorval Airport test site. Tests in conditions of simulated freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface were conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa.

The holdover time values in the frost columns of the various holdover time tables have been determined by the SAE G-12 Holdover Time Subcommittee using the results of high humidity endurance time (HHET) tests conducted as part of the fluid certification process. APS had not conducted holdover time tests in simulated frost conditions prior to the 1999-2000 test season. Preliminary tests in simulated frost conditions were conducted by APS at the Institut de Recherche d'Hydro-Québec (IREQ) high humidity chamber in Varennes to determine the capabilities of this chamber for future tests in conditions of simulated frost. The results of these tests are presented in Transport Canada report TP 13659E [2]. Additional testing in frost conditions was performed by APS during 2000-01. The results of these tests appear in an associated report, TP 13831E [3].

In total, 812 holdover time tests were conducted during the 2000-01 test season. The results of flat plate and cold-soak box endurance time tests were presented to the SAE G-12 Holdover Time Subcommittee in New Orleans, where they were reviewed and discussed. New holdover time guidelines, based largely on this work, were proposed and accepted by the SAE G-12 Committee. These tables were implemented worldwide for the 2001-02 winter season. The tables are presented in Subsection 4.6.

1.2 Objectives

The detailed objectives of the holdover time test program for the 2000-01 winter season are provided in the work statement given in Appendix A. The primary objective of the test program was to conduct flat plate tests under conditions of natural and simulated precipitation to record the endurance times, and to develop individual holdover time tables based on samples of newly and previously qualified deicing and anti-icing fluids.

1.3 Report Format

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

- Section 2 describes the test conditions and methodologies used, as well as equipment and personnel requirements necessary to carry out testing;
- Section 3 describes the different conditions in which data were collected;
- Section 4 discusses endurance time testing data and results. The most recently generated, proposed, and accepted generic and fluid-specific holdover time tables designed for use during the 2001-02 winter season are also presented;
- Section 5 presents results and general information related to supplementary tests performed during the 2000-01 winter test season;
- Section 6 presents conclusions derived from the complete test program; and
- Section 7 lists recommendations for future testing.

TABLE 1.5

"*FLUID-SPECIFIC* " TYPE II FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

KILFROST ABC-II PLUS

Viscosity of Neat 100% Fluid Tested: 3 600 cP

20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, guard leg

OAT		Type II Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	CAUTION No holdover time guidelines exist
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15		
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:35	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.6

"*FLUID-SPECIFIC* " TYPE II FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

CLARIANT SAFEWING MPII 1951

Viscosity of Neat 100% Fluid Tested: 8 700 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	**°F**		***FROST**	**FREEZING FOG**	**SNOW ①**	*****FREEZING DRIZZLE**	**LIGHT FRZ RAIN**	**RAIN ON COLD SOAKED WING**	**OTHER******
above 0º	**above 32º**	**100/0**	12:00	0:55-1:40	0:30-0:55	0:35-0:55	0:20-0:30	0:10-0:50	
		75/25	6:00	0:45-1:15	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:40	
		50/50	4:00	0:20-0:30	0:05-0:20	0:05-0:15	0:05-0:10		
0 to -3	**32 to 27**	**100/0**	8:00	0:55-1:40	0:25-0:45	0:35-0:55	0:20-0:30	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	0:45-1:15	0:15-0:35	0:25-0:45	0:15-0:25		
		50/50	3:00	0:20-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	**below 27 to 7**	**100/0**	8:00	0:45-1:25	0:20-0:40	**0:25-0:50	**0:15-0:30		
		75/25	5:00	0:35-1:00	0:15-0:25	**0:20-0:35	**0:15-0:20		
below -14 to -25	**below 7 to -13**	**100/0**	8:00	0:20-0:40	0:20-0:35				
below -25	**below -13**	**100/0**	SAE TYPE II fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.7

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

CLARIANT SAFEWING MPIV 1957

Viscosity of Neat 100% Fluid Tested: 16 200 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15		
0 to -3	32 to 27	**100/0**	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40	**CAUTION No holdover time guidelines exist**	
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:45-1:30	0:30-0:50	**0:35-0:55	**0:20-0:35		
		75/25	5:00	0:25-1:10	0:20-0:40	**0:25-0:55	**0:15-0:30		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.8

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

CLARIANT SAFEWING MPIV 2001

Viscosity of Neat 100% Fluid Tested: 18 000 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT °C	OAT °F	Type IV Fluid Concentration NeatFluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	18:00	1:20-3:20	1:55-2:00	0:55-1:55	0:40-1:00	0:15-2:00	CAUTION No holdover time guidelines exist
		75/25	6:00	1:20-2:00	0:50-1:25	0:35-1:10	0:25-0:35	0:10-1:25	
		50/50	4:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
0 to -3	32 to 27	**100/0**	12:00	1:20-3:20	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:20-2:00	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:45-1:35	0:30-0:50	**0:55-1:35	**0:30-0:45		
		75/25	5:00	0:30-1:00	0:20-0:35	**0:40-1:10	**0:20-0:30		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:20-0:45	0:20-0:35				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.9

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

CLARIANT SAFEWING FOUR

Viscosity of Neat 100% Fluid Tested: 6 400 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	1:50-2:45	0:45-1:45	1:05-1:45	0:50-1:05	0:10-1:20	
		75/25	6:00	1:45-2:25	0:40-1:25	0:50-1:30	0:30-0:45	0:15-1:25	
		50/50	4:00	0:30-0:45	0:15-0:25	0:15-0:25	0:10-0:15		
0 to -3	32 to 27	100/0	12:00	1:50-2:45	0:35-1:20	1:05-1:45	0:50-1:05	CAUTION No holdover time guidelines exist	
		75/25	5:00	1:45-2:25	0:30-1:05	0:50-1:30	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:30-1:30	0:25-0:55	**0:25-1:05	**0:15-0:30		
		75/25	5:00	0:30-1:05	0:20-0:45	**0:20-0:50	**0:15-0:25		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.10

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

KILFROST ABC-S

Viscosity of Fluid Tested: 17 000 cP

20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, guard leg

OAT °C	OAT °F	Type IV Fluid Concentration Neat Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25	CAUTION No holdover time guidelines exist	
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-2:05	0:45-1:20	**0:20-1:00	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:25-0:50	**0:20-1:10	**0:10-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hai

① Snow includes snow grains.

TABLE 1.11

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

OCTAGON MAX-FLIGHT

Viscosity of Neat 100% Fluid Tested: 2 920 cP

20°C, 0.3 rpm, Spindle LV1, 600 mL beaker, 500 mL fluid, 33 min 20 sec, guard leg

OAT °C	OAT °F	Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	2:15-4:00	1:00-1:30	0:55-1:55	0:30-0:50	0:10-1:15	CAUTION No holdover time guidelines exist
		75/25	6:00	1:30-2:50	0:40-1:30	0:50-1:20	0:20-0:40	0:05-0:40	
		50/50	4:00	0:30-0:50	0:15-0:35	0:15-0:25	0:05-0:15		
0 to -3	32 to 27	100/0	12:00	2:15-4:00	0:50-1:20	0:55-1:55	0:30-0:50		
		75/25	5:00	1:30-2:50	0:30-1:00	0:50-1:20	0:20-0:40		
		50/50	3:00	0:30-0:50	0:15-0:30	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:55	0:25-0:50	**0:25-1:10	**0:15-0:40		
		75/25	5:00	0:30-1:10	0:20-0:40	**0:20-1:00	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:20-0:40				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

TABLE 1.12

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

SPCA AD-480

Viscosity of Neat 100% Fluid Tested: 15 200 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min

OAT		Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	2:00-3:30	0:55-1:50	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION No holdover time guidelines exist
		75/25	6:00	1:30-2:45	0:40-1:20	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	4:00	0:30-0:45	0:15-0:30	0:15-0:25	0:05-0:15		
0 to -3	32 to 27	100/0	12:00	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55		
		75/25	5:00	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:30-0:55	**0:25-1:20	**0:15-0:30		
		75/25	5:00	0:25-0:50	0:20-0:45	**0:25-1:05	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:25-0:40				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 1.13

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2000-01

UCAR ULTRA +

Viscosity of Neat 100% Fluid Tested: 36 000 cP

0°C, 0.3 rpm, Spindle SC4-31/13R, 10 mL fluid, 10 min

OAT °C	OAT °F	Type IV Fluid Concentration Neat Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	CAUTION No holdover time guidelines exist
		75/25							
		50/50							
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	**0:45-1:25	**0:30-0:45		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40-2:10	0:20-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

This page intentionally left blank.

2. METHODOLOGY

Described in this section are the tests, equipment, and procedures employed during the 2000-01 test season. The definition of weather, test sites, test conditions, equipment, procedures, fluid failure criteria, data forms, fluids, personnel, and analysis methodology are presented in subsections.

2.1 Weather Conditions

Holdover times (see Tables 1.2 to 1.13) are provided as a function of *weather condition*, fluid mixture, and outside air temperature (OAT). The objective of the winter test program was to substantiate these holdover times in the various conditions or to develop new holdover times based on the most recent test data.

Table 2.1 provides definitions of most weather conditions experienced in winter operations and includes the criteria used to determine precipitation intensity (light, moderate, and heavy). This table was compiled by the National Center for Atmospheric Research (NCAR) from the World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983) [4], and from the American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS) (3/94) [5].

Table 2.1 includes definitions for the weather conditions noted in the holdover time tables (presented in subsection 1.1): frost, freezing fog, snow, freezing drizzle, light freezing rain, and rain. Definitions for hail and ice pellets are also presented; however, these are conditions for which holdover time guidelines do not exist.

The test methodology traditionally used to determine fluid failure times has included the upper and lower limits for precipitation rates for each type of precipitation. These limits were discussed in detail at a meeting in 1997 of the SAE G-12 Holdover Time Subcommittee, where standard definitions of upper and lower precipitation rate limits were approved for each category of precipitation. These limits are documented and discussed in Subsection 2.9.

2.1.1 Snow

Table 2.1 contains the criteria generally used to estimate the intensity of snow. These criteria are based on horizontal visibility. Three intensity levels are defined as follows:

TABLE 2.1

DEFINITION OF WEATHER PHENOMENA

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 visibility at the earth's surface to less than 1 km (5/8 mile).
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 (23°F), the crystals are generally agglomerated into snowflakes.
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 the ground or other exposed objects.
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 mm (0.02 in.) or smaller drops which, in contrast to drizzle, are widely separated.
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)	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 in.). Grains are brittle, easily crushed; they bounce and break on hard ground.
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 in.). When the grains hit hard ground, they do not bounce or shatter.
HAIL (GR)	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to 2.0 in.) falling either separately or agglomerated.
ICE PELLETS (PE) Note: Includes Sleet and Small Hail	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.) or less. The pellets of ice usually bounce when hitting hard ground.

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG),Frz Drizzle(FZDZ)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (S) Intensity***	**Definition and Horizontal Visibility**
Light (-)	If visibility is: **≥ 5/8 mi** (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm or 10.0 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 or 25.0 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 shown that visibility and precipitation intensity are not always directly correlated.

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm 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)
Measured Intensity — **Light (-)**	Up to 0.10 in/hr (2.5 mm or 25 gr/dm²/hr); Maximum 0.01 inch in 6 minutes
Estimated Intensity — **Light (-)**	From scattered drops that, regardless of duration, do not completely wet an exposed surface up to a condition where individual drops are easily seen.
Measured Intensity — **Moderate**	0.11 in to 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.01 to 0.03 inch in 6 minutes
Estimated Intensity — **Moderate**	Individual drops are not clearly identifiable; spray is observable just above pavement and other hard surfaces.
Measured Intensity — **Heavy (+)**	More than 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.03 inch in 6 minutes
Estimated Intensity — **Heavy (+)**	Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to height of several inches is observed over hard surfaces.

* 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 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 June 17, 1997 (Updated for METAR codes)

cm1680/report/hot/WTH_PHEN

- Light Visibility is greater than or equal to 1.0 km;
- Moderate Visibility is 0.5 km to less than1.0 km; and
- Heavy Visibility is less than 0.5 km.

As stated in a cautionary note in Table 2.1, visibility is only an indicator of snow intensity, and the two parameters are not always correlated.

Table 2.2 provides more detail about snow visibility than outlined in Table 2.1. Devised by NCAR and Transport Canada [6], this table is based on NCAR field data and theoretical work on classes of snow. NCAR has classified the snow data by crystal arrangement and temperature and has correlated this information with visibility measurements. The table gives visibility in distance for three snowfall intensities both in daylight and in darkness (at night). The circled values in Table 2.2 most closely represent the previous designations. The Snow Visibility versus Snowfall Intensity Chart, shown in Table 2.2, is published annually by Transport Canada for use in winter operations (see Transport Canada website [7]).

2.1.2 Freezing Drizzle

Freezing drizzle is composed of closely spaced fine water droplets with a diameter of less than 0.5 mm (see Table 2.1). Like snow, the intensity of freezing drizzle is estimated through the measurement of horizontal visibility. The holdover time table has one column for freezing drizzle, but Table 2.1 shows three intensity levels (light, moderate, and heavy). For example, under moderate freezing drizzle, the rate of precipitation should range between 2.5 and 5.1 g/dm²/h. For heavy freezing drizzle, the definition indicates that the intensity is greater than 5 g/dm²/h. The upper limit value of 12.7 g/dm²/h for freezing drizzle was discussed and set by United Airlines, NCAR, and NRC. This value was also used as the lower limit for light freezing rain.

2.1.3 Freezing Rain

Freezing rain exists in the form of droplets distinguished by a diameter size of greater or less than 0.5 mm. In contrast to drizzle, freezing rain droplets are widely separated. For each of the three intensities of freezing rain given in Table 2.1, a visual description is supplied to provide a subjective guideline for estimating rain intensity. However, when an instrument is available to measure the intensity of precipitation, the following definitions apply:

TABLE 2.2

SNOW VISIBILITY CHART

Lighting	Temp. Range		Visibility		
	°C	°F	Heavy	Moderate	Light
Daylight	Above -1	Above 30	< 1.6 km < 1 mi	1.6 - 3.2 km 1 - 2 mi	> 3.2 km > 2 mi
	-1 to -7	30 to 19	< 0.8 km < 1/2 mi	0.8 - 2.0 km 1/2 - 1 1/4 mi	> 2.0 km > 1 1/4 mi
	Below -7	Below 19	< 0.6 km < 3/8 mi	0.6 - 1.0 km 3/8 - 5/8 mi	> 1.0 km > 5/8 mi
Darkness	Above -1	Above 30	< 3.2 km < 2 mi	3.2 - 6.4 km 2 - 4 mi	> 6.4 km > 4 mi
	-1 to -7	30 to 19	< 1.6 km < 1 mi	1.6 - 4.0 km 1 - 2 1/2 mi	> 4.0 km > 2 1/2 mi
	Below -7	Below 19	< 1.2 km < 3/4 mi	1.2 - 2.0 km 3/4 - 1 1/4 mi	> 2.0 km > 1 1/4 mi

Light snow intensity is defined as less than 1 mm/h, moderate intensity as 1 mm/h to 2.5 mm/h, and heavy as greater than 2.5 mm/h.

Values that most closely relate to previous visibility definition.

- Light Precipitation rate is $\leq$ 25 g/dm²/h;
- Moderate Precipitation rate is > 25 g/dm²/h but $\leq$76 g/dm²/h; and
- Heavy Precipitation rate is > 76 g/dm²/h.

2.1.4 Freezing Fog

Freezing fog is defined as suspended minute water droplets that freeze upon impact with the ground or exposed objects. Table 2.1 reports that the horizontal visibility is reduced to less than 1 km but does not provide any indication of intensity or liquid water content of the fog.

2.2 Test Sites

Natural snow testing for the 2000-01 winter was performed at the APS Dorval Airport test site. The location of the site is shown on the plan view of the airport in Figure 2.1. Photo 2.1 was taken at the site and shows a remote sensor mounted on top of the test stand on the left and a trailer at the back. The same trailer used in past winters was used in the 2000-01 test season. Due to space limitations, an additional trailer was rented and the two trailers were located adjacent to each other. The second trailer was used only for equipment storage. The APS test site is located near Environment Canada's MSC automated weather observation station (Photo 2.2).

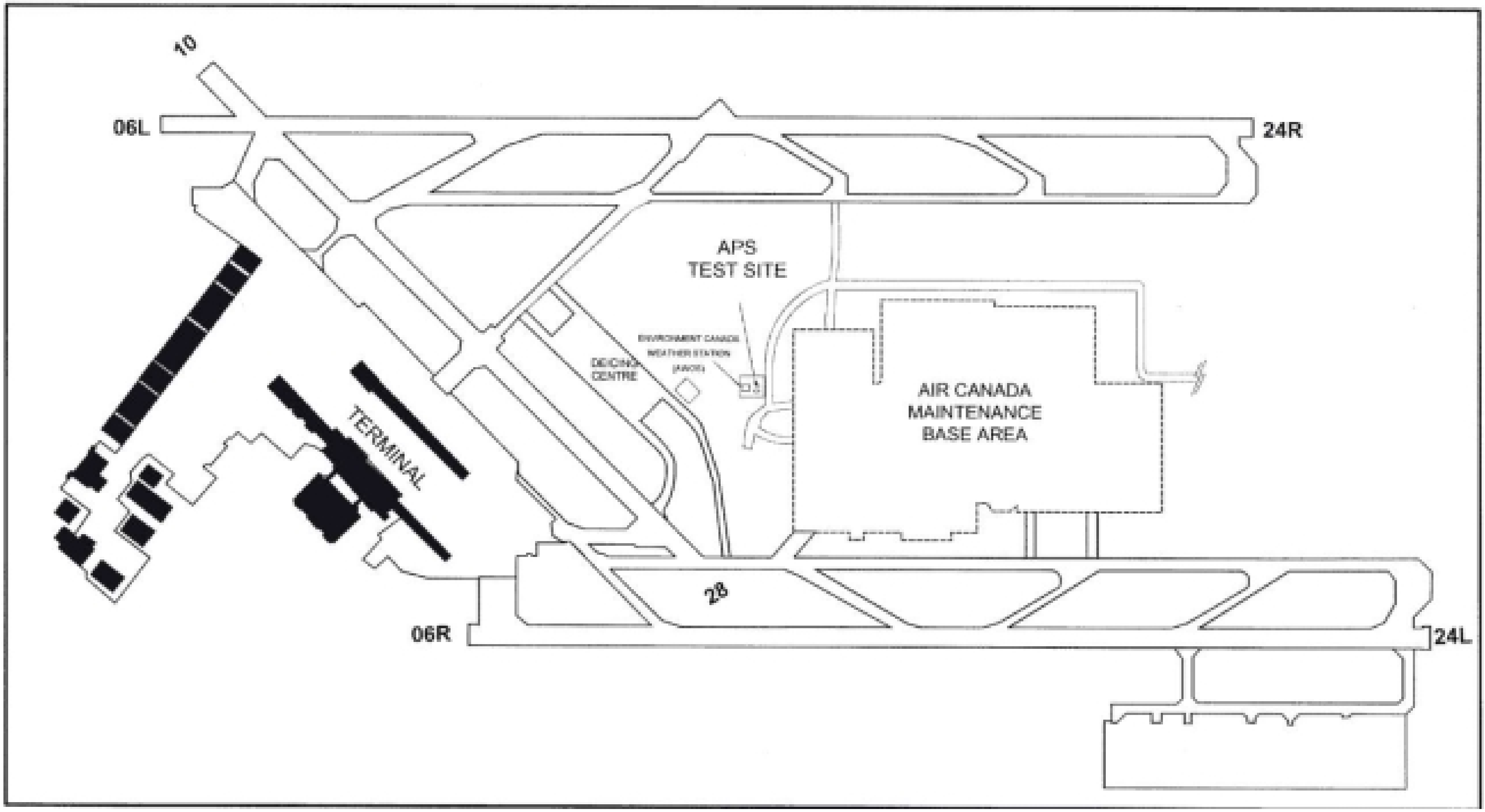
Tests under conditions of freezing fog, rain on a cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC's CEF, where simulated precipitation was produced. Tests in artificial snow conditions were also conducted at the CEF using the NCAR artificial snowmaking system.

For the purpose of this report, i.e., the term "simulated" means simulating the effects of the precipitation (i.e., not producing the real precipitation in significant detail but providing equivalent results). The term "artificial" signifies that precipitation is produced and significant details are well simulated; however, equivalent results may not be achieved for test purposes.

The CEF is partitioned into two sections separated by an insulated dividing door. Conditions in each section can be controlled independently, permitting different tests to be conducted simultaneously. Photo 2.3 provides a view of the building from the outside. Photos 2.4 and 2.5 provide interior images of the small and large ends of the facility. The size of the chamber is 30 m by 5.4 m, with a height of 8 m. The lowest temperature achievable is -46ºC.

FIGURE 2.1

APS TEST SITE LOCATION AT DORVAL AIRPORT



Preliminary testing in simulated frost conditions was conducted at IREQ's high humidity chamber in Varennes. The evaluation of the IREQ chamber for future use in frost endurance time testing is presented in an associated report, TP 13831E [3].

2.3 Test Conditions

Outdoor testing was conducted during natural precipitation events. Supplementary tests to simulate freezing precipitation were carried out at the CEF (see Photo 2.4). Subsections 2.3.1 and 2.3.2 provide descriptions of the spray assembly (see Photo 2.6) and of the methods used to produce and calibrate the fine water droplets in these simulated precipitation tests. Subsection 2.3.3 provides a summary of the categories and characteristics of each precipitation type produced for these tests.

2.3.1 Droplet Size and Rate of Precipitation

In the past few years, more industry attention has been given to the influence of droplet size on holdover time. To explore this relationship further, experiments were performed to measure droplet sizes produced by various nozzles (hypodermic needle tips) at various water and air pressures in the spray delivery unit. Although the gauge of the needles is an important factor in the production of water droplets with appropriate dimensions, the air and water pressure levels in the sprayer system are equally important.

A new and improved sprayer assembly was developed in 1997-98 by NRC and is shown in Photo 2.6. The new sprayer provides a larger scan area and improved spray uniformity over the test bed area. The sprayer 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 amounts to having 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 2.7.

Prior to 1995, calibration experiments were conducted by NRC using an optical gauge manufactured by HSS (see Photo 2.8) to verify that the simulation of freezing fog, freezing drizzle, and light freezing rain provided adequate droplet sizes.

Since 1995, droplet size calibration has been carried out by the APS team using a manual dye-stain technique employed by personnel at the CEF. This technique consists of dusting Whatman # 1 filter paper discs with a water-activated, very finely divided powder form of methylene blue dye. The prepared discs are manually positioned (Photo 2.9) under artificial precipitation for a fixed time to acquire a droplet size pattern. A calibration curve is then used to convert the measured diameter of the droplets on the pattern to the experimental median volume diameter (MVD).

To determine whether droplets produced in the CEF resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at Dorval Airport. Droplets were measured and compared to the droplet sizes of simulated light freezing rain obtained from tests conducted at NRC. The results of these tests are as follows:

- *For the outdoor test:*
  Location: Dorval Airport
  Precipitation: Natural Light Freezing Rain
  Precipitation Rate: 20 $g/dm^2/h$
  Calibrated MVD: 1.0 mm

- *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 median volume diameter for both natural and simulated light freezing rain was 1 mm.

In 2000-01, droplet size verification was conducted by APS staff using both the dye-stain and slide impact method. The slide impact method consists of spreading mineral or silicone oil with a known viscosity (5000 mPas) onto a microscope slide, and placing the slide under precipitation to collect water droplets within the oil on the slide. The droplet size is then determined either by direct observation under a microscope equipped with a ruled graticule eyepiece or from enlarged photographs of the slide.

2.3.2 Median Volume Diameter of Raindrops

The median volume diameter (MVD) of a rain droplet was researched and found to be related to the precipitation rate as follows:

$$MVD = (\text{precipitation rate}/10)^{0.23}$$

where the MVD is in mm and the rate of precipitation is in g/dm²/h. At 25 g/dm²/h, this equation gives an MVD of 1.2 mm, and at 76 g/dm²/h the MVD is 1.6 mm.

The theoretical MVD for rain at various rates of precipitation were determined based on this equation. These values are listed below along with the experimental MVDs for each precipitation condition.

- Experimental **MVD (mm):**

Moderate Rain (High rate: 76 g/dm²/h)	1.4
Light Rain (Low rate: 12.7 g/dm²/h)	1.0
Light Rain (High rate: 25 g/dm²/h)	1.0
Drizzle (Low rate: 5 g/dm²/h)	0.25
Drizzle (High rate: 12.7 g/dm²/h)	0.35

- Theoretical **MVD (mm):**

Moderate Rain (High rate: 76 g/dm²/h)	1.6
Light Rain (Low rate: 12.7 g/dm²/h)	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.2
Drizzle (Low rate: 5 g/dm²/h)	< 0.5
Drizzle (High rate: 12.7 g/dm²/h)	< 0.5
Fog	< 0.1

2.3.3 Characteristics of Precipitation Produced

This subsection gives a summary in point form of the characteristics of the precipitation produced in conditions of freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog. The characteristics specified include precipitation rate, droplet MVD, the size of the hypodermic needle producing the droplet, and air temperature.

- Freezing Drizzle:
  High precipitation rate: 12.7 g/dm²/h;
  Droplet MVD: 350 µm;
  Droplets produced with two # 23 hypodermic needles; and
  Air temperature: -3 and -10ºC.

Low precipitation rate: 5 g/dm²/h;
Droplet MVD: 250 µm***;***
Droplets produced with two # 24 hypodermic needles; and
Air temperature: -3 and -10ºC.

- Light Freezing Rain:
  High precipitation rate: 25 g/dm²/h;
  Droplet MVD: 1 000 µm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and -10ºC.

  Low precipitation rate: 12.7 g/dm²/h;
  Droplet MVD: 1 000 µm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and -10ºC.

- Drizzle on a Cold-Soaked Surface:
  Precipitation rate: 5 g/dm²/h;
  Droplet MVD: 250 µm;
  Droplets produced with two # 24 hypodermic needles; and
  Air temperature: +1ºC.

- Moderate Rain on a Cold-Soaked Surface:
  Precipitation rate: 76 g/dm²/h;
  Droplet MVD: 1 400 µm;
  Droplets produced with two # 17 hypodermic needles; and
  Air temperature: +1ºC.

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

2.4 Equipment

Figure 2.2 shows a schematic of the test platform used in holdover time testing. For natural snow tests, six standard test plates are mounted on the test stand, which has a working surface inclined at 10º to the horizontal. Each plate represents a flat plate test.

The standard test plate, for the purpose of this document, is restricted to the plate used in endurance time testing. It is an aluminum alloy plate 50 cm (20 in.) long and 30 cm (12 in.) wide adopted by SAE for the evaluation and certification of de/anti-icing fluid performance. For testing it is mounted at 10° to the horizontal. Along the top and two sides a line is marked 2.5 cm (1 in.) from the edge; ice crystals commencing in these zones are ignored as outside the test area. The bottom edge is a special case because the fluid is held back and is excessively thick there. The test area of the test plate is about 75 percent of the total area. The plate is marked with horizontal lines parallel to the top edge at 7.5 cm (3 in.), 15 cm (6 in.), 22.5 cm (9 in.), 30 cm (12 in.), and 37.5 cm (15 in.). On each of these lines are marked three crosshairs, one in the middle of the line and the other two evenly spaced 7.5 cm (3 in.) each side of it for a total of 15 crosshair sites [8]. Figure 2.2 depicts the size and surface markings of a standard flat plate. The crosshair sites are used in determining whether end conditions (see Subsection 2.5.2 for definition) were achieved. Photo 2.10, taken outdoors at Dorval, shows six test plates mounted on a stand; two plates (shown as U and W in Figure 2.2) are equipped with Allied Signal Contaminant/Fluid Integrity Monitoring System (C/FIMS) ice detection sensors mounted at the 15 cm (6 in.) line. For simulated freezing precipitation tests at NRC, 12 plates were mounted on the stand and numbered from 1 to 12, as shown in Figure 2.2.

Figure 2.3 shows the collection (plate) pan, which is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 2.11 shows the collection pans used for measuring precipitation rates indoors at NRC.

A new snow gauge, CR21X, was made available to measure precipitation during the 1996-97 winter season. However, the unit was exposed during this early testing and gave inaccurate results. Over the past several years, a shield was installed around the CR21X gauge, which has contributed to improved accuracy and resolution over instrumentation used in previous seasons. Detailed analysis of the results obtained since 1995 using the CR21X snow gauge is presented in Transport Canada report, TP 13830E [9].

Sealed boxes (7.5 cm deep) were used for simulating a cold-soaked wing (see Figure 2.3). The top of the cold-soak box consisted of an aluminum flat plate identical to the standard flat plate. A box-shaped reservoir was welded to the bottom of the plate. The volume (depth) of the reservoir was selected based on the analyses contained in Transport Canada report, TP 12899E [10].

Two large digital clocks purchased in 1998-99 were visible from a considerable distance and facilitated the recording of precipitation rate collection times in natural and simulated conditions (see Photo 2.12).

Fluid freeze points were measured using a hand-held Misco refractometer with a Brix scale (see Photo 2.13).

FIGURE 2.2

FLAT PLATE TEST SET-UP

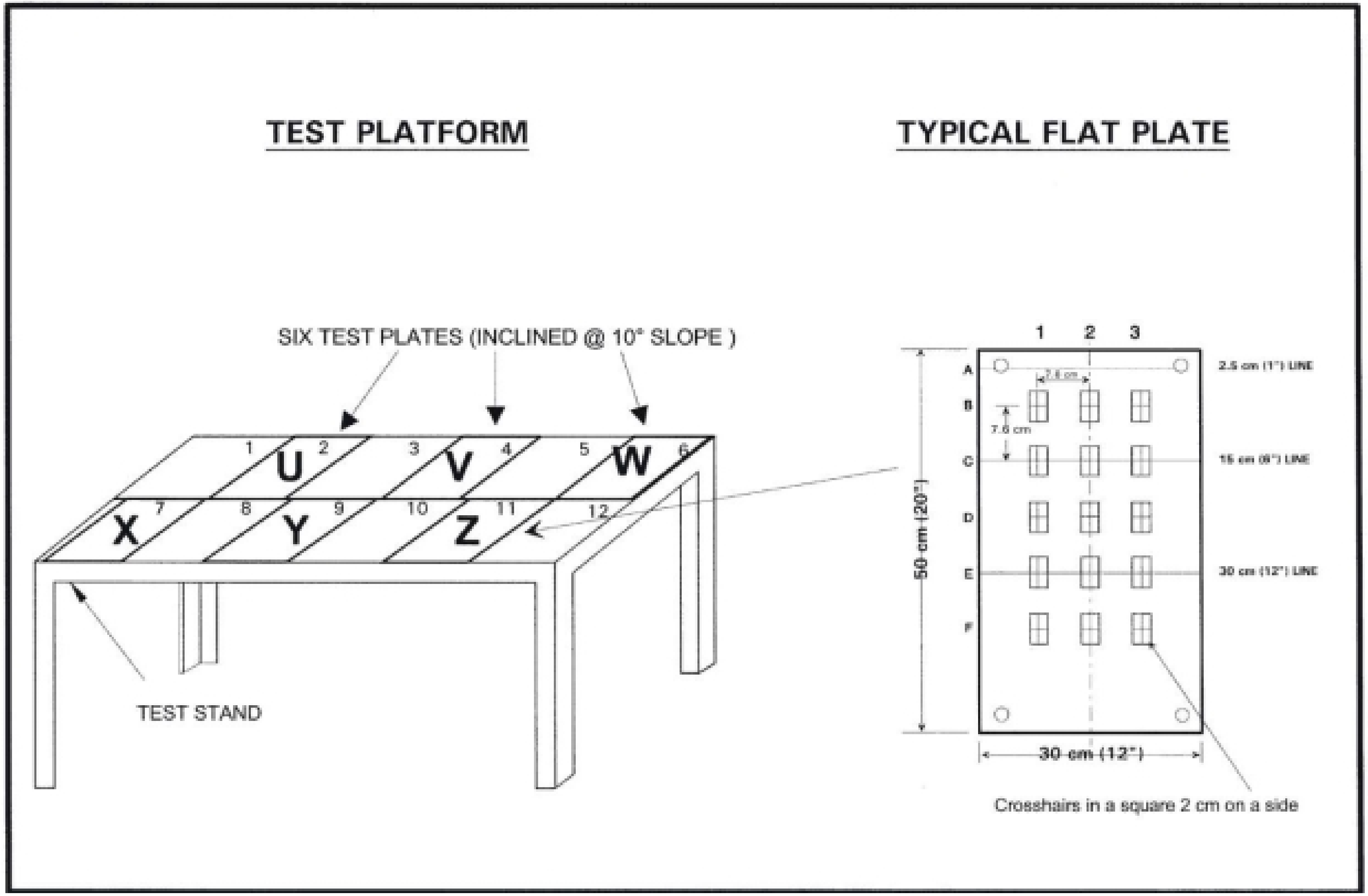
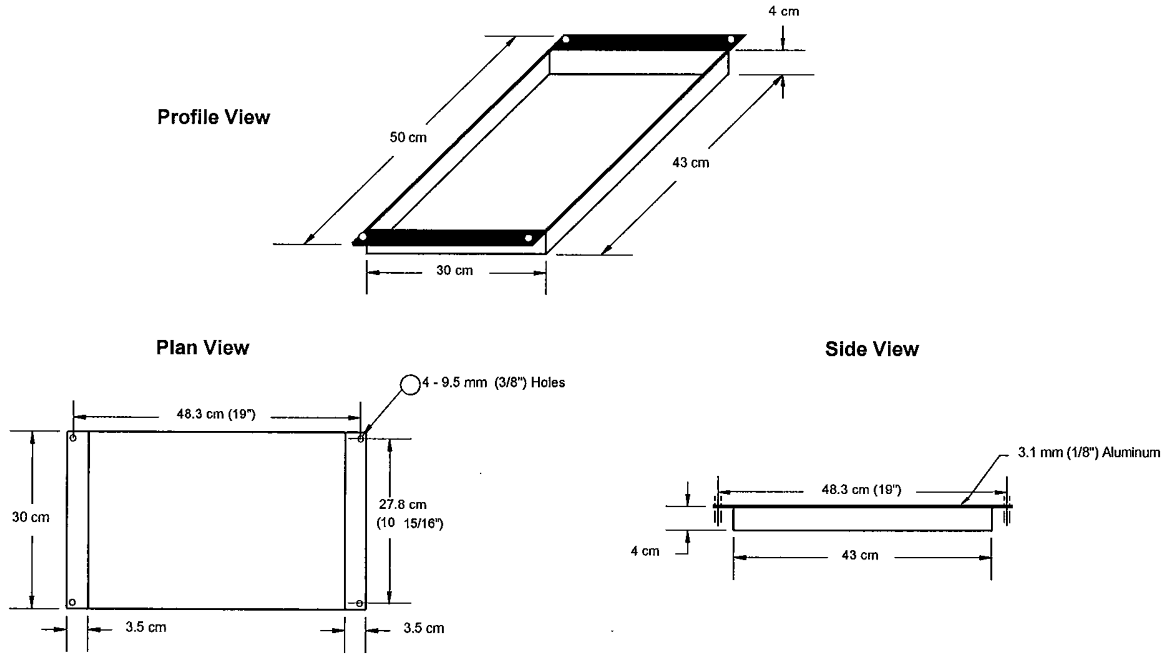


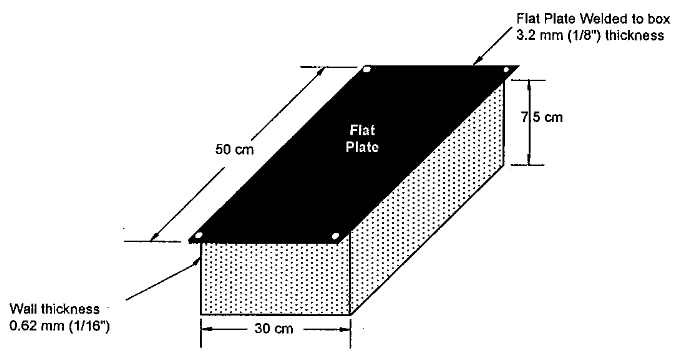
FIGURE 2.3

SCHEMATICS OF PLATE PAN AND SEALED BOXES

PLATE PAN USED OUTDOORS



SEALED BOXES FOR COLD-SOAK SIMULATION



cm1589\reports\holdover time\pan&box.drw

One-litre pour containers were purchased to ensure that accurate quantities of fluid were being applied to the test plates in all endurance time tests.

Equipment to measure temperature, wind speed, and wind direction was purchased several years ago (see Photo 2.1). Additional measurements of these parameters were obtained using equipment provided by Environment Canada, shown in Photo 2.2.

In addition to the data collected using the meteorological equipment at the APS Dorval site, data from Environment Canada's automated weather observation equipment located on a lot adjacent to the APS test site, were made available. This equipment, the Remote Environmental Automatic Data Acquisition Concept (READAC), relayed information electronically on a minute-by-minute basis to MSC for the entire winter. The READAC equipment provides an indispensable means of monitoring meteorological conditions for test programs such as this. It comprises the following instruments:

- *Relative Humidity Gauge* and *Thermometer*;

- *Anemometer* and *wind vane* at a 10 m height;

- *Precipitation Occurrence Sensing System (POSS)*: The POSS system (instrument shown at the rear in Photo 2.14) consists of a Doppler radar set with a transmitter and a receiver as separate units (bi-static set-up). The Doppler frequency shift of the returned signal provides the precipitation type, and the power spectrum of the returned signal provides a measure of the intensity (light, moderate or heavy) of precipitation. The output of the system consists of the start time, stop time, type, and intensity of precipitation;

- *Precipitation Gauge*: The READAC precipitation gauge (instrument shown at the right in Photo 2.14) is a modified Belfort weighing gauge. A bucket is attached to a spring balance and cable pulley arrangement, which is connected to a rotating shaft. The degree of rotation of the shaft corresponds to the amount of accumulated precipitation in the bucket. The total amount of precipitation is the only value returned by the precipitation gauge arrangement. The gauge output resolution is 0.5 mm (liquid water equivalent); and

- *Belfort Forward Scattermeter*: The Belfort Forward Scattermeter (instrument shown at the left in Photo 2.14) provides an estimate of visibility. The system consists of a Xenon bulb transmitter and a receiver both at an angle of 22º below the horizontal aimed at a 0.02 m^3 sample volume of air 2.5 m above the ground. The transmitter illuminates the sample. The receiver measures the amount of light scattering off the aerosols present in the sample volume of air. The measurement is inversely proportional to visibility. The instrument output scale is in units of miles. The measurements outputted by the instrument are the time-averaged signal envelopes from the previous 10 minutes of monitoring.

2.5 Test Procedures

Tests consisted of pouring deicing or anti-icing fluids directly onto clean test panels (exposed to various winter precipitation conditions) and recording the elapsed time for each crosshair to fail until the test panels reached the defined end condition (see Subsection 2.5.2).

2.5.1 Test Protocol

For the tests at Dorval, a test stand contained six test plates, each plate representing a flat plate test. The procedure for natural snow flat plate tests was developed by the SAE G-12 Holdover Time Subcommittee. The major steps in the natural snow flat plate test procedure are:

- Synchronize all timepieces;
- Clean the panels and start;
- Apply (pour) fluids to the test panels. Type I fluids are at room temperature (20ºC ± 3°C). Type II and Type IV fluids are applied at the outdoor ambient temperature. Fluids are poured using a single-step fluid application;
- Record crosshair end condition times;
- Continue testing until at least five crosshairs or 1/3 of the plate have failed;
- Record weather conditions; and
- Clean panels and restart.

Complete details of the test procedures are provided in Appendix B.

Appendix C contains the procedures used for testing at the CEF in conditions of freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surfaces.

2.5.2 End Condition Definitions

The test procedures and the determination of defined end conditions evolved from the experience the APS team has accumulated from previous winter season test programs. Either of the following descriptions provide the general guidelines observers use to judge when fluid failure occurs and to determine the extent of contamination or failure:

- There is a visible accumulation of snow bridging on top of the fluid or plate when viewed from the front. There should be an indication that the fluid can no longer absorb the precipitation; or

- Ice has formed or accumulated on top of the plate or fluid, or ice is suspended within the fluid (freezing precipitation tests).

The standard flat plate end condition is achieved when visual failures occur at any five of the crosshair markings on the plate or when the general failure coverage reaches 1/3 of the entire test plate surface.

For further fluid failure criteria and icing definitions, please see Transport Canada report, TP 13832E [8]. Listed below is a subset of those definitions that pertain to fluid failure criteria.

Protection time: The period that an anti-icing treatment protects aerodynamically critical surfaces from the adhesion of contamination and the resulting roughness that could cause a premature stall or result in loss of control and prevent the crew from safely operating the aircraft.

Endurance time: The time from initial application of anti-icing fluid to a standard test plate to the moment of the standard plate failure for a specific test condition simulating a weather condition.

Holdover time: The time from initial application of anti-icing fluid onto an aircraft to the moment the fluid can no longer be guaranteed to provide protection at the anticipated takeoff time. These times must be at least five minutes less than the protection time, and may be substantially less.

Visual failure: A layer of ice crystals is plainly visible at the surface and the layer is building up thickness as precipitation continues. Generally, in the case of Type II, III, and IV fluids, uncontaminated fluid is in contact with the supporting surface at this time and therefore the ice crystal layer is not in contact with that surface and is not adhering to it. The growth of crystals in the fluid is compounded by incoming precipitation, resulting in an increased accumulation of crystals on the surface and thus in a visibly contaminated surface. When this area is large enough to be seen by an observer, a visual failure is adjudged. Obviously, the distance of the observer from the surface will influence what can be seen. For a test technician observing a plate from inches away, visual failure is characterized as a loss of gloss or obscuration of the surface by ice or slush affecting one third of a standard test plate surface. For an aircrew member viewing a wing through a window at night at a distance of several feet, only slush or bridging snow covering about one third of a critical area such as an aileron or a leading edge will be visible. Visual failure on test plates is the mode used to establish endurance times and thus holdover times.

Failure front: Anti-icing fluid varies in thickness over a surface as a result of the unevenness of the application, gaps or recesses in the surface, and surface gradients. Generally, the thinner areas of fluid are diluted more rapidly, so that an ice crystal layer forms at these thin fluid locations and an icing front advances into the thicker areas with continuing precipitation.

Standard plate failure: Failure is established as a visual failure of one third of the test surface based on the observation of conditions on full-scale aircraft. This usually occurs when the failure front on the plate crosses the 15 cm (6 in.) line. However, in outside snow tests, because there is usually wind, the start point may be anywhere on the plate and the progression in any direction. Under these conditions, visual failure may be estimated. Alternatively, when contamination is visible on 5 of the 15 cross hairs, the plate is determined to be one-third covered and therefore visually failed.

Fifth cross hair failure: When the ice crystals that indicate visual failure obliterate only four cross hairs on a standard test plate, the fluid is considered to be good. When the fifth cross hair is obscured, the fluid is considered to be visually failed. This represents a standard plate failure mode.

2.5.3 Precipitation Rate Measurement Procedures

2.5.3.1 Simulated precipitation conditions

Prior to the start of the rate collection, 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, marking each pan with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period, typically 10 minutes.

The pans are weighed prior to exposure to precipitation and the weights are recorded. Before the precipitation catch period begins, the exact time (hh:mm:ss) is recorded. 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, the water spray unit is re-calibrated. If the rates are deemed acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has ended, the pans are again re-weighed and the rates computed.

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

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

Following the failure of a fluid on 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.

A program was developed to manage the collection of precipitation rates in simulated conditions. The program runs in Microsoft Excel, and the spreadsheet contains several macros. The rate program spreadsheet guide appears in Appendix H.

The following procedure is used for measuring the distribution of precipitation rate distribution in simulated conditions:

- Clean test plates are placed on the test stand prior to rate collection, and are exposed to the simulated precipitation to verify that an even ice formation occurs over the entire test area. If this visual inspection proves satisfactory, the rate collection period will begin. If this visual inspection proves unsatisfactory, the test stand must be repositioned under the spray device and the process repeated;

- To verify the rate distribution on the test stand, a continuous rate-monitoring pan is replaced with a detailed rate distribution pan, which consists of four small pans of equivalent size. The area of the four small pans combined is similar to that of a standard rate collection pan. The small pans are weighed and placed at these locations and re-weighed at fixed intervals. The typical collection period for rate distribution is 60 minutes; however, this interval may be shorter if all tests have been completed within an hour. The variation between the rate of any of the four small pans and that of the average rate of that location has typically been found to be less than 10 percent; and

- Two examples of the detailed rate distributions are shown in Table 2.3. Both rate distribution tests were conducted in freezing drizzle, one at the low rate (5 g/dm^2/h) and the other at the high rate (12.7 g/dm^2/h). The average precipitation rate over the entire position in the low rate example in Table 2.3 was 5.1 g/dm^2/h. The individual rates of the four smaller pans were 5.0, 4.9, 5.2, and 5.3 g/dm^2/h, suggesting a maximum variation of 4.1 percent from the average rate over the entire position.

2.5.3.2 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 0.2 g. The start time of the rate collection period is recorded (h:min:sec) from the digital clock located near the rate station before the pans are brought outside the trailer.

The pans are positioned at locations 6 and 7 (see Figure 2.2) to collect precipitation for 10-minute intervals in normal conditions and for 5-minute intervals in periods of high precipitation rates and high winds. Before the plate pans are removed from the test stand and re-weighed, 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 to be re-weighed. 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 repeated until the final plate on the test stand has failed.

The rate for any holdover time 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 the particular test.

TABLE 2.3

DETAILED RATE DISTRIBUTION

Simulated Precipitation Conditions

Freezing Drizzle (low rate)

ZD AT NRC (-3°C)

DETAILED RATE OF PRECIPITATION

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1 (g)	t2-t1 (min)	RATE (g/dm²/h)
3	2-top left	14:02	14:34	81.6	88.8	7.2	31.9	5.0
4	2-top right	14:02	14:34	81.6	88.6	7	31.9	4.9
5	2-bottom left	14:02	14:34	81.8	89.2	7.4	31.9	5.2
6	2-bottom right	14:02	14:34	81.6	89.2	7.6	31.9	5.3

	3	4		5		STD DEV
	5.0	4.9		-1.4%	-4.1%	0.181
	5.2	5.3		1.4%	4.1%	
	5	6				

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

Freezing Drizzle (high rate)

ZD AT NRC (-3°C)

DETAILED RATE OF PRECIPITATION

FORM: 1

PAN #	Plate Loc.	t1 TIME BEFORE	t2 TIME AFTER	w1 WEIGHT BEFORE	w2 WEIGHT AFTER	w2-w1 (g)	t2-t1 (min)	RATE (g/dm²/h)
3	5-top left	12:12	12:43	81.8	98.8	17	30.8	12.3
4	5-top right	12:12	12:43	81.6	98.8	17.2	30.8	12.5
5	5-bottom left	12:12	12:43	81.6	100.2	18.6	30.8	13.5
6	5-bottom right	12:12	12:43	81.6	100.2	18.6	30.8	13.5

	3	4		12.9		STD DEV
	12.3	12.5		-4.8%	-3.6%	0.631
	13.5	13.5		4.2%	4.2%	
	5	6				

X Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

Y Axis	Area	Full	Y
		Partial	
	Speed	High	Y
		Low	

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.4. Typically, two collections pans are used for each test. The start and end times of the test are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t_1, t_2, and t_3 (minutes). The calculated rates for each collection period are indicated by R_1, R_2, and R_3 (g/dm^2/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 2.4, 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/dm^2/h. The average rate for the other collection pan is calculated in a similar fashion, and the average of the two rates is then taken.

2.6 Data Forms

Two data forms were used to manually record data at Dorval during the 2000-01 winter season. The form used to record fluid failure times for each crosshair on the plates is shown in Table 2.4. The second form (Table 2.5) was used to record data related to meteorological conditions during tests. One half of the form was designated for plate pan precipitation rate measurements, and the rest for recording meteorological conditions.

The data forms used in simulated precipitation tests at NRC were similar to those used in natural precipitation tests and are shown in Appendix C.

2.7 Fluids

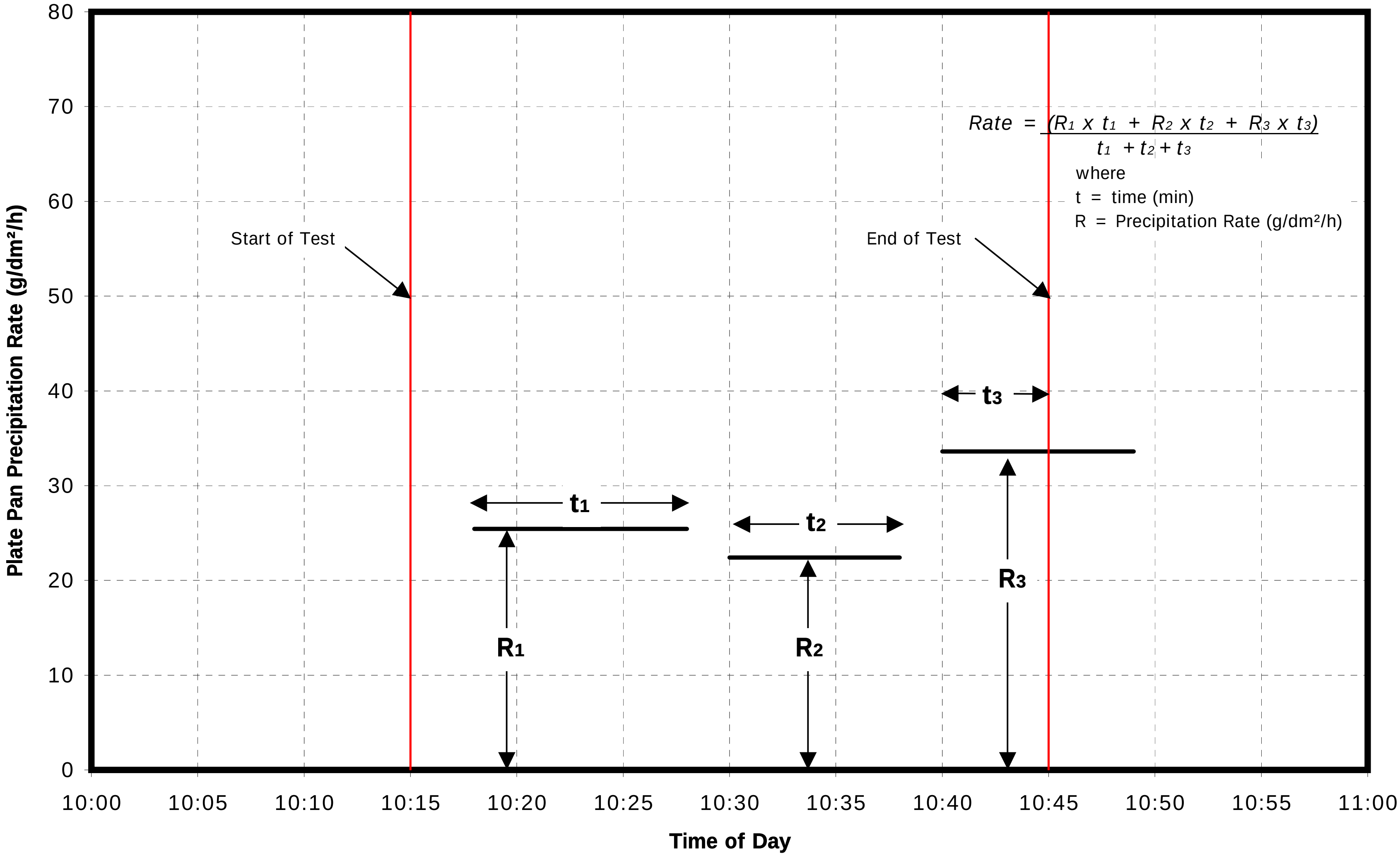
2.7.1 General

Type I fluids were obtained from manufacturers in concentrated form. Tests with Type I fluids in the 2000-01 winter were conducted with diluted solutions specific to particular test temperature requirements. Whenever fluid dilution was required, the concentrations were adjusted by mixing with hard water and verified by measuring the refractive index of the resulting solution.

FIGURE 2.4

CALCULATION OF OUTDOOR PRECIPITATION RATE

TYPICAL TEST



cm1680/report/holdover time/Rate Example
At: RATE

TABLE 2.4

END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

VERSION 6.0 Winter 1999/2000

LOCATION: **DATE:** **RUN # :** **STAND # :**

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NUMBER: ____ ____ ____ ____ ____ ____

DIRECTION OF STAND: ________ o

OTHER COMMENTS (Fluid Batch, etc):

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

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

Time of Fluid Application: ________ h:min:ss ________ h:min:ss ________ h:min:ss

	Plate U			Plate V			Plate W		
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 / TEMPERATURE AT START	/			/			/		

Time of Fluid Application: ________ h:min:ss ________ h:min:ss ________ h:min:ss

	Plate X			Plate Y			Plate Z		
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 / TEMPERATURE AT START	/			/			/		

M\Groups\CM1680 (exBM3833)\Reports\HOT\Tables Figures\end_form

TABLE 2.5
METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME | VERSION 6.0 | Winter 98/99

LOCATION: **DATE:** **RUN # :** **STAND # :**

HAND HELD VIDEO CASSETTE #:

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 (△ w*4.7/ △t) ($g/dm^2/h$)

*measurements every 15 min. and at failure time of each test panel.

METEO OBSERVATIONS **

TIME (h:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See Fig. 3)	If SNOW, WET or DRY

**observations at beginning, end, and every 10 min. intervals. Additional observations when there are significant changes.

TEMPERATURE AT START OF TEST _________ ºC

WIND SPEED AT START OF TEST _________ kph

WIND DIRECTION AT START OF TEST _________ º

COMMENTS : ____

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	____________	____________
VIDEO BY :	____________	____________
TEST SITE LEADER :	____________	____________

The hard water was produced according to AMS 1424. To produce 18 L of hard water, 6.54 g of Calcium Acetate Monohydrate and 5.04 g of Magnesium Sulfate Heptahydrate were weighed and added to 18 L of distilled water.

All holdover time testing conducted with Type I fluids during the 2000-01 winter used solutions *diluted to a 10°C buffer*. The 10°C buffer implies that for any test, the diluted test solution must possess a freeze point 10°C below that of the ambient test temperature. For example, if a given test was performed at 0ºC, the concentration of the test solution was adjusted for the fluid to freeze at -10ºC.

Type II and Type IV fluids are often delivered by manufacturers to air carriers at a concentration designated as neat (100 percent). These fluids actually contain a minimum of 50 percent glycol and are thickened by incorporating additives to the fluid formulations. These additives are rheological and therefore modify the viscosities and flow properties of the fluid. The modified formulations enable anti-icing fluids to assume thicker films and to remain on the aircraft surfaces until the time of takeoff. In some cases, (mostly in Europe), neat Type II and Type IV fluids are mixed with water as follows:

- 75 percent neat formulation and 25 percent water by volume. These are designated Type II or Type IV 75/25; and

- 50 percent neat formulation and 50 percent water by volume. These are designated Type II or Type IV 50/50.

2.7.2 Fluids Tested

The de/anti-icing fluids used in tests in 2000-01 were formulated with ethylene glycol (EG), propylene glycol (PG) or diethylene glycol (DEG).

Type I testing with fluids diluted to a 10°C buffer was carried out using Lyondell ArcoPlus (PG); an experimental fluid from Lyondell, originally designated ArcoPlus-ST (PG); Clariant EG I 1996 (EG); Clariant MP I 1938 (PG); and Newave Aerochemical FCY-1A (EG). All five Type I fluids were provided to APS in their concentrated form. Subsequent dilution was performed with the addition of hard water.

To prepare the fluids for endurance time testing, hard water and concentrated Type I fluid was mixed in 10 L containers according to the mixture recipes prepared for each fluid (Appendix E). Following the mixture of any dilute fluid, the refractive index was verified to ensure the accuracy of the fluid freeze point. If the freeze point of the mixed fluid matched that indicated in Appendix E Table 1, the fluid was ready for testing. If the freeze point did not match that indicated in the table, either concentrated fluid or hard water was added to the mixture. This step was repeated until the desired freeze point was attained.

One Type II fluid, SPCA Ecowing 26 (PG) was tested in 2000-01. Four Type IV fluids were also tested: Clariant Safewing MP IV Protect 2012 (PG), Clariant MP IV 2015 TF (PG), Octagon Max-Flight (PG), and an experimental fluid from UCAR (DEG). In addition, a limited investigation was performed with a degraded viscosity sample of Kilfrost ABC-S that was also tested in the 1999-2000 winter.

A list of the fluids requested for testing, the dates they were received, batch numbers, and fluid freeze points has been compiled in Table 2.6.

The fluids were received in 20 L containers or in 200 L drums. For anti-icing fluids, the addition of hard water to obtain either 50/50 or 75/25 formulations was carried out by the fluid manufacturers in their production facilities.

2.7.3 Evolution of Type IV Fluids

Tests with several Type IV fluids have been conducted since 1996; however, some fluids are no longer available or the formulations have been modified.

The fluid viscosities of the different anti-icing fluids used in testing have also changed. In holdover time testing conducted in 1996-97 and 1997-98, Type IV fluids consisted mainly of mid-range viscosity fluids. In 1998-99, tests were conducted using fluids representative of the manufacturers' lowest recommended on-wing viscosity. In 1999-2000 and 2000-01, the viscosities of the various fluids tested were selected by the fluid manufacturers using the sample selection procedures agreed upon at the SAE G-12 Fluids Subcommittee meeting in Toronto in 1999. Fluid-specific holdover time guidelines were developed for the anti-icing fluids, and these are described in detail in Subsection 4.2.1 of this report.

A summary of the changes for each fluid is presented below according to manufacturer.

2.7.3.1 Union Carbide/Dow

UCAR Ultra was the first fluid tested several years ago and had far superior holdover times than other Type II fluids. This fluid led to the development of Type IV fluids. An improved formulation, UCAR Ultra+, was tested in 1996-97 and 1998-99. Following the initial testing with UCAR Ultra+, APS was informed that the fluid was not certified for use in diluted forms.

TABLE 2.6
FLUID REQUEST/RECEIPT

Bottle	Fluid Manufac.	Fluid Type	Date Received	Quantity Ordered (Litres)	Brand Name Received	Quantity Received (Litres)	Batch #	Brix Stated/Freezing Point (°C)	Brix Measured	Viscosity Stated Using Manufacturer's Method (mPas)	Viscosity Measured Using Manufacturer's Method (mPas)	Comments
S	Octagon	T IV Neat	October 10, 2000	-	Maxflight	80	F- 21290		37	**5900**	**5990**	
T	Octagon	T IV 75/25	October 10, 2000	-	Maxflight	60	F- 21290		28.75	**-**	**34950 ***	
U	Octagon	T IV 50/50	October 10, 2000	-	Maxflight	40	F- 21290		21	**-**	**41300 ***	
V	Kilfrost	T IV Neat	March 27, 2000	-	ABC-S - degraded viscosity	20	P711		36.25	2600	2450	
Z	Lyondell	T I	October 25, 2000	200	ARCOPLUS ST		4CE 101 311	-	-	-	-	
AG	CAAC	T I	February 18, 2001	200	Newave Aerochemical		FCY-1A	-	-	-	-	
L	Clariant	T IV Neat	January 28, 2001	300	Safewing MP IV 2015 TF	300	TV 324	-34°C		18400	15100	
M	Clariant	T IV 75/25	January 28, 2001	200	Safewing MP IV 2015 TF	200	TV 324	-21°C		19200	16500	
N	Clariant	T IV 50/50	January 28, 2001	140	Safewing MP IV 2015 TF	100	TV 324	-10°C		3800	2200	
W	Clariant	T IV Neat	January 8, 2001	300	Safewing MP IV Protect 2012	300	TV 317	-34°C	35	9800	7800	Sheared
X	Clariant	T IV 75/25	January 8, 2001	200	Safewing MP IV Protect 2012	200	TV 317	-21°C	27.5	17200	13900	Sheared
Y	Clariant	T IV 50/50	January 8, 2001	140	Safewing MP IV Protect 2012	140	TV 317	-10°C	18.5	6200	6800	Sheared
AH	UCAR DOW	T IV Neat	March 9, 2001		18 MJM 101		18 MJM 101			15475	15500	small sample
	UCAR DOW	T IV 75/25	March 9, 2001		18 MJM 101		18 MJM 101					
	UCAR DOW	T IV 50/50	March 9, 2001		18 MJM 101		18 MJM 101					
AD	SPCA	T II Neat	February 18, 2001	300	ECOWING 26	300	L 1043	-36°C	36.5	5200	4900	
AE	SPCA	T II 75/25	February 18, 2001	200	ECOWING 26	200	L 1043	-21°C	28.75	3400	3700	
AF	SPCA	T II 50/50	February 18, 2001	140	ECOWING 26	140	L 1043	-10°C	20	1300	1000	

* Viscosity was not stable

Two additional Type IV fluids from Union Carbide, UCAR Ultra IV and UCAR PG AAF, were tested in 1997-98; however, these fluids were never produced.

In 2000-01, APS tested an experimental Type IV fluid on behalf of Union Carbide/Dow. Dow requested that testing with this product be discontinued prior to its completion.

2.7.3.2 Clariant/Hoechst

Type IV Hoechst MPIV 1957 was first tested during the winter of 1996-97. In the winter of 1997-98, the manufacturer changed its name to Clariant and reformulated the MPIV 1957 product. For clarity, the fluid tested in 1996-97 is referred to as Hoechst MPIV 1957, while the fluid tested in 1997-98 and 1998-99 is referred to as Clariant MPIV 1957. In addition, Clariant developed a new Type IV fluid, Clariant MPIV 2001, which was tested in 1997-98. Additional testing was conducted with the MPIV 2001 product in 1999-2000 in conditions of freezing fog and rain on a cold-soaked wing.

In 1998-99, APS was provided with another Type IV fluid for testing: Clariant Safewing Four. Despite having tested the fluid in all conditions in 1998-99, Clariant chose not to produce the fluid in 1999-2000. In 1999-2000, Clariant provided APS with two samples of a newly formulated Clariant Safewing Four product, a high viscosity sample (Safewing Four Plus) and a low viscosity sample (Safewing Four). Following the SAE meetings in Toulouse in May 2000, APS was informed that the Clariant Safewing Four Plus would not be produced commercially.

In 2000-01, Clariant furnished APS with two additional Type IV fluids for testing, Clariant Safewing MPIV Protect 2012 and Clariant Safewing MPIV 2015 TF. The test results for both fluids were presented at the SAE G-12 Holdover Time Subcommittee meeting in New Orleans in May 2001. Shortly after the meeting, Clariant informed the industry that the 2015 TF product would not be manufactured. In September 2001, APS was informed that production of Clariant Safewing Four would be discontinued immediately.

2.7.3.3 SPCA

SPCA AD-404 was tested in the 1995-96 and 1997-98 winters. A new Type IV fluid, SPCA AD-480, was tested for the first time in 1997-98. Additional testing with the AD-480 fluid was conducted in natural snow in 1998-99 due to a lack of data points at cold temperatures from the previous year. A low viscosity sample of the AD-480 product was tested again in 1999-2000. SPCA AD-404 is no longer available.

2.7.3.4 Kilfrost

Type IV Kilfrost ABC-S fluid was tested during three seasons: 1996-97, 1997-98, and 1998-99. A degraded viscosity sample of the Kilfrost ABC-S was delivered to APS during the 1999-2000 and 2000-01 winters for holdover time testing. In this case, a degraded fluid would be considered to have changed/altered from its primary/natural state, either as a result of time or by the influence of precipitation.

2.7.3.5 Octagon

Type IV Octagon Max-Flight was tested during four seasons: 1996-97, 1997-98, 1998-99, and 2000-01. In 1998-99, Octagon supplied APS with a low viscosity sample of Max-Flight for holdover time testing. The result was substantially lower fluid-specific holdover times.

In 2000-01, Octagon tested a higher viscosity sample of Max-Flight in an attempt to increase the fluid-specific holdover times for this fluid. The results of 1998-99 tests with the low viscosity fluid were discarded and are not included in this report.

2.8 Personnel

The site at Dorval was staffed mainly by technicians and university students, and supervised by APS project staff. Depending on the rate and duration of precipitation, as many as four test stands were in use at Dorval. Nine testers with the following responsibilities (see Appendix B, Attachment II for details) were enlisted to operate four test stands:

- *Test Site Leader (1):* Supervise and train site personnel, ensure that the site is functional, and ensure that test procedures are adhered to. Video-record fluid failure, as required;
- *End Condition (4):* Record end condition times for each crosshair; and
- *Meteo (4):* Record meteorological conditions during every test.

Because prolonged precipitation events require backup personnel, a fairly large number of technicians were trained to perform experiments. Due to the nature, scale, and schedule of the testing (both holdover time and full-scale) and the requirement to keep costs to a minimum, a pool of students was considered to be the best option for the manpower requirements of these tests.

Personnel responsibilities for the cold chamber indoor tests were slightly different. To ensure that the cold chamber facility was utilized at all times, technicians were often assigned specific tasks. For example, fluids were prepared, mixed, cooled and replenished after every test. During cold-soak testing, one technician verified that the cold-soak boxes were properly thermostatted. To ensure accurate precipitation rate measurements, the rate measurement procedure was semi-automated and a technician was assigned the task of calculating and displaying printed summaries of the precipitation rates. A computer and printer were dedicated for this process.

In order to obtain consistent results from fluid failure calls, the same individual has recorded the end conditions for the NRC freezing precipitation tests since the 1996-97 test season. This individual has pilot experience, was available during all natural snow tests conducted at Dorval Airport, and supervised most of the failure calls.

2.9 Analysis Methodology

This section of the report describes the various categories of precipitation and the precipitation rate limits used during the course of holdover time testing. The process of data analysis used in the evaluation of fluid holdover times is also described.

2.9.1 Descriptions of Data Ranges and Precipitation Definitions

The test program developed to measure fluid failure times was carried out in five general categories of precipitation:

- Natural snow;
- Freezing drizzle;
- Light freezing rain;
- Freezing fog; and
- Rain on a cold-soaked surface.

Tests were conducted over temperature and precipitation rate ranges specific to each category of precipitation. A multi-variable regression analysis was used to evaluate fluid holdover times (first presented in Transport Canada report, TP 13131E [11]). This procedure is based on the refinement of an equation for a curve that best represents the fluid failure time test data, and involves solving that equation at the upper and lower limits of a defined precipitation range. To support this procedure, precipitation rate limits for each specific category of precipitation were defined, reviewed, and approved.

The precipitation rate limits used for the evaluation of holdover times are represented schematically in Figure 2.5.

Detailed definitions and explanations of the data types and ranges are described in the following subsections. Meteorological definitions of these conditions are outlined in Table 2.1.

2.9.1.1 Natural snow

All fluid failure tests in natural snow were conducted at the APS Dorval Airport test site. Data were collected for precipitation rates that ranged from less than 10 $g/dm^2/h$ to greater than 25 $g/dm^2/h$. However, upper and lower limits for each cell in this column of the holdover time tables were determined at rates of 10 and 25 $g/dm^2/h$, respectively.

If precipitation rates less than the lower limit (light snow) were encountered in actual operation, the upper time limit of the holdover time range was selected for use.

The upper precipitation rate limit (25 $g/dm^2/h$) corresponds to the onset of heavy snow. Above this rate, it is standard practice to refer to the cautionary note included in the holdover time tables indicating that the time of protection will be shortened in heavy weather conditions (i.e., heavy precipitation or high moisture content).

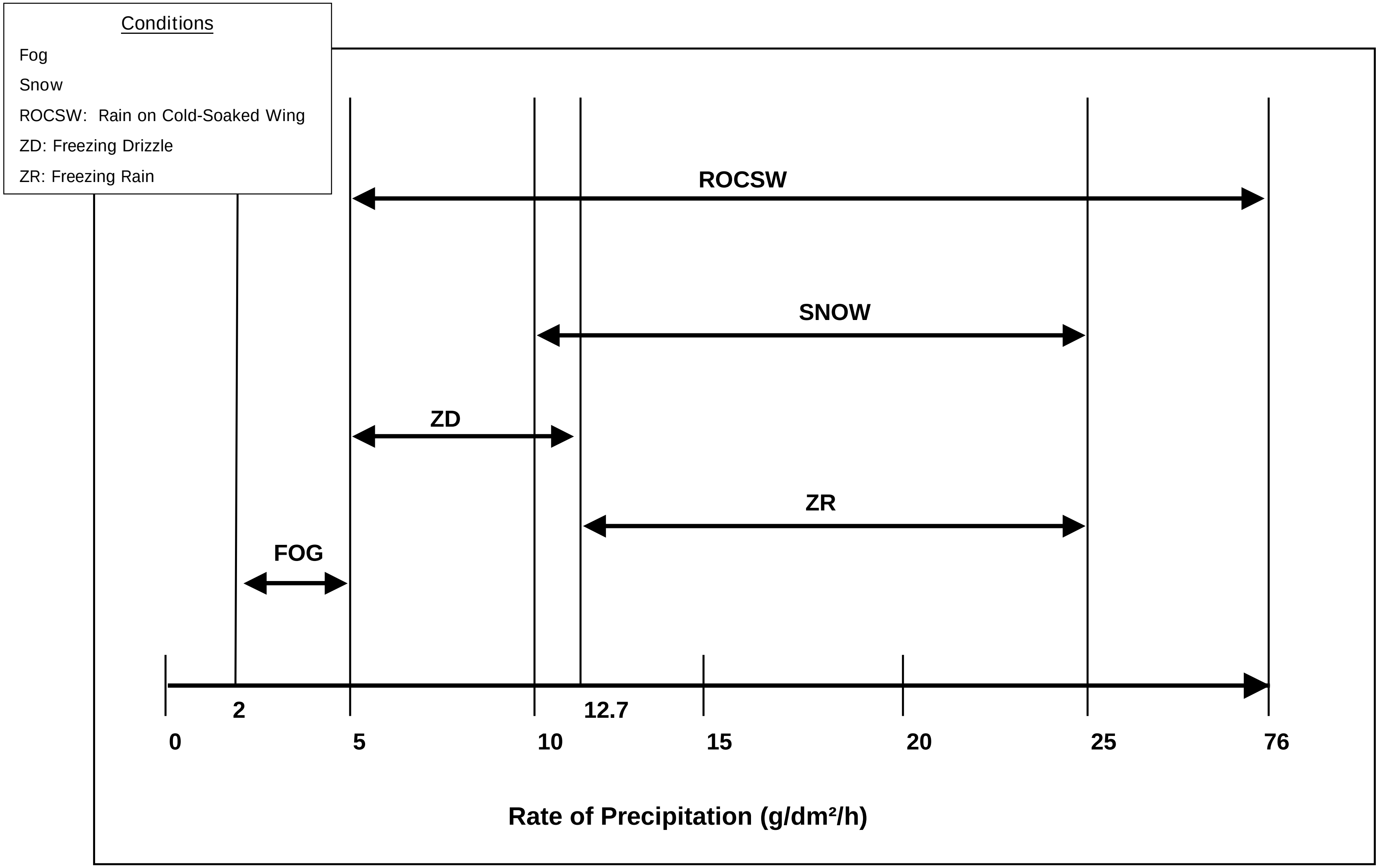
2.9.1.2 Freezing drizzle

Freezing drizzle is considered to occur over the range of 0 to 12.7 $g/dm^2/h$. The upper limit in this range was not specifically defined in Table 2.1, but has been adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 Holdover Time Subcommittee.

For test purposes, the precipitation rate spectrum for freezing drizzle is confined to rates between 5 and 12.7 $g/dm^2/h$, inclusively. This rate range corresponds to heavy drizzle and was selected to provide aircraft operators with a greater margin of safety.

FIGURE 2.5

PRECIPITATION RATE RANGES USED FOR EVALUATION OF HOLDOVER TIME LIMITS



H:cm1680/report/hot/ranges.ppt

A note of caution is included in the holdover time tables indicating that if positive identification of freezing drizzle is not possible, operators should refer to the holdover time for light freezing rain.

2.9.1.3 Light freezing rain

Freezing rain conditions span the range of precipitation rates from 12.7 to 25 g/dm^2/h, inclusively. This range falls in the category of light freezing rain and is the only freezing rain category considered, as operations in moderate or heavy freezing rain are deemed unsafe.

2.9.1.4 Freezing fog

The precipitation rate limits for freezing fog were determined with input from meteorologists from NRC, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). The LWC, 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. The precipitation rate for fog, referred to as *fog deposition* or simply as *deposition*, is given by the empirical expression

Deposition = LWC x Wind Velocity x Sin 10° x Collection Efficiency

where the sin 10° term accounts for the 10° inclination of the test plates into the direction of the wind.

For a plate in conditions of fog with a 0.6 g/m^3 LWC, a wind velocity of 6 km/h, and a collection efficiency of 80 percent, a deposition of 5 g/dm^2/h is obtained. For an aircraft taxiing at 12 km/h relative to the same wind in a 0.6 g/m^3 LWC fog, a collection efficiency of 40 percent might be expected in this situation, and again a deposition rate equal to 5 g/dm^2/h is achieved.

The meteorological circumstances (LWC value and wind speed) and the speed and orientation of the airfoil relative to the wind (stationary or taxiing) contribute to uncertainties in the values that the variables in the equation can assume.

The upper and lower holdover times for freezing fog were determined subjectively from the test data in previous years. It was agreed (at the 1997 Chicago SAE G-12 Holdover Time Subcommittee meeting) that the lower and upper holdover times for fog be evaluated at rates of 5 g/dm^2/h and 2 g/dm^2/h, respectively. The general sentiment during the 1998 SAE G-12 Holdover Time

Subcommittee meeting in Vienna was that 2 g/dm²/h was not indicative of low-rate natural fog. As a result, the upper holdover times in each of the freezing fog cells of the holdover time tables remained the same in the 1998-99 winter operating season. During a meeting of the Workgroup on Laboratory Methods to Derive Holdover Time Guidelines in Montreal in March 1999, it was again agreed that the rate of 2 g/dm²/h would be used in subsequent holdover time testing to determine the upper holdover time limit in freezing fog conditions.

Substantial improvements were made to the freezing fog spray delivery system during the 1998-99 test season. These changes afforded improved control over fog deposition rates during 1998-99 and 1999-2000 indoor tests. In previous years, freezing fog was sprayed horizontally from the walls of the chamber onto the test plates. In 1998-99, the spray assembly was positioned above the test stand, allowing the freezing fog to be sprayed vertically down onto the plates. In addition, a snowfence was set up at the NRC chamber for freezing fog tests to shield the spray assembly from horizontal air currents caused by the cooling systems (see Photo 2.15).

A study to quantify freezing fog deposition rates was conducted by APS during the 1999-2000 season. The objective of this study was to calculate and correlate the range of deposition rates that occurs naturally in fog with the range from 2 g/dm²/h to 5 g/dm²/h achieved in environmental chambers. For a full account of these tests, refer to Subsection 6.4 of TP 13659E [2].

2.9.1.5 Rain on a cold-soaked surface

Data used for the evaluation of holdover times for this category of precipitation were limited to precipitation rates ranging from 5 to 76 g/dm²/h, which encompasses drizzle (5 to 12.7 g/dm²/h), light rain (12.7 to 25 g/dm²/h), and moderate rain (25 to 76 g/dm²/h). The heavy rain category is covered by the cautionary note at the bottom of the holdover time table regarding heavy weather conditions.

2.9.2 Protocol for the Determination of Holdover Times

Each cell in a holdover time table represents a range of time during which a fluid at a specified concentration will provide protection for a particular temperature range in a particular category of precipitation. The Type II and Type IV holdover time tables are composed of a maximum of 45 cells. Each cell contains a lower and upper time limit (except for frost) for a maximum of 81 time values.

Holdover time values in each cell are determined by plotting *failure time* versus *rate of precipitation* and recording the failure time at two pre-selected rate limits. In previous years, several protocols were employed in determining endurance times. Due to the subjective natures of these different protocols, different interpretations of the data were possible. A multi-variable regression approach was subsequently devised in 1996-97 (see Transport Canada report, TP 13131E [11]) and has been used to evaluate fluid endurance times for the past four test seasons. Endurance times were then converted to holdover times by the SAE G-12 Holdover Time Subcommittee.

2.9.2.1 Multi-variable regression protocol

Data corresponding to each cell in the holdover time table were assembled and sorted according to precipitation type, fluid manufacturer, dilution factor, and temperature range. The data for each fluid and each cell in the holdover time table were plotted. The data points on each graph were used to fit an equation of the form

$$t = cR^a$$

where

t = Time (minutes);
R = Rate of precipitation ($g/dm^2/h$); and
a,c = Coefficients determined from the regression.

The coefficient a gives the rate dependency of the failure time.

A plot of **Log t** versus **Log R** is shown in Figure 2.6. The plot contains data from one temperature range for one Neat Type IV fluid 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 selected.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 2.7.

The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The holdover time range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

FIGURE 2.6

EXAMPLE OF REGRESSION METHOD ON LOG-LOG CHART

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

CLARIANT SAFEWING 1957 TYPE IV NEAT

LIGHT FREEZING RAIN

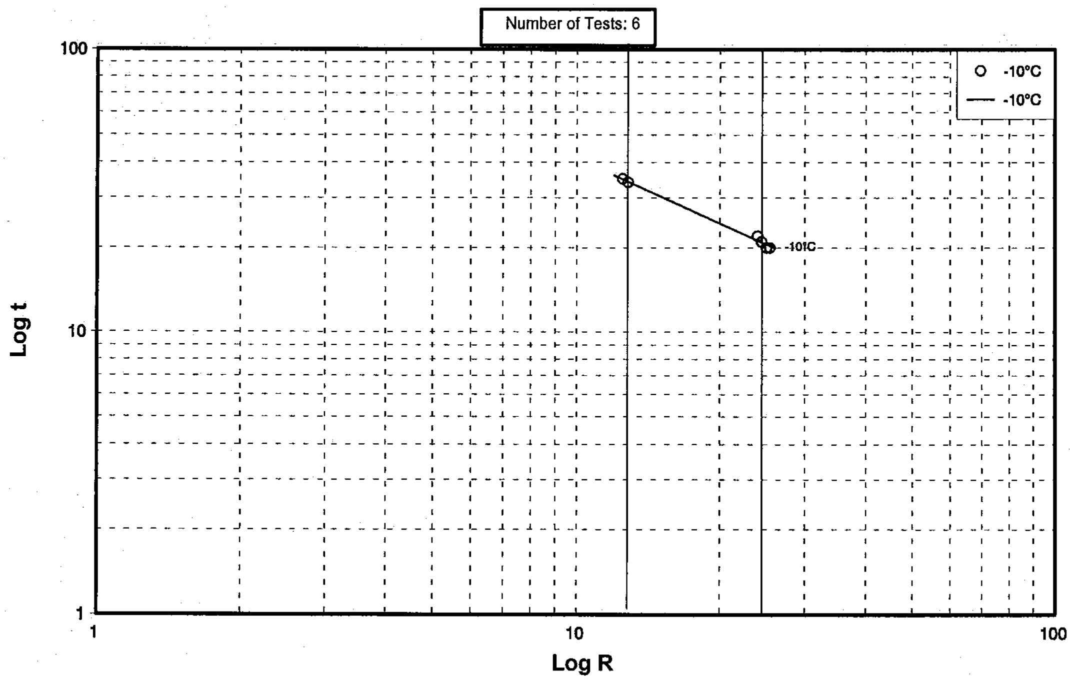


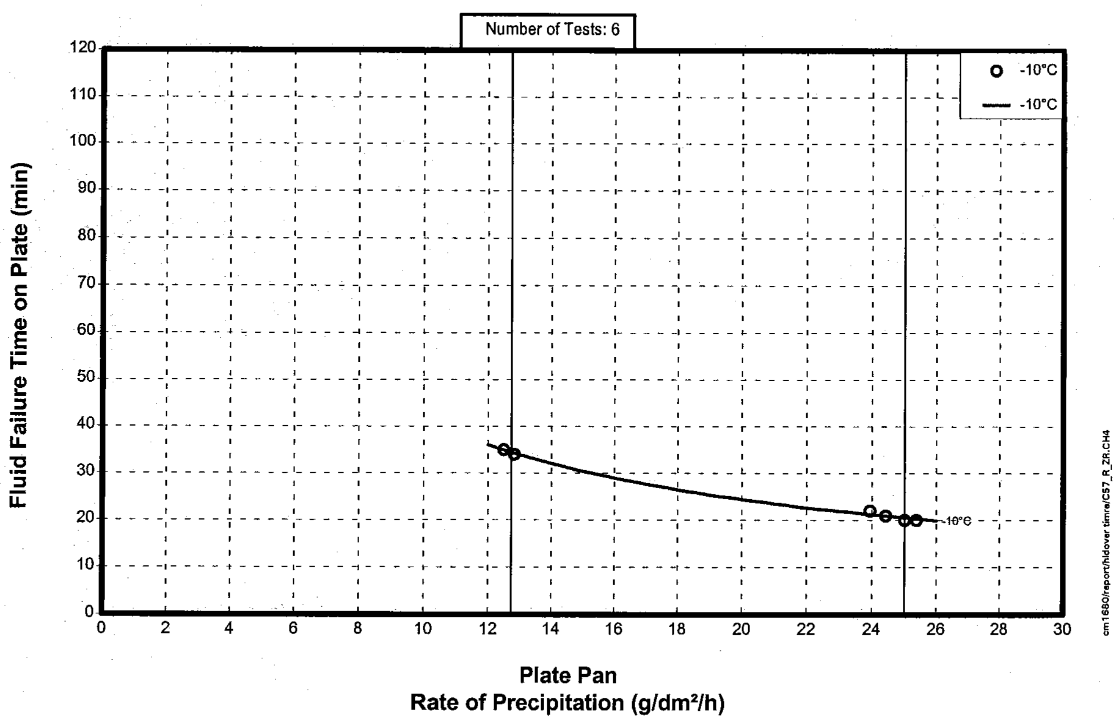
FIGURE 2.7

EXAMPLE OF REGRESSION METHOD ON STANDARD CHART

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

CLARIANT SAFEWING 1957 TYPE IV NEAT

LIGHT FREEZING RAIN



The holdover times for this fluid at -10°C are 34 minutes at 12.7 $g/dm^2/h$ and 20 minutes at 25 $g/dm^2/h$, establishing the holdover time range for this particular fluid. This illustrates the general approach used in the determination of a fluid holdover time range for any given cell in the holdover time table.

Appendix F lists the results of all the regression analyses performed and includes all the corresponding equations, with their associated coefficients determined, from each analysis and their associated output summaries.

The categories of precipitation are separated into five groups: natural snow, freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface. Each group was subject to a slightly modified version of the general equation given above, as described below.

- Light Freezing Rain and Freezing Drizzle

  The equation used to treat the data in these categories of precipitation is the unaltered form of the original equation:

  $$t = cR^a$$

  Tests in freezing drizzle and light freezing rain were conducted at predetermined temperature limits (-3 and -10°C). The best-fit curves for data corresponding to a given cell in the holdover time table in these conditions were also obtained by using the most restrictive (lowest) temperature cell range.

  An exception was made for temperatures above 0°C. Because experiments for freezing drizzle and light freezing rain could not be performed artificially at temperatures above 0°C, the equation could not be calculated for this temperature range. Consequently, Type IV endurance times noted in the holdover time table for temperatures above 0°C were obtained by using the same values calculated at -3°C. For Type I fluids, the times from tests at -10°C were used in the Above 0°C cell.

- Simulated Freezing Fog

  The same method used to evaluate freezing fog data in 1996-97 (see Transport Canada report, TP 13131E [11]) was also used to evaluate 2000-01 freezing fog data. The original equation is used to treat the data:

  $$t = cR^a$$

- Natural Snow

  The general form of the regression equation was modified for natural snow by substituting (2-T) for the variable T to prevent taking the log of a negative number, as natural snow can occur at temperatures approaching 2°C.

  $$t = cR^a(2-T)^b$$

  Best-fit curves were plotted for each fluid in each cell of the snow column using the most restrictive (lowest) temperature for that cell. For example, in cases of natural snow tests conducted at ambient temperatures above 0°C, the temperature value used in the procedure was 0°C.

  The upper and lower holdover time values were determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively.

- Rain on a Cold-Soaked Wing

  The same method for the evaluation of holdover times in light freezing rain and freezing drizzle was used for this category of precipitation.

2.9.3 Determination of Generic and Fluid-Specific Holdover Times

At the SAE Holdover Time Subcommittee meeting in Chicago in July 1997, Type IV fluid holdover times obtained using the multi-variable regression protocol of data analysis were presented. Wide variations in fluid performance among the different Type IV fluid brands precipitated the development of a *generic* or *SAE* Type IV holdover time table as well as *fluid-specific* Type IV holdover time tables. *Generic* and *fluid-specific* holdover time tables have subsequently been generated in 1997-98, 1998-99, 1999-2000, and 2000-01.

During the 1998-99 winter testing, a new Type II fluid also demonstrated superior performance in some conditions. This finding resulted in the development of a *fluid-specific* holdover time table for this fluid. Additional testing of Type II fluids in 1999-2000 and 2000-01 has prompted the compilation of two more Type II fluid-specific tables which will be available for use in 2001-02 winter operations.

The generic holdover time guidelines were endorsed and published by SAE until 2000. The generic holdover time guidelines for use in 2001-02 winter operations will be made available by Transport Canada and the FAA.

2.9.3.1 Generic holdover time guidelines

The plots containing the data from tests conducted in the winter of 2000-01 and illustrating the effect of fluid brand and rate of precipitation on holdover time were assembled according to the procedure outlined in Subsection 2.9.2.1 (see Appendix G). The holdover time results from tests conducted in 1996-97, 1997-98, 1998-99, and 1999-2000 used the same regression method of analysis and appear in Section 4 of this report. The results were compared on a cell-by-cell basis to determine the worst possible holdover time values in each cell of the holdover time table. The *generic* holdover time table for Type IV fluid (approved for use in 2001-02) contains the worst performing fluid holdover time values from tests conducted in 1996-97, 1997-98, 1998-99, 1999-2000, and 2000-01 tests and is included in Section 4.

Although no single *worst-case* fluid exists, the concept of a *worst-case* or *generic* fluid possessing performance characteristics that reflect the worst-case holdover times is useful for the purpose of discussion. The term *generic* is used in the remainder of this report and refers to a hypothetical fluid that exhibits the *worst-case* holdover time performance.

2.9.3.2 Fluid-specific holdover time tables

The development of a fluid-specific holdover time table was prompted by the fact that certain Type IV fluid brands were observed to significantly outperform other fluids under conditions corresponding to particular cells in the holdover time tables. In general, any one fluid brand does not globally outperform the other fluid brands, but rather does so at a specific dilution, temperature range, and/or category of precipitation.

At the meeting in Chicago in 1997, most members of the SAE G-12 Holdover Time Subcommittee did not favour the creation of *fluid-specific* tables. However, significant reductions to holdover times for the cells corresponding to the most common Type IV fluid usage convinced the committee of the need to consider the development of *fluid-specific* and *generic* tables. Furthermore, some members wanted to take advantage of the significant benefits exhibited by some fluids in certain conditions.

Fluid-specific holdover times were adopted for use in 1997-98 and 1998-99 winter operations for the three most commonly occurring precipitation categories in the holdover time tables: freezing drizzle, light freezing rain, and snow. For the other categories of precipitation (freezing fog, rain on cold-soaked surfaces, and frost), *generic* holdover times were adopted.

Beginning in the 1999-2000 winter operation season, *fluid-specific* holdover time values were adopted for all categories of precipitation with the exception of frost.

Following is a summary of the steps to determine specific values for each fluid:

- The method used to determine holdover times was generally the same as the one agreed upon in Chicago in 1997 at the SAE G-12 Holdover Time Subcommittee meeting;
- For each cell of the holdover time tables, four tests were typically conducted at the lowest temperature in the temperature range for that cell. Two tests were conducted at the low precipitation rate condition and at the high precipitation rate condition, for a total of four tests per cell;
- For each cell of the holdover time table (except frost), a best-fit power law curve for each fluid was developed from the tests conducted at the low and high precipitation rate condition of that cell;
- Regression-generated holdover times were rounded off to the nearest whole "5" digit. For example, 55.1 to 57.4 minutes was rounded down to 55 minutes; 57.5 to 59.9 minutes was rounded up to 60 minutes;
- In all cases where the regression-generated holdover times were below 10 minutes, the numbers were rounded down as a precautionary measure. For example, 9 minutes was rounded down to 5 minutes; and
- Values were capped at 2 hours for all precipitation conditions except freezing fog, for which they were capped at 4 hours.

Photo 2.1
View of Dorval Test Site and Associated Equipment

Photo 2.2
Environment Canada's Weather Observation Station at Dorval Airport

This page intentionally left blank.

Photo 2.3
Outdoor View of National Research Council Canada's Climatic Engineering Facility

Photo 2.4
Inside View of Small End of Climatic Engineering Facility

This page intentionally left blank.

Photo 2.5
Inside View of Large End of Climatic Engineering Facility

Photo 2.6
Sprayer Assembly Used at National Research Council Canada

This page intentionally left blank.

Photo 2.7
Sprayer Nozzle

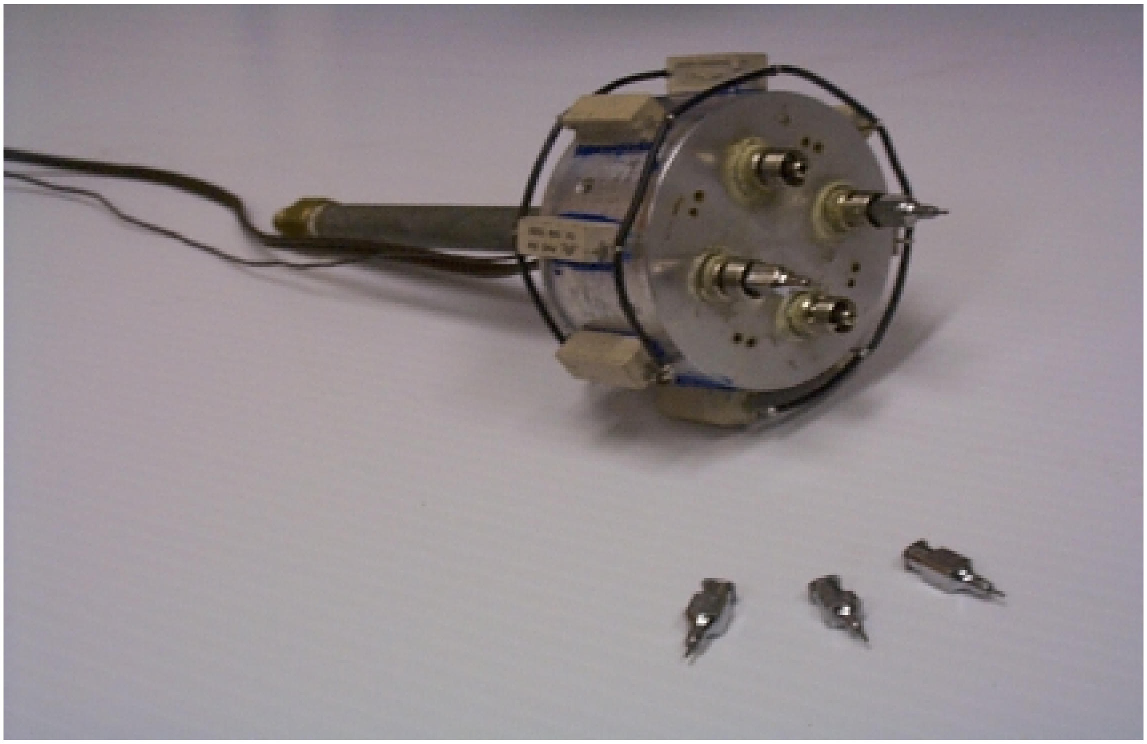
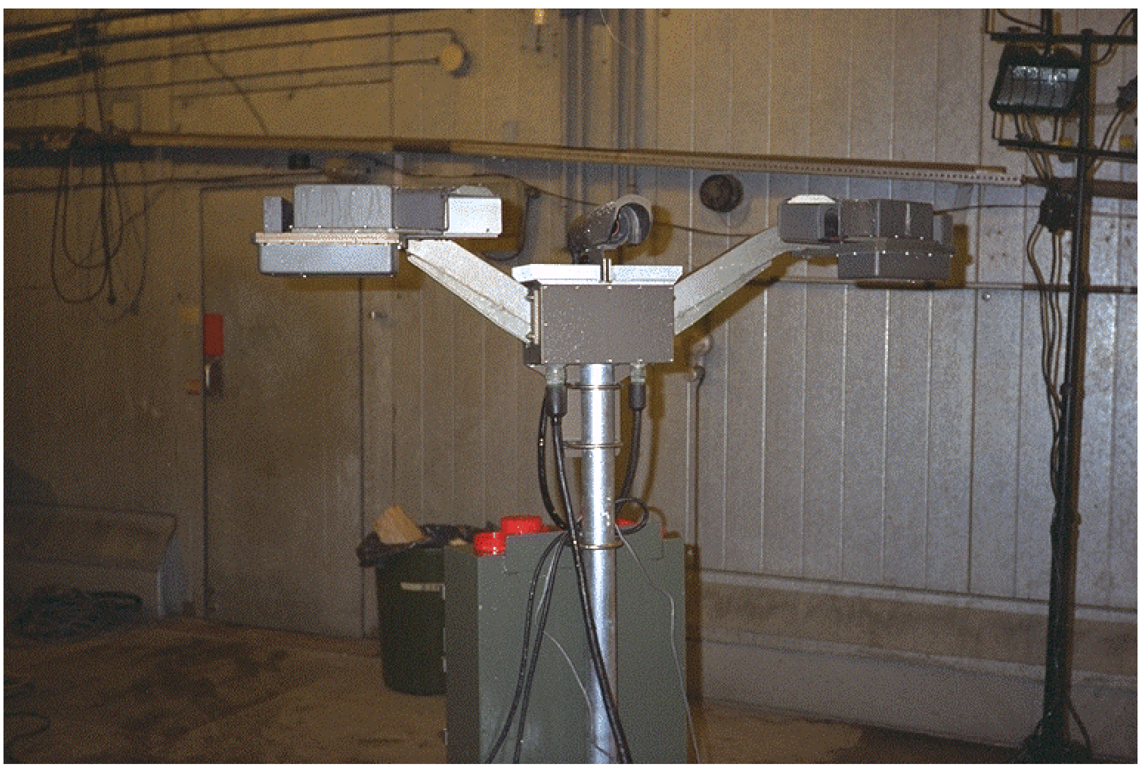


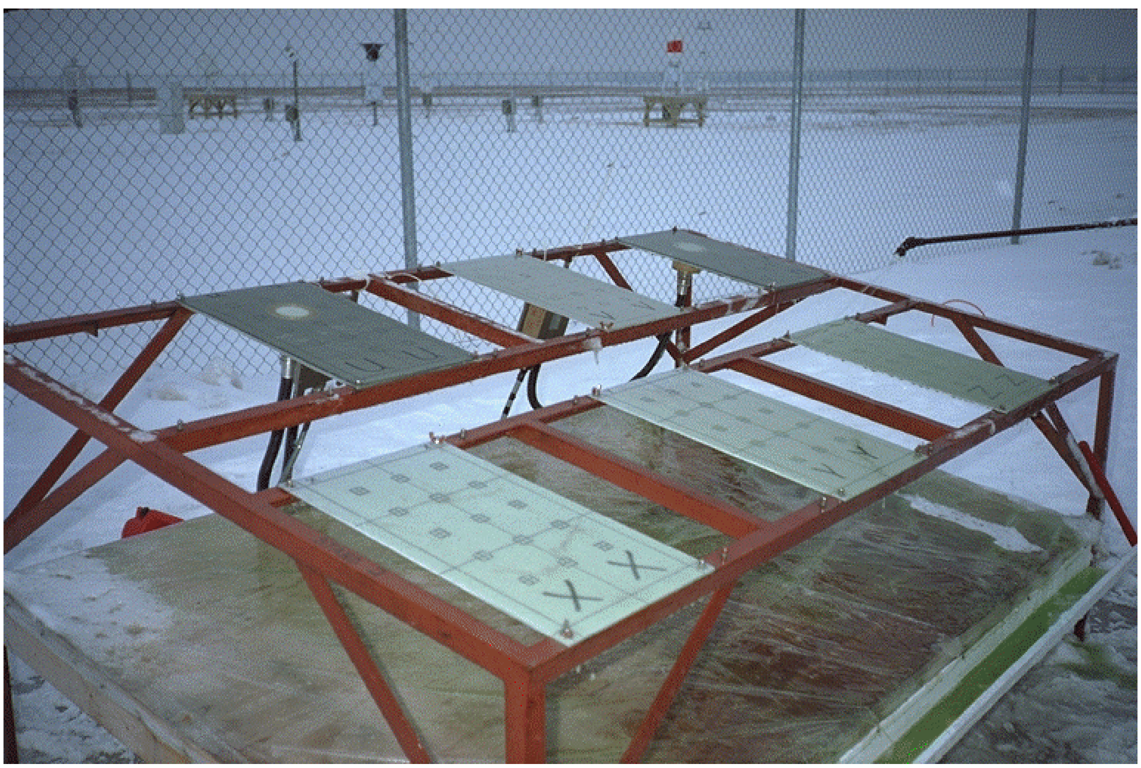
Photo 2.8
Optical Gauge Manufactured by HSS to Measure Droplet Size



This page intentionally left blank.

Photo 2.9
Examples of Droplet Sizes Produced by National Research Council Canada's Spray System

Photo 2.10
Test Plates Mounted on a Stand



This page intentionally left blank.

Photo 2.11
Collection Pans Used Indoors at National Research Council Canada

Photo 2.12
Digital Clock Used in Holdover Time Testing

This page intentionally left blank.

Photo 2.13
Misco Refractometer Used to Measure Freeze Point

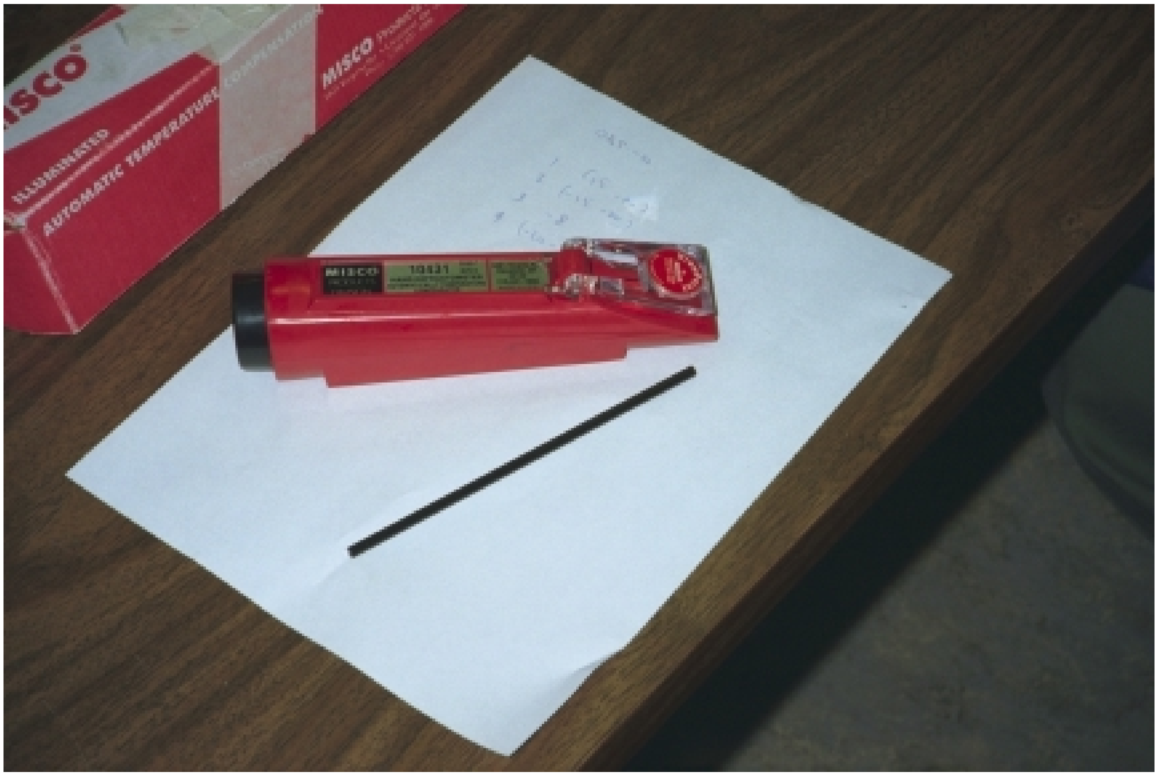


Photo 2.14
Meteorological Services Canada's Automated Weather Station Instruments

This page intentionally left blank.

Photo 2.15
Snow Fence Used in Freezing Fog Tests to Reduce Air Currents

This page intentionally left blank.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted for natural snow, simulated light freezing rain, simulated freezing drizzle, simulated freezing fog, and rain on cold-soaked surfaces. The quantity of tests performed is presented according to fluid type and weather parameters such as temperature, precipitation rate, and wind speed.

Natural snow tests were conducted at the APS test site, located at Dorval Airport. A total of 445 usable tests were conducted over the 2000-01 winter season.

Simulated light freezing rain, drizzle, fog, and rain on cold-soak box tests were conducted at NRC's CEF in Ottawa.

The complete log of endurance time tests conducted in 2000-01 appears in Appendix K.

3.1 Dorval Natural Snow Tests

3.1.1 Data Acquisition

The test plan developed for experiments conducted in natural snow conditions is described in Appendix B. During the 2000-01 test season, a total of 445 tests were performed on flat plates at the APS test site at Dorval Airport. All 445 data points were collected during natural precipitation.

The breakdown, by fluid type, of the 445 usable tests conducted in natural snow is shown in Figure 3.1.

Table 3.1 provides a summary of the anti-icing fluid tests that were conducted in natural snow conditions on a month-by-month basis. The largest number of tests was conducted in the month of March.

3.1.2 Test Location and Fluids Tested

The Type I, Type II, and Type IV fluids tested at Dorval Airport were manufactured by Clariant, Octagon, Lyondell, Newave Aerochemical, SPCA, and Union Carbide/Dow. Figure 3.1 shows all the fluid brands and dilutions tested in natural snow conditions at Dorval Airport, including the number of tests conducted.

FIGURE 3.1

NUMBER OF NATURAL SNOW TESTS

2000-01 Test Season at Dorval

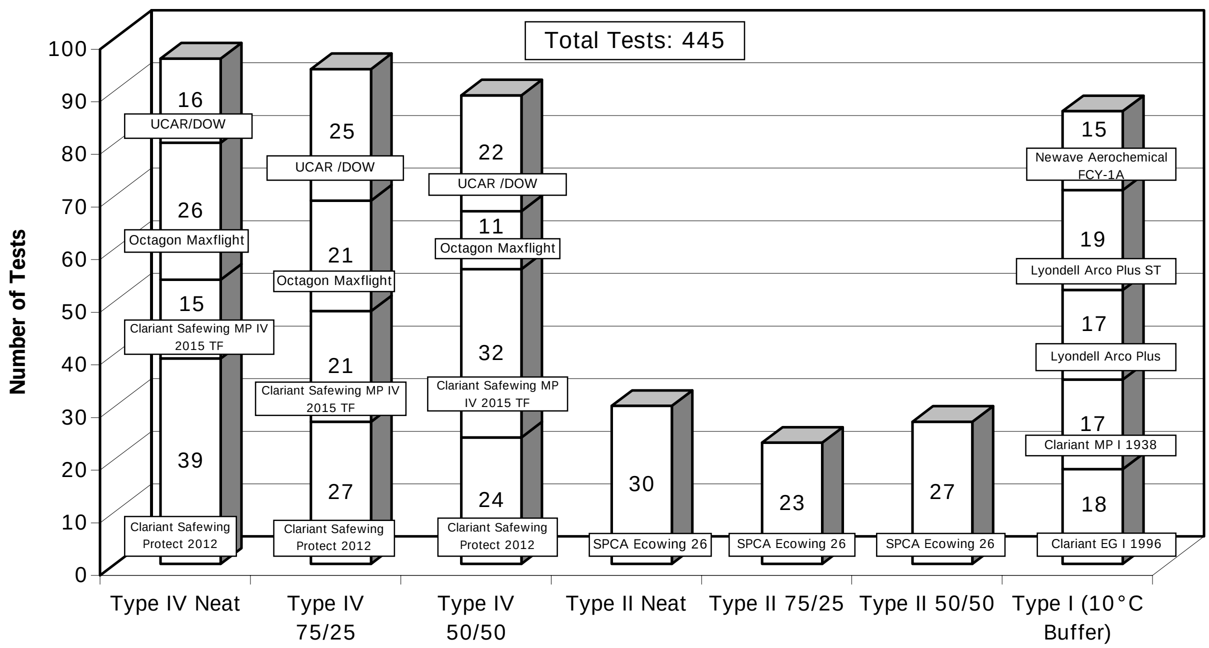


TABLE 3.1

DORVAL NATURAL SNOW DATA

Type II and Type IV Fluids

(Number of Tests: 359)

Fluid	Neat	75/25	50/50	Total
CLARIANT SAFEWING PROTECT 2012	39	27	24	90
CLARIANT SAFEWING MP IV 2015 TF	15	21	32	68
OCTAGON MAXFLIGHT	26	21	11	58
UCAR/DOW TYPE IV	16	25	22	63
SPCA ECOWING 26	30	23	27	80
Total:	126	117	116	359

December 2000

Sun	Mon	Tues	Weds	Thurs	Fri	Sat
					1	2
3	4	5	6	7	8	9
10	11 **4**	12	13	14 **6**	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30 **4**
31						

January 2001

Sun	Mon	Tues	Weds	Thurs	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15 **8**	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30 **11**	31 **18**			

February 2001

Sun	Mon	Tues	Weds	Thurs	Fri	Sat
				1	2 **7**	3
4	5 **15**	6	7	8	9	10
11	12	13	14 **25**	15	16	17
18	19 **29**	20	21	22 **14**	23 **16**	24
25 **14**	26	27	28			

March 2001

Sun	Mon	Tues	Weds	Thurs	Fri	Sat
				1	2	3
4	5 **38**	6 **12**	7	8	9 **19**	10
11 **39**	12	13 **71**	14	15	16	17
18	19	20	21	22	23 **9**	24
25	26	27	28	29	30	31

3.1.3 Distribution of Average Precipitation Rates

Precipitation at Dorval was measured using plate pans and two automated gauges from Environment Canada (READAC and CR21X). The rates of precipitation used in this report were computed using the plate pan method. Environment Canada gauges were used as a backup and also for evaluation of weather snow data, which is described in a separate report, TP 13830E [9].

The distribution of the average precipitation rate for the tests is summarized in Figure 3.2 for Type IV fluids, Figure 3.3 for Type II fluids, and Figure 3.4 for Type I fluids.

3.1.4 Distribution of Other Meteorological Conditions

Air temperature and wind speed data were obtained from Environment Canada's automated weather station (READAC). In previous years, these parameters were measured with instruments purchased by APS on behalf of Transport Canada. These instruments were used in 2000-01 for weather monitoring purposes only.

A summary of the distribution of the READAC measurements for each fluid type is illustrated in Figures 3.5 to 3.10 as follows:

- Figure 3.5 Distribution of Air Temperature for Type IV Fluids;
- Figure 3.6 Distribution of Air Temperature for Type II Fluids;
- Figure 3.7 Distribution of Air Temperature for Type I Fluids;
- Figure 3.8 Distribution of Wind Speed for Type IV Fluids;
- Figure 3.9 Distribution of Wind Speed for Type II Fluids; and
- Figure 3.10 Distribution of Wind Speed for Type I Fluids.

3.2 Freezing Drizzle and Light Freezing Rain Tests

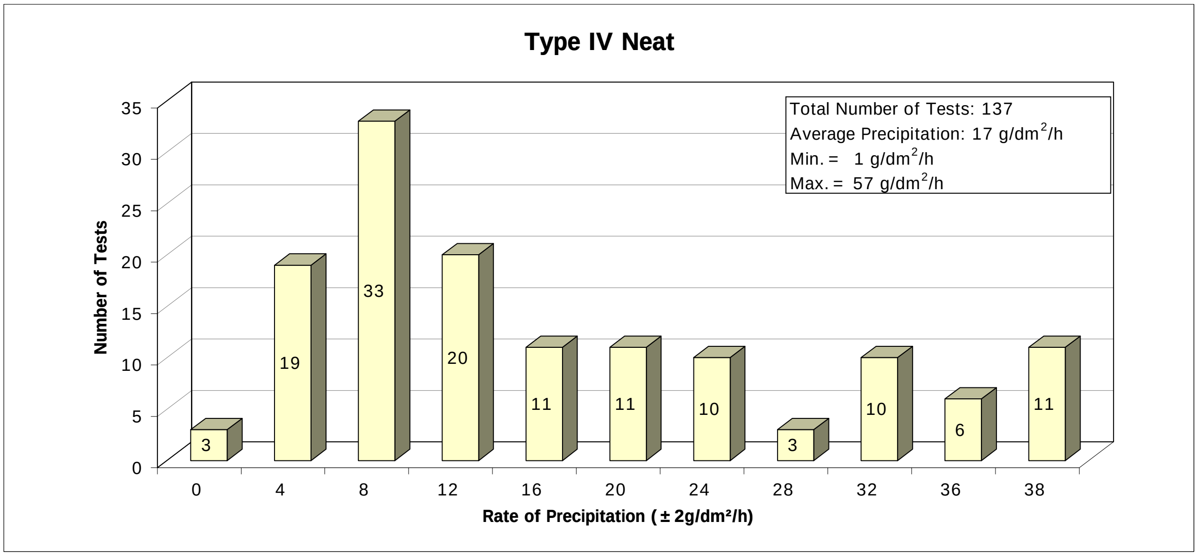
3.2.1 Data Acquisition

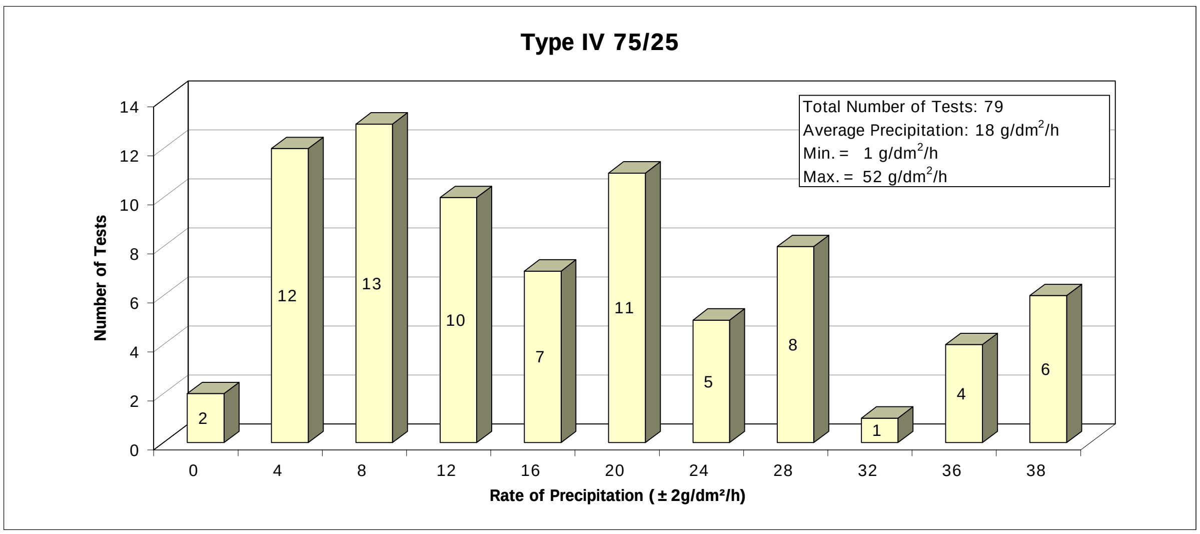
The test plan developed for experiments conducted in freezing drizzle and light freezing rain is described in Appendix C. A total of 105 freezing drizzle tests and 92 light freezing rain tests were carried out in the 2000-01 winter, as shown in Figure 3.11.

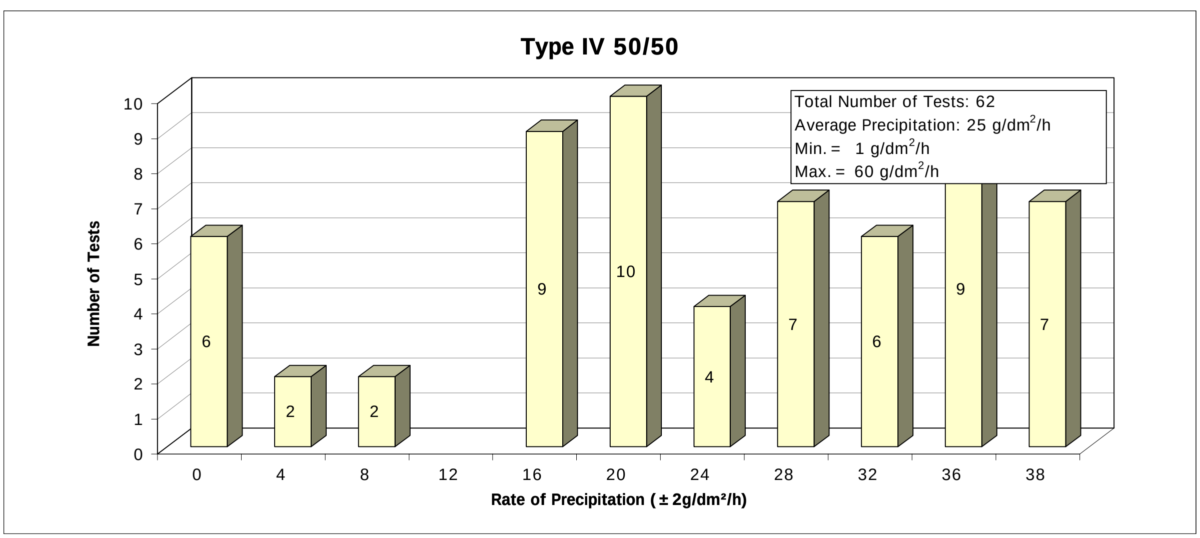
FIGURE 3.2

DISTRIBUTION OF PRECIPTATION RATE - TYPE IV FLUIDS

Natural Snow Tests 2001-02





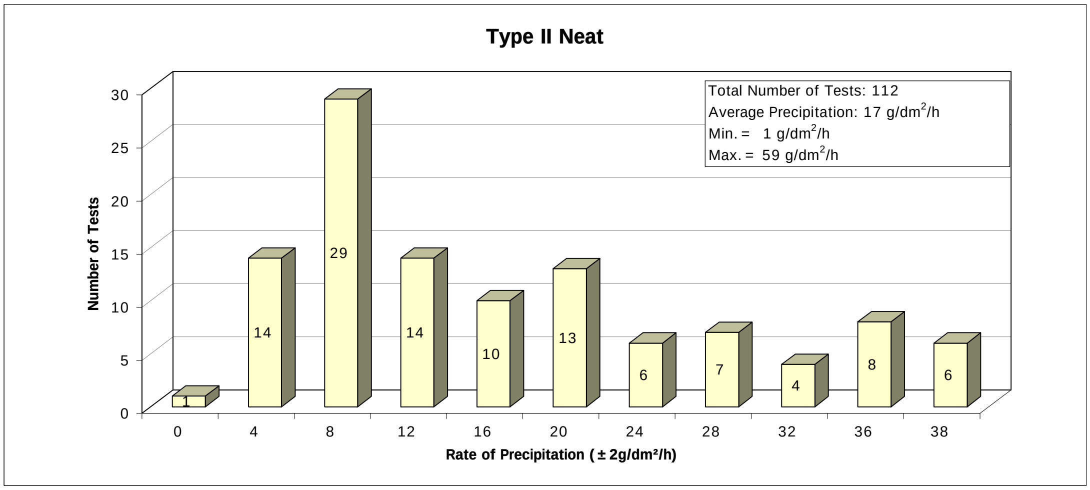


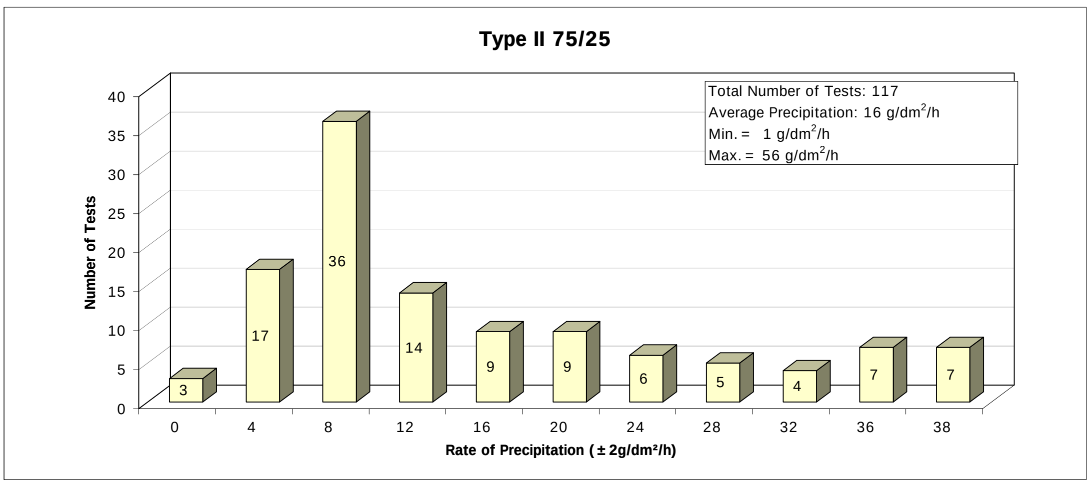
CM1680(exBM3833)\Analysis\HOT\type CM1680\Analysis\HOT\TypeIV\test summaryA\Figures 3.2etc
At:type IV

FIGURE 3.3

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

Natural Snow Tests 2001-02





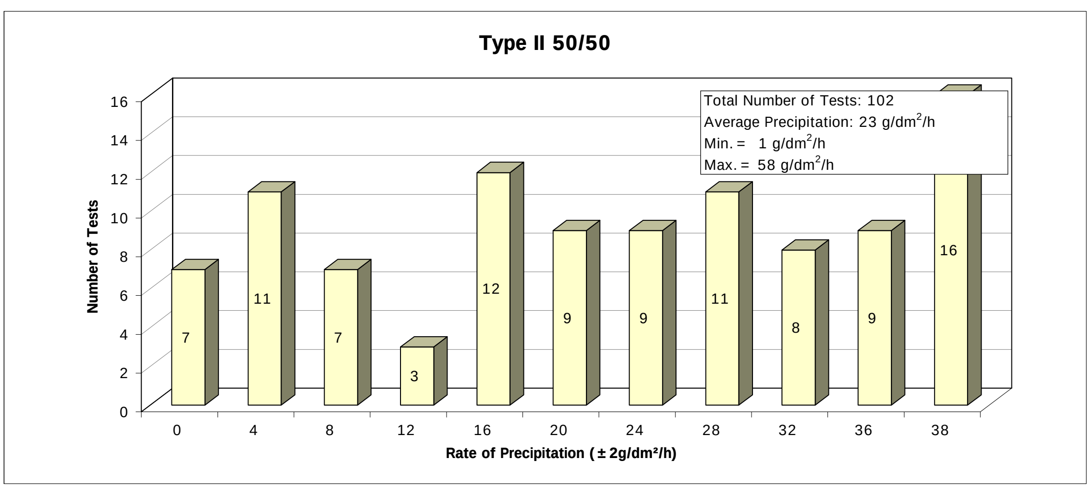
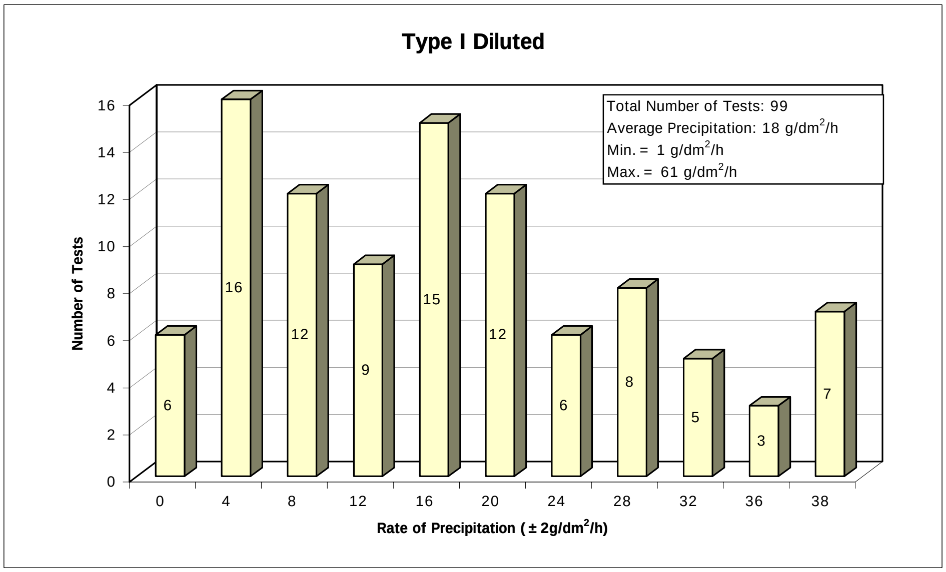


FIGURE 3.4

DISTRIBUTION OF PRECIPITATION RATE - TYPE I FLUIDS

Natural Snow Tests 2001-02

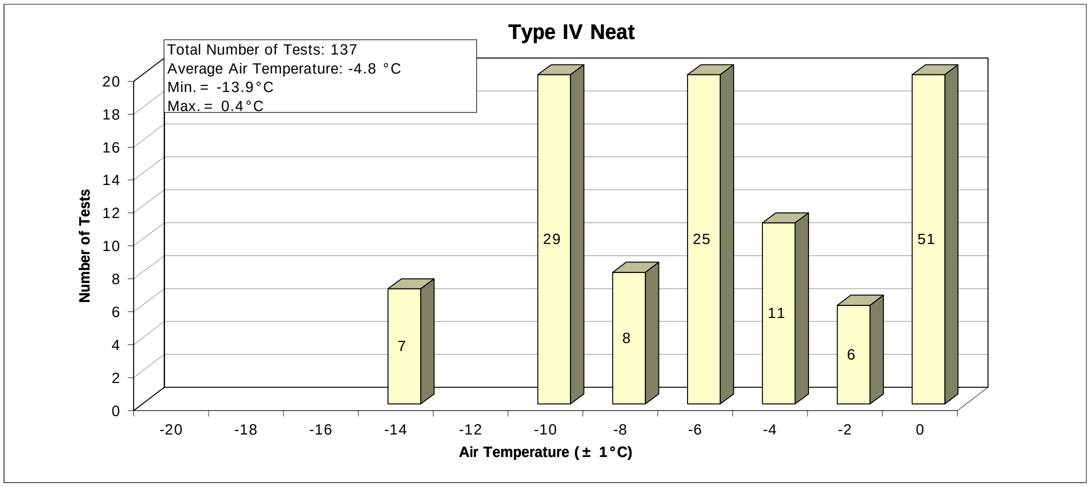


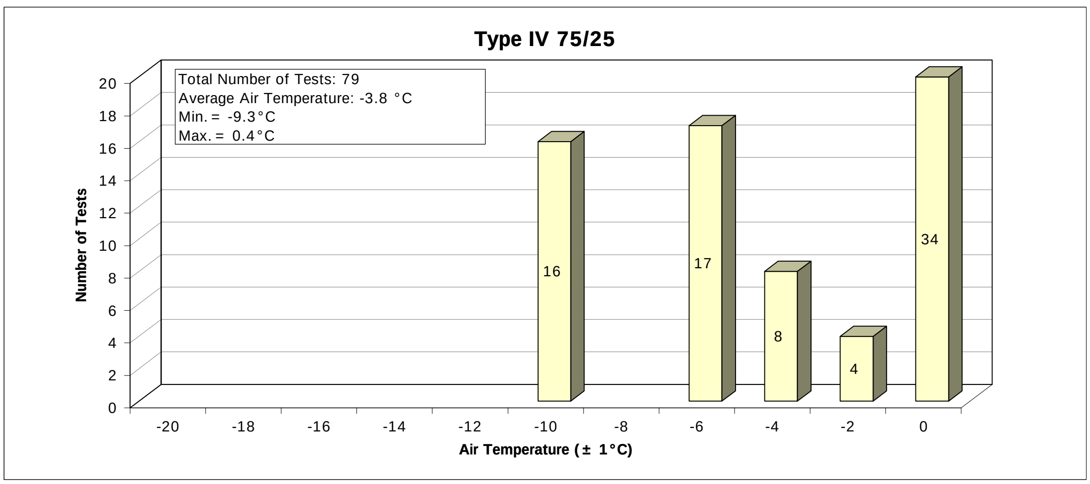
CM1680(exBM3833)\Analysis\HOT\Figures 3.2etc
At:type I

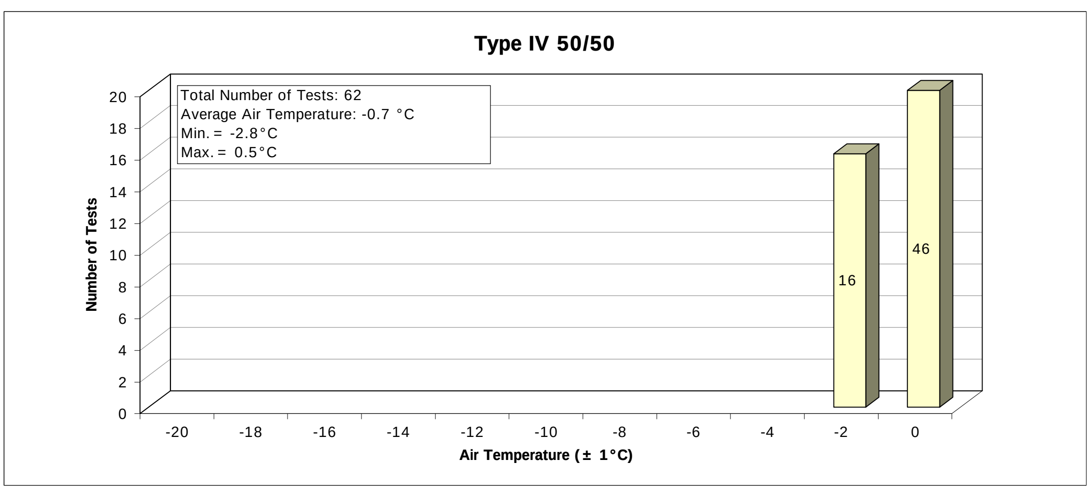
FIGURE 3.5

DISTRIBUTION OF AIR TEMPERATURE - TYPE IV FLUIDS

Natural Snow Tests 2001-02

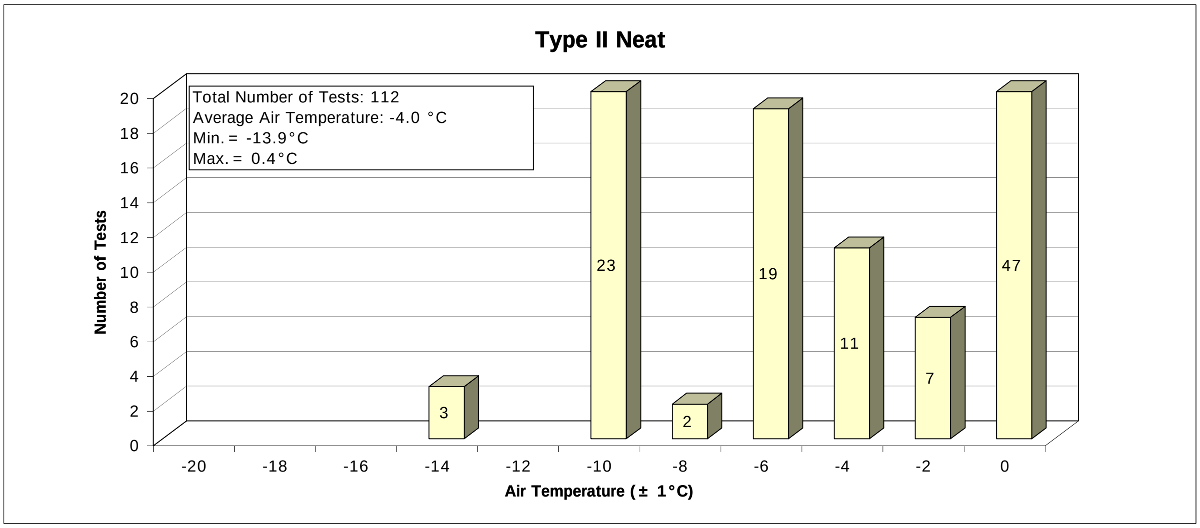


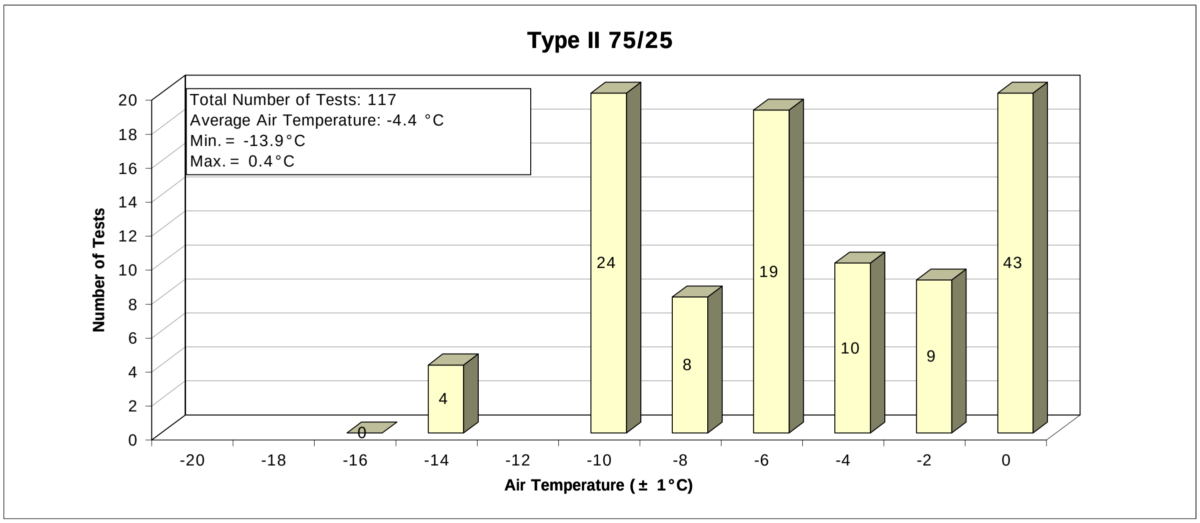


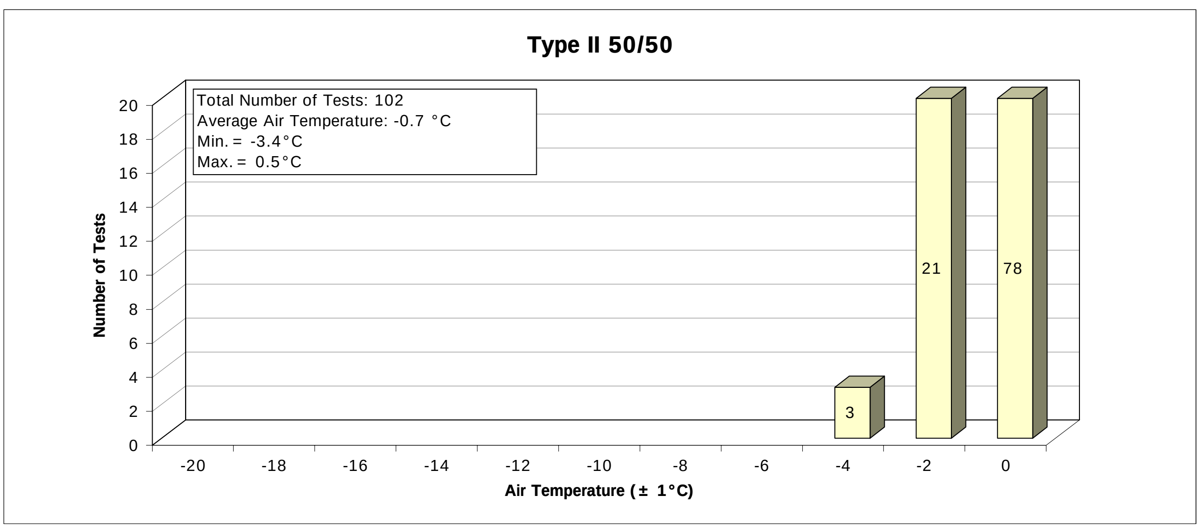


I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\Figures 3.2etc
At:Air type IV
Printed:12:06 PM, 9/13/2005

FIGURE 3.6
DISTRIBUTION OF AIR TEMPERATURE - TYPE II FLUIDS
Natural Snow Tests 2001-02





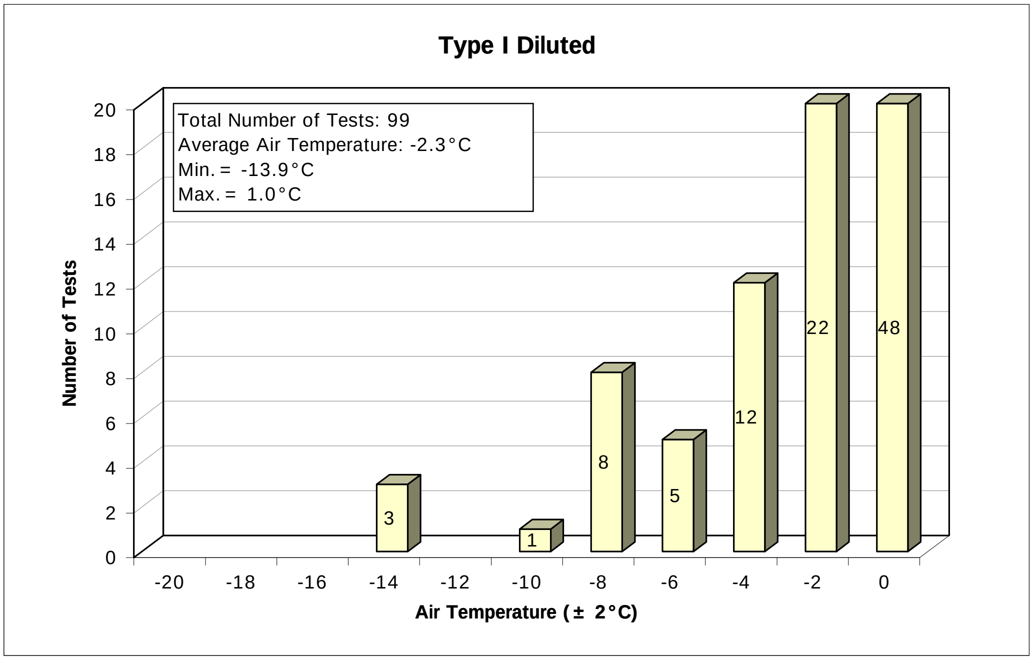


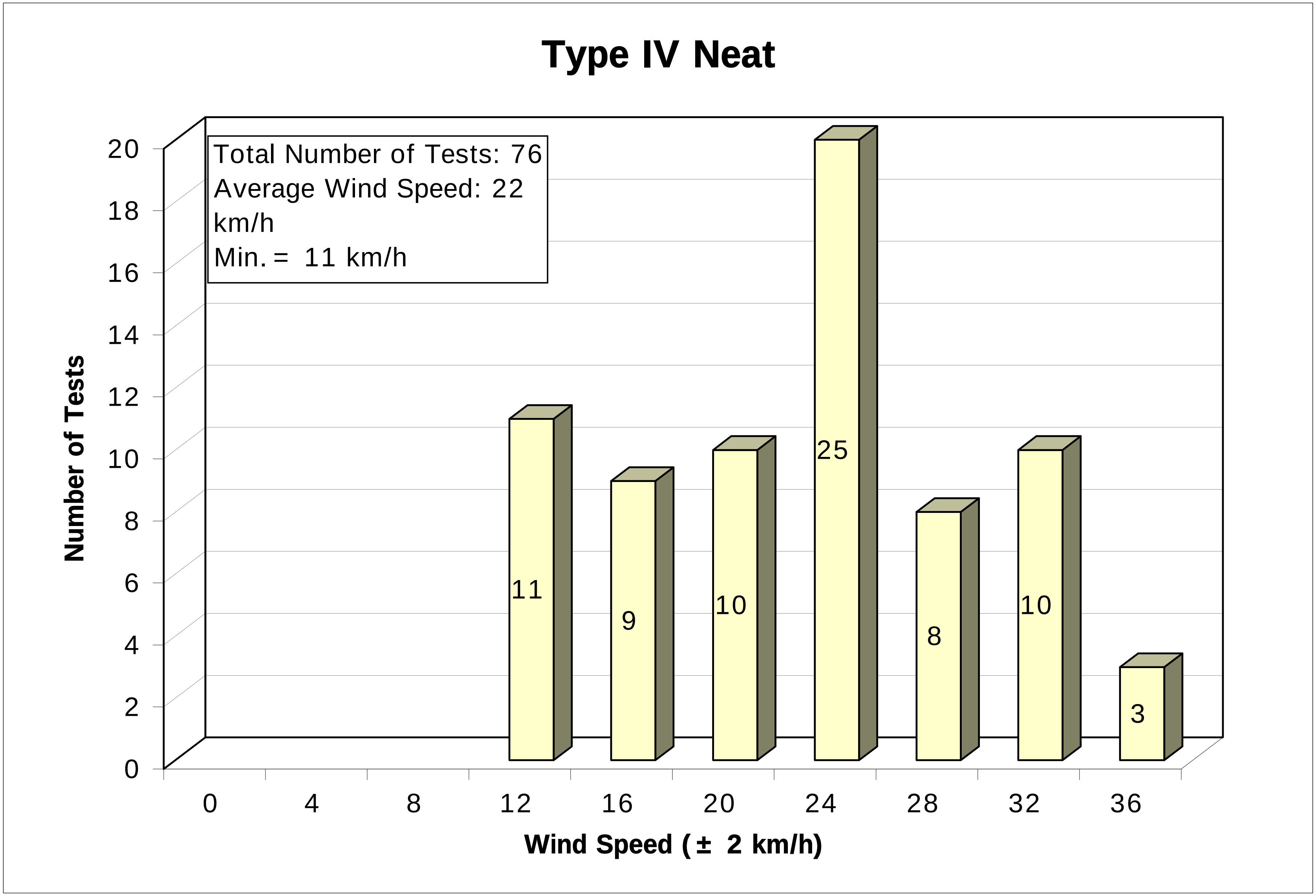
CM1680(exBM3833)\Analysis\HOT\Figures 3.2etc
At:Air type II
Printed:12:07 PM, 9/13/2005

FIGURE 3.7

ISTRIBUTION OF AIR TEMPERATURE - DILUTED TYPE I FLUID

Natural Snow Tests 2001-02





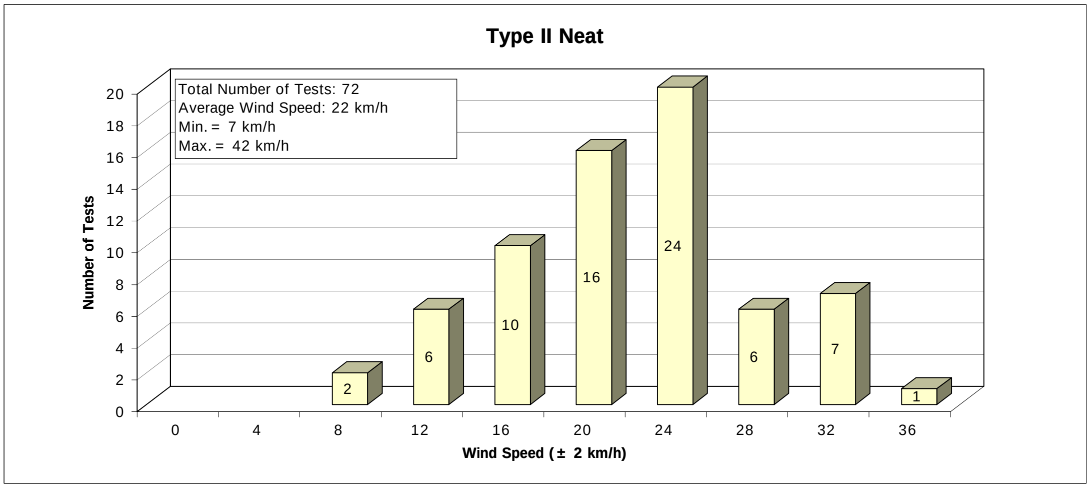
CM1680(exBM3833)\Analysis\HOT\wind type IV Chart 1

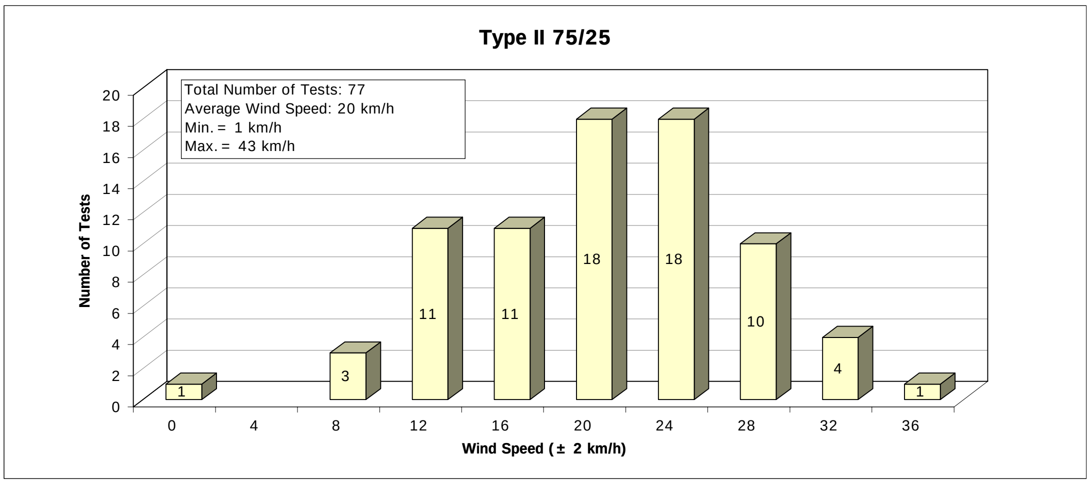
At:wind type IV Chart 1

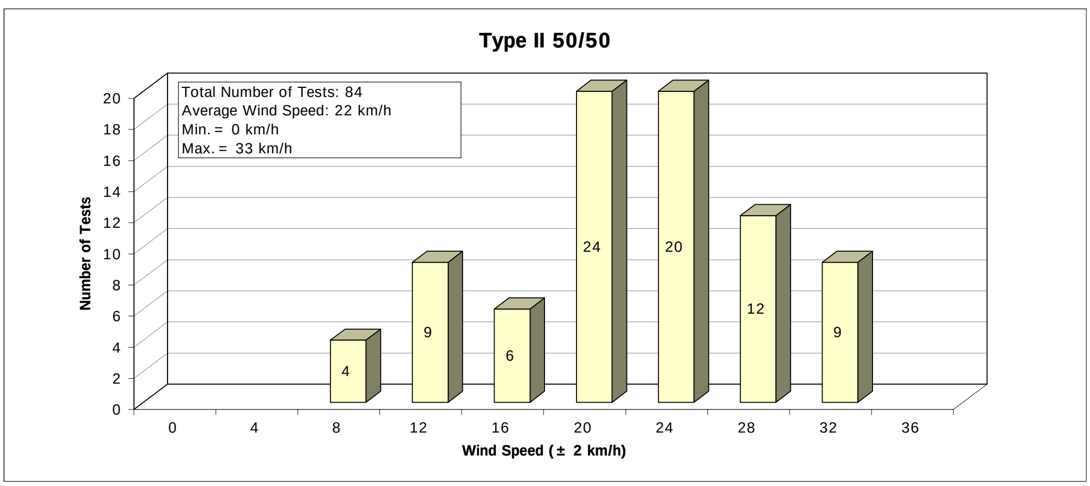
FIGURE 3.9

DISTRIBUTION OF WIND SPEED - TYPE II FLUIDS

Natural Snow Tests 2001-02





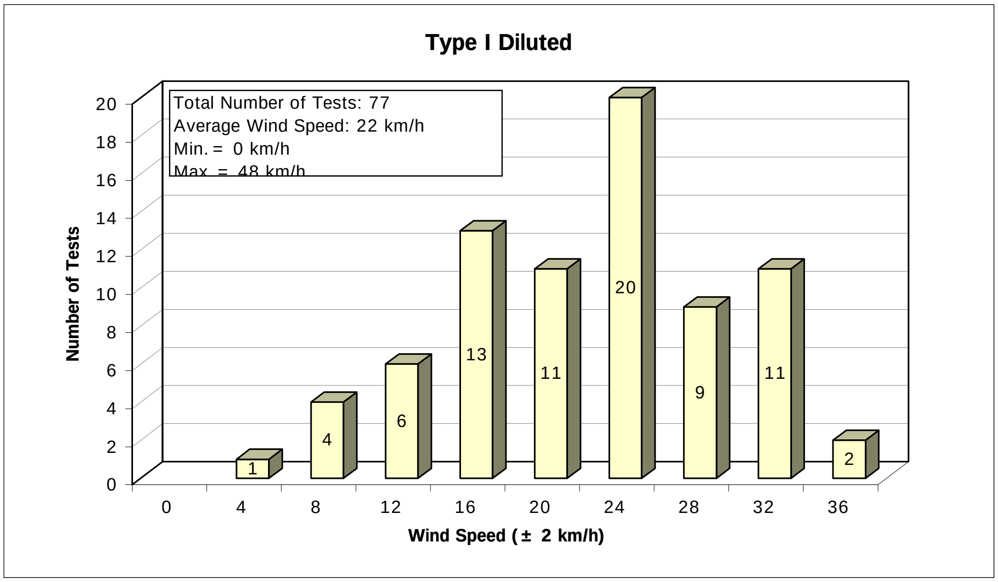


CM1680(exBM3833)\Analysis\HOT\Figures 3.2etc
At:wind Type II

FIGURE 3.10

DISTRIBUTION OF WIND SPEED - DILUTED TYPE I FLUIDS

Natural Snow Tests 2001-02

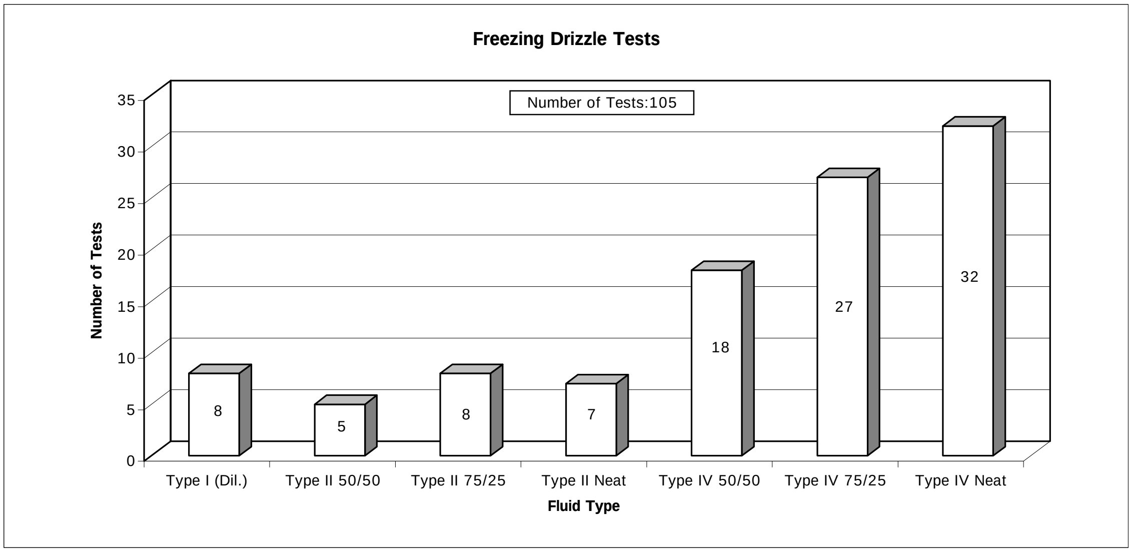


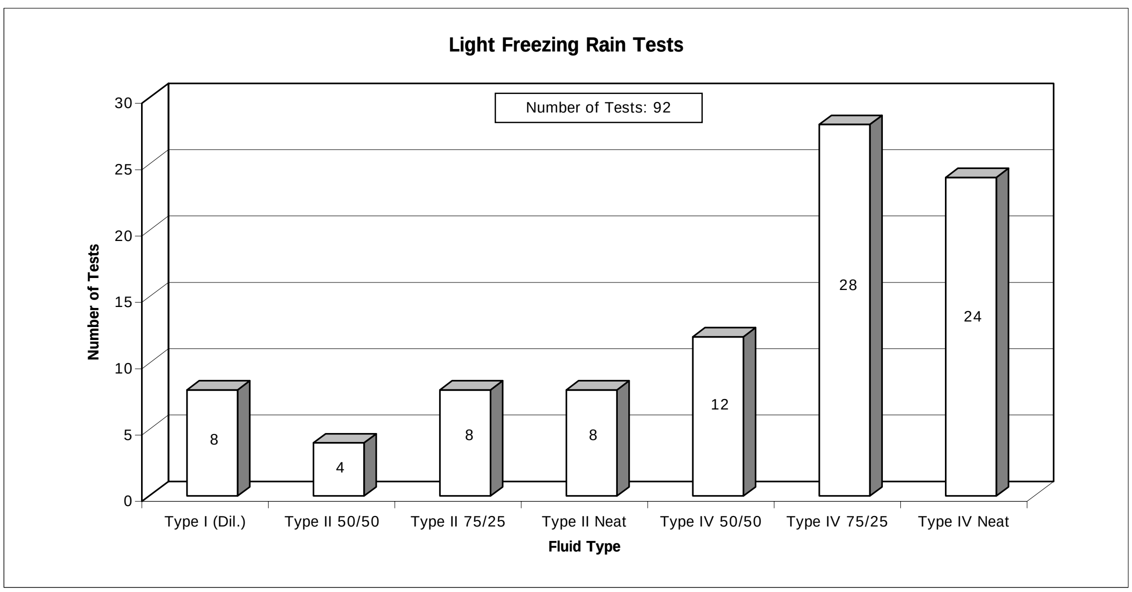
CM1680(exBM3833)\Analysis\HOT\Figures 3.2etc
At:wind type I

FIGURE 3.11

NUMBER OF SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN TESTS

2000-01 Test Season





M\Groups\CM1680 (exBM3833)\Analysis\HOT\type IV\figs & tables chap 3
AT:fig 3.11

3.2.2 Test Location and Fluids Tested

All 197 freezing precipitation tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Lyondell, Newave Aerochemical, Octagon, SPCA, and Union Carbide/Dow.

3.2.3 Distribution of Average Precipitation Rates

Table 3.2 shows the distribution of average precipitation rates recorded for fluid Types I, II, and IV. As described in Section 2, the average precipitation rates for freezing drizzle and light freezing rain were computed from weight measurements taken with plate pans. The pans were positioned on the stand at every plate position before and after each run for a minimum of two 10-minute periods.

All fluids were tested at the upper and lower precipitation rate limits. The limits were 5 and 12.7 g/dm²/h for freezing drizzle, and 12.7 and 25 g/dm²/h for light freezing rain, respectively.

3.2.4 Distribution of Other Meteorological Conditions

Air temperature was the only other meteorological factor that varied during the freezing drizzle and light freezing rain tests. The distribution of air temperatures is presented in Table 3.2.

3.3 Simulated Freezing Fog Tests

3.3.1 Data Acquisition

A total of 121 tests were conducted with Type I, Type II, and Type IV fluids in freezing fog conditions. The breakdown of these tests is shown in Figure 3.12.

3.3.2 Test Location and Fluids Tested

All 121 freezing fog tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Lyondell, Newave Aerochemical, Octagon, SPCA, and UCAR/Dow.

TABLE 3.2

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

Simulated Freezing Drizzle, Light Freezing Rain Tests

2000-2001

(No. of Tests)

Type I Diluted

	ZD		ZR	
	-3ºC	-10ºC	-3ºC	-10ºC
Low Rate		4		4
High Rate		4		4

Type II

	ZD (-10°C)		ZD (-3°C)			ZR (-10°C)		ZR (-3°C)		
	Neat	75/25	Neat	75/25	50/50	Neat	75/25	Neat	75/25	50/50
Low Rate	2	2	2	2	3	2	2	2	2	2
High Rate	2	2	1	2	2	2	2	2	2	2

Type IV

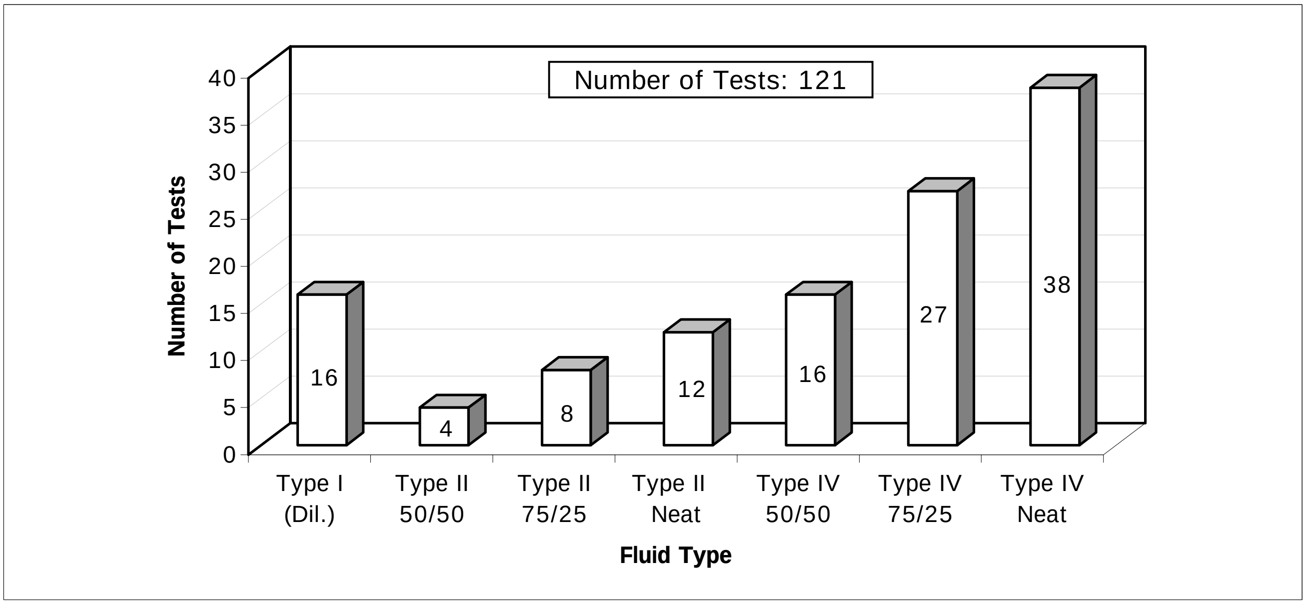
	ZD (-10°C)		ZD (-3°C)			ZR (-10°C)		ZR (-3°C)		
	Neat	75/25	Neat	75/25	50/50	Neat	75/25	Neat	75/25	50/50
Low Rate	8	8	9	9	10	6	6	6	10	6
High Rate	6	6	7	6	8	6	6	6	6	6

I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\figs & tables chap 3
At:table 3.2

FIGURE 3.12

NUMBER OF SIMULATED FREEZING FOG TESTS

2000-01 Test Season



3.3.3 Distribution of Average Precipitation Rates

Table 3.3 shows the distribution of average precipitation rates recorded for all holdover time tests. As described in Section 2, the average precipitation rates for freezing fog were computed from weight measurements taken with plate pans. The pans were positioned on the stand at every plate location before and after each run for two 10- to 15-minute periods. Holdover time tests were conducted at precipitation rates of 2 to 5 g/dm²/h.

3.3.4 Distribution of Tests by Air Temperature

The other variable in freezing fog tests was temperature. The distributions of air temperatures for freezing fog tests are presented in Table 3.3.

3.4 Simulated Rain on Cold-Soaked Surface Tests

3.4.1 Data Acquisition

A total of 49 cold-soak tests, using 7.5 cm deep-sealed boxes, were conducted during the 2000-01 test season. The breakdown of tests is shown in Figure 3.13.

3.4.2 Test Location and Fluids Tested

All 49 tests were conducted at NRC's CEF in Ottawa. The fluids tested were supplied by Clariant, Lyondell, Newave Aerochemical, Octagon, SPCA, and UCAR/Dow.

3.4.3 Distribution of Average Precipitation Rates

Table 3.4 shows the distribution of precipitation rate. The average precipitation rate was measured using plate pans. The precipitation for drizzle was produced using the same apparatus as was used for freezing drizzle. Moderate rain was also produced using the same equipment, but with different hypodermic needles and water/air pressures.

TABLE 3.3

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

Simulated Freezing Fog Tests

2000-01

(No. of Tests)

Type I Diluted

	-3°C	-10°C	-14ºC	-25°C
Low Rate		0		4
High Rate		4		4

Type II

	-3°C			-14°C		-25°C
	Neat	75/25	50/50	Neat	75/25	Neat
Low Rate	2	2	2	2	2	2
High Rate	2	2	2	2	2	2

Type IV

	-3°C			-14°C		-25°C
	Neat	75/25	50/50	Neat	75/25	Neat
Low Rate	7	7	8	6	6	6
High Rate	7	8	8	6	6	6

FIGURE 3.13

Number of Cold-Soak Box Tests

2000-01 Test Season

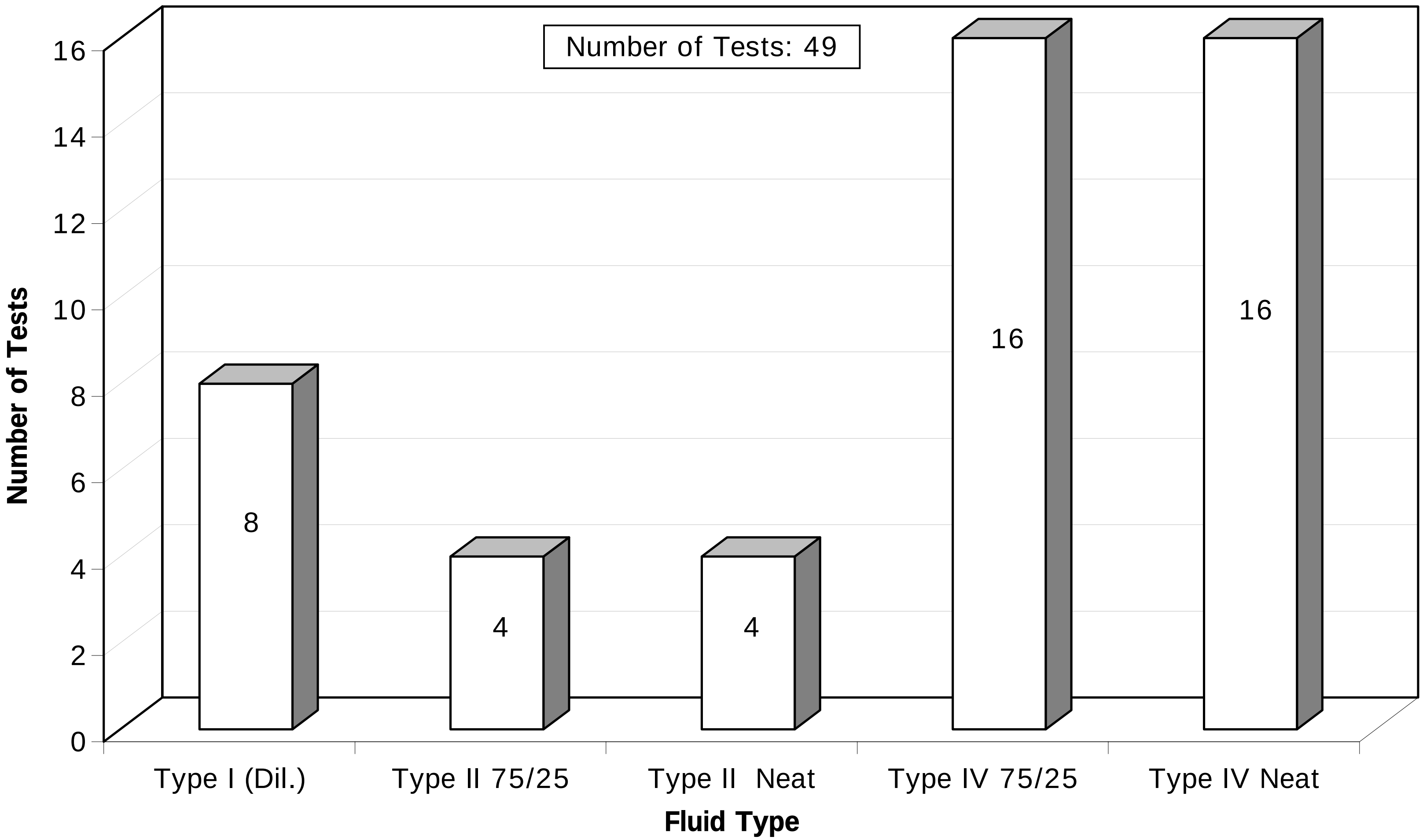


TABLE 3.4

DISTRIBUTION OF HOLDOVER TIME TESTS CONDUCTED BY TEMPERATURE AND PRECIPITATION RATE

Cold-Soak Box Tests

2000-01

(No. of Tests)

Type I

	Diluted
Low Rate	4
High Rate	4

Type II

	Neat	75/25
Low Rate	2	2
High Rate	2	2

Type IV

	Neat	75/25
Low Rate	8	8
High Rate	8	8

This page intentionally left blank.

4. HOLDOVER TIME TABLES, RESULTS, AND DISCUSSIONS

The methods used to evaluate the test data are reviewed in Subsection 2.9. In this section, the officially accepted holdover time guidelines are presented and important findings are discussed. Each of the different categories of precipitation is introduced in a cell-by-cell fashion with comments and discussions. Type IV fluid results are discussed in Subsection 4.2, Type II fluids are discussed in Subsection 4.3, Type I in Subsection 4.4, and Type III in Subsection 4.5.

All the holdover time guidelines are presented in Subsection 4.6. These include the generic Type I, Type II, and Type IV holdover time guidelines; the three Type II fluid-specific guidelines; and the eight Type IV fluid-specific guidelines. These tables are proposed for use worldwide during the 2001-02 winter season.

4.1 Background

4.1.1 Viscosity of Anti-icing Fluid Tested in 1996-97

In 1996-97, fluid manufacturers provided mid-production range viscosity samples for fluid holdover time testing. During a meeting of the Workgroup on Laboratory Methods to Derive Holdover Time Guidelines in Montreal in November 1997, it was decided that low viscosity fluid samples should be tested in future holdover time tests. It was understood that this would result in more conservative holdover time values. Subsequently, APS requested that fluid manufacturers ship pre-sheared fluids that were representative of the lower end of the production viscosity range for 1997-98 test purposes.

4.1.2 Viscosity of Anti-icing Fluids Tested in 1997-98

Following several holdover time test sessions at the Dorval site in 1997-98, the results using a Kilfrost fluid were found to be inferior to those obtained in previous tests conducted with the same fluid. As a result, APS examined the different batches of fluid delivered by the manufacturers. The Kilfrost fluid was found to have a viscosity level below the production range for this fluid. Examination of the viscosity levels of the other fluids revealed other inconsistencies. The fluid samples for Clariant MPIV 1957 and MPIV 2001 were believed to be at the low end of the production range for these fluids. The remainder of the fluid samples provided to APS had viscosity levels representative of the mid-production range, not the lower end of the production range, as requested.

Prior to the start of testing in freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked wing at the CEF in April 1998, APS requested that Kilfrost and Clariant provide mid-range viscosity fluids for these tests to ensure that all fluids were tested on an even par. As a result, the holdover time tests conducted in 1997-98 were performed using mid-production range viscosity fluids.

4.1.3 Viscosity of Anti-icing Fluids Tested in 1998-99

For holdover time testing in 1998-99, manufacturers were asked to provide fluid samples representative of the lowest recommended on-wing viscosity. Upon reception of the individual fluid samples, APS personnel verified the fluid viscosity measurements obtained from the manufacturers. For the first time, each manufacturer was required to send a sample of the fluid provided for holdover time testing to Anti-icing Materials International Laboratory (AMIL) for Water Spray Endurance Time (WSET) testing.

At the SAE G-12 meetings in Toronto in May 1999, the results of the WSET tests were discussed. Specifications precluded that a Type IV fluid must achieve a minimum of 80 minutes in the WSET test to pass certification. However, several of the fluid samples tested by APS in 1998-99 had WSET results below the minimum, due to the shearing required to reduce the fluid viscosities for holdover time testing. After considerable discussion, the results of holdover time tests conducted with Clariant MPIV 1957, Octagon Max-Flight, and Kilfrost ABC-S were accepted, despite the fact that the samples had WSET results inferior to the minimum requirements.

To obtain a fluid-specific table for their fluid, manufacturers were required to conduct holdover time tests in 1998-99 using a lowest on-wing viscosity fluid, regardless of whether the fluid had been tested previously. Two fluid manufacturers, Clariant and SPCA, insisted that the Clariant MPIV 2001 and SPCA AD-480 fluids delivered for testing in 1997-98 were representative of the manufacturers' recommended lowest on-wing viscosity. As a result, no holdover time testing was conducted using these two fluids in order to generate fluid-specific values.

At the Holdover Time Subcommittee meeting in Toronto in May 1999, Clariant was asked to provide a sample of the MPIV 2001 fluid sent to APS for holdover time testing in 1997-98, to AMIL for WSET verification. The average WSET of the sheared sample was 81 minutes. A sample was also provided to APS for viscosity testing. The viscosity measurement obtained by APS (18 000 cP, 20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 minutes) appears in the fluid-specific holdover time table for Clariant MPIV 2001.

It was also decided in Toronto that the viscosity of the fluid sample used in holdover time testing, as measured by the testing agency, would now appear on the fluid-specific holdover time table for any given fluid. In addition to noting the viscosity, the instrument spindle, chamber size, temperature, and rotations per minute are also documented. To maintain the validity of the fluid-specific values, operators must ensure that the viscosity of the fluid used is superior to the viscosity published by the manufacturers by following the same viscosity measurement method published.

Several viscosity measurements of the various anti-icing fluids obtained by APS during the 1998-99 test season were acquired using different methods and spindles from the manufacturers. In most cases, APS employed a common method when conducting viscosity measurements: Spindle SC4-31/13R, 20°C, 33 minutes and 20 seconds, 0.3 rpm, and 10 mL of fluid. This approach caused much confusion at the SAE G-12 Holdover Time Subcommittee meeting in Toronto, as the fluid viscosities documented by APS and the fluid manufacturers were not comparable. After much discussion, it was resolved that APS would re-measure all anti-icing fluid viscosities using the same method employed by the manufacturers.

Due to ongoing confusion over the test samples required for holdover time test purposes on a yearly basis, sample selection procedures were devised and agreed upon by the SAE G-12 Holdover Time Subcommittee in Toronto in May 1999. These new documents will appear in Proposed SAE Aerospace Standard 5485 to regulate the test samples that are delivered to the various testing agencies. The new documents allow the various manufacturers to select the fluid viscosity to be tested and to appear on the fluid-specific table, provided that the WSET values of the fluids selected achieve the minimum requirements.

4.1.4 Viscosity of Anti-icing Fluids Tested in 2000-01

Four different Type IV fluids were provided to APS for 2000-01 endurance time testing: Clariant Safewing MPIV Protect 2012, Clariant Safewing MPIV 2015 TF, Octagon Max-Flight, and an experimental Type IV fluid from UCAR/Dow. Testing with the UCAR/Dow product was discontinued prior to its completion.

The Octagon Max-Flight testing was conducted in a bid to increase the fluid-specific holdover times for this fluid. The results of 1998-99 Max-Flight tests with a low viscosity fluid were omitted and are not included in this report.

Prior to the publication of the holdover time guidelines, APS was informed that one fluid, Clariant Safewing MPIV 2015 TF, which was tested extensively during the past test season, would not be produced commercially for the upcoming winter. Consequently, the results obtained with this fluid have not been included in the production of the generic Type IV fluid holdover time guidelines.

The viscosity values of the Type IV fluids tested in 2000-01 appear in Table 4.1. The WSET results of the same fluids appear in Table 4.2.

At the SAE G-12 Holdover Time Subcommittee meeting in Toulouse in May 2000, it was decided that snow grains would be included in the snow column of the various holdover time tables for fluid Types I, II, and IV. These changes were included in the official holdover time tables accepted for use in 2000-01 winter operations.

4.2 Type IV Fluids

New Fluids Introduced: Four Type IV fluids from three different manufacturers were tested during the 2000-01 winter test season: Clariant Safewing MPIV Protect 2012, Clariant Safewing MPIV 2015 TF, Octagon Max-Flight, and an experimental Type IV from UCAR/Dow. The Clariant Safewing MP IV 2015 TF and UCAR/Dow products were later removed from this list after the manufacturers indicated that the fluids would not be produced in the upcoming year.

Old Fluids Removed: A total of nine different fluids tested since 1996-97 were used to develop the generic holdover time table for Type IV fluids: Clariant Safewing Four, Clariant MPIV 1957, Clariant MPIV 2001, Clariant Safewing MPIV Protect 2012, Kilfrost ABC-S, Octagon Max-Flight, SPCA AD-404, SPCA AD-480, and UCAR/Dow Ultra+.

At the SAE G-12 Holdover Time Subcommittee meeting in New Orleans in May 2001, it was decided that test data from fluids that have not been commercially available for four years would be eliminated from the generic tables. Two fluids, Hoechst MP IV 1957 and diluted forms of UCAR Ultra+, were eliminated, which resulted in several increases to the generic holdover time table.

The results of Type IV tests conducted in 2000-01 are shown in Figures 4.3 to 4.29. The results of tests conducted in 1996-97, 1997-98, 1998-99, and 1999-2000 appear in report TP 13659E [2].

TABLE 4.1
FLUID VISCOSITY
FLUIDS TESTED IN 2000-2001

FLUID	Manufacturer Value Using Manufacturer Method (cP)	APS Value Using Manufacturer Method (cP)
Clariant Safewing MPIV 2012 Protect	**9800**	**7800**
	20ºC, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min	20ºC, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min
Octagon Max-Flight	**5990**	**5900/5540**
	20ºC, 0.3 rpm, Spindle LV1, 600 mL beaker, 500 mL fluid, 33 min 20 sec, guard leg	20ºC, 0.3 rpm, Spindle LV1, 600 mL beaker, 500 mL fluid, 33 min 20 sec, guard leg
SPCA ECOWING 26	**5200**	**4900**
	20ºC, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min	20ºC, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min

TABLE 4.2
WSET VALUES OF SAMPLES TESTED
(FIRST ICE EVENT)
FLUIDS TESTED IN 2000-01

FLUID	MINUTES
Clariant Safewing MPIV 2012 Protect	131
Octagon Max-Flight	120
SPCA Ecowing 26	56

4.2.1 Methodology Used in the Determination of Fluid-Specific Holdover Times

The different methodologies and holdover time values used in the determination of Type IV *fluid-specific* holdover times proposed for use in 2001-02 operations are explained in this section for each fluid.

At the SAE G-12 Holdover Time Subcommittee meeting held in New Orleans in May 2001, it was decided that test data from fluids that have not been commercially available for four years or more would be eliminated from the generic tables. Two fluids have since been eliminated for this reason: Hoechst MP IV 1957 and diluted forms of UCAR Ultra+. The removal of these fluids resulted in the increase in the generic holdover time guidelines.

4.2.1.1 Clariant Safewing Four

- Holdover time values for all conditions were obtained from 1999-2000 tests conducted with this fluid.

4.2.1.2 Clariant Safewing MPIV Protect 2012

- Holdover time values for all conditions were obtained from 2000-01 tests conducted with this fluid.

4.2.1.3 Clariant MPIV 1957

- Freezing fog holdover time values were acquired from 1998-99 testing with Clariant MPIV 1957 fluid;
- Values for light freezing rain, freezing drizzle, snow, and rain on a cold-soaked wing are the lowest numbers obtained from 1997-98 and 1998-99 testing with this fluid; and
- Hoechst MPIV 1957 values have not been included.

4.2.1.4 Clariant MPIV 2001

- Freezing fog and rain on a cold-soaked wing holdover time values were obtained from the 1999-2000 tests conducted with this fluid. Generic holdover time values were assigned to these same two columns of the 1999-2000 fluid-specific table for Clariant MP IV 2001 due to a lack of data; and

  Values for light freezing rain, freezing drizzle, and snow were acquired from 1997-98 tests conducted with this fluid.

4.2.1.5 Kilfrost ABC-S

- Freezing fog holdover time values were obtained from 1998-99 testing with this fluid;
- Light freezing rain, freezing drizzle, and snow values are the lowest numbers from testing in 1996-97, 1997-98 and 1998-99 with this fluid; and
- Values for rain on a cold-soaked wing are the lowest results obtained from testing with this fluid in 1997-98 and 1998-99.

4.2.1.6 Octagon Max-Flight

- The tests conducted with the low viscosity sample of Octagon Max-Flight in 1998-99 were eliminated;
- Freezing fog holdover time values were acquired from 2000-01 testing with this fluid;
- Values obtained in conditions of light freezing rain, freezing drizzle, and snow are the lowest numbers achieved from testing with this fluid in 1996-97, 1997-98, and 2000-01; and
- Rain on a cold-soaked wing values are the lowest results acquired from 1997-98 and 2000-01 testing with this fluid.

4.2.1.7 SPCA AD-480

- Tests were conducted with this fluid in 1997-98 and 1999-2000. Due to a lack of data below -7°C in 1997-98 tests, additional tests in natural snow were conducted in 1998-99;
- Freezing fog and rain on a cold-soaked wing holdover time values were obtained from 1999-2000 tests conducted with this fluid. Generic holdover time values were used in these columns of the 1998-99 fluid-specific table for this fluid due to a lack of data;
- Light freezing rain and freezing drizzle values are the lowest numbers from 1999-2000 and 1997-98 tests conducted with SPCA AD-480 fluid; and
- In natural snow, the results of the 1997-98 and 1998-99 tests were combined. The snow values in the 2000-01 fluid-specific table are the lowest of tests conducted in 1999-2000 and of the two years 1997-98 and 1998-99, which appeared in the 1999-2000 fluid-specific table for this fluid.

4.2.1.8 UCAR Ultra+

- Freezing fog holdover time values were obtained from 1998-99 testing with this fluid;
- Light freezing rain, freezing drizzle, and snow holdover time values are the lowest results of 1996-97 and 1998-99 testing with this fluid; and
- Rain on a cold-soaked wing holdover time values were acquired from 1998-99 testing conducted with this fluid.

4.2.2 Natural Snow

The natural snow holdover time data were obtained from tests conducted by APS at the Dorval Airport test facility. The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix G). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation. It is used here to present the changes proposed to the holdover times and to allow direct comparison to the numbers obtained from the regression analyses.

Subsections 4.2.2.1.1 to 4.2.2.1.9 contain the Type IV fluid holdover time results in the snow column. They are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom.

For each fluid tested in natural snow conditions, a family of curves has been drawn based on the data collected using the formula outlined in Subsection 2.9.2.1. An example of the family of curves generated by the snow regression analysis for a given fluid is shown in Figure 4.1. Using this method, curves were drawn at the most restrictive temperatures in each of the cells of the snow column for this fluid.

<u>Generic Holdover Time Guidelines</u>

For the process of evaluating the generic holdover time guidelines in each cell of the generic holdover time table, the curves for each fluid drawn at a specific temperature have been removed from the individual fluid charts and placed in Figures 4.3 to 4.11. For example, in Figure 4.2, the curves drawn at -3°C for Octagon Max-Flight and Clariant Safewing MPIV 2012 Protect were removed from the individual fluid charts and were placed in the chart used to evaluate the holdover time performance of Type IV fluids in the 0°C to -3°C cell. This process was followed for each cell of the snow column. If the values determined from the brand specific fluids are lower that the generic holdover guidelines, then the generic holdover guidelines are reduced.

FIGURE 4.1

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SAMPLE TYPE IV NEAT

NATURAL SNOW CONDITIONS

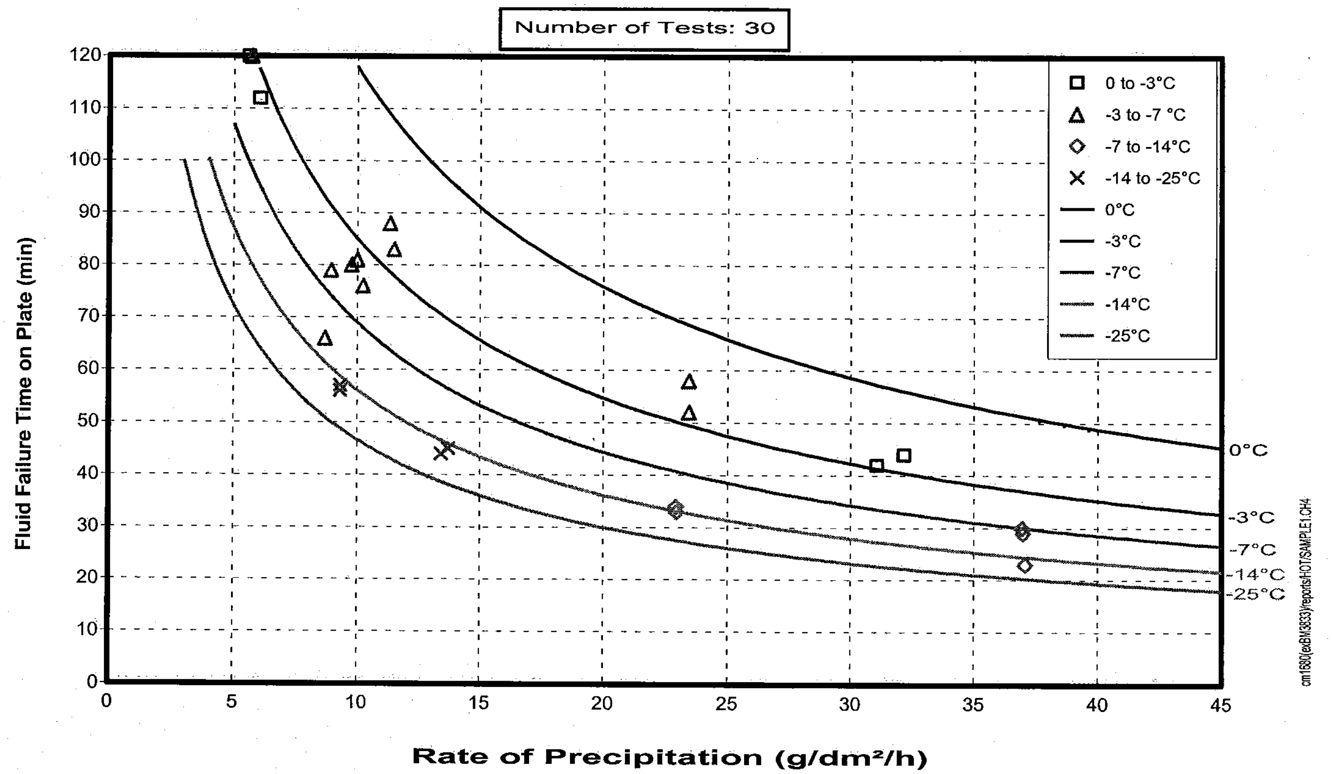


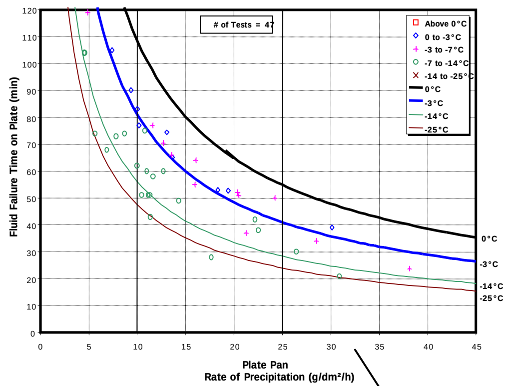
FIGURE 4.2

PROCESS FOR EVALUATING HOLDOVER TIMES

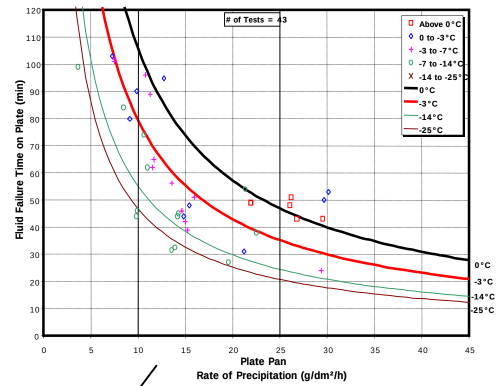
NATURAL SNOW

Family of Curves

CLARIANT SAFEWING MPIV 2012 PROTECT

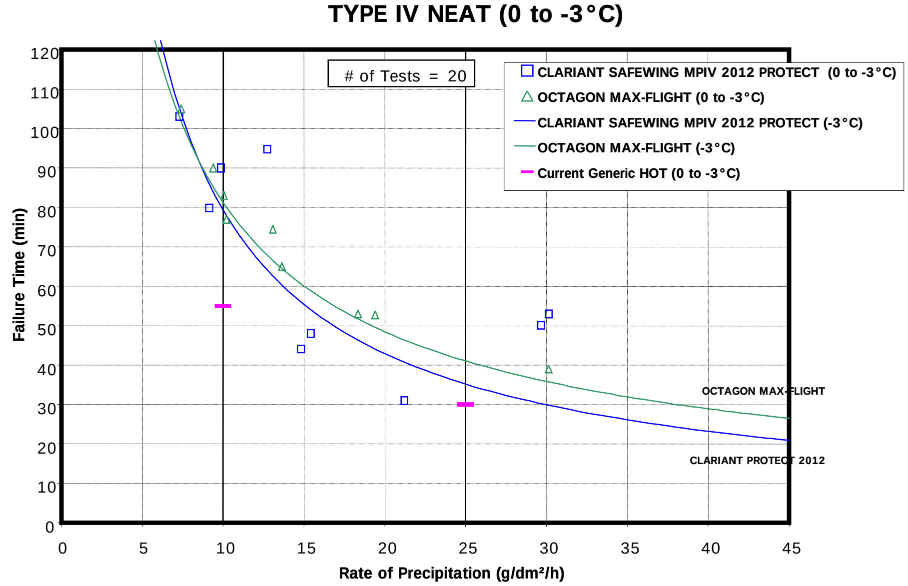


OCTAGON MAX-FLIGHT



Cell Evaluation

TYPE IV NEAT (0 to -3°C)



h:\cm1680(exBM3833)\reports\HOT\Family of Curves1.pt

4.2.2.1 Changes to Type IV fluid holdover times for snow

The results of Type IV fluid testing in 1996-97, 1997-98, 1998-99, 1999-2000, and 2000-01 are presented in this section. The first horizontal row of values in each of the tables that follow contains the generic and fluid-specific holdover time values used in 1997-98, a result of tests conducted in 1996-97. The second line in each table contains the endurance time results from 1997-98 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1998-99. The fourth set of values is the endurance time test results from 1998-99 testing. The fifth row in each table contains the generic and fluid-specific holdover time values accepted for use in 1999-2000 winter operations. The sixth row in each table contains the endurance time results from 1999-2000 testing. The seventh row contains the generic and fluid-specific holdover time results accepted for use in winter operations in 2000-01. The eighth row contains the endurance time test results from 2000-01 testing. The ninth and final row in each of the tables contains the generic and fluid-specific holdover times accepted for use in 2001-02 winter operations. The underlined holdover time values in the tables indicate the fluids responsible for the generic holdover time.

Despite being removed from the SAE test data at the G-12 meetings in New Orleans, the test data for Hoechst MPIV 1957 and diluted forms of Ultra+ are presented in each of the tables for the purpose of highlighting increases made to the various times. The values, although crossed out, remain in the table to chart the history of the generic and fluid-specific holdover time tables.

Due to space limitations, the fluid codes indicated in brackets are used in the tables: Hoechst MPIV 1957 (H-1957); Kilfrost ABC-S (K-ABC-S); Octagon Max-Flight (Oct Max); UCAR Ultra+ (Ultra+); Clariant MPIV 1957 (C-1957) [Clariant reformulated Hoechst MPIV 1957 and changed its name as described in Section 2.7.3.2]; Clariant MPIV 2001 (C-2001); Clariant Safewing Four (C-S4); Clariant Safewing MPIV Protect 2012 (C-2012); SPCA AD-404 (S-404); SPCA AD-480 (S-480).

4.2.2.1.1 Neat fluid, above 0°C, snow (Figure 4.3)

In this cell, the generic holdover times have remained unchanged and are based on the results of the low-viscosity Clariant MPIV 1957 fluid tested in 1998-99. Several upper fluid-specific holdover times have been limited to two hours in order to prevent the appearance of excessively long times in the holdover time tables.

TABLE 4.3
Holdover Time Guidelines for Neat Fluid, Above 0°C, Snow

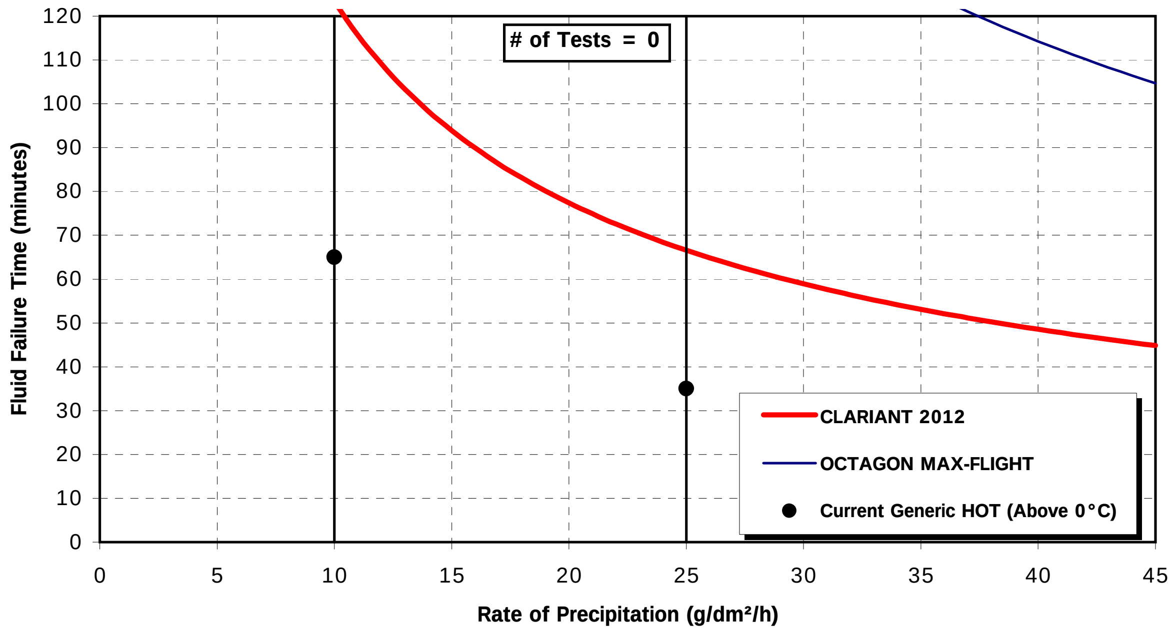
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:45-1:25	1:15-2:00	1:10-2:00		~~0:45-1:25~~		0:50-1:40				
	1997-98 Endurance Time Test Results				1:05-2:00				1:10-2:00	1:55-2:00		1:40-2:00
	1998-99 HOT Table Values	0:45-1:25	1:15-2:00	1:10-2:00	1:05-2:00			0:50-1:40	1:10-2:00	1:55-2:00		1:40-2:00
	1998-99 Endurance Time Test Results		~~1:00-1:30~~	1:10-2:00	0:35-1:05			0:40-1:25	1:45-2:00			
	1999-2000 HOT Table Values	0:35-1:05	1:00-1:30	1:10-2:00	0:35-1:05			0:40-1:25	1:10-2:00	1:55-2:00		
	1999-2000 Endurance Time Test Results						0:45-1:45		0:55-1:50			
	2000-01 HOT Table Values	0:35-1:05	1:00-1:30	1:10-2:00	0:35-1:05		0:45-1:45	0:40-1:25	0:55-1:50	1:55-2:00		
CURRENT	**2000-01 Endurance Time Test Results**		2:00-2:00								1:05-2:00	
	2001-02 HOT Table Values	0:35-1:05	1:15-2:00	1:10-2:00	0:35-1:05		0:45-1:45	0:40-1:25	0:55-1:50	1:55-2:00	1:05-2:00	

FIGURE 4.3

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (Above 0°C)

NATURAL SNOW



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IVHOT Summary snow1
At: Neat 0°C

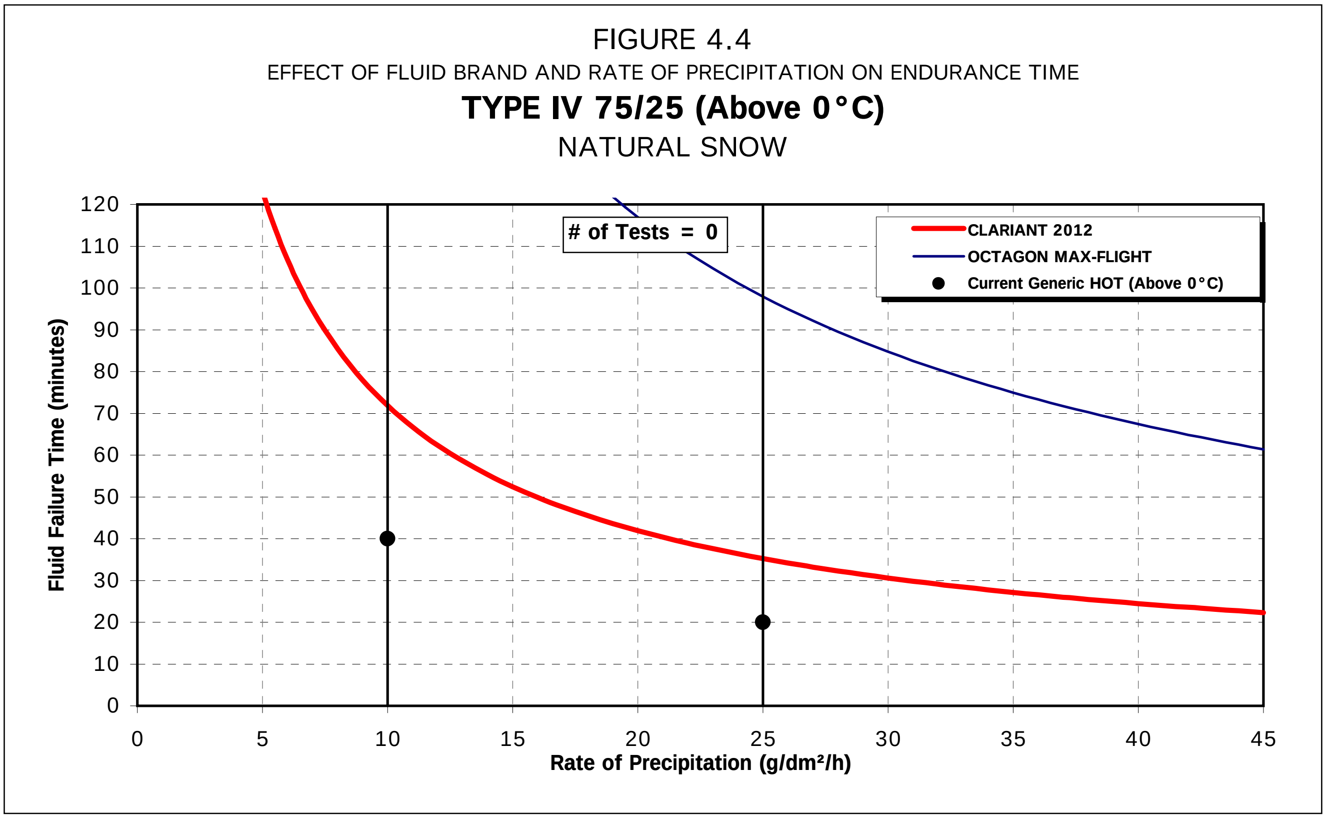
4.2.2.1.2 75/25 fluid, above 0°C, snow (Figure 4.4)

The generic holdover times in this cell have increased significantly from the 2000-01 values (30 to 65 minutes vs. 20 to 40 minutes). These changes occurred as a result of the elimination of the diluted Ultra+ data from 1996-97 tests. Holdover times for dilutions of this fluid will continue to be presented in this report only for the purpose of identifying the fluid(s) responsible for the generic holdover times.

TABLE 4.4

Holdover Time Guidelines for 75/25 Fluid, Above 0°C, Snow

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+ (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:20-0:40	1:20-2:00	0:35-1:05		~~0:35-1:10~~		~~0:20-0:40~~				
	1997-98 Endurance Time Test Results				0:45-1:25				1:00-1:55	0:50-1:25		0:50-1:45
	1998-99 HOT Table Values	0:20-0:40	1:20-2:00	0:35-1:05	0:45-1:25				1:00-1:55	0:50-1:25		0:50-1:45
	1998-99 Endurance Time Test Results		~~0:40-1:30~~	0:30-1:05	0:35-1:05				0:45-1:25			
	1999-2000 HOT Table Values	0:20-0:40	0:40-1:30	0:30-1:05	0:35-1:05				0:45-1:25	0:50-1:25		
	1999-2000 Endurance Time Test Results						0:40-1:25		0:40-1:20			
	2000-01 HOT Table Values	0:20-0:40	0:40-1:30	0:30-1:05	0:35-1:05		0:40-1:25		0:40-1:20	0:50-1:25		
CURRENT	2000-01 Endurance Time Test Results		1:35-2:00								0:35-1:10	
	2001-02 HOT Table Values	0:30-1:05	1:20-2:00	0:30-1:05	0:35-1:05		0:40-1:25		0:40-1:20	0:50-1:25	0:35-1:10	



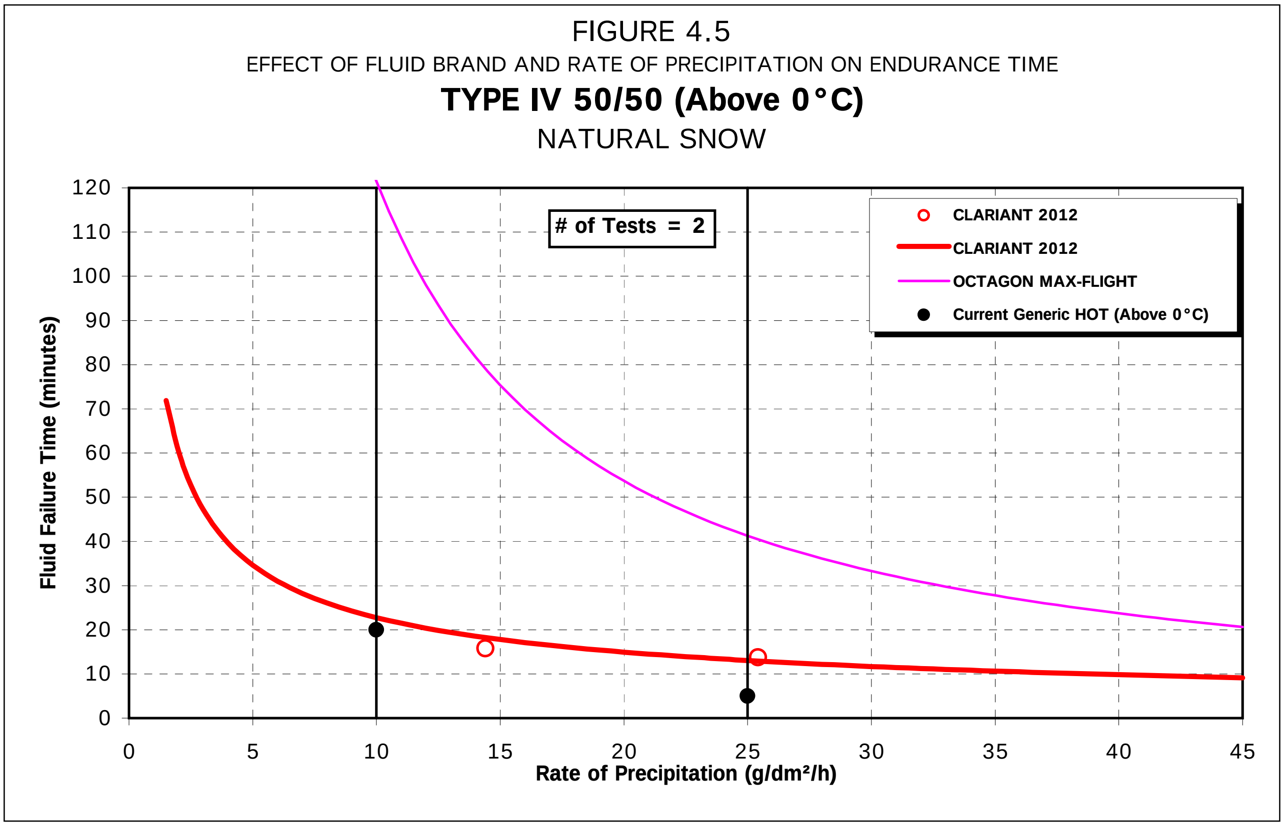
I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary snow1
At: 75% 0°C
Printed:9/13/2005, 12:44 PM

4.2.2.1.3 50/50 fluid, above 0°C, snow (Figure 4.5)

The generic holdover times in this cell are unchanged from last year and are based on the results of two fluids, Kilfrost ABC-S and Clariant MPIV 2001.

TABLE 4.5
Holdover Time Guidelines for 50/50 Fluid, Above 0°C, Snow

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:05-0:20	0:40-1:20	0:05-0:20		~~0:15-0:25~~		~~0:05-0:20~~				
	1997-98 Endurance Time Test Results				0:15-0:30				0:15-0:35	0:10-0:20		0:20-0:45
	1998-99 HOT Table Values	0:05-0:20	0:40-1:20	0:05-0:20	0:15-0:30				0:15-0:35	0:10-0:20		0:20-0:45
	1998-99 Endurance Time Test Results		~~0:15-0:35~~	0:10-0:20	0:15-0:30							
	1999-2000 HOT Table Values	0:05-0:20	0:15-0:35	0:05-0:20	0:15-0:30				0:15-0:35	0:10-0:20		
	1999-2000 Endurance Time Test Results						0:15-0:25		0:15-0:30			
	2000-01 HOT Table Values	0:05-0:20	0:15-0:35	0:05-0:20	0:15-0:30		0:15-0:25		0:15-0:30	0:10-0:20		
CURRENT	**2000-01 Endurance Time Test Results**		0:40-1:35								0:15-0:25	
	2001-02 HOT Table Values	0:05-0:20	0:40-1:20	0:05-0:20	0:15-0:30		0:15-0:25		0:15-0:30	0:10-0:20	0:15-0:25	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IVHOT Summary snow1
At: 50% 0°C

4.2.2.1.4 Neat fluid, 0°C to -3°C, snow (Figure 4.6)

The upper and lower generic holdover times at this temperature and concentration have remained unchanged from the values used in 1999-2000 winter operations, and are based on the results of Clariant 1957 fluid from testing in 1998-99.

TABLE 4.6

Holdover Time Guidelines for Neat Fluid, 0°C to -3°C, Snow

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:35-1:00	0:50-1:35	1:00-1:40		~~0:35-1:00~~		0:35-1:15				
	1997-98 Endurance Time Test Results				0:45-1:25				1:05-2:00	1:00-1:55		1:00-1:45
	1998-99 HOT Table Values	0:35-1:00	0:50-1:35	1:00-1:40	0:45-1:25			0:35-1:15	1:05-2:00	1:00-1:55		1:00-1:45
	1998-99 Endurance Time Test Results		~~0:50-1:20~~	1:00-1:40	<u>0:30-0:55</u>			0:35-1:15	1:05-1:50			
	1999-2000 HOT Table Values	0:30-0:55	0:50-1:20	1:00-1:40	0:30-0:55			0:35-1:15	1:05-1:50	1:00-1:55		
	1999-2000 Endurance Time Test Results						0:35-1:20		0:40-1:20			
	2000-01 HOT Table Values	0:30-0:55	0:50-1:20	1:00-1:40	0:30-0:55		0:35-1:20	0:35-1:15	0:40-1:20	1:00-1:55		
CURRENT	2000-01 Endurance Time Test Results		1:25-2:00								0:40-1:15	
	2001-02 HOT Table Values	0:30-0:55	0:50-1:35	1:00-1:40	0:30-0:55		0:35-1:20	0:35-1:15	0:40-1:20	1:00-1:55	0:40-1:15	

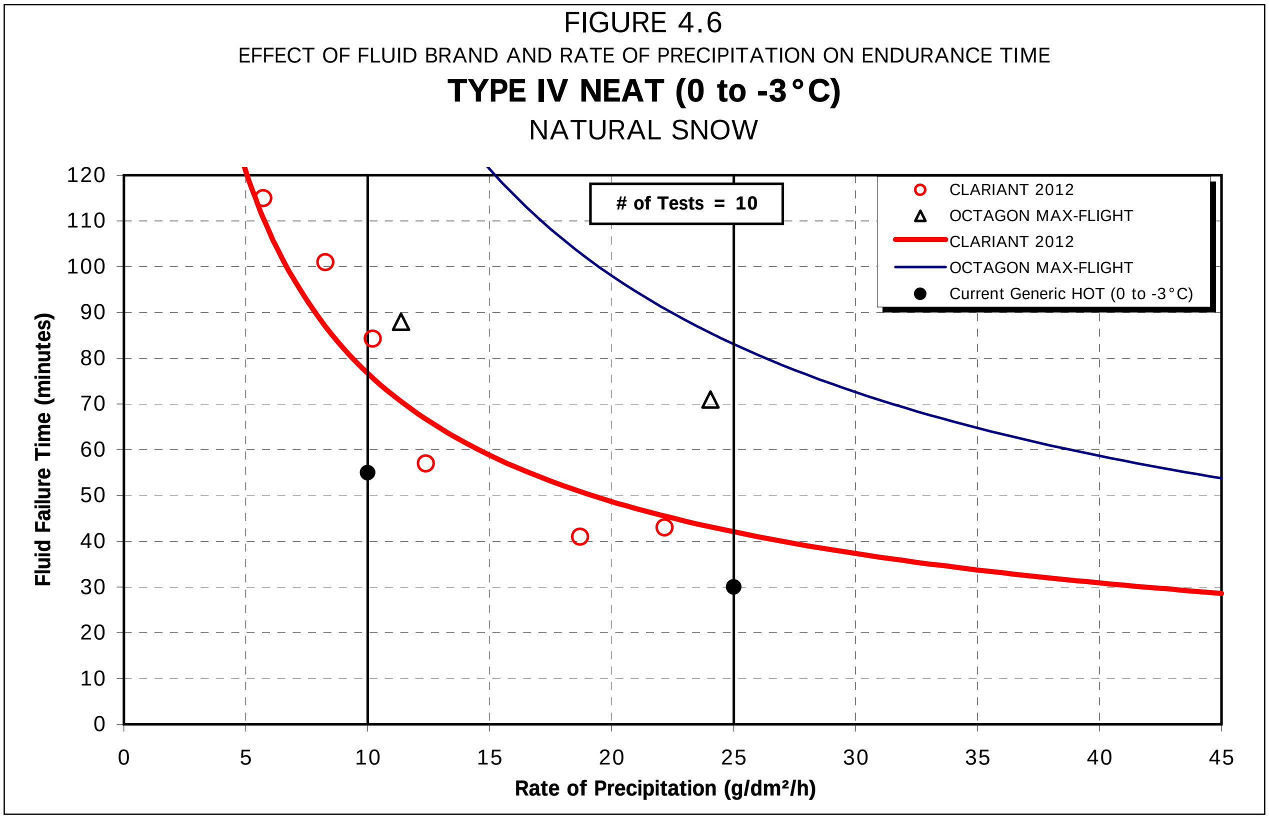


FIGURE 4.6
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV NEAT (0 to -3°C)
NATURAL SNOW
# of Tests = 10
CLARIANT 2012
OCTAGON MAX-FLIGHT
CLARIANT 2012
OCTAGON MAX-FLIGHT
Current Generic HOT (0 to -3°C)
Fluid Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
5
10
15
20
25
30
35
40
45

4.2.2.1.5 75/25 fluid, 0°C to -3°C, snow (Figure 4.7)

The generic holdover times in this cell have increased over those used in 2000-01 winter operations with the elimination of the Ultra+ data from 1996-97. The Octagon Max-Flight fluid-specific times have also increased with the elimination of the 1998-99 test data for this fluid.

TABLE 4.7

Holdover Time Guidelines for 75/25 Fluid, 0°C to -3°C, Snow

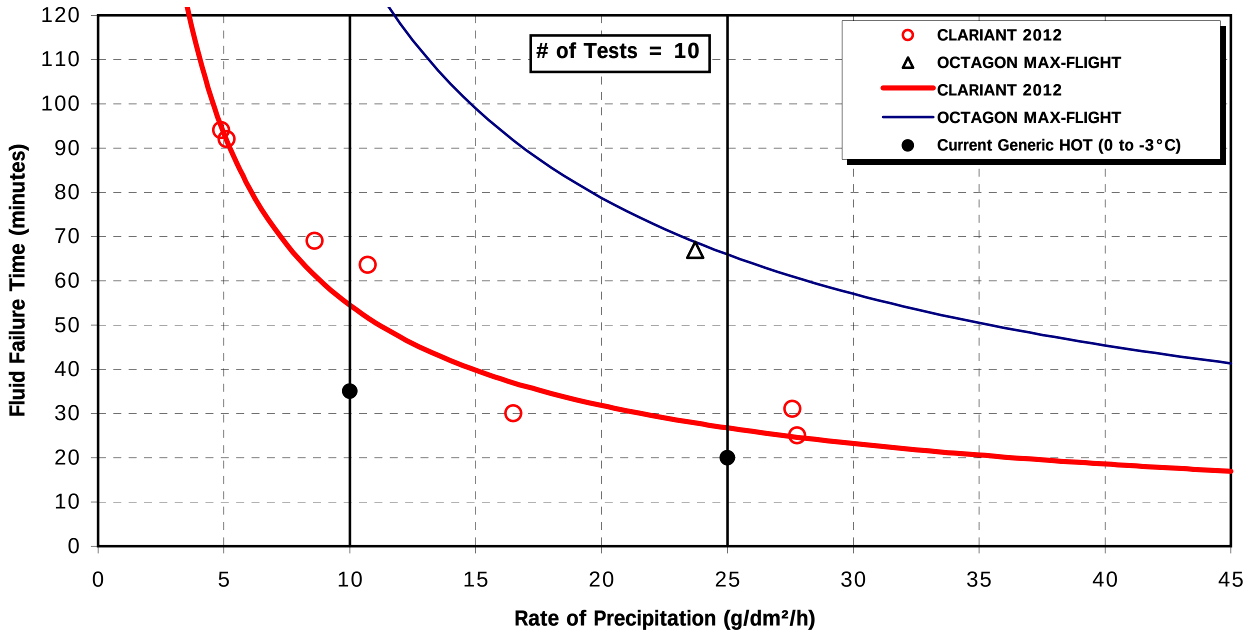
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+ (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:20-0:35	0:45-1:45	0:35-1:05		~~0:25-0:50~~		~~0:20-0:35~~				
HISTORICAL	1997-98 Endurance Time Test Results				0:30-1:00				0:45-1:25	0:35-1:00		0:25-1:00
HISTORICAL	1998-99 HOT Table Values	0:20-0:35	0:45-1:45	0:35-1:05	0:30-1:00				0:45-1:25	0:35-1:00		0:25-1:00
HISTORICAL	1998-99 Endurance Time Test Results		~~0:30-1:00~~	0:30-0:55	0:30-0:50				0:45-1:25			
HISTORICAL	1999-2000 HOT Table Values	0:20-0:35	0:30-1:00	0:30-0:55	0:30-0:50				0:45-1:25	0:35-1:00		
HISTORICAL	1999-2000 Endurance Time Test Results						0:30-1:05		0:30-1:05			
HISTORICAL	2000-01 HOT Table Values	0:20-0:35	0:30-1:00	0:30-0:55	0:30-0:50		0:30-1:05		0:30-1:05	0:35-1:00		
CURRENT	2000-01 Endurance Time Test Results		1:05-2:00								0:25-0:55	
CURRENT	2001-02 HOT Table Values	0:25-0:50	0:45-1:45	0:30-0:55	0:30-0:50		0:30-1:05		0:30-1:05	0:35-1:00	0:25-0:55	

FIGURE 4.7

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 75/25 (0 to -3°C)

NATURAL SNOW



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IVHOT Summary snow1
At: 75% -3°C

4.2.2.1.6 50/50 fluid, 0°C to -3°C, snow (Figure 4.8)

The generic holdover times in this cell remain unchanged from those used in 2000-01 winter operations. The holdover time performances of the various fluids are quite similar at this dilution and temperature range, with the exception of Octagon Max-Flight, which significantly outperforms the rest. The Octagon Max-Flight fluid-specific times have also increased with the elimination of the 1998-99 test data for this fluid.

TABLE 4.8

Holdover Time Guidelines for 50/50 Fluid, 0°C to -3°C, Snow

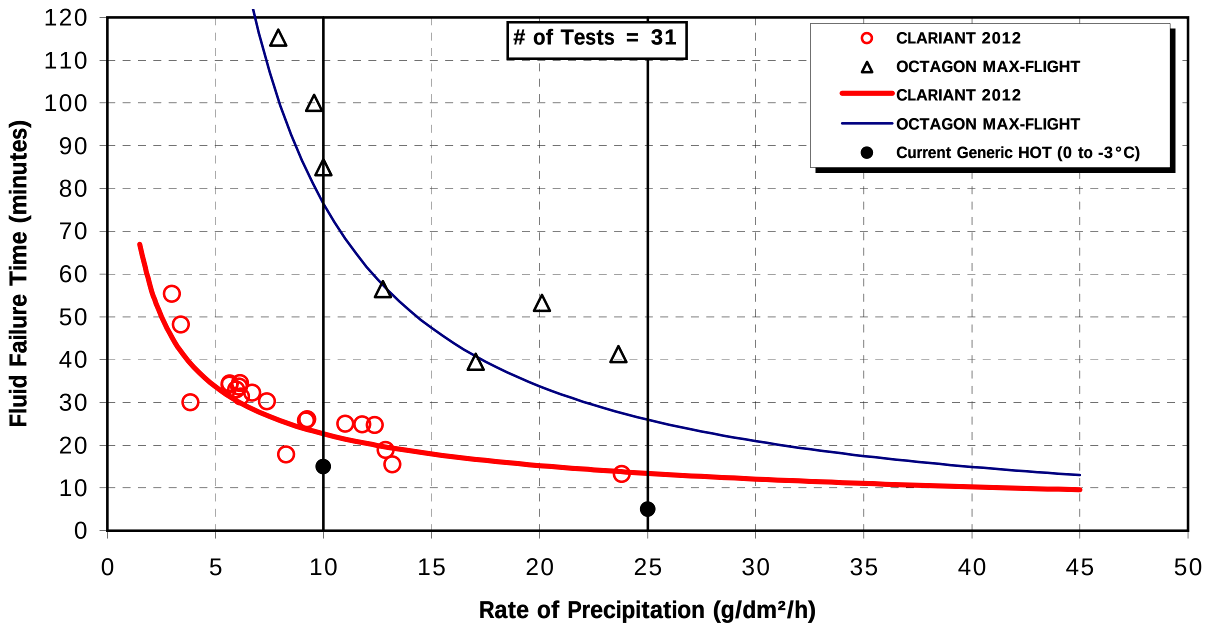
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:05-0:15	0:40-1:20	0:05-0:15		~~0:15-0:25~~		~~0:05-0:15~~				
HISTORICAL	**1997-98 Endurance Time Test Results**		0:40-1:20	0:05-0:15	0:10-0:20				0:10-0:30	0:10-0:20		0:15-0:30
HISTORICAL	**1998-99 HOT Table Values**	0:05-0:15	0:40-1:20	0:05-0:15	0:10-0:20				0:10-0:30	0:10-0:20		0:15-0:30
HISTORICAL	**1998-99 Endurance Time Test Results**	0:05-0:15	~~0:15-0:30~~	0:05-0:15	0:10-0:20							
HISTORICAL	**1999-2000 HOT Table Values**	0:05-0:15	0:15-0:30	0:05-0:15	0:10-0:20				0:10-0:30	0:10-0:20		
HISTORICAL	**1999-2000 Endurance Time Test Results**						0:10-0:20		0:10-0:20			
HISTORICAL	**2000-01 HOT Table Values**	0:05-0:15	0:15-0:30	0:05-0:15	0:10-0:20		0:10-0:20		0:10-0:20	0:10-0:20		
CURRENT	**2000-01 Endurance Time Test Results**		0:25-1:15								0:15-0:25	
CURRENT	**2001-02 HOT Table Values**	0:05-0:15	0:25-1:15	0:05-0:15	0:10-0:20		0:10-0:20		0:10-0:20	0:10-0:20	0:15-0:25	

FIGURE 4.8

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV 50/50 (0 to -3°C)

NATURAL SNOW



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IVHOT Summary snow1
At: 50% -3°C

4.2.2.1.7 Neat fluid, -3°C to -14°C, snow (Figure 4.9)

The generic holdover times for this temperature range and concentration were based on test results obtained from 1996-97 testing with a fluid that is no longer commercially available (Hoechst MP IV 1957). Although the data for this fluid was removed during the past year, a new fluid tested in 2000-01, Clariant 2012, had holdover times identical to the generic values. As such, the generic times have not changed from those used in 2000-01 winter operations. In 1998-99, the SPCA AD-480 holdover time range was reduced to equal that of the generic holdover time range due to a lack of data points for this fluid below -7°C. Tests with this fluid were subsequently conducted and the holdover fluid-specific times were increased from the generic values.

TABLE 4.9

Holdover Time Guidelines for Neat Fluid, -3°C to -14°C, Snow

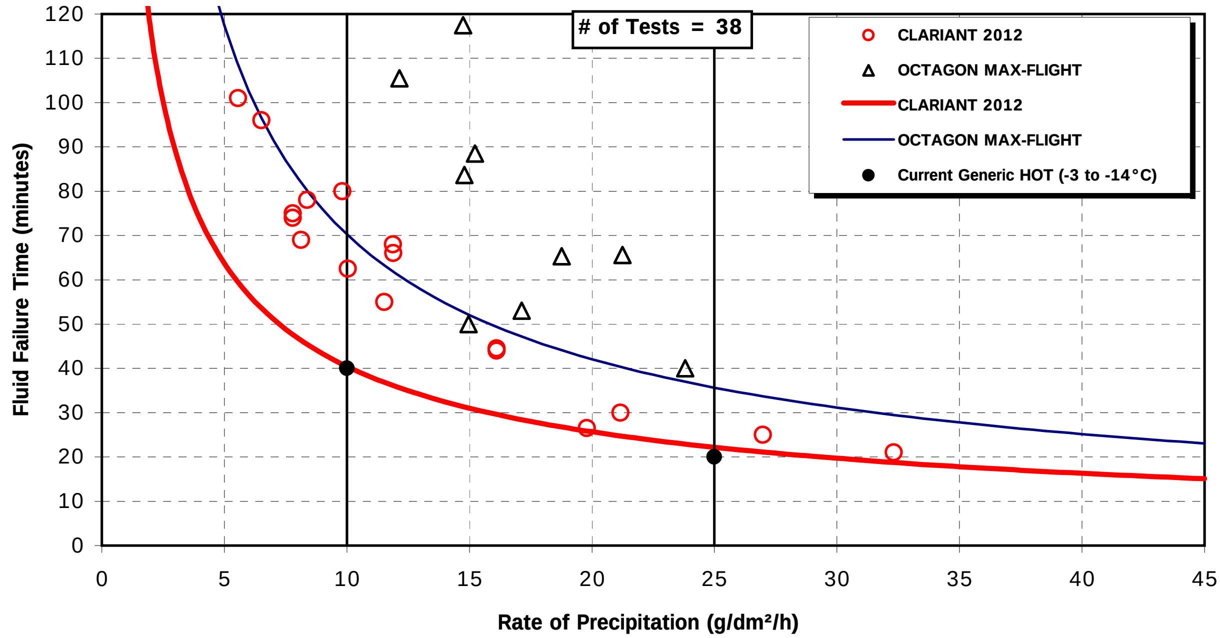
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra +	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:20-0:40	0:25-0:50	0:45-1:20		~~0:20-0:40~~		0:25-0:55				
	1997-98 Endurance Time Test Results				0:30-0:55				0:20-0:40	0:30-0:50		0:35-1:00
	1998-99 HOT Table Values	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:55			0:25-0:55	0:20-0:40	0:30-0:50		0:35-1:00
	1998-99 Endurance Time Test Results		~~0:45-1:05~~	0:45-1:20	0:30-0:50			0:30-1:00	0:30-0:55			
	1999-2000 HOT Table Values	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:50			0:25-0:55	0:30-0:55	0:30-0:50		
	1999-2000 Endurance Time Test Results						0:25-0:55		0:30-0:55			
	2000-01 HOT Table Values	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:50		0:25-0:55	0:25-0:55	0:30-0:55	0:30-0:50		
CURRENT	**2000-01 Endurance Time Test Results**		0:35-1:10								0:20-0:40	
	2001-02 HOT Table Values	0:20-0:40	0:25-0:50	0:45-1:20	0:30-0:50		0:25-0:55	0:25-0:55	0:30-0:55	0:30-0:50	0:20-0:40	

FIGURE 4.9

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (-3 to -14°C)

NATURAL SNOW



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IVHOT Summary snow1
At: Neat -14°C

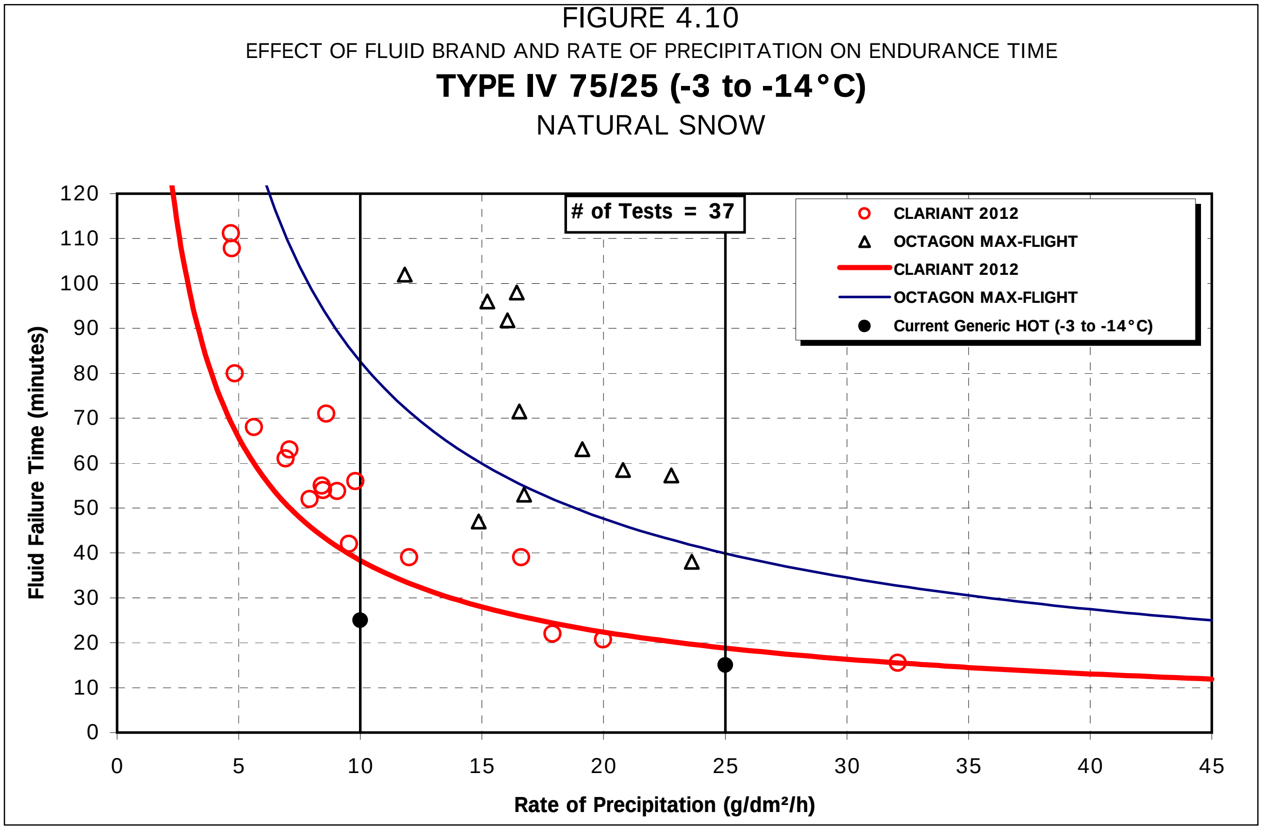
4.2.2.1.8 75/25 fluid, -3°C to -14°C, snow (Figure 4.10)

The upper and lower generic holdover times in this cell have remained the same as last year, and are based on testing with a fluid that is no longer commercially available, SPCA AD-404.

In 1998-99, the SPCA AD-480 holdover time range was reduced to equal that of the generic holdover time range due to a lack of data points for this fluid below -7°C. During the 1998-99 test season, tests with this fluid were conducted and the holdover times were increased from the generic numbers. Additional tests were conducted in 1999-2000 with a lower viscosity sample of SPCA AD-480, which resulted in a 5 minute decrease to lower limit fluid-specific value.

TABLE 4.10
Holdover Time Guidelines for 75/25 Fluid, -3°C to -14°C, Snow

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+ (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:15-0:30	0:20-0:50	0:35-1:05		~~0:15-0:30~~		~~0:15-0:30~~				
HISTORICAL	1997-98 Endurance Time Test Results				0:20-0:40				0:15-0:25	0:20-0:35		0:15-0:25
HISTORICAL	1998-99 HOT Table Values	0:15-0:25	0:20-0:50	0:35-1:05	0:20-0:40				0:15-0:25	0:20-0:35		0:15-0:25
HISTORICAL	1998-99 Endurance Time Test Results		~~0:20-0:40~~	0:25-0:50	0:20-0:40				0:25-0:45			
HISTORICAL	1999-2000 HOT Table Values	0:15-0:25	0:20-0:40	0:25-0:50	0:20-0:40				0:25-0:45	0:20-0:35		
HISTORICAL	1999-2000 Endurance Time Test Results						0:20-0:45		0:20-0:45			
HISTORICAL	2000-01 HOT Table Values	0:15-0:25	0:20-0:40	0:25-0:50	0:20-0:40		0:20-0:45		0:20-0:45	0:20-0:35		
CURRENT	2000-01 Endurance Time Test Results		0:40-1:20								0:20-0:40	
CURRENT	2001-02 HOT Table Values	0:15-0:25	0:20-0:50	0:25-0:50	0:20-0:40		0:20-0:45		0:20-0:45	0:20-0:35	0:20-0:40	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\HOT Summary snow1
At: 75% -14ºC

4.2.2.1.9 *Neat fluid, -14°C to -25°C, snow (Figure 4.11)*

The generic holdover times for this cell are unchanged from 2000-01 table values, which were based on results from 1996-97 testing with a fluid that has recently been removed from the data set. The generic holdover times for this cell were maintained because in 2000-01 Clariant 2012 exhibited testing fluid performance identical to the previous generic values of 15 to 30 minutes.

Regression curves were generated using the most restrictive temperature in this range (-25°C). In 1998-99, the holdover times for SPCA AD-404 and SPCA AD-480 in this cell were reduced to match the generic holdover times, due to a lack of data points. The SPCA AD-480 holdover times were increased based on the results of tests conducted during the past two years.

TABLE 4.11

Holdover Time Guidelines for Neat Fluid, -14°C to -25°C, Snow

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:15-0:30	0:20-0:40	0:40-1:10		~~0:15-0:30~~		0:20-0:45				
	1997-98 Endurance Time Test Results				0:25-0:45				0:15-0:30	0:20-0:35		0:15-0:30
	1998-99 HOT Table Values	0:15-0:30	0:20-0:40	0:40-1:10	0:25-0:45			0:20-0:45	0:15-0:30	0:20-0:35		0:15-0:30
	1998-99 Endurance Time Test Results		~~0:40-1:00~~	0:40-1:10	0:25-0:45			0:30-0:55	0:25-0:40			
	1999-2000 HOT Table Values	0:15-0:30	0:20-0:40	0:40-1:10	0:25-0:45			0:20-0:45	0:25-0:40	0:20-0:35		
	1999-2000 Endurance Time Test Results						0:20-0:45		0:25-0:50			
	2000-01 HOT Table Values	0:15-0:30	0:20-0:40	0:40-1:10	0:25-0:45		0:20-0:45	0:20-0:45	0:25-0:40	0:20-0:35		
CURRENT	2000-01 Endurance Time Test Results		0:25-0:50								0:15-0:30	
	2001-02 HOT Table Values	0:15-0:30	0:20-0:40	0:40-1:10	0:25-0:45		0:20-0:45	0:20-0:45	0:25-0:40	0:20-0:35	0:15-0:30	

4.2.2.2 *Overall perspective on snow results*

No reductions have been made to the snow column of the generic Type IV holdover time tables based on the results of tests conducted in 2000-01.

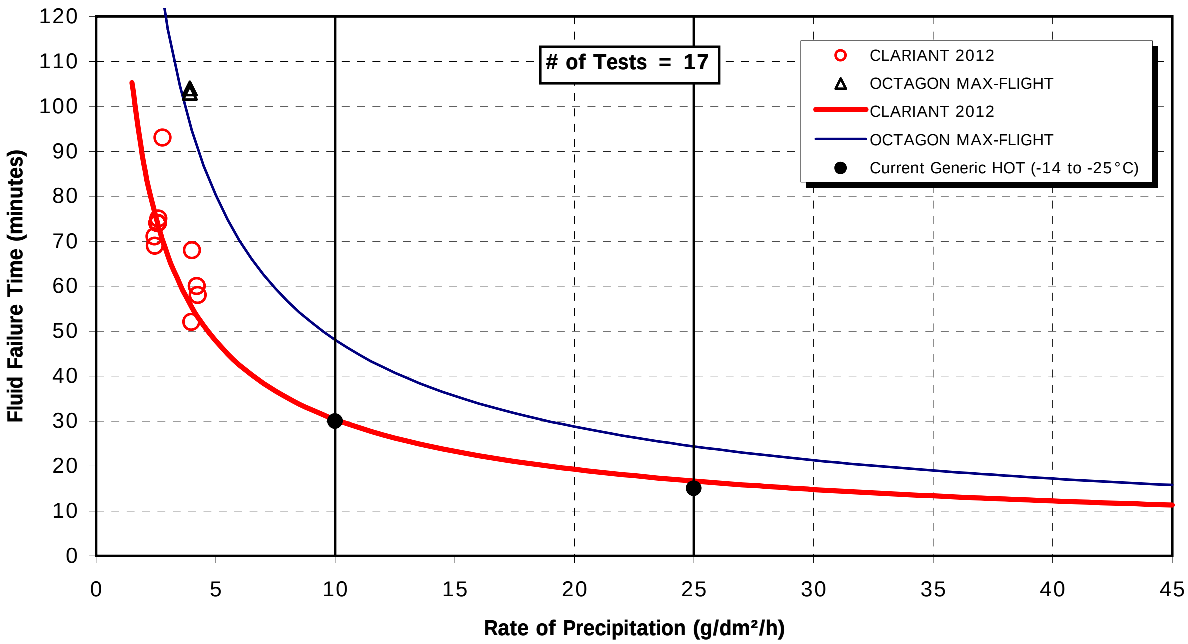
Four holdover times in the snow column were increased following the SAE G-12 Holdover Time Subcommittee meeting in New Orleans, as a result of the elimination of Hoechst 1957 and diluted Ultra+ test data. Both the upper and lower holdover time limits for 75/25 fluid in two cells, above 0°C and from 0ºC to -3°C, were increased.

FIGURE 4.11

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV NEAT (-14 to -25°C)

NATURAL SNOW



4.2.3 Freezing Drizzle

The freezing drizzle holdover time data originated from tests conducted by APS at the NRC test facility in Ottawa. The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix G). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation and accompanies discussions regarding changes to holdover times. These plots appear in the body of the text as Figures 4.12 to 4.16.

Subsections 4.2.3.1.1 to 4.2.3.1.5 contain the Type IV fluid holdover time results in the freezing drizzle column. They are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for this category of precipitation are identical to those in the range of 0°C to -3°C.

4.2.3.1 Changes to Type IV fluid holdover times for freezing drizzle

The results of Type IV fluid testing from 1996-97, 1997-98, 1998-99 1999-2000, and 2000-01 in conditions of freezing drizzle are presented in this section in the same format as presented for snow. (Refer to the explanation of holdover time results in natural snow tests in Subsection 4.2.2.1).

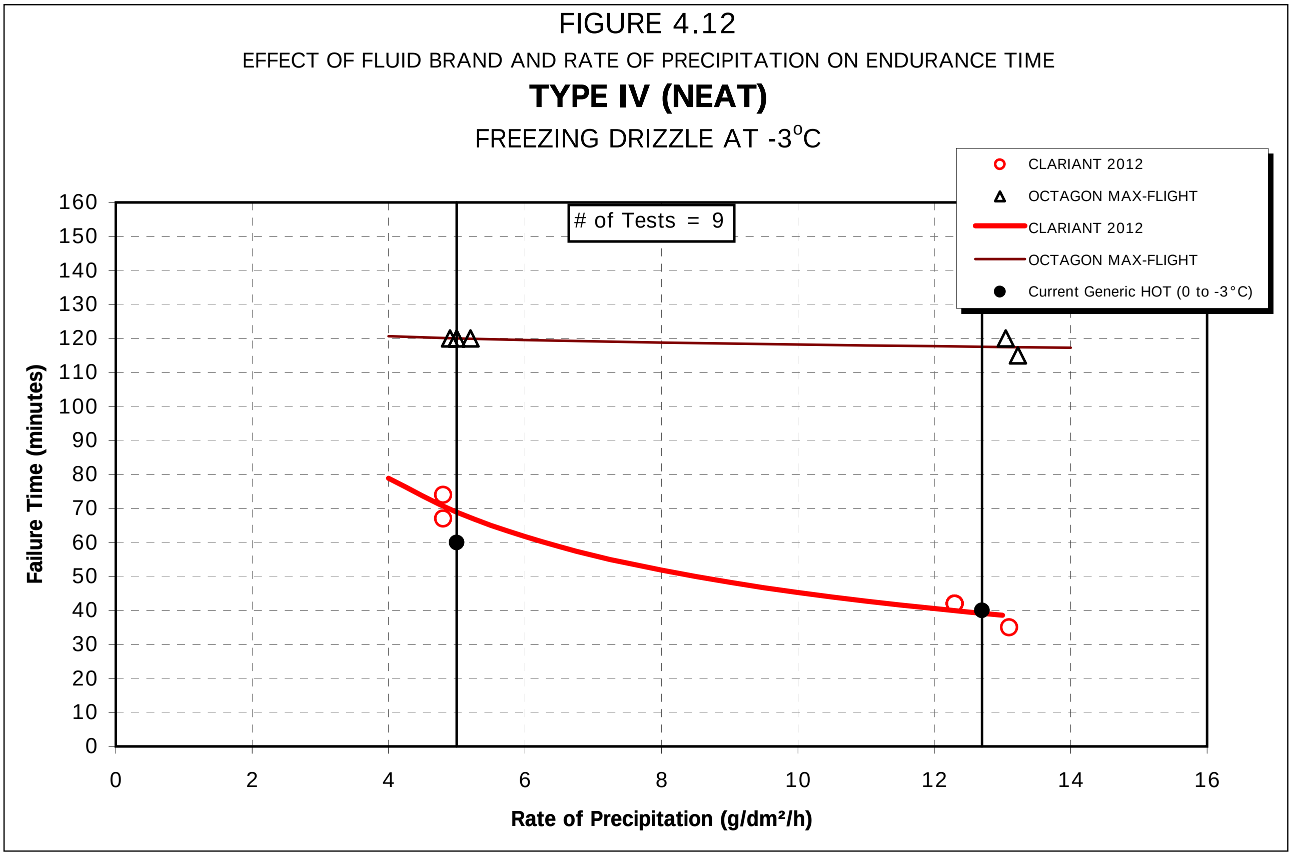
4.2.3.1.1 *Neat fluid, above 0°C and 0ºC to -3°C, freezing drizzle (Figure 4.12)*

The upper limit generic holdover times in these two cells have increased by 10 minutes from last year and are based on the results of tests conducted in 1998-99 and 2000-01 with Clariant 1957 and 2012 products, respectively. The lower limit generic holdover times have remained unchanged from those used in 2000-01 winter operations.

TABLE 4.12

Holdover Time Guidelines for Neat Fluid, Above 0°C and 0ºC to -3°C, Freezing Drizzle

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra +	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:40-1:00	0:55-2:00	1:20-1:50		~~0:40-1:00~~		1:00-2:00				
	1997-98 Endurance Time Test Results		1:10-2:00	1:55-2:00	0:50-1:40				1:05-2:00	0:55-1:55		1:40-2:00
	1998-99 HOT Table Values	0:40-1:00	0:55-2:00	1:20-1:50	0:50-1:40			1:00-2:00	1:05-2:00	0:55-1:55		1:40-2:00
	1998-99 Endurance Time Test Results		~~1:00-1:55~~	2:00-2:00	0:40-1:10			0:45-1:35				
	1999-2000 HOT Table Values	0:40-1:00	0:55-1:55	1:20-1:50	0:40-1:10			0:45-1:35	1:05-2:00	0:55-1:55		
	1999-2000 Endurance Time Test Results						1:05-1:45		0:50-1:30			
	2000-01 HOT Table Values	0:40-1:00	0:55-1:55	1:20-1:50	0:40-1:10		1:05-1:45	0:45-1:35	0:50-1:30	0:55-1:55		
CURRENT	2000-01 Endurance Time Test Results		2:00-2:00								0:40-1:10	
	2001-02 HOT Table Values	0:40-1:10	0:55-2:00	1:20-1:50	0:40-1:10		1:05-1:45	0:45-1:35	0:50-1:30	0:55-1:55	0:40-1:10	



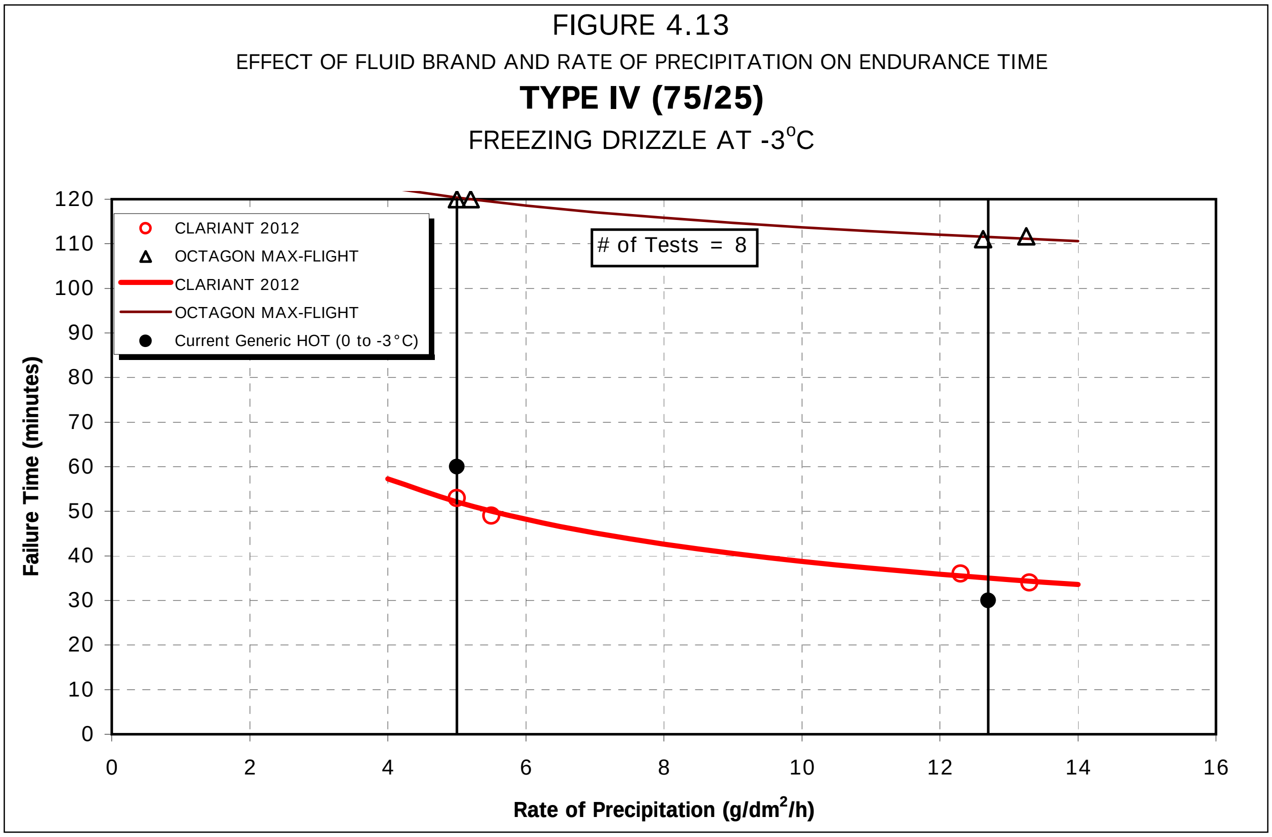
I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ARTIF1
At: Neat ZD -3°C

4.2.3.1.2 75/25 fluid, above 0°C and 0ºC to -3°C, freezing drizzle (Figure 4.13)

Both generic holdover times have changed from the values used in 2000-01 winter operations. The lower holdover time limit was increased by 5 minutes following the removal of the diluted Ultra+ data from 1996-97 testing. The upper holdover time limit has been reduced by 10 minutes based on the results of tests with Clariant 2012 in 2000-01 testing with this fluid.

TABLE 4.13
Holdover Time Guidelines for 75/25 Fluid, Above 0°C and 0°C to -3°C, Freezing Drizzle

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+ (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:30-1:00	1:15-2:00	0:50-1:25		~~0:40-1:05~~		~~0:30-1:00~~				
HISTORICAL	1997-98 Endurance Time Test Results		1:20-2:00	0:50-1:10	0:45-1:15				0:50-1:20	0:35-1:10		0:50-1:50
HISTORICAL	1998-99 HOT Table Values	0:30-1:00	1:15-2:00	0:50-1:10	0:45-1:15				0:50-1:20	0:35-1:10		0:50-1:50
HISTORICAL	1998-99 Endurance Time Test Results		~~0:50-1:20~~	0:45-1:10	0:35-1:05							
HISTORICAL	1999-2000 HOT Table Values	0:30-1:00	0:50-1:20	0:45-1:10	0:35-1:05				0:50-1:20	0:35-1:10		
HISTORICAL	1999-2000 Endurance Time Test Results						0:50-1:30		0:50-1:15			
HISTORICAL	2000-01 HOT Table Values	0:30-1:00	0:50-1:20	0:45-1:10	0:35-1:05		0:50-1:30		0:50-1:15	0:35-1:10		
CURRENT	2000-01 Endurance Time Test Results		1:50-2:00								0:35-0:50	
CURRENT	2001-02 HOT Table Values	0:35-0:50	1:15-2:00	0:45-1:10	0:35-1:05		0:50-1:30		0:50-1:15	0:35-1:10	0:35-0:50	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ARTIF1
At: 75-25 ZD -3°C

4.2.3.1.3 50/50 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 4.14)

The generic holdover times for these two cells remain unchanged from last year and are based on test results with two different fluids. The fluid-specific values for Octagon Max-Flight have increased substantially with the removal of the 1998-99 test data with this fluid.

TABLE 4.14

Holdover Time Guidelines for 50/50 Fluid, Above 0°C and 0°C to -3°C, Freezing Drizzle

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:10-0:20	0:55-1:40	0:15-0:25		~~0:20-0:35~~		~~0:10-0:20~~				
HISTORICAL	1997-98 Endurance Time Test Results		0:35-1:00	0:15-0:20	0:15-0:25				0:15-0:35	0:10-0:20		0:25-0:55
HISTORICAL	1998-99 HOT Table Values	0:10-0:20	0:35-1:00	0:15-0:20	0:15-0:25				0:15-0:35	0:10-0:20		0:25-0:55
HISTORICAL	1998-99 Endurance Time Test Results		~~0:15-0:25~~	0:15-0:20	0:15-0:25							
HISTORICAL	1999-2000 HOT Table Values	0:10-0:20	0:15-0:25	0:15-0:20	0:15-0:25				0:15-0:35	0:10-0:20		
HISTORICAL	1999-2000 Endurance Time Test Results						0:15-0:25		0:15-0:25			
HISTORICAL	2000-01 HOT Table Values	0:10-0:20	0:15-0:25	0:15-0:20	0:15-0:25		0:15-0:25		0:15-0:25	0:10-0:20		
CURRENT	2000-01 Endurance Time Test Results		0:35-1:10								0:15-0:20	
CURRENT	2001-02 HOT Table Values	0:10-0:20	0:35-1:00	0:15-0:20	0:15-0:25		0:15-0:25		0:15-0:25	0:10-0:20	0:15-0:20	

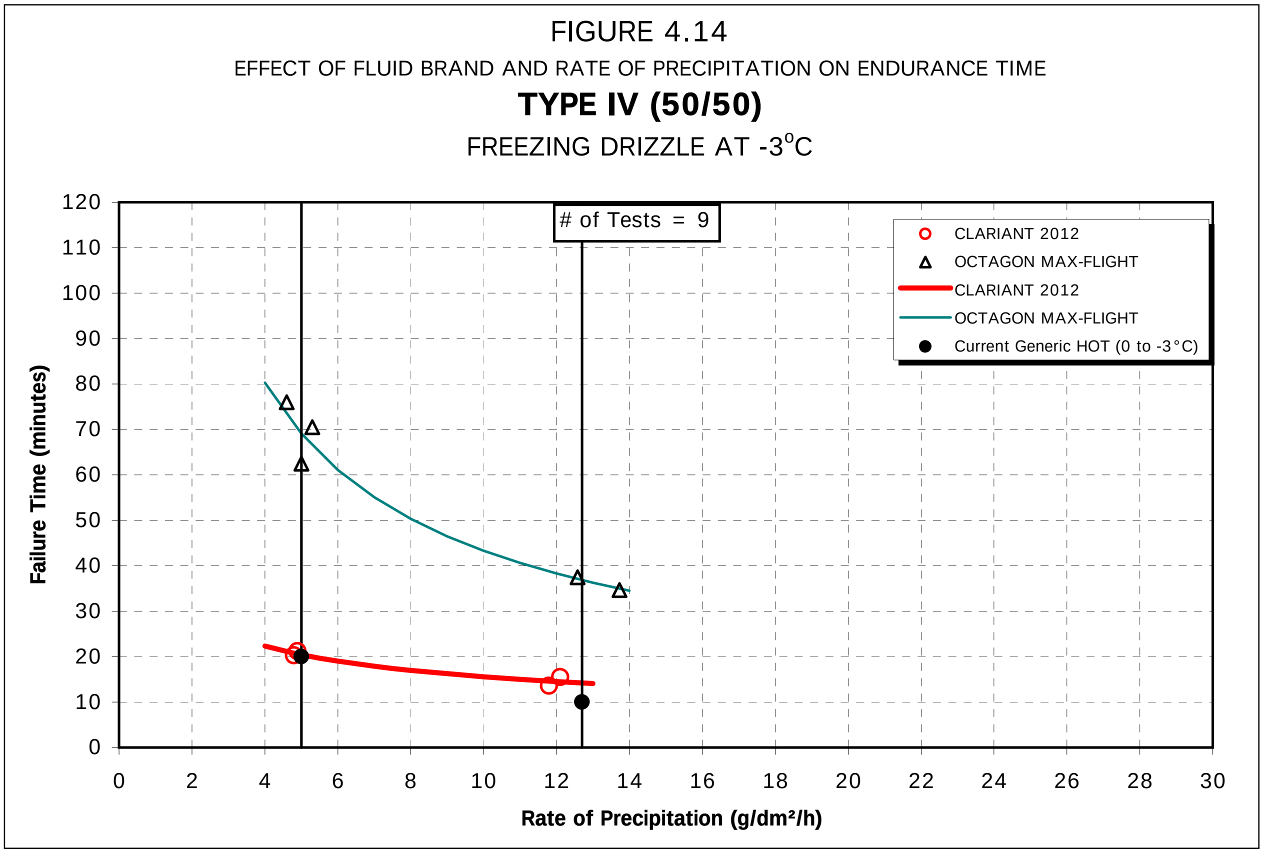


FIGURE 4.14
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV (50/50)
FREEZING DRIZZLE AT -3°C
# of Tests = 9
CLARIANT 2012
OCTAGON MAX-FLIGHT
CLARIANT 2012
OCTAGON MAX-FLIGHT
Current Generic HOT (0 to -3°C)
Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

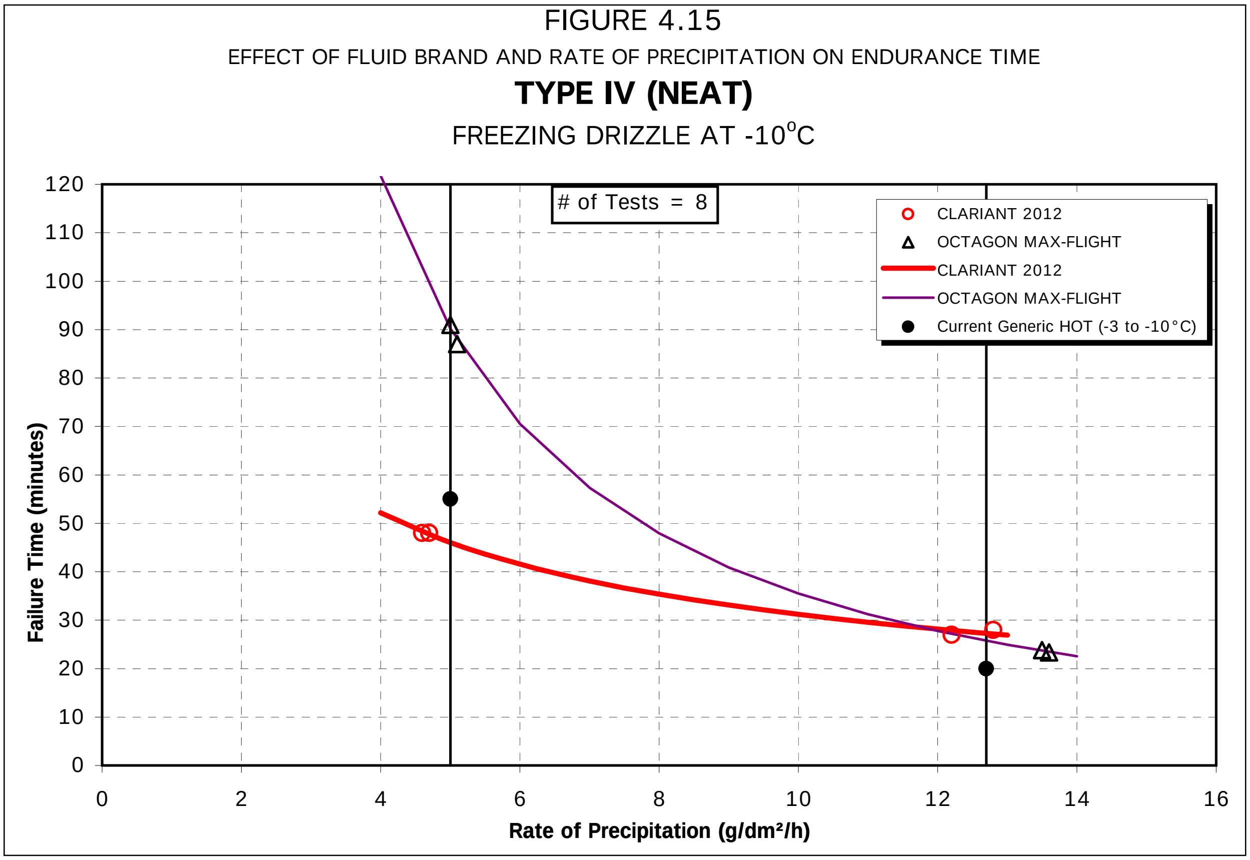
4.2.3.1.4 Neat fluid, -3°C to -10°C, freezing drizzle (Figure 4.15)

The generic lower holdover time limit for neat fluid in this temperature range and precipitation type has remained unchanged from the values used during the past year, and is based on tests conducted with Kilfrost ABC-S in 1998-99. The upper generic holdover time limit was reduced by 10 minutes based on the results of tests with Clariant 2012 in 2000-01.

TABLE 4.15

Holdover Time Guidelines for Neat Fluid, -3°C to -10°C, Freezing Drizzle

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra +	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:30-1:00	0:30-1:10	0:35-1:00		~~0:40-1:00~~		0:50-1:35				
	1997-98 Endurance Time Test Results		0:30-1:25	0:40-1:20	0:55-1:25				0:25-1:20	0:55-1:35		1:05-2:00
	1998-99 HOT Table Values	0:25-1:00	0:30-1:10	0:35-1:00	0:55-1:25			0:50-1:35	0:25-1:20	0:55-1:35		1:05-2:00
	1998-99 Endurance Time Test Results		~~0:25-1:15~~	0:20-1:30	0:35-0:55			0:45-1:25				
	1999-2000 HOT Table Values	0:20-0:55	0:25-1:10	0:20-1:00	0:35-0:55			0:45-1:25	0:25-1:20	0:55-1:35		
	1999-2000 Endurance Time Test Results						0:25-1:05		0:25-1:20			
	2000-01 HOT Table Values	0:20-0:55	0:25-1:10	0:20-1:00	0:35-0:55		0:25-1:05	0:45-1:25	0:25-1:20	0:55-1:35		
CURRENT	2000-01 Endurance Time Test Results		0:25-1:30								0:25-0:45	
	2001-02 HOT Table Values	0:20-0:45	0:25-1:10	0:20-1:00	0:35-0:55		0:25-1:05	0:45-1:25	0:25-1:20	0:55-1:35	0:25-0:45	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ARTIF1
At: Neat ZD -10°C

4.2.3.1.5 75/25 fluid, -3°C to -10°C, freezing drizzle (Figure 4.16)

The generic holdover time range for 75/25 fluid in freezing drizzle was reduced from 20 – 50 minutes to 15 – 30 minutes, based on the 2000-01 test results with the Clariant 2012 fluid.

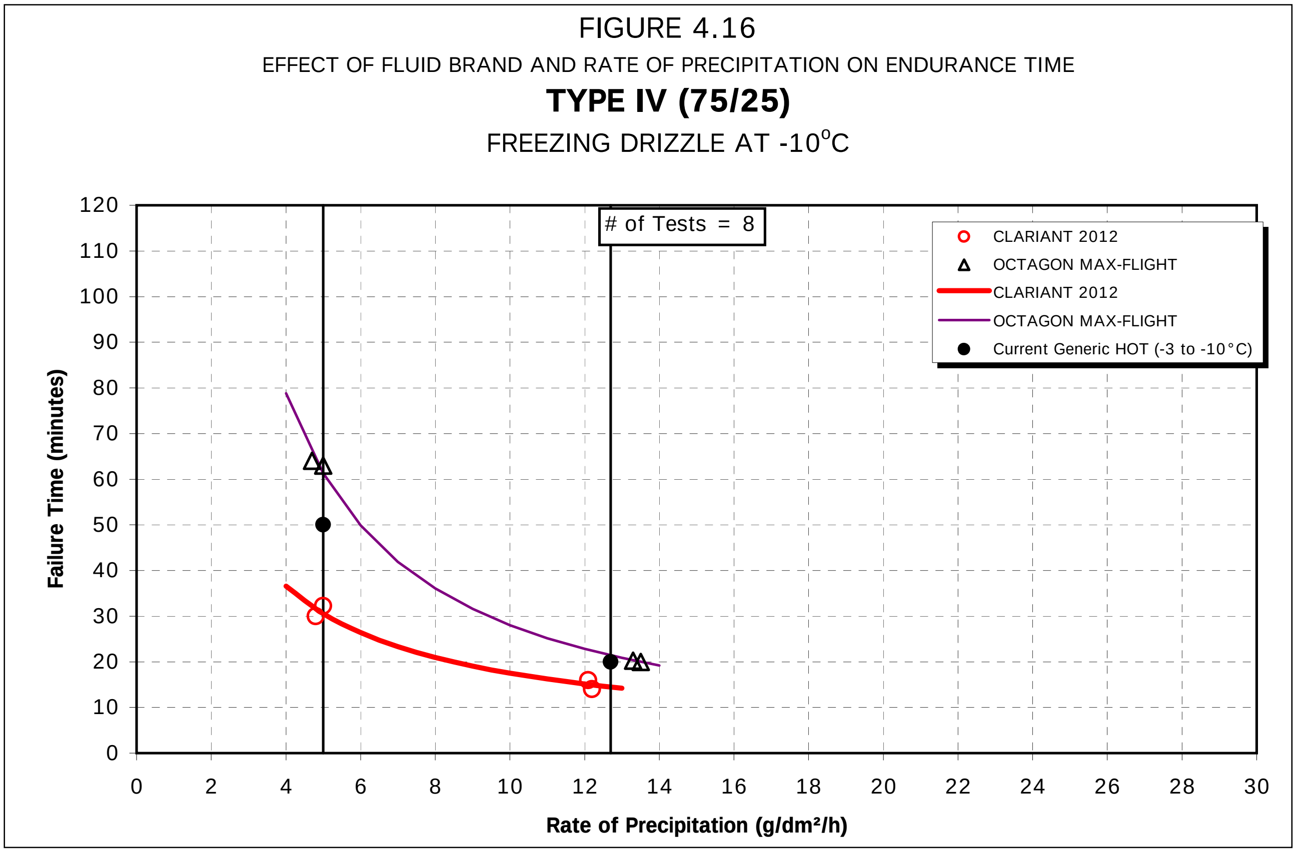
TABLE 4.16

Holdover Time Guidelines for 75/25 Fluid, -3°C to -10°C, Freezing Drizzle

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:30-1:00	0:30-1:05	0:50-1:25		~~0:40-1:05~~		~~0:30-1:00~~				
HISTORICAL	1997-98 Endurance Time Test Results		0:25-1:20	0:30-1:10	0:45-1:15				0:30-1:15	0:40-1:10		0:30-1:45
HISTORICAL	1998-99 HOT Table Values	0:30-1:00	0:25-1:05	0:30-1:10	0:45-1:15				0:30-1:15	0:40-1:10		0:30-1:45
HISTORICAL	1998-99 Endurance Time Test Results		~~0:20-1:00~~	0:20-1:30	0:25-0:55							
HISTORICAL	1999-2000 HOT Table Values	0:20-0:55	0:20-1:00	0:20-1:10	0:25-0:55				0:30-1:15	0:40-1:10		
HISTORICAL	1999-2000 Endurance Time Test Results						0:20-0:50		0:25-1:05			
HISTORICAL	2000-01 HOT Table Values	0:20-0:50	0:20-1:00	0:20-1:10	0:25-0:55		0:20-0:50		0:25-1:05	0:40-1:10		
CURRENT	2000-01 Endurance Time Test Results		0:20-1:00								0:15-0:30	
CURRENT	2001-02 HOT Table Values	0:15-0:30	0:20-1:00	0:20-1:10	0:25-0:55		0:20-0:50		0:25-1:05	0:40-1:10	0:15-0:30	

4.2.3.2 Overall perspective on freezing drizzle results

Several reductions and increases have been made to the freezing drizzle column of the generic Type IV holdover time table. The five reductions range from 5 to 20 minutes and are a result of tests conducted during the 2000-01 test season with Clariant 2012 fluid. In addition to the five reductions, four increases were made to the freezing drizzle column of the generic Type IV holdover time table. Obsolete test data from 1996-97 testing were removed, resulting in two 5-minute and two 10-minute increases to the generic numbers.



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ARTIF1
At: 75-25 ZD -10°C

4.2.4 Light Freezing Rain

The light freezing rain endurance time data were obtained from tests conducted by APS at the NRC test facility in Ottawa. The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix G). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation and accompanies discussions regarding changes to holdover times. These plots appear in the body of the text as Figures 4.17 to 4.21.

Subsections 4.2.4.1.1 to 4.2.4.1.5 contain the Type IV fluid holdover time results in the light freezing rain column. Results are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time values for the category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

4.2.4.1 Changes to Type IV fluid holdover times for light freezing rain

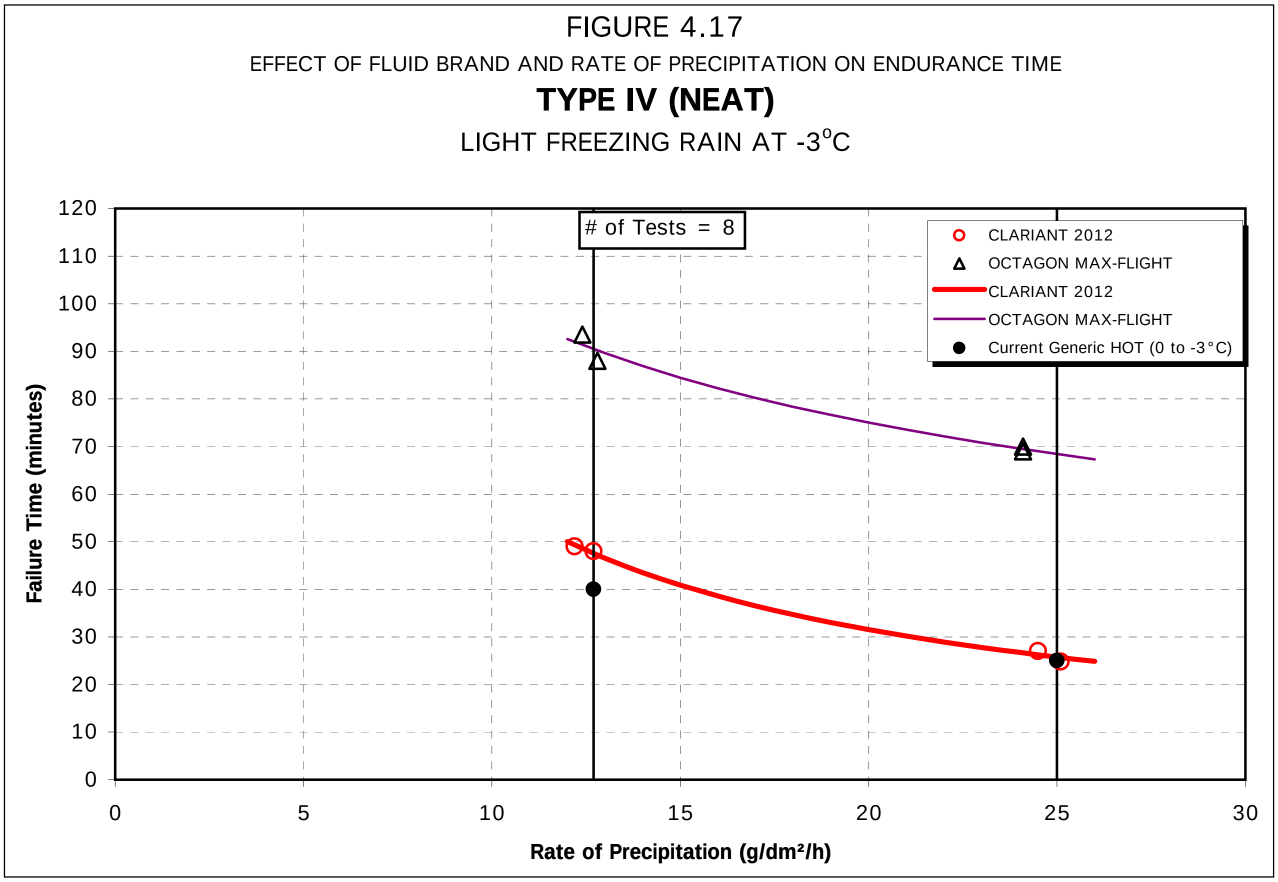
The results of Type IV fluid testing from 1996-97, 1997-98, 1998-99, and 1999-2000 in conditions of light freezing rain are presented in this subsection in the same format as for freezing drizzle and snow. (Refer to the explanation of holdover time results in natural snow tests in Subsection 4.2.2.1).

4.2.4.1.1 Neat fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.17)

Both the upper and lower holdover times in this cell have remained unchanged from previous values. One fluid, UCAR Ultra+ tested in 1998-99 and is responsible for both generic values. The fluid-specific values of the different Type IV fluids vary greatly in this cell.

TABLE 4.17
Holdover Time Guidelines for Neat Fluid, Above 0°C and 0°C to -3°C, Light Freezing Rain

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:35-0:55	0:40-1:15	1:00-1:25		~~0:40-0:55~~		0:35-1:00				
	1997-98 Endurance Time Test Results		0:35-1:00	1:20-2:00	0:40-1:00				0:50-1:10	0:40-1:00		0:45-1:20
	1998-99 HOT Table Values	0:35-0:55	0:35-1:00	1:00-1:25	0:40-1:00			0:35-1:00	0:50-1:10	0:40-1:00		0:45-1:20
	1998-99 Endurance Time Test Results		~~0:30-0:50~~	1:20-2:00	0:30-0:45			0:25-0:40				
	1999-2000 HOT Table Values	0:25-0:40	0:30-0:50	1:00-1:25	0:30-0:45			0:25-0:40	0:50-1:10	0:40-1:00		
	1999-2000 Endurance Time Test Results						0:50-1:05		0:35-0:55			
	2000-01 HOT Table Values	0:25-0:40	0:30-0:50	1:00-1:25	0:30-0:45		0:50-1:05		0:35-0:55	0:40-1:00		
CURRENT	2000-01 Endurance Time Test Results		1:10-1:30								0:25-0:45	
	2001-02 HOT Table Values	0:25-0:40	0:35-1:00	1:00-1:25	0:30-0:45		0:50-1:05	0:25-0:40	0:35-0:55	0:40-1:00	0:25-0:45	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZR1
At: Neat ZR -3°C

4.2.4.1.2 *75/25 fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.18)*

The generic holdover times in these two cells have remained unchanged and are now based on the results of tests conducted with Clariant 2012 in 2000-01.

TABLE 4.18

Holdover Time Guidelines for 75/25 Fluid, Above 0°C and 0°C to -3°C, Light Freezing Rain

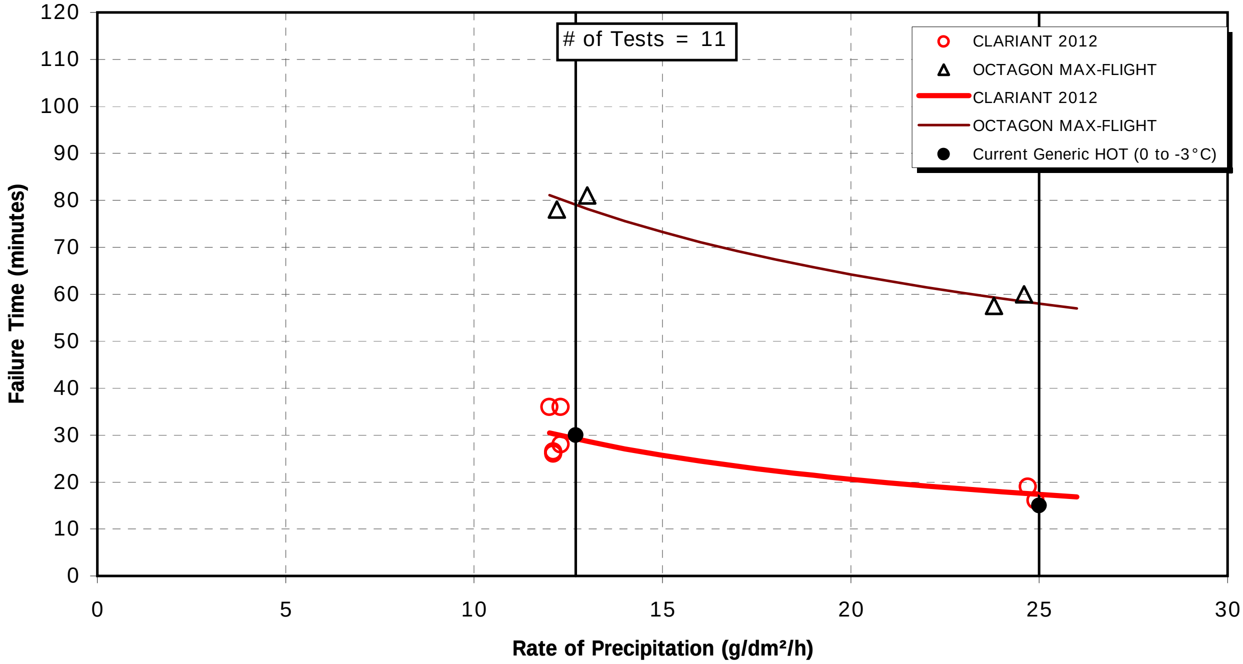
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:15-0:30	0:50-1:15	0:35-0:50		~~0:25-0:40~~		~~0:15-0:30~~				
	1997-98 Endurance Time Test Results		0:35-1:10	0:40-0:55	0:30-0:40				0:35-0:50	0:25-0:35		0:30-0:50
	1998-99 HOT Table Values	0:15-0:30	0:35-1:10	0:35-0:50	0:30-0:40				0:35-0:50	0:25-0:35		0:30-0:50
	1998-99 Endurance Time Test Results		~~0:20-0:40~~	0:35-0:50	0:25-0:40							
	1999-2000 HOT Table Values	0:15-0:30	0:20-0:40	0:35-0:50	0:25-0:40				0:35-0:50	0:25-0:35		
	1999-2000 Endurance Time Test Results						0:30-0:45		0:30-0:45			
	2000-01 HOT Table Values	0:15-0:30	0:20-0:40	0:35-0:50	0:25-0:40		0:30-0:45		0:30-0:45	0:25-0:35		
CURRENT	2000-01 Endurance Time Test Results		1:00-1:20								0:15-0:30	
	2001-02 HOT Table Values	0:15-0:30	0:35-1:10	0:35-0:50	0:25-0:40		0:30-0:45		0:30-0:45	0:25-0:35	0:15-0:30	

FIGURE 4.18

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV (75/25)

LIGHT FREEZING RAIN AT -3°C



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZR1
At: 75-25 ZR-3°C

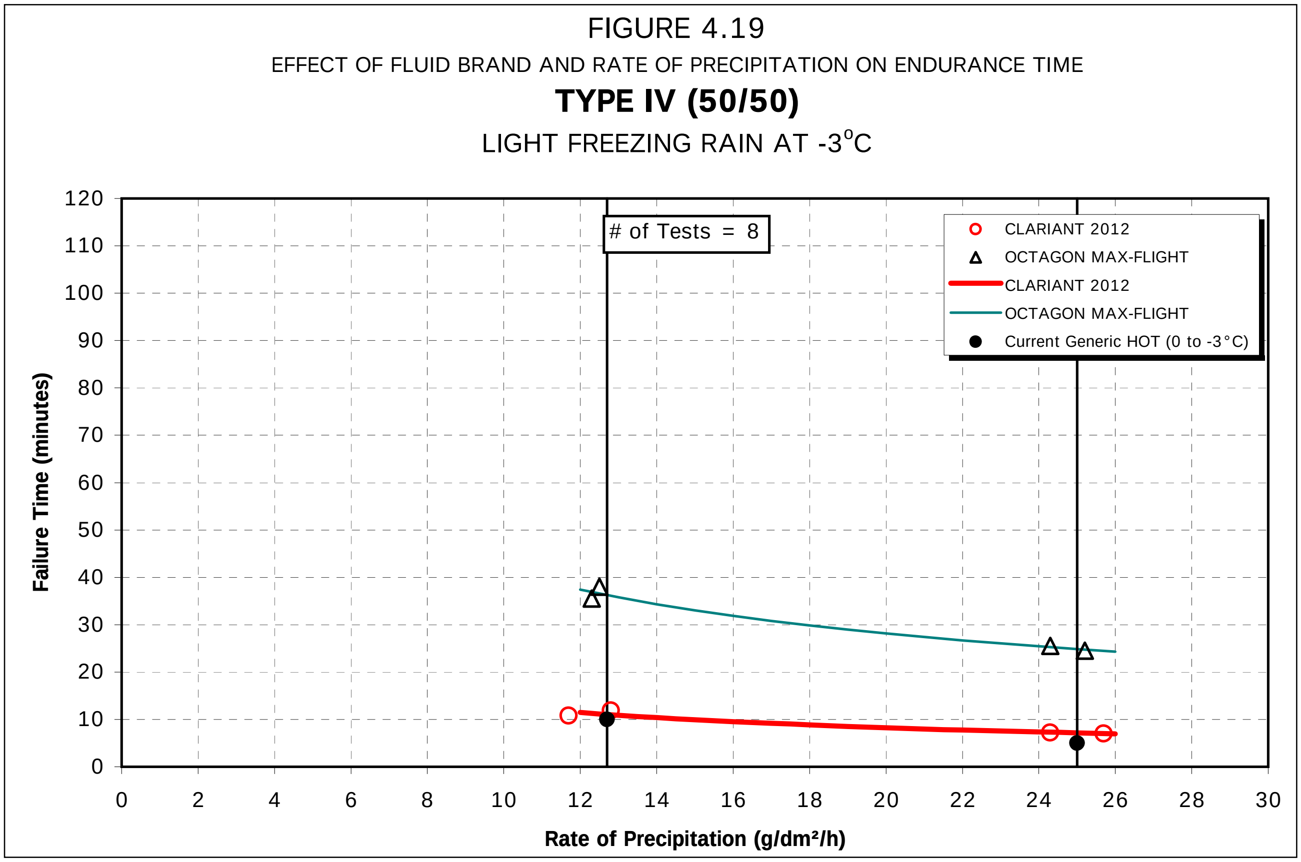
4.2.4.1.3 50/50 fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.19)

The generic values have not changed in these two cells. Four different fluids are responsible for the generic values in this cell: Kilfrost ABC-S, Clariant MPIV 1957, SPCA AD-480, and Clariant Safewing MPIV Protect 2012. In 1998-99, holdover time results below 10 minutes were rounded down to the nearest whole "5" value as a precautionary measure. As a result, the lower holdover time limit for Clariant 2001 was rounded down to 5 minutes.

TABLE 4.19

Holdover Time Guidelines for 50/50 Fluid, Above 0°C and 0°C to -3°C, Light Freezing Rain

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:05-0:10	0:30-0:55	0:10-0:15		~~0:15-0:20~~		~~0:05-0:10~~				
	1997-98 Endurance Time Test Results	0:05-0:10	0:15-0:30	0:10-0:15	0:10-0:15				0:10-0:25	0:10-0:15		0:15-0:35
	1998-99 HOT Table Values	0:05-0:10	0:15-0:30	0:10-0:15	0:10-0:15				0:10-0:25	0:10-0:15		0:15-0:35
	1998-99 Endurance Time Test Results	0:05-0:10	~~0:05-0:15~~	0:05-0:10	0:05-0:15							
	1999-2000 HOT Table Values	0:05-0:10	0:05-0:15	0:05-0:10	0:05-0:15				0:10-0:25	0:05-0:15		
	1999-2000 Endurance Time Test Results						0:10-0:15		0:05-0:15			
	2000-01 HOT Table Values	0:05-0:10	0:05-0:15	0:05-0:10	0:05-0:15		0:10-0:15		0:05-0:15	0:05-0:15		
CURRENT	2000-01 Endurance Time Test Results		0:25-0:35								0:05-0:10	
	2001-02 HOT Table Values	0:05-0:10	0:15-0:30	0:05-0:10	0:05-0:15		0:10-0:15		0:05-0:15	0:05-0:15	0:05-0:10	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZR1
At: 50-50 ZR -3°C

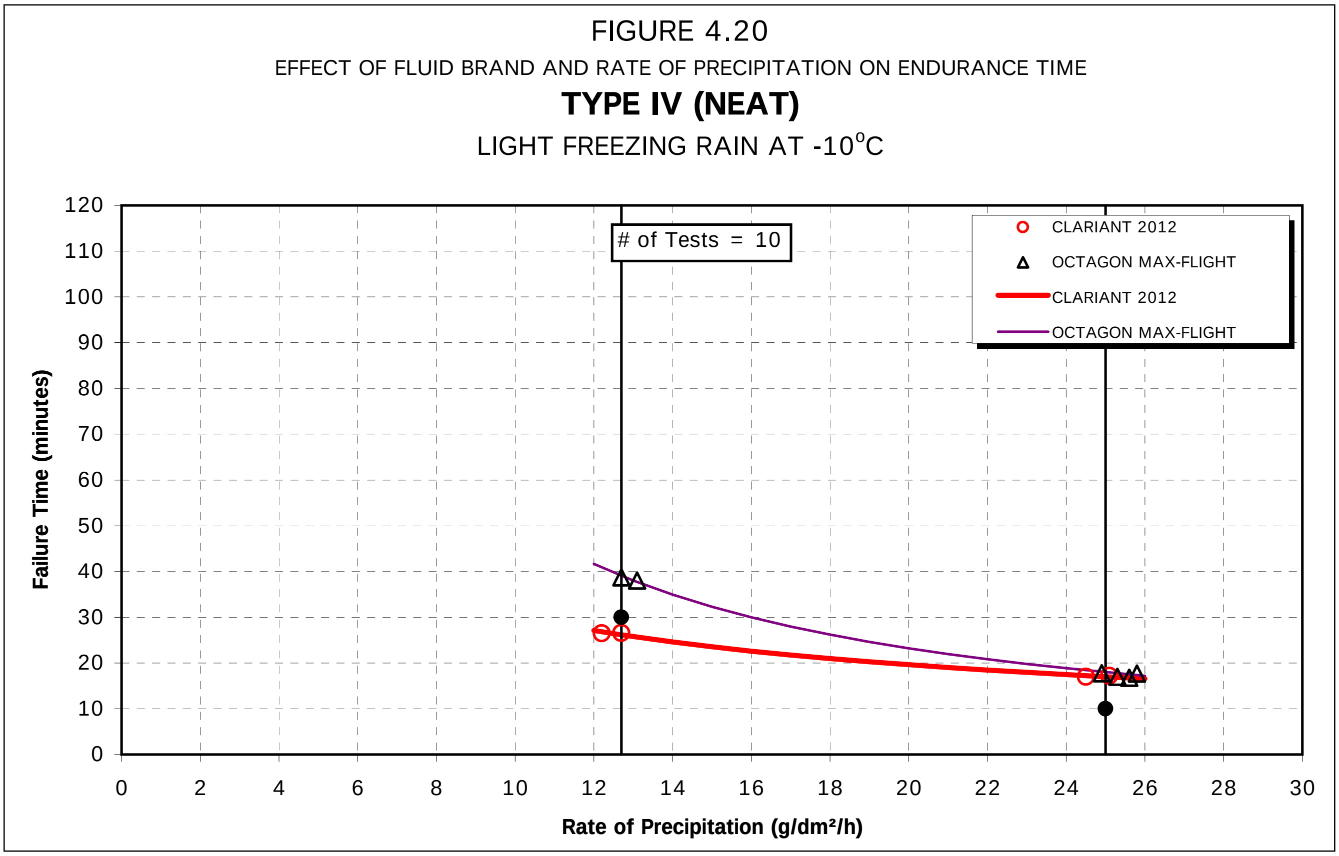
4.2.4.1.4 *Neat fluid, -3° C to -10°C, light freezing rain (Figure 4.20)*

The upper generic holdover time for neat fluid in this temperature range and precipitation type has been reduced based on the results of testing with Clariant 2012 in 2000-01. The lower generic value remains unchanged.

TABLE 4.20

Holdover Time Guidelines for Neat Fluid, -3°C to -10°C, Light Freezing Rain

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:30-0:45	0:30-0:55	0:30-0:45		~~0:30-0:50~~		0:30-0:50				
	1997-98 Endurance Time Test Results		0:20-0:40	0:20-0:40	0:30-0:45				0:20-0:40	0:30-0:45		0:35-1:20
	1998-99 HOT Table Values	0:15-0:30	0:20-0:40	0:20-0:40	0:30-0:45			0:30-0:50	0:20-0:40	0:30-0:45		0:35-1:20
	1998-99 Endurance Time Test Results		~~0:15-0:40~~	0:10-0:30	0:20-0:35			0:30-0:45				
	1999-2000 HOT Table Values	0:10-0:30	0:15-0:40	0:10-0:30	0:20-0:35			0:30-0:45	0:20-0:40	0:30-0:45		
	1999-2000 Endurance Time Test Results						0:15-0:30		0:15-0:30			
	2000-01 HOT Table Values	0:10-0:30	0:15-0:40	0:10-0:30	0:20-0:35		0:15-0:30	0:30-0:45	0:15-0:30	0:30-0:45		
CURRENT	2000-01 Endurance Time Test Results		0:20-0:40								0:15-0:25	
	2001-02 HOT Table Values	0:10-0:25	0:20-0:40	0:10-0:30	0:20-0:35		0:15-0:30	0:30-0:45	0:15-0:30	0:30-0:45	0:15-0:25	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZR1
At: Neat ZR -10ºC

4.2.4.1.5 75/25 fluid, -3°C to -10°C, light freezing rain (Figure 4.21)

The upper generic holdover time in this cell has been reduced by 5 minutes, based on the results of Clariant 2012 testing in 2000-01. The same fluid, along with one fluid tested in 1998-99 (Kilfrost ABC-S) exhibits holdover time performance equal to that of the lower generic value.

TABLE 4.21

Holdover Time Guidelines for 75/25 Fluid, -3°C to -10°C, Light Freezing Rain

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:15-0:30	0:25-0:35	0:35-0:50		~~0:25-0:40~~		~~0:15-0:30~~				
	1997-98 Endurance Time Test Results		0:20-0:30	0:25-0:35	0:25-0:35				0:20-0:35	0:20-0:30		0:30-0:45
	1998-99 HOT Table Values	0:15-0:30	0:20-0:30	0:25-0:35	0:25-0:35				0:20-0:35	0:20-0:30		0:30-0:45
	1998-99 Endurance Time Test Results		~~0:15-0:30~~	0:10-0:35	0:15-0:30							
	1999-2000 HOT Table Values	0:10-0:30	0:15-0:30	0:10-0:35	0:15-0:30				0:20-0:35	0:20-0:30		
	1999-2000 Endurance Time Test Results						0:15-0:25		0:15-0:30			
	2000-01 HOT Table Values	0:10-0:25	0:15-0:30	0:10-0:35	0:15-0:30		0:15-0:25		0:15-0:30	0:20-0:30		
CURRENT	2000-01 Endurance Time Test Results		0:15-0:30								0:10-0:20	
	2001-02 HOT Table Values	0:10-0:20	0:15-0:30	0:10-0:35	0:15-0:30		0:15-0:25		0:15-0:30	0:20-0:30	0:10-0:20	

4.2.4.2 Overall perspective on light freezing rain results

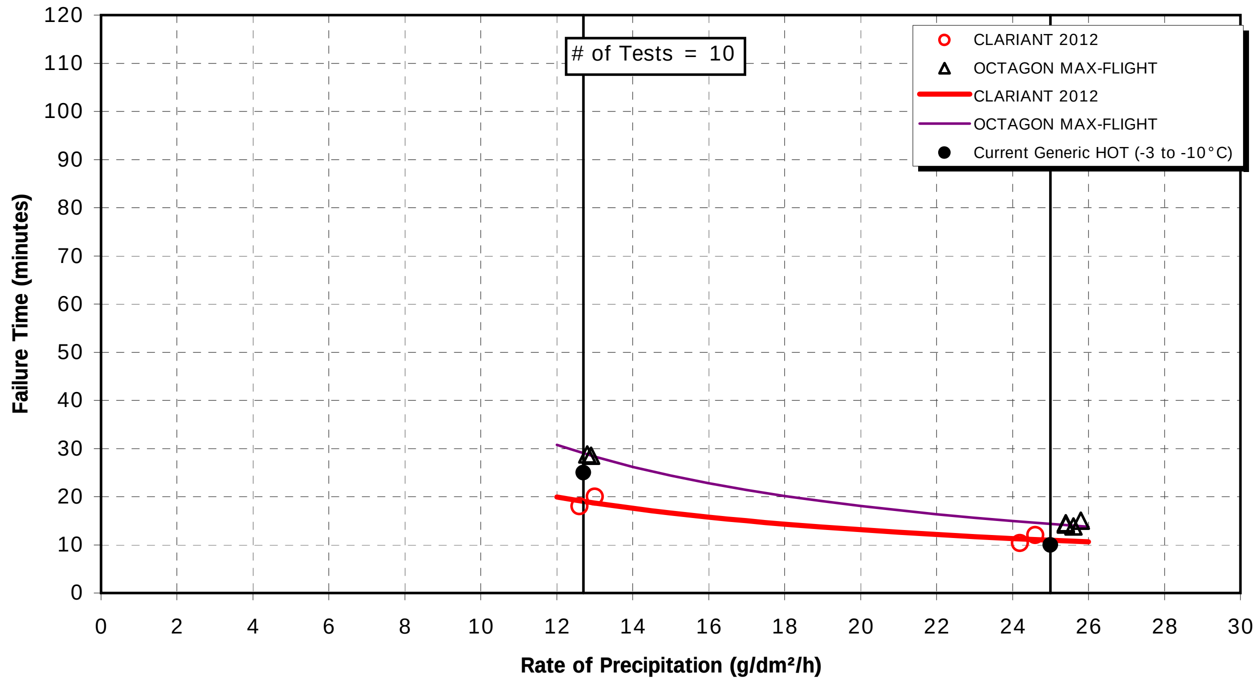
Two changes have been made to the light freezing rain column of the generic Type IV holdover time table. The upper holdover time limits in the -3°C to -10°C cells for Neat and 75/25 fluids have been reduced by five minutes.

FIGURE 4.21

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV (75/25)

LIGHT FREEZING RAIN AT -10°C



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZR1
At: 75-25 ZR -10°C

4.2.5 Freezing Fog

The freezing fog holdover time data originated from tests conducted by APS at the NRC test facility in Ottawa. The freezing fog category is divided into nine cells. The data were collected under precipitation rates of 2 and 5 g/dm^2/h. From these data, lower holdover times for each cell were determined at 5 g/dm^2/h. In 1997-98, the upper holdover times were to be determined by tests conducted at 2 g/dm^2/h; however, the general consensus among attendees at a conference in Vienna in May 1998 was that this rate limit was not indicative of low-rate natural fog. As a result, the upper holdover times in each of the fog cells were left untouched for use in 1998-99 winter operations. The lower rate limit of 2 g/dm^2/h was re-established as the lower precipitation rate limit for freezing fog prior to 1998-99 testing.

Failure times were measured at three different temperatures: -3°C, -14°C, and -25°C. Due to the inability to produce freezing fog at temperatures above 0°C, holdover times for the temperature range above 0°C are identical to those in the range from 0 to -3°C.

4.2.5.1 Changes to Type IV fluid holdover times for freezing fog

In previous years, fluid-specific values were not adopted by the SAE G-12 Holdover Time Subcommittee for this category of precipitation. It was decided at the Toronto SAE meeting in May 1999 that fluid-specific holdover times for fog would be adopted for the first time for use in 1999-2000 winter operations. These holdover times were based on the results of tests conducted during 1998-99 only, since this was the first year that tests were conducted at both rate limits.

The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix G). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation and accompanies discussions regarding changes to holdover times. These plots appear in the body of the text as Figures 4.22 to 4.27.

The fluid-specific results of Type IV fluid testing from 1996-97 and 1997-98 in freezing fog conditions are not presented in this section, because fluid-specific values in the freezing fog columns only became available during the 1998-99 test season. The first horizontal row of values in each of the following tables contains the generic holdover time values used in 1997-98. The second line in each table does not contain any information, because fluid-specific values were not available. The third line contains the generic holdover time values that were used in winter operations in 1998-99. The fourth set of values is the endurance time test results from 1998-99 testing. The fifth row in each table contains the generic and fluid-specific holdover time values accepted for use in 1999-2000 winter operations. The sixth row contains the endurance time results from 1999-2000 testing. The seventh presents the generic and fluid-specific holdover time results accepted for use in winter operations in 2000-01. The eighth row contains the endurance time test results from 2000-01 testing. The ninth and final row in each of the tables contains the generic and fluid-specific holdover times accepted for use in 2001-02 winter operations. The underlined holdover time values in the tables indicate the fluids responsible for the generic holdover time.

4.2.5.1.1 Neat fluid, above 0°C and 0°C to -3°C, freezing fog (Figure 4.22)

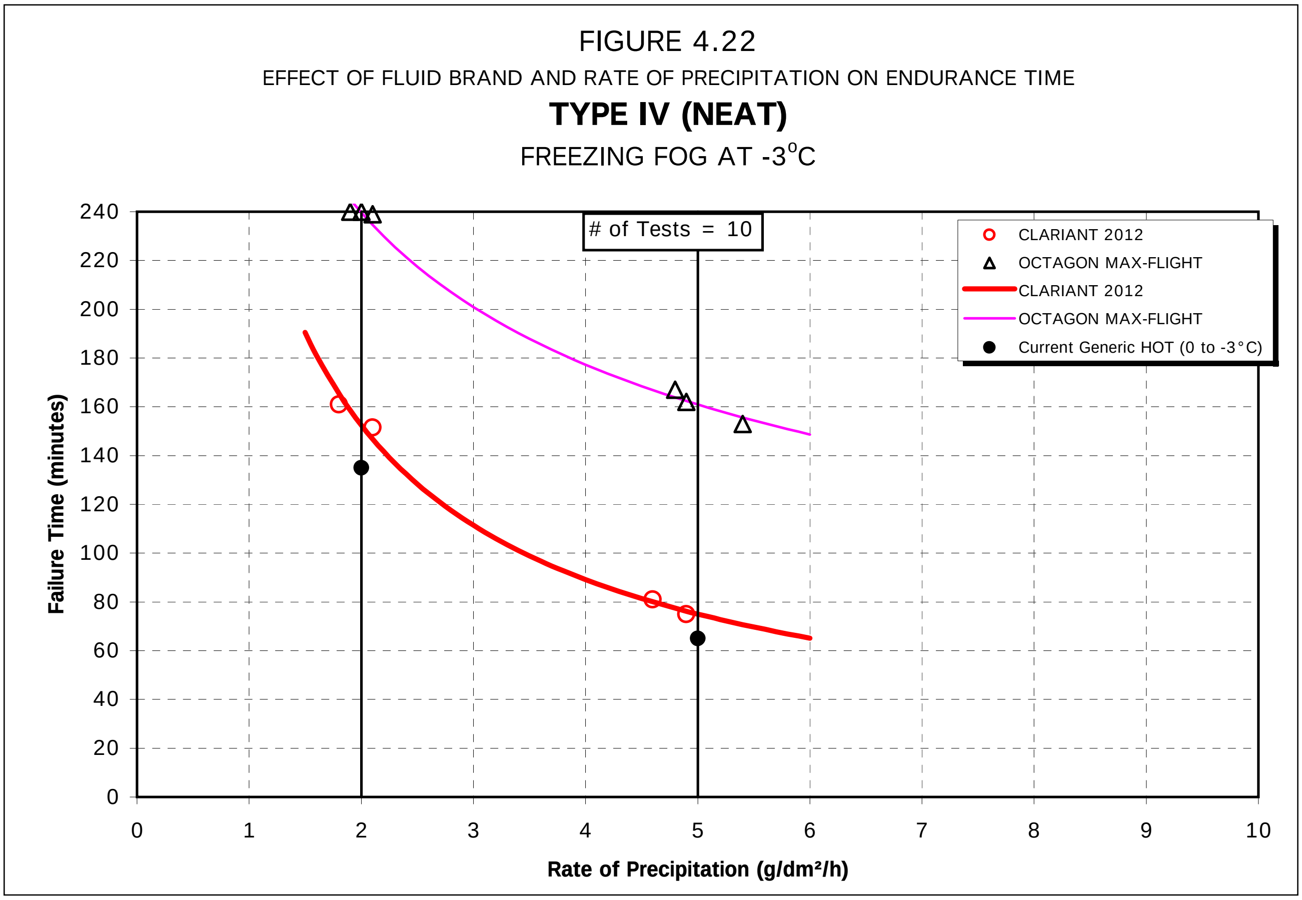
The upper and lower generic holdover time limits have remained unchanged from last year, and are based on 1998-99 test results using the Clariant MPIV 1957 fluid. A wide variation exists in the holdover performances of the various fluids in this condition. The upper fluid-specific values for Kilfrost and Octagon fluids have been capped at four hours.

The Clariant MPIV 2001 and SPCA AD-480 products were originally tested as part of the 1997-98 test season. However, since these fluids were not re-tested in 1998-99, both fluids were assigned generic numbers in the freezing fog columns of their fluid-specific tables for 1999-2000 winter operations. Both fluids were tested again in freezing fog in 1999-2000. The fluid-specific values for both fluids have increased from the generic values as a result of this testing.

TABLE 4.22

Holdover Time Guidelines for Neat Fluid, Above 0°C and 0°C to -3°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	2:20-3:00										
	1997-98 Endurance Time Test Results											
	1998-99 HOT Table Values	2:00-3:00										
	1998-99 Endurance Time Test Results		~~2:15-4:00~~	2:35-4:00	1:05-2:15			1:35-3:35				
	1999-2000 HOT Table Values	1:05-2:15	2:15-4:00	2:35-4:00	1:05-2:15			1:35-3:35	1:05-2:15	1:05-2:15		
	1999-2000 Endurance Time Test Results						1:50-2:45		2:00-3:30	1:20-3:20		
	2000-01 HOT Table Values	1:05-2:15	2:15-4:00	2:35-4:00	1:05-2:15		1:50-2:45	1:35-3:35	2:00-3:30	1:20-3:20		
CURRENT	**2000-01 Endurance Time Test Results**		2:40-4:00								1:15-2:30	
	2001-02 HOT Table Values	1:05-2:15	2:40-4:00	2:35-4:00	1:05-2:15		1:50-2:45	1:35-3:35	2:00-3:30	1:20-3:20	1:15-2:30	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZF1
At: Neat ZF -3ºC

4.2.5.1.2 75/25 fluid, above 0°C and 0ºC to -3°C, freezing fog (Figure 4.23)

The upper and lower SAE holdover times for fluids in these cells are based on the result of endurance time tests conducted using one fluid during 1998-99 testing. Because the SPCA AD-480 and Clariant MPIV 2001 fluid-specific values in the 1999-2000 tables were generic, the values for both fluids were increased for the subsequent operational season to match the results of tests conducted in the 1999-2000 test season.

TABLE 4.23
Holdover Time Guidelines for 75/25 Fluid, Above 0°C and 0°C to -3°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	1:05-2:00										
HISTORICAL	1997-98 Endurance Time Test Results											
HISTORICAL	1998-99 HOT Table Values	1:05-2:00										
HISTORICAL	1998-99 Endurance Time Test Results		~~1:30-2:50~~	1:05-1:45	1:10-2:10							
HISTORICAL	1999-2000 HOT Table Values	1:05-1:45	1:30-2:50	1:05-1:45	1:10-2:10				1:05-1:45	1:05-1:45		
HISTORICAL	1999-2000 Endurance Time Test Results						1:45-2:25		1:30-2:45	1:20-2:00		
HISTORICAL	2000-01 HOT Table Values	1:05-1:45	1:30-2:50	1:05-1:45	1:10-2:10		1:45-2:25		1:30-2:45	1:20-2:00		
CURRENT	2000-01 Endurance Time Test Results		2:05-3:15								1:10-2:05	
CURRENT	2001-02 HOT Table Values	1:05-1:45	2:05-3:15	1:05-1:45	1:10-2:10		1:45-2:25		1:30-2:45	1:20-2:00	1:10-2:05	

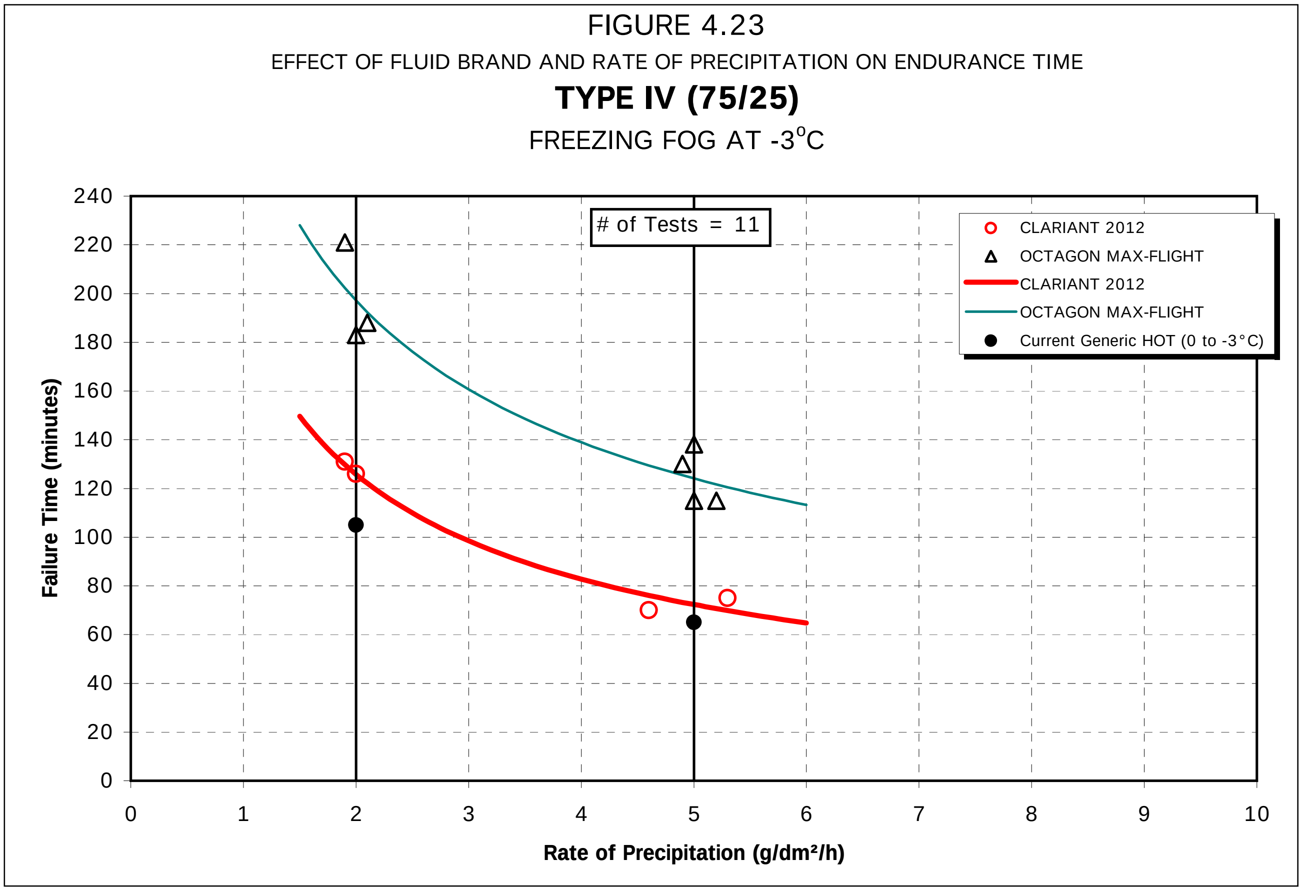


FIGURE 4.23
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE IV (75/25)
FREEZING FOG AT -3°C
# of Tests = 11
CLARIANT 2012
OCTAGON MAX-FLIGHT
CLARIANT 2012
OCTAGON MAX-FLIGHT
Current Generic HOT (0 to -3°C)
Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
20
40
60
80
100
120
140
160
180
200
220
240
0
1
2
3
4
5
6
7
8
9
10

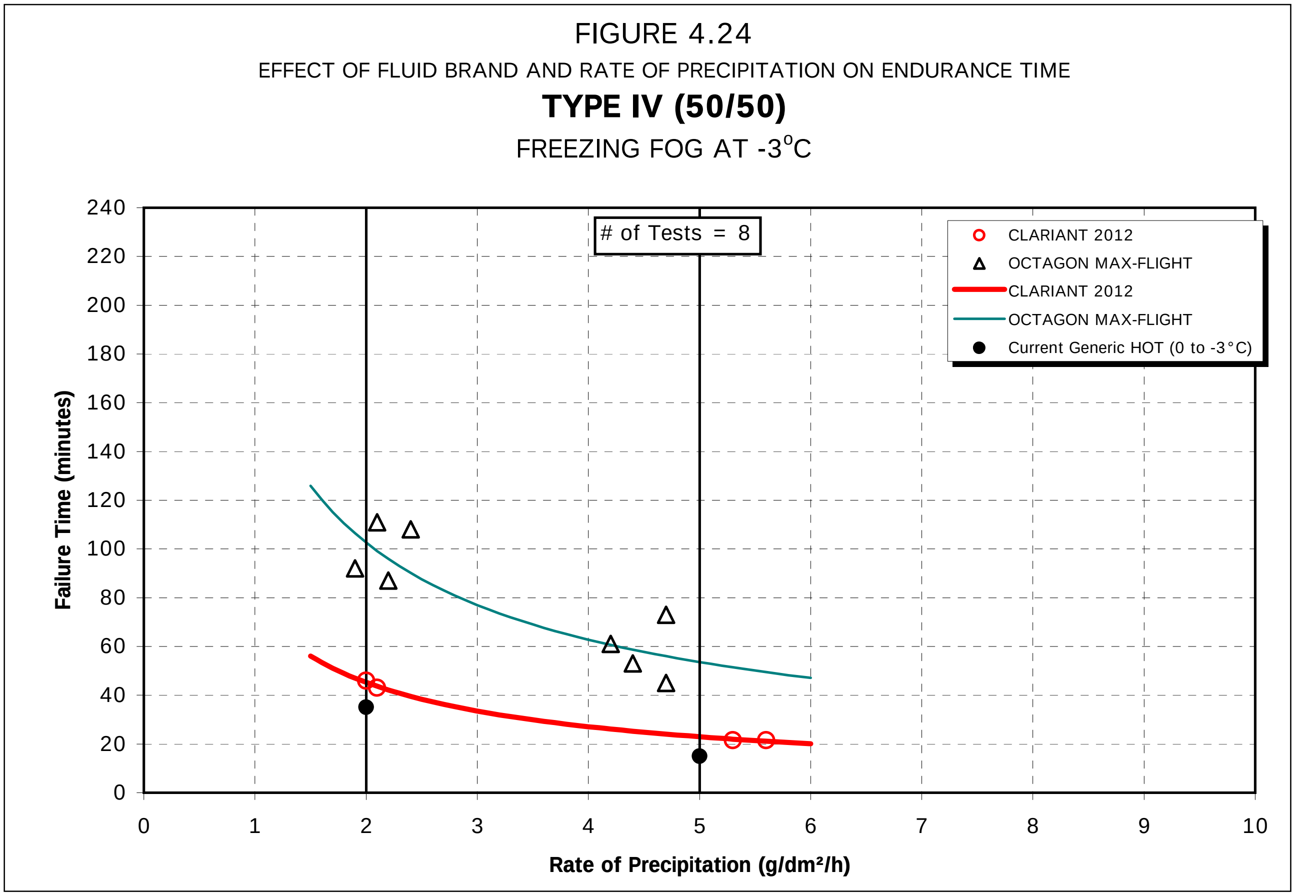
4.2.5.1.3 50/50 fluid, above 0°C and 0ºC to -3°C, freezing fog (Figure 4.24)

The generic holdover times for fluids in these cells have remained unchanged from the numbers used in 2000-01 winter operations, and are based on past test results with Kilfrost ABC-S and Clariant MPIV 2001 fluids. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the 1999-2000 winter operation fluid-specific values for these fluids match the generic values. The values for both fluids were altered to match the results of tests conducted in the 1999-2000 test season.

TABLE 4.24

Holdover Time Guidelines for 50/50 Fluid, Above 0°C and 0°C to -3°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:20-0:45										
	1997-98 Endurance Time Test Results											
	1998-99 HOT Table Values	0:20-0:45										
	1998-99 Endurance Time Test Results		~~0:30-0:50~~	0:20-0:35	0:25-0:50							
	1999-2000 HOT Table Values	0:20-0:35	0:30-0:50	0:20-0:35	0:25-0:50				0:20-0:35	0:20-0:35		
	1999-2000 Endurance Time Test Results						0:30-0:45		0:30-0:45	0:15-0:40		
	2000-01 HOT Table Values	0:15-0:35	0:30-0:50	0:20-0:35	0:25-0:50		0:30-0:45		0:30-0:45	0:15-0:40		
CURRENT	2000-01 Endurance Time Test Results		0:55-1:45								0:25-0:45	
	2001-02 HOT Table Values	0:15-0:35	0:55-1:45	0:20-0:35	0:25-0:50		0:30-0:45		0:30-0:45	0:15-0:40	0:25-0:45	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZF1
At: 50-50

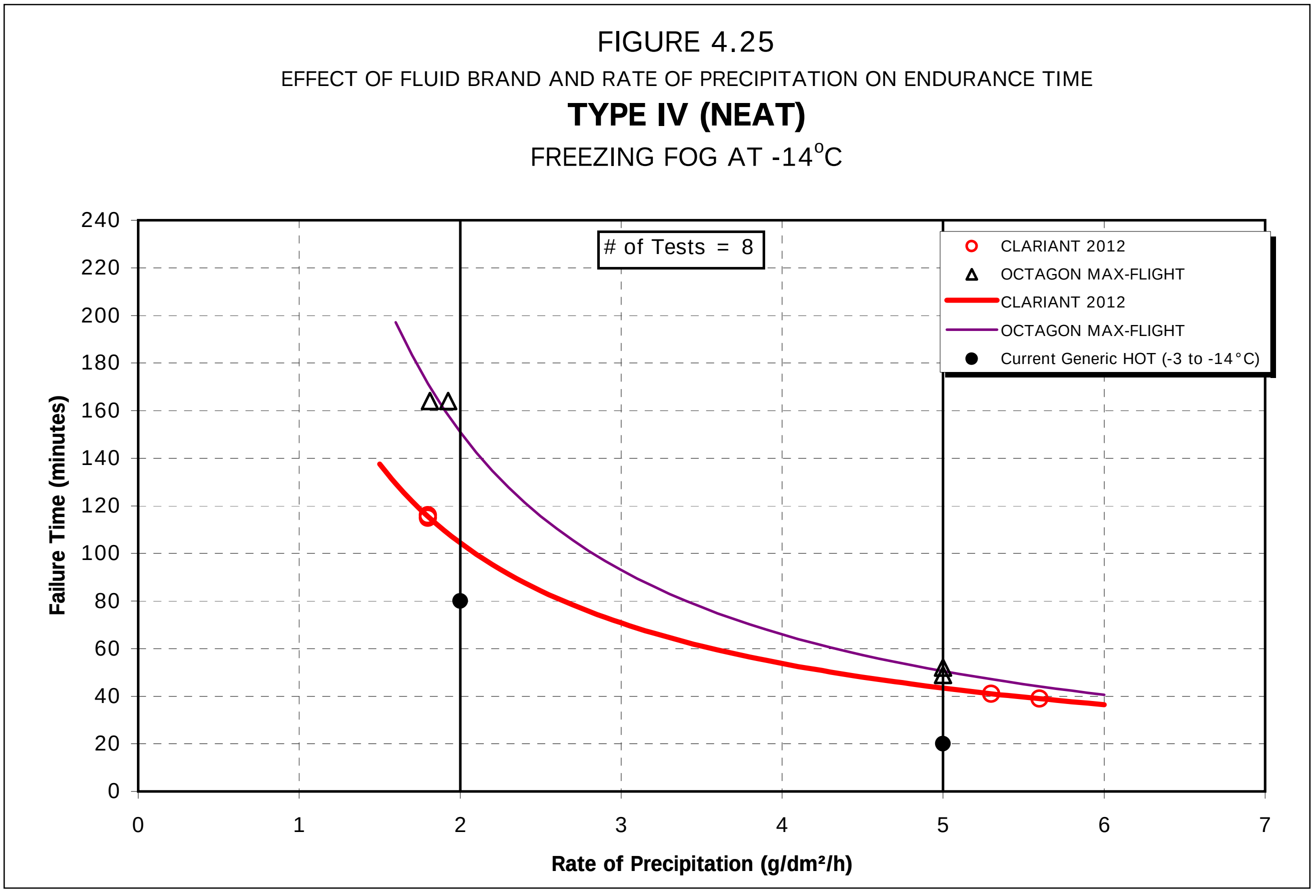
4.2.5.1.4 Neat fluid, -3ºC to -14°C, freezing fog (Figure 4.25)

The upper and lower generic holdover times have remained unchanged from last year and are based on the results of tests conducted with SPCA AD-480 fluid during the 1999-2000 test season. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the 1999-2000 fluid-specific values for these fluids match the generic values.

TABLE 4.25

Holdover Time Guidelines for Neat Fluid, -3°C to -14°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:40-3:00										
	1997-98 Endurance Time Test Results											
	1998-99 HOT Table Values	0:40-3:00										
	1998-99 Endurance Time Test Results		~~0:45-1:55~~	0:45-2:05	0:45-1:30			1:25-3:00				
	1999-2000 HOT Table Values	0:40-1:30	0:45-1:55	0:45-2:05	0:45-1:30			1:25-3:00	0:40-1:30	0:40-1:30		
	1999-2000 Endurance Time Test Results						0:30-1:30		0:20-1:20	0:45-1:35		
	2000-01 HOT Table Values	0:20-1:20	0:45-1:55	0:45-2:05	0:45-1:30		0:30-1:30	1:25-3:00	0:20-1:20	0:45-1:35		
CURRENT	2000-01 Endurance Time Test Results		0:50-2:30								0:45-1:45	
	2001-02 HOT Table Values	0:20-1:20	0:50-2:30	0:45-2:05	0:45-1:30		0:30-1:30	1:25-3:00	0:20-1:20	0:45-1:35	0:45-1:45	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZF1
At: Neat ZF -14ºC

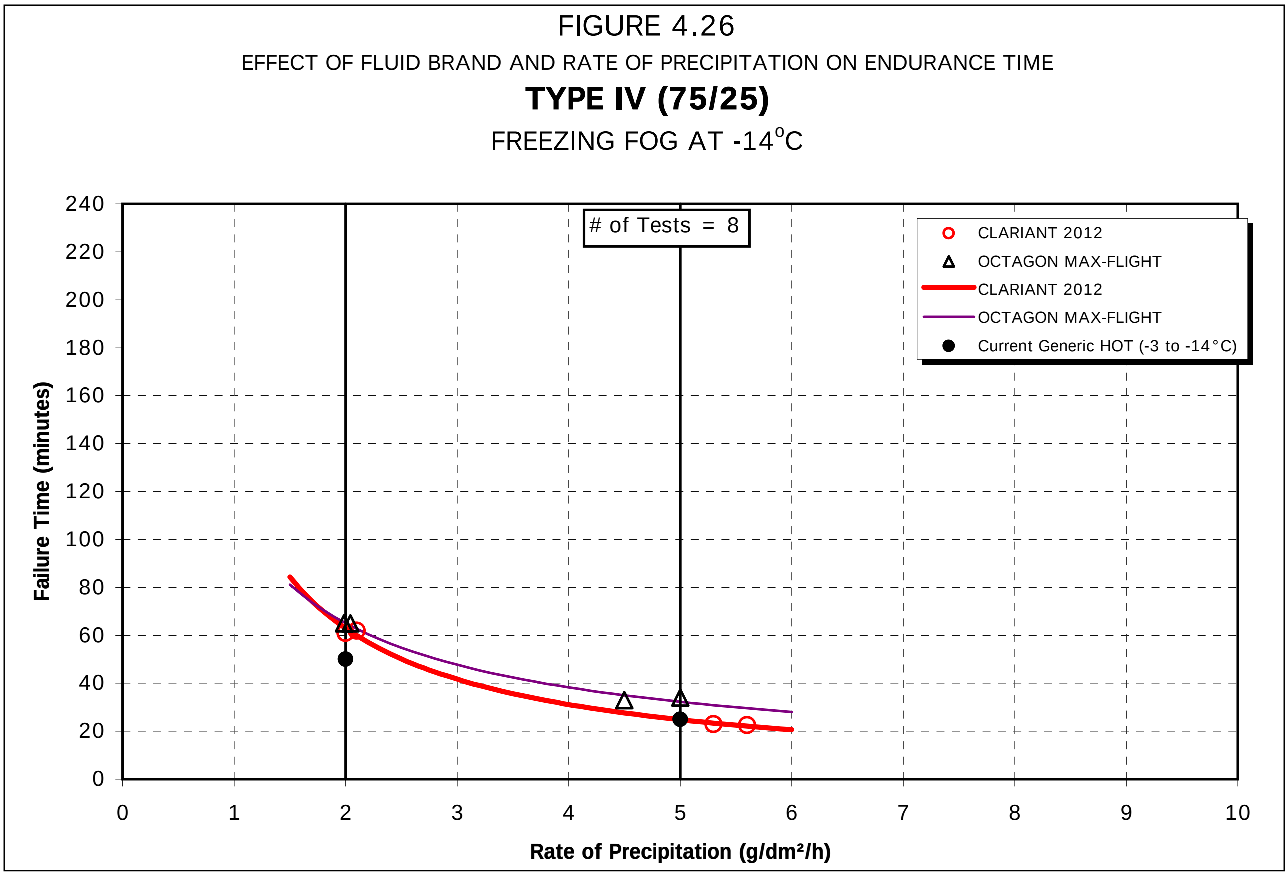
4.2.5.1.5 75/25 fluid, -3ºC to -14°C, freezing fog (Figure 4.26)

The generic holdover times in this cell have not been modified based on the most recent testing with Type IV fluids. All fluids display similar holdover time performance in this cell of the holdover time table. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the 1999-2000 fluid-specific values for these fluids match the generic values.

TABLE 4.26

Holdover Time Guidelines for 75/25 Fluid, -3°C to -14°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+ (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:35-2:00										
HISTORICAL	**1997-98 Endurance Time Test Results**											
HISTORICAL	**1998-99 HOT Table Values**	0:30-2:00										
HISTORICAL	**1998-99 Endurance Time Test Results**		~~0:30-1:10~~	0:25-1:00	0:25-1:10							
HISTORICAL	**1999-2000 HOT Table Values**	0:25-1:00	0:30-1:10	0:25-1:00	0:25-1:10				0:25-1:00	0:25-1:00		
HISTORICAL	**1999-2000 Endurance Time Test Results**						0:30-1:05		0:25-0:50	0:30-1:00		
HISTORICAL	**2000-01 HOT Table Values**	0:25-0:50	0:30-1:10	0:25-1:00	0:25-1:10		0:30-1:05		0:25-0:50	0:30-1:00		
CURRENT	**2000-01 Endurance Time Test Results**		030-1:05								0:25-1:05	
CURRENT	**2001-02 HOT Table Values**	0:25-0:50	030-1:05	0:25-1:00	0:25-1:10		0:30-1:05		0:25-0:50	0:30-1:00	0:25-1:05	



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZF1
At: 75-25 ZF-14ºC

4.2.5.1.6 Neat fluid, -14°C to -25°C, freezing fog (Figure 4.27)

The generic holdover times for fluids in this cell remain unchanged from last year. While the propylene fluid-specific numbers are very similar, UCAR/Dow Ultra+ greatly outperforms the rest at this low temperature. This is likely due to the ease of dilution of UCAR Ultra+ relative to the propylene-based fluids at this temperature. At such a low temperature range, the fluid's tendency to flow and shed accumulated solid contamination is enhanced. The SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99; therefore, the fluid-specific values for these fluids in 1999-2000 operations match the generic values.

TABLE 4.27
Holdover Time Guidelines for Neat Fluid, -14°C to -25°C, Freezing Fog

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:20-2:00										
HISTORICAL	1997-98 Endurance Time Test Results											
HISTORICAL	1998-99 HOT Table Values	0:20-2:00										
HISTORICAL	1998-99 Endurance Time Test Results		~~0:20-0:40~~	0:20-0:40	0:25-0:40			0:40-2:10				
HISTORICAL	1999-2000 HOT Table Values	0:20-0:40	0:20-0:40	0:20-0:40	0:25-0:40			0:40-2:10	0:20-0:40	0:20-0:40		
HISTORICAL	1999-2000 Endurance Time Test Results						0:20-0:45		0:15-0:40	0:20-0:45		
HISTORICAL	2000-01 HOT Table Values	0:15-0:40	0:20-0:40	0:20-0:40	0:25-0:40		0:20-0:45	0:40-2:10	0:15-0:40	0:20-0:45		
CURRENT	2000-01 Endurance Time Test Results		0:20-0:45								0:20-0:45	
CURRENT	2001-02 HOT Table Values	0:15-0:40	0:20-0:45	0:20-0:40	0:25-0:40		0:20-0:45	0:40-2:10	0:15-0:40	0:20-0:45	0:20-0:45	

4.2.5.2 Overall perspective on freezing fog results

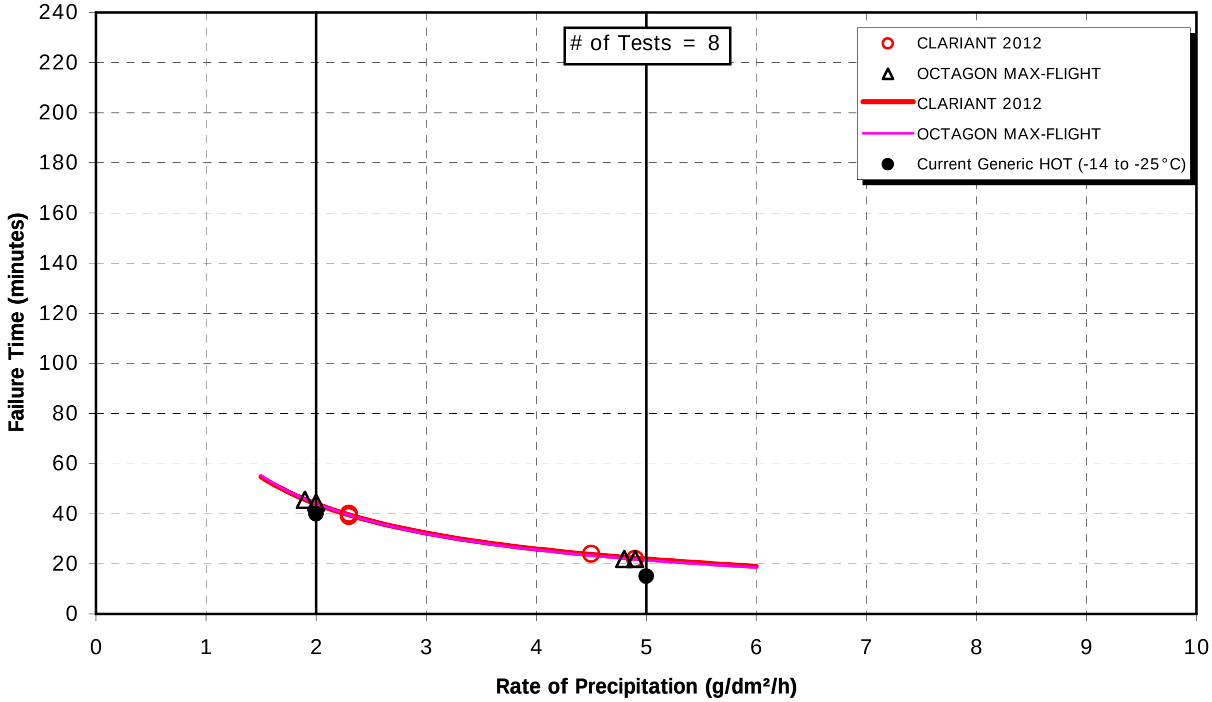
No changes have been made to the freezing fog column of the generic Type IV fluid holdover time table for the upcoming year.

FIGURE 4.27

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV (NEAT)

FREEZING FOG AT -25°C



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\HOT Summary ZF1
At: Neat ZF -25ºC

4.2.6 Rain on a Cold-Soaked Wing

The rain on a cold-soaked wing endurance time data originated from tests conducted by APS at the NRC test facility in Ottawa. The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 5 g/dm^2/h to 76 g/dm^2/h. This encompasses heavy drizzle (5 to 12.7 g/dm^2/h), light rain (12.7 to 25 g/dm^2/h), and moderate rain (25 to 76 g/dm^2/h). The cold-soak boxes used for testing were 7.5 cm deep. Dimensional details are described in Section 2. The box temperature prior to the start of testing was -10°C. The data are plotted for two Type IV fluid concentrations: neat fluid and 75/25 fluid.

4.2.6.1 Changes to Type IV fluid holdover times for rain on a cold-soaked wing

Fluid-specific values were not adopted by the SAE G-12 Holdover Time Subcommittee in previous years for this category of precipitation. It was decided at the Toronto SAE meeting in May 1999 that fluid-specific holdover time guidelines for rain on a cold-soaked wing would be adopted for use for the first time in 1999-2000 winter operations, if this information was available.

The fluid failure time versus precipitation rate data have been plotted either as a function of temperature or as a function of fluid brand (Appendix G). The latter plot format lends itself more easily to the cell-by-cell presentation of results for each category of precipitation and accompanies discussions regarding changes to holdover times. These plots appear in the body of the text as Figures 4.28 and 4.29.

The fluid-specific results of Type IV fluid testing from 1996-97 in rain on a cold-soaked wing are not presented in this section. Results from testing in subsequent seasons are presented in the same format as for freezing fog, explained in Subsection 4.2.5.1.

4.2.6.1.1 *Neat fluid, above 0°C, rain on a cold-soaked wing (Figure 4.28)*

Although the holdover times in this cell remain unchanged from 2000-01 table values, one fluid tested during the past year, Clariant Safewing MPIV Protect 2012, displayed a holdover time performance equal to that of the lower generic holdover time. The upper generic holdover time is based on the results of past testing. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the 1999-2000 fluid-specific values for these fluids match the generic values.

TABLE 4.28

Holdover Time Guidelines for Neat Fluid, Above 0°C, Rain on a Cold-Soaked Wing (ROCSW)

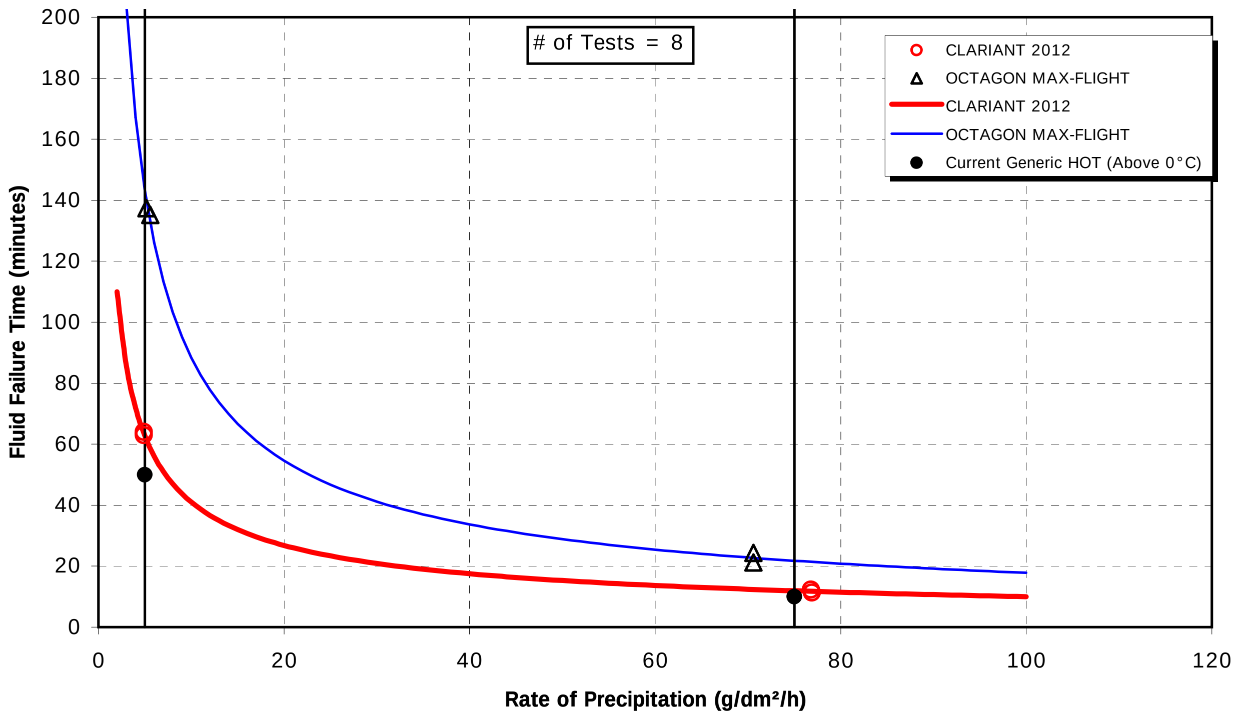
		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra+	S-480	C-2001	C-2012	S-404
HISOTRICAL	**1996-97 Test Results and Table Values Used in 1997-98**	0:10-0:50										
	1997-98 Endurance Time Test Results		0:15-1:15	0:20-1:15	0:15-1:20							
	1998-99 HOT Table Values	0:10-0:50										
	1998-99 Endurance Time Test Results		~~0:10-2:00~~	0:30-2:00	0:15-1:10			0:10-1:20				
	1999-2000 HOT Table Values	0:10-0:50	0:10-1:15	0:20-1:15	0:15-1:10			0:10-1:20	0:10-0:50	0:10-0:50		
	1999-2000 Endurance Test Results						0:10-1:20		0:15-1:35	0:15-2:00		
	2000-01 HOT Table Values	0:10-0:50	0:10-1:15	0:20-1:15	0:15-1:10		0:10-1:20	0:10-1:20	0:15-1:35	0:15-2:00		
CURRENT	**2000-01 Endurance Time Test Results**		0:20-2:00								0:10-1:05	
	2001-02 HOT Table Values	0:10-0:50	0:15-1:15	0:20-1:15	0:15-1:10		0:10-1:20	0:10-1:20	0:15-1:35	0:15-2:00	0:10-1:05	

FIGURE 4.28

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE IV (NEAT)

RAIN ON COLD-SOAKED SURFACE



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\test summary cs1
At: Neat

4.2.6.1.2 75/25 fluid, above 0°C, rain on a cold-soaked wing (Figure 4.29)

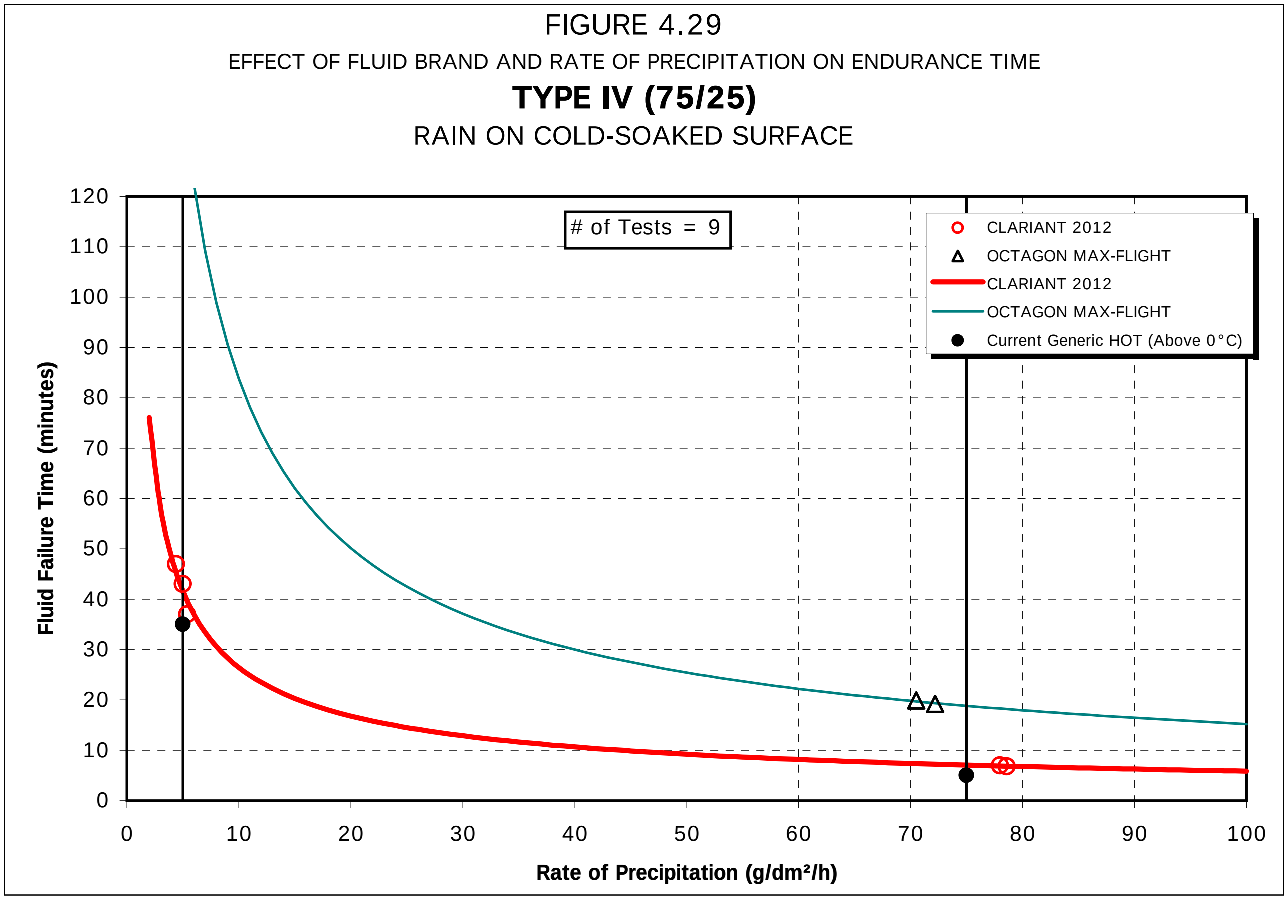
At this concentration, no changes were made to the generic holdover time values. Only one fluid tested in 2000-01, Clariant Safewing MPIV Protect 2012, displayed a performance equal to the lower generic holdover time. The upper holdover time is based on previous testing. Because the SPCA AD-480 and Clariant 2001 products were not re-tested in 1998-99, the 1999-2000 fluid-specific values for these fluids match the generic values.

TABLE 4.29
Holdover Time Guidelines for 75/25 Fluid, Above 0°C, ROCSW

		SAE	Oct Max	K-ABC-S	C-1957	H-1957	C-S4	Ultra + (do not use)	S-480	C-2001	C-2012	S-404
HISTORICAL	1996-97 Test Results and Table Values Used in 1997-98	0:05-0:35										
HISTORICAL	1997-98 Endurance Time Test Results		0:10-0:40	0:10-0:50	0:10-1:00							
HISTORICAL	1998-99 HOT Table Values	0:05-0:35										
HISTORICAL	1998-99 Endurance Time Test Results		~~0:05-1:15~~	0:10-1:15	0:10-1:05							
HISTORICAL	1999-2000 HOT Table Values	0:05-0:35	0:05-0:40	0:10-0:50	0:10-1:00				0:05-0:35	0:05-0:35		
HISTORICAL	1999-2000 Endurance Time Test Results						0:15-1:25		0:10-1:15	0:10-1:25		
HISTORICAL	2000-01 HOT Table Values	0:05-0:35	0:05-0:40	0:10-0:50	0:10-1:00		0:15-1:25		0:10-1:15	0:10-1:25		
CURRENT	2000-01 Endurance Time Test Results		0:20-2:00								0:05-0:40	
CURRENT	2001-02 HOT Table Values	0:05-0:35	0:10-0:40	0:10-0:50	0:10-1:00		0:15-1:25		0:10-1:15	0:10-1:25	0:05-0:40	

4.2.6.2 Overall perspective on rain on a cold-soaked wing results

No changes were made to the generic holdover times in the rain on a cold-soaked wing condition.



I:\Groups\CM1680(exBM3833)\Analysis\HOT\type IV\test summary cs1
At: 75-25

4.2.7 Frost Testing

APS had not conducted holdover time tests in simulated frost conditions prior to the 1999-2000 test season. Preliminary tests in simulated frost conditions were conducted by APS at the IREQ high humidity chamber in Varennes to determine the capabilities of this chamber for future tests in conditions of simulated frost. The results of these tests are presented in Transport Canada report TP 13659E [2]. Additional testing in frost conditions was performed by APS during 2000-01, refer to TP 13831E [3] for these results.

4.2.8 Changes to the Generic Type IV Table

Seven reductions have been made to the generic Type IV table based on the results of Type IV fluid tests in 2000-01. Five reductions were made in the freezing drizzle column, and two reductions occur in the light freezing rain category.

Obsolete data from tests conducted in 1996-97 were eliminated. Subsequently, eight generic holdover time values were increased, four each in the snow and freezing drizzle columns of the generic Type IV table.

4.2.9 Worst Case Fluids

The fluid(s) responsible for the values in each cell of the generic Type IV fluid holdover time table and the year the fluid was tested are shown in Table 4.30.

TABLE 4.30

Fluids Responsible for the SAE Type IV Fluid Holdover Time Table Values

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW	**FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING
above 0º	above 32º	100/0		C-1957(98/99) **B**	C-1957(98/99) **B**	C-1957 (98/99) **B** C-2012 (00/01) **B**	ULTRA+ (98/99) **B** C-2012 (00/01) **L**	ULTRA+ (98/99) **L** C-2012 (00/01) **L** C-S4 (99/00) **L** Old data **U**
		75/25		ABC-S (98/99) **B**	ABC-S (98/99) **B** C-1957(98/99) **U**	C-1957 (98/99) **L** C-2001 (97/98) **L** C-2012 (00/01) **B**	C-2012 (00/01) **B**	C-2012 (00/01) **L** Old data **B**
		50/50		ABC-S (98/99) **U** C-2001 (99/00) **L**	ABC-S (96/97) B C-2001 (97/98) **U** ABC-S (98/99) **U**	C-2012 (00/01) **U** C-2001 (97/98) **B** ABC-S (97/98) **U** ABC-S (98/99) **U**	C-2012 (00/01) **B** C-1957(98/99) **L** ABC-S (98/99) **B** S 480 (99/00) **L**	
0 to -3	32 to 27	100/0		C-1957(98/99) **B**	C-1957(98/99) **B**	C-1957 (98/99) **B** C-2012 (00/01) **B**	ULTRA+ (98/99) **B** C-2012 (00/01) **L**	
		75/25		ABC-S (98/99) **B**	C-1957 (98/99) **U** C-2012 (00/01) **L**	C-1957 (98/99) **L** C-2001 (97/98) **L** C-2012 (00/01) **B**	C-2012 (00/01) **B**	
		50/50		ABC-S (98/99) **U** C-2001 (99/00) **L**	ABC-S (97/98) **B** ABC-S (98/99) **B**	C-2012 (00/01) **U** C-2001 (97/98) **B** ABC-S (97/98) **U** ABC-S (98/99) **U**	C-2012 (00/01) **B** C-1957(98/99) **L** ABC-S (98/99) **B** S 480 (99/00) **L**	
below -3 to -14	below 27 to 7	100/0		S 480 (99/00) **B**	C-2012 (00/01) **B**	ABC-S (98/99) **L** C-2012 (00/01) **U**	ABC-S (98/99) **L** C-2012 (00/01) **U**	
		75/25		C-2012 (00/01) **L** ABC-S (98/99) **L** C-1957(98/99) **L** S 480 (99/00) **U**	S-404 (97/98) **B**	C-2012 (00/01) **B**	ABC-S (98/99) **L** C-2012 (00/01) **B**	
below -14 to -25	below 7 to -13	100/0		S 480 (99/00) **B** C-1957(98/99) **U** ABC-S (98/99) **U**	C-2012 (00/01) **B**			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.				**LEGEND** L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH	

* During conditions that apply to aircraft protection for ACTIVE FROST.

** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

4.3 Type II Fluid Holdover Time Tests

Type II fluid is a thickened fluid used to provide anti-icing protection to aircraft surfaces following deicing. The Type II fluid holdover time table, substantiated by previous testing and accepted for use in 2000-01, is shown in Table 1.3 (Section 1). A new Type II holdover time table, which was accepted for use in 2001-02 by the SAE G-12 Holdover Time Subcommittee in New Orleans, and the fluid-specific holdover time tables for Kilfrost ABC-II Plus, Clariant MP II 1951, and SPCA Ecowing 26, are shown in Tables 4.64 to 4.67 (Section 4.6).

The generic holdover time guidelines for Type II fluid were developed based on the results of endurance time tests conducted during previous years. In addition to these tests, one Type II fluid, Kilfrost ABC-II Plus (formerly Kilfrost ABC-3+), was tested by APS during the 1998-99 test season. At the SAE Holdover Time Subcommittee meetings in Toronto in May 1999, the fluid manufacturer requested a fluid-specific table for this fluid. The request was accepted. Two additional Type II fluids, SPCA AD-260 and Clariant MP II 1951, were tested during the 1999-2000 test season. At the SAE Holdover Time Meeting in Toulouse in May 2000, SPCA informed the committee that the SPCA AD-260 product would not be made commercially available for winter operations in 2000-01. A new Type II fluid from SPCA, Ecowing 26, was tested by APS during the 2000-01 test season. The results are discussed in this section.

The SAE G-12 Holdover Time Subcommittee stipulated that the holdover times for any cell in the Type II table may not exceed the holdover times for that same cell in the Type IV fluid table. This is primarily because all Type IV fluids qualify as Type II fluids and are expected to exhibit superior performance to Type II fluids. Type II fluids, on the other hand, do not qualify as Type IV fluids. The imposition of holdover time reductions based on this consideration has been referred to as *Type IV fluid holdover time constraint*.

Due to space limitations, the fluid codes indicated in brackets will be used in the tables: Kilfrost ABC-II Plus (ABC-II+); Clariant MPII 1951 (C-1951); SPCA Ecowing 26 (S E26).

4.3.1 Natural Snow

The natural snow endurance time test data for SPCA Ecowing 26 Type II fluid derived from 2000-01 tests conducted at the Dorval Airport test facility.

4.3.1.1 Changes to the Type II fluid holdover times for snow

The tables presented in this subsection show columns containing the generic and fluid-specific holdover time results of testing with Type II fluids. The first horizontal row of values contains the generic holdover time values used in 1998-99. The second line contains the endurance time results from 1998-99 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1999-2000. The fourth set of values is the endurance time results from 1999-2000 testing. The fifth row contains the generic and fluid-specific holdover time values accepted for use in 2000-01 winter operations. The sixth set of values is the endurance time test results from 2000-01 testing. The seventh and final line contains the generic and fluid-specific holdover time values for use in 2001-02 winter operations. The underlined holdover time values indicate the fluids responsible for the generic holdover time.

4.3.1.1.1 Neat fluid, above 0°C, snow (Figure 4.30)

The generic holdover times in this cell have remained unchanged from last year.

TABLE 4.31
Holdover Time Guidelines for Neat Fluid, Above 0°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:20-1:00			
	1998-99 Endurance Time Test Results		0:35-1:20		
	1999-2000 HOT Table Values	0:20-1:00	0:35-1:20		
	1999-2000 Endurance Time Test Results			0:30-0:55	
	2000-01 HOT Table Values	0:20-0:55	0:35-1:20	0:30-0:55	
CURRENT	2000-01 Endurance Time Test Results				0:45-1:10
	2001-02 HOT Table Values	0:20-0:55	0:35-1:20	0:30-0:55	0:45-1:10

4.3.1.1.2 75/25 fluid, above 0°C, snow (Figure 4.31)

The generic holdover time numbers in this cell remain unchanged from last year. The upper fluid-specific value for Clariant MP II 1951 matches the generic value.

TABLE 4.32
Holdover Time Guidelines for 75/25 Fluid, Above 0°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:40			
	1998-99 Endurance Time Test Results		0:35-1:10		
	1999-2000 HOT Table Values	0:15-0:40	0:35-1:10		
	1999-2000 Endurance Time Test Results			0:20-0:40	
	2000-01 HOT Table Values	0:15-0:40	0:35-1:10	0:20-0:40	
CURRENT	2000-01 Endurance Time Test Results				0:30-0:55
	2001-02 HOT Table Values	0:15-0:40	0:35-1:10	0:20-0:40	0:30-0:55

FIGURE 4.30

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II NEAT (Above 0°C)

NATURAL SNOW

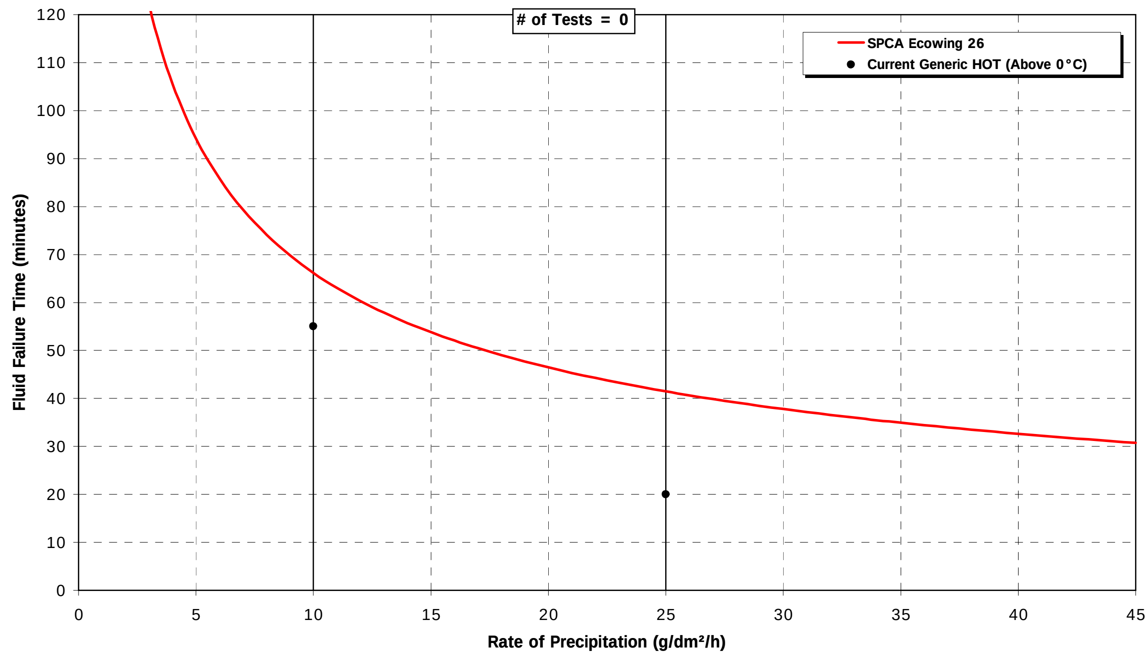
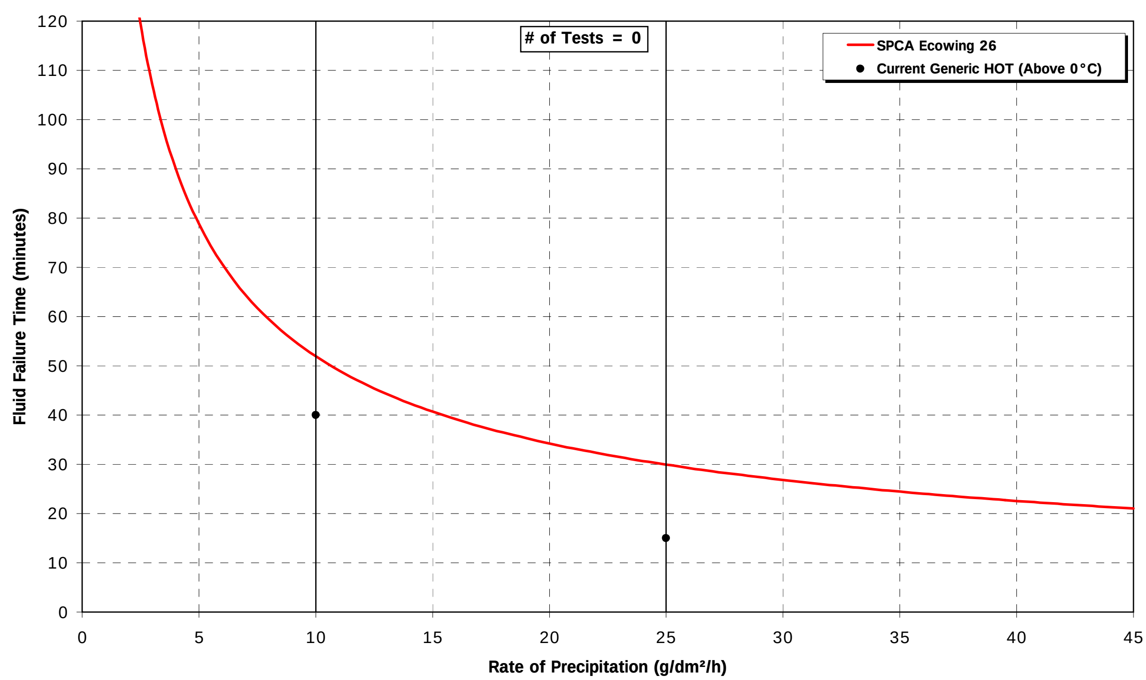


FIGURE 4.31

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II 75/25 (Above 0°C)

NATURAL SNOW



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary snow
At:fig 4.30-4.31

4.3.1.1.3 50/50 fluid, above 0°C, snow (Figure 4.32)

The generic holdover times in this cell are unchanged from last year. The Clariant fluid tested in 1999-2000 has a holdover time equal to that of the lower generic value. The upper generic value is based on testing from previous years.

TABLE 4.33
Holdover Time Guidelines for 50/50 Fluid, Above 0°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:05-0:15			
	1998-99 Endurance Time Test Results		0:20-0:40		
	1999-2000 HOT Table Values	0:05-0:15	0:20-0:40		
	1999-2000 Endurance Time Test Results			0:05-0:20	
	2000-01 HOT Table Values	0:05-0:15	0:20-0:40	0:05-0:20	
CURRENT	**2000-01 Endurance Time Test Results**				0:10-0:20
	2001-02 HOT Table Values	0:05-0:15	0:20-0:40	0:05-0:20	0:10-0:20

4.3.1.1.4 Neat fluid, 0°C to -3°C, snow (Figure 4.33)

The generic holdover times in this cell are unchanged from last year. The upper holdover time of the Clariant fluid is equal to the generic value.

TABLE 4.34
Holdover Time Guidelines for Neat Fluid, 0°C to -3°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:20-0:45			
	1998-99 Endurance Time Test Results		0:25-0:55		
	1999-2000 HOT Table Values	0:20-0:45	0:25-0:55		
	1999-2000 Endurance Time Test Results			0:20-0:45	
	2000-01 HOT Table Values	0:20-0:45	0:25-0:55	0:20-0:45	
CURRENT	**2000-01 Endurance Time Test Results**				0:35-1:00
	2001-02 HOT Table Values	0:20-0:45	0:25-0:55	0:20-0:45	0:35-1:00

FIGURE 4.32
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II 50/50 (Above 0°C)
NATURAL SNOW

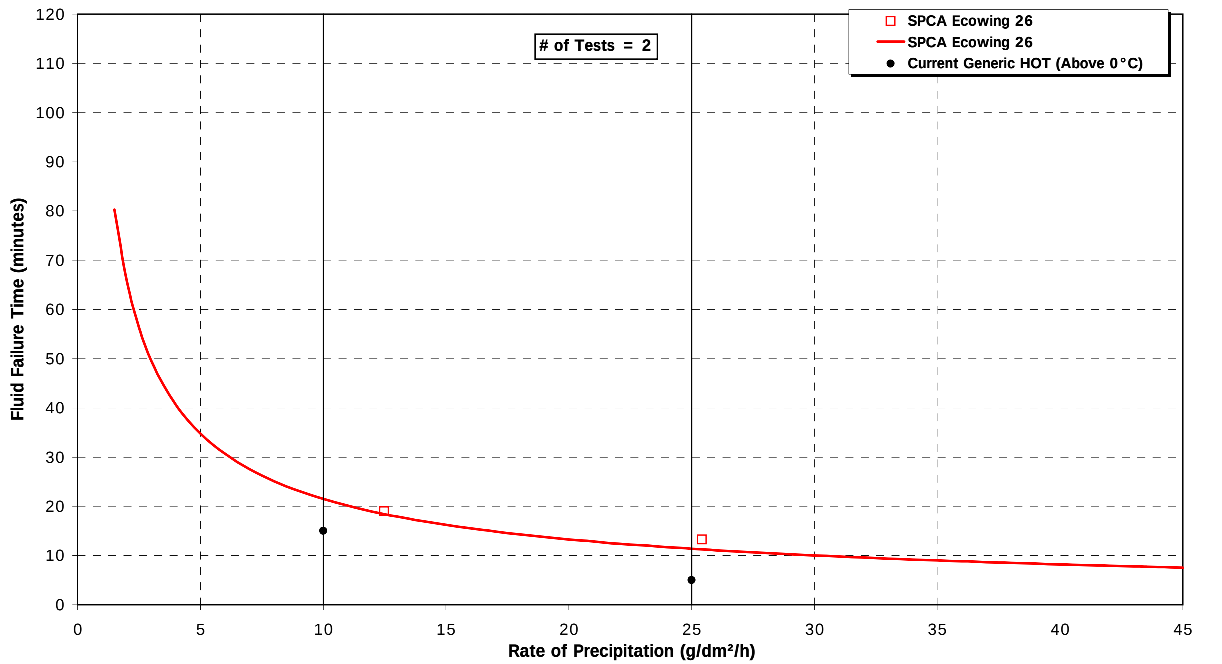
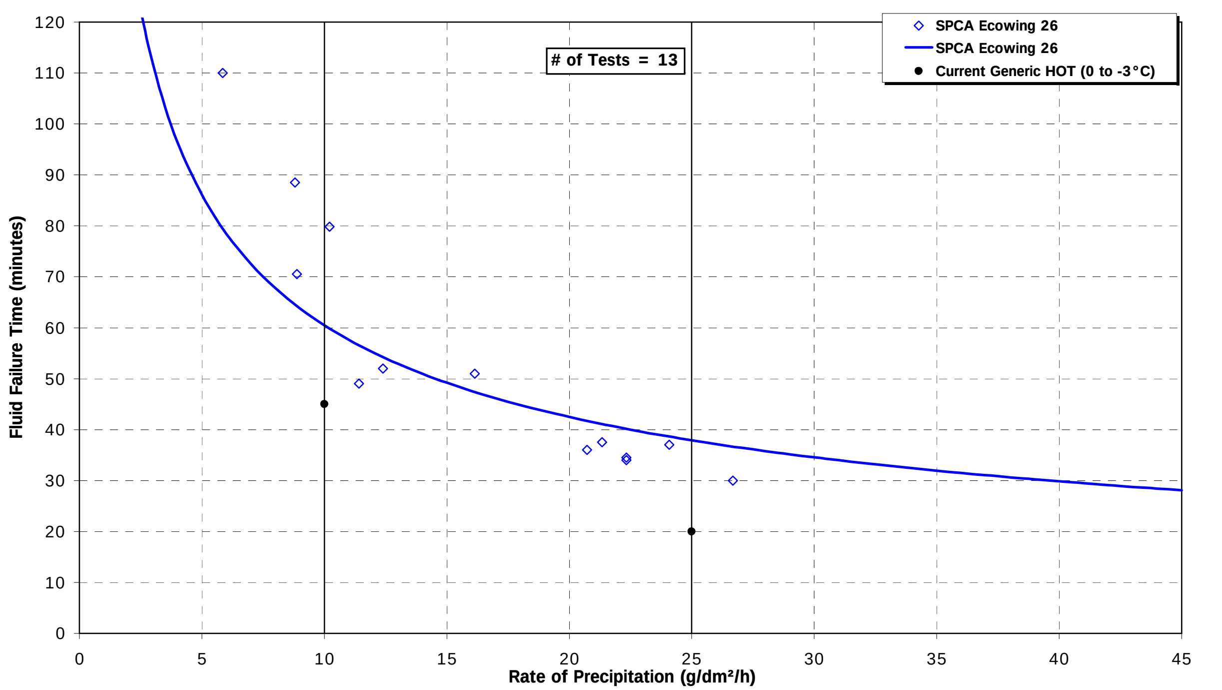


FIGURE 4.33
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II NEAT (0 to -3°C)
NATURAL SNOW



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary snow
At:fig 4.32-4.33

4.3.1.1.5 75/25 fluid, 0°C to -3°C, snow (Figure 4.34)

The generic holdover times in this cell are unchanged from last year. The Clariant fluid has a lower holdover time equal to the generic value.

TABLE 4.35

Holdover Time Guidelines for 75/25 Fluid, 0°C to -3°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:30			
	1998-99 Endurance Time Test Results		0:25-0:50		
	1999-2000 HOT Table Values	0:15-0:30	0:25-0:50		
	1999-2000 Endurance Time Test Results			0:15-0:35	
	2000-01 HOT Table Values	0:15-0:30	0:25-0:50	0:15-0:35	
CURRENT	2000-01 Endurance Time Test Results				0:25-0:45
	2001-02 HOT Table Values	0:15-0:30	0:25-0:50	0:15-0:35	0:25-0:45

4.3.1.1.6 50/50 fluid, 0°C to -3°C, snow (Figure 4.35)

The generic holdover times in this cell are unchanged from last year and are based on the results of the Clariant fluid tested in 1999-2000.

TABLE 4.36

Holdover Time Guidelines for 50/50 Fluid, 0°C to -3°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:05-0:15			
	1998-99 Endurance Time Test Results		0:15-0:35		
	1999-2000 HOT Table Values	0:05-0:15	0:15-0:35		
	1999-2000 Endurance Time Test Results			0:05-0:15	
	2000-01 HOT Table Values	0:05-0:15	0:15-0:35	0:05-0:15	
CURRENT	2000-01 Endurance Time Test Results				0:10-0:20
	2001-02 HOT Table Values	0:05-0:15	0:15-0:35	0:05-0:15	0:10-0:20

FIGURE 4.34
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II 75/25 (0 to -3°C)
NATURAL SNOW

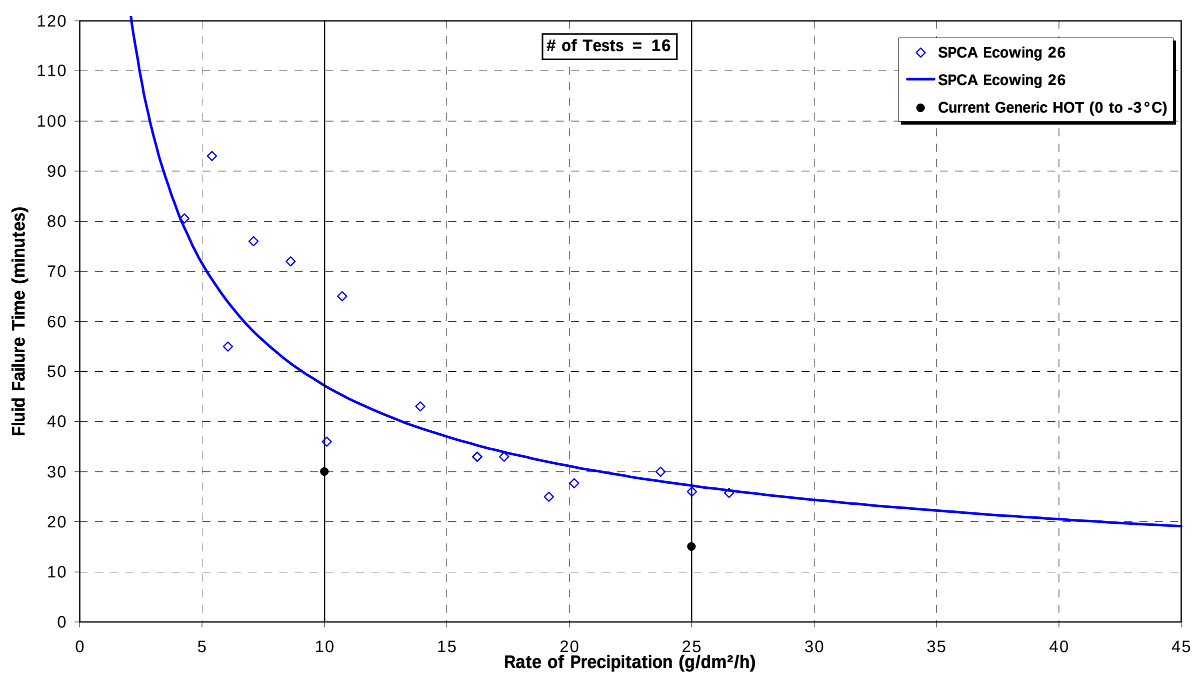
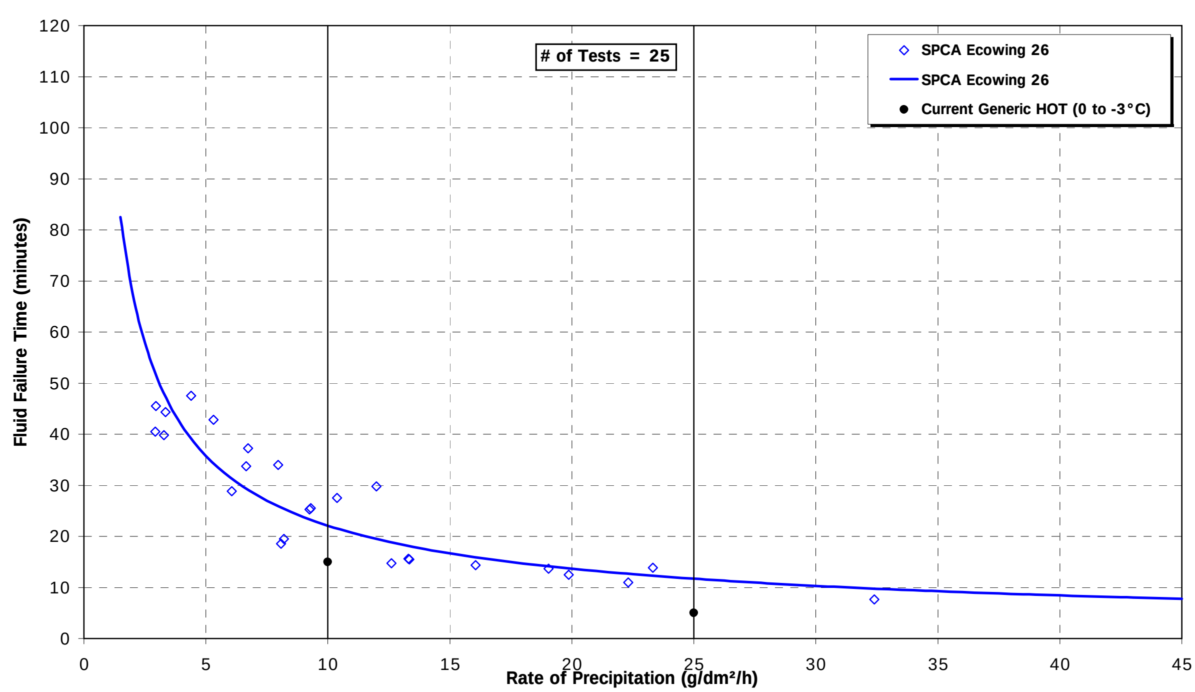


FIGURE 4.35
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II 50/50 (0 to -3°C)
NATURAL SNOW



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary snow
At:Sheet3

4.3.1.1.7 Neat fluid, -3°C to -14°C, snow (Figure 4.36)

The generic values in this cell have remained unchanged.

TABLE 4.37
Holdover Time Guidelines for Neat Fluid, -3°C to -14°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:40			
	1998-99 Endurance Time Test Results		0:15-0:35		
	1999-2000 HOT Table Values	0:15-0:35	0:15-0:35		
	1999-2000 Endurance Time Test Results			0:20-0:40	
	2000-01 HOT Table Values	0:15-0:35	0:15-0:35	0:20-0:40	
CURRENT	2000-01 Endurance Time Test Results				0:30-0:50
	2001-02 HOT Table Values	0:15-0:35	0:15-0:35	0:20-0:40	0:30-0:50

4.3.1.1.8 75/25 fluid, -3°C to -14°C, snow (Figure 4.37)

In the 1999-2000 generic table, the upper generic Type II holdover time in this cell was reduced by five minutes based on Type IV fluid tests. During the 1999-2000 test season, tests conducted with the Clariant fluid provided holdover times equal to the generic values. The generic times have not changed from last year.

TABLE 4.38
Holdover Time Guidelines for 75/25 Fluid, -3°C to -14°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:30			
	1998-99 Endurance Time Test Results		0:15-0:35		
	1999-2000 HOT Table Values	0:15-0:25	0:15-0:35		
	1999-2000 Endurance Time Test Results			0:15-0:25	
	2000-01 HOT Table Values	0:15-0:25	0:15-0:35	0:15-0:25	
CURRENT	2000-01 Endurance Time Test Results				0:20-0:40
	2001-02 HOT Table Values	0:15-0:25	0:15-0:35	0:15-0:25	0:20-0:40

FIGURE 4.36

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II NEAT (-3 to -14°C)

NATURAL SNOW

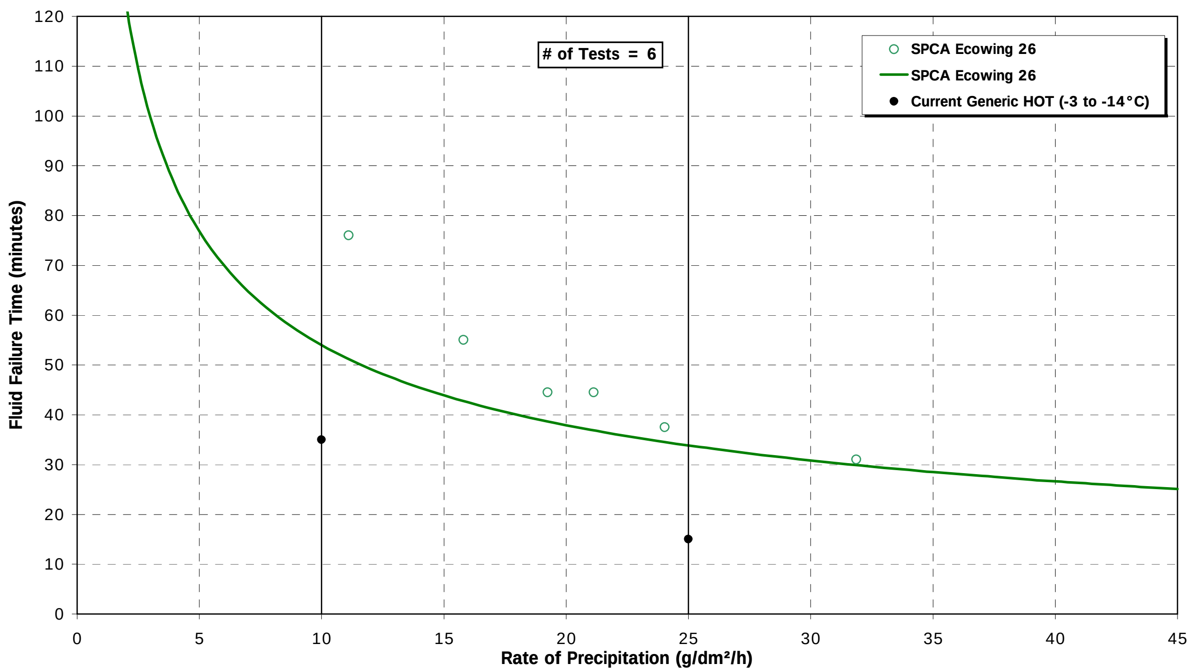
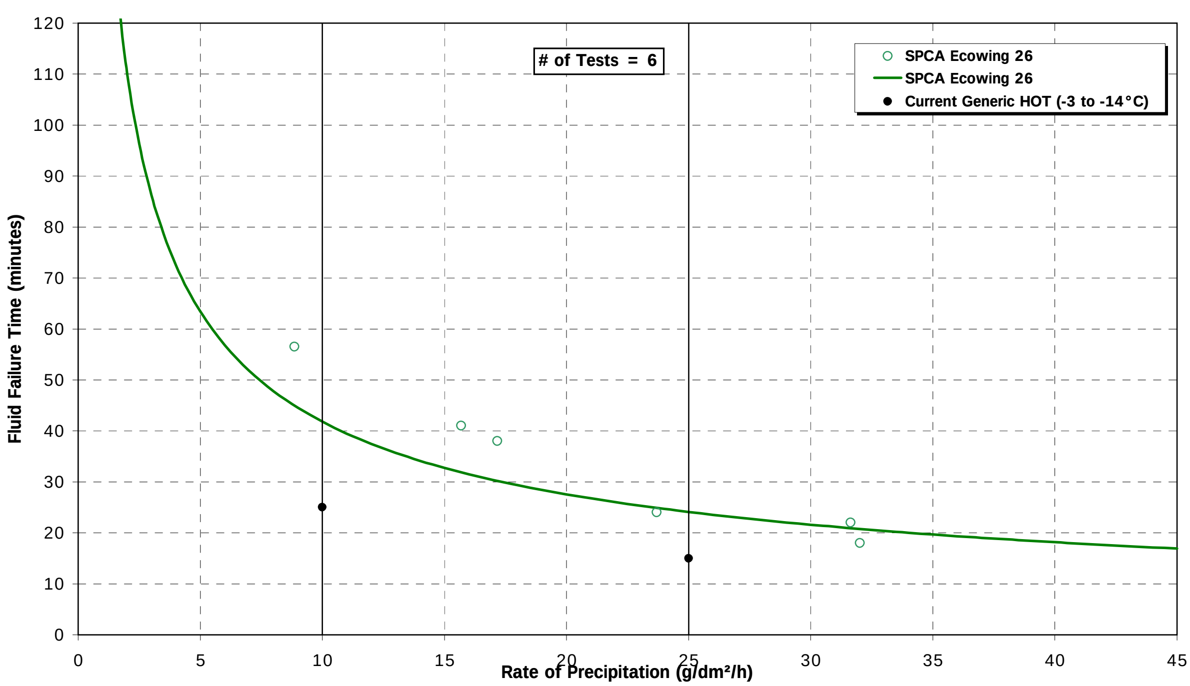


FIGURE 4.37

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II 75/25 (-3 to -14°C)

NATURAL SNOW



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary snow
At:fig 4.36-4.37

4.3.1.1.9 Neat fluid, -14°C to -25°C, snow (Figure 4.38)

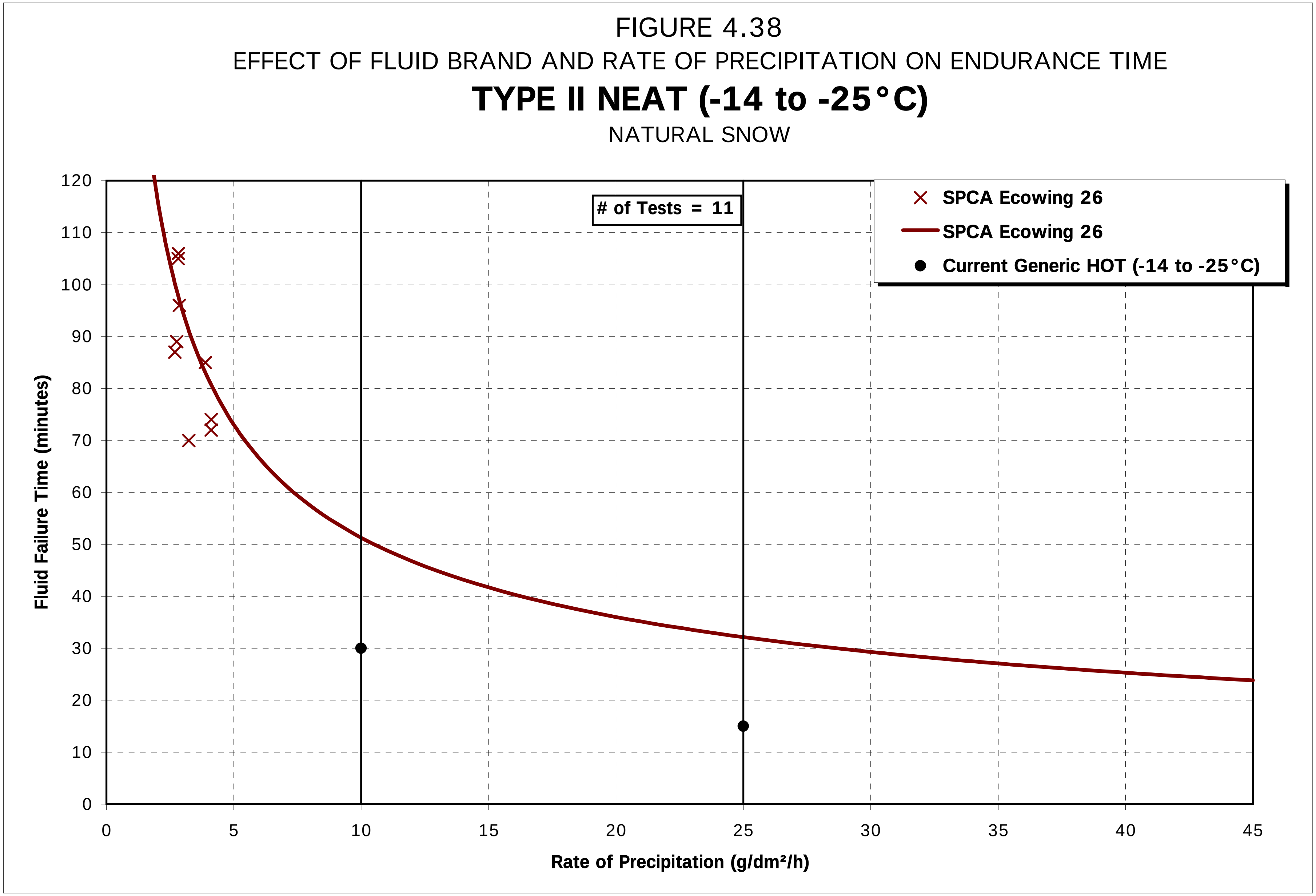
The holdover times in this cell have remained unchanged from last year.

TABLE 4.39
Holdover Time Guidelines for Neat Fluid, -14°C to -25°C, Snow

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:15-0:30			
	1998-99 Endurance Time Test Results		0:15-0:30		
	1999-2000 HOT Table Values	0:15-0:30	0:15-0:30		
	1999-2000 Endurance Time Test Results			0:20-0:35	
	2000-01 HOT Table Values	0:15-0:30	0:15-0:30	0:20-0:35	
CURRENT	**2000-01 Endurance Time Test Results**				0:30-0:50
	2001-02 HOT Table Values	0:15-0:30	0:15-0:30	0:20-0:35	0:30-0:50

4.3.1.2 Overall perspective on snow results

No changes were made to the current generic Type II table based on the results of testing conducted with SPCA Ecowing 26.



CM1680(exBM3833)\Analysis\HOT\type II\fig 4.38 Chart 1
At:fig 4.38 Chart 1

4.3.2 Freezing Drizzle

The freezing drizzle endurance time data were derived from tests conducted by APS at the NRC test facility in Ottawa. Subsections 4.3.2.1.1 to 4.3.2.1.5 contain the Type II fluid holdover time results in the freezing drizzle column. They are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for this category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

4.3.2.1 Changes to Type II fluid holdover times for freezing drizzle

The tables presented in this subsection show columns containing the generic and fluid-specific holdover time results of testing with Type II fluids. The first horizontal row of values contains the generic holdover time values used in 1998-99. The second line contains the endurance time results from 1998-99 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1999-2000. The fourth set of values is the endurance time results from 1999-2000 testing. The fifth row contains the generic and fluid-specific holdover time values accepted for use in 2000-01 winter operations. The sixth set of values is the endurance time test results from 2000-01 testing. The seventh and final line contains the generic and fluid-specific holdover time values for use in 2001-02 winter operations. The underlined holdover time values indicate the fluids responsible for the generic holdover time.

4.3.2.1.1 Neat fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 4.39)

The generic holdover times for fluid in these cells have remained unchanged from last year.

TABLE 4.40

Holdover Time Guidelines for Neat Fluid, Above 0°C and 0°C to -3°C, Freezing Drizzle

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:30-1:00			
	1998-99 Endurance Time Test Results		0:35-1:10		
	1999-2000 HOT Table Values	0:30-1:00	0:35-1:10		
	1999-2000 Endurance Time Test Results			0:35-0:55	
	2000-01 HOT Table Values	0:30-0:55	0:35-1:10	0:35-0:55	
CURRENT	2000-01 Endurance Time Test Results				0:50-1:35
	2001-02 HOT Table Values	0:30-0:55	0:35-1:10	0:35-0:55	0:50-1:35

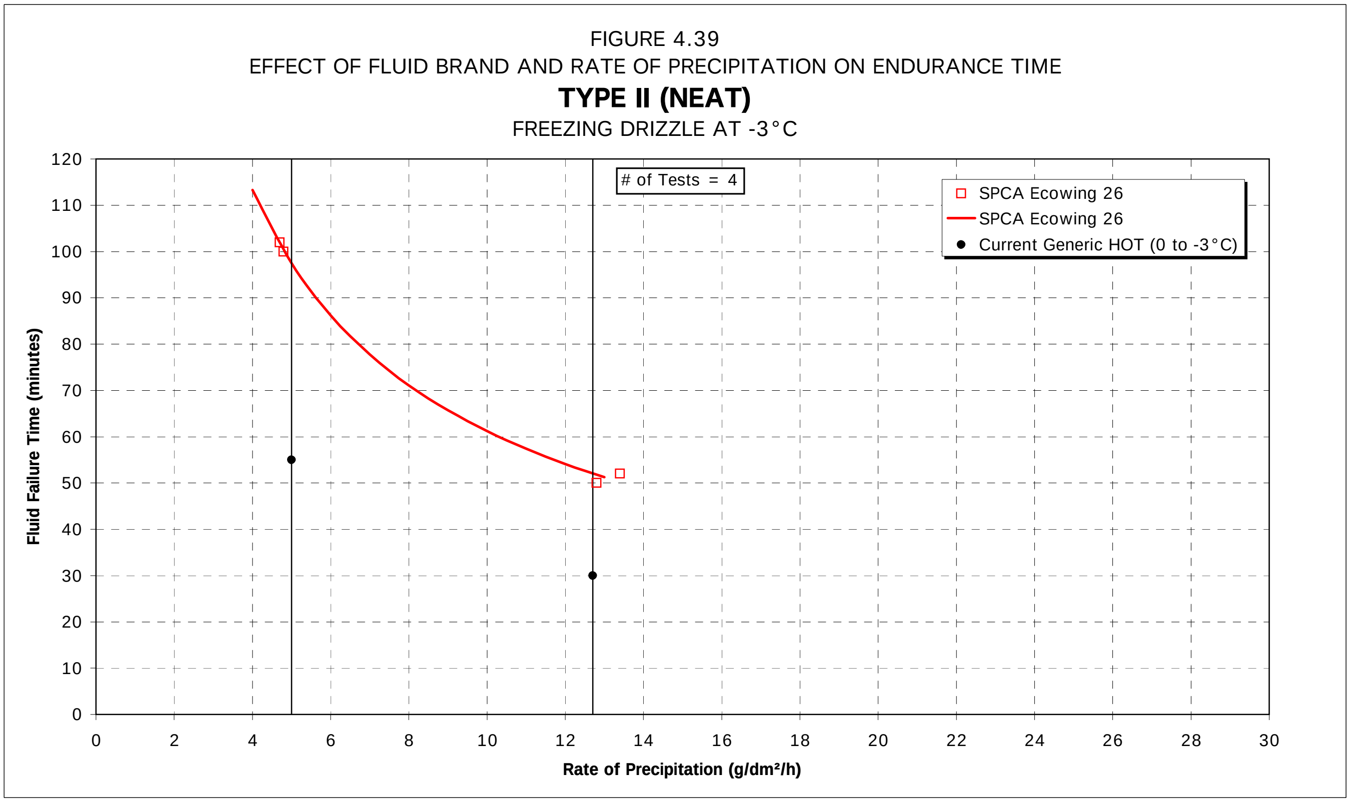
4.3.2.1.2 75/25 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 4.40)

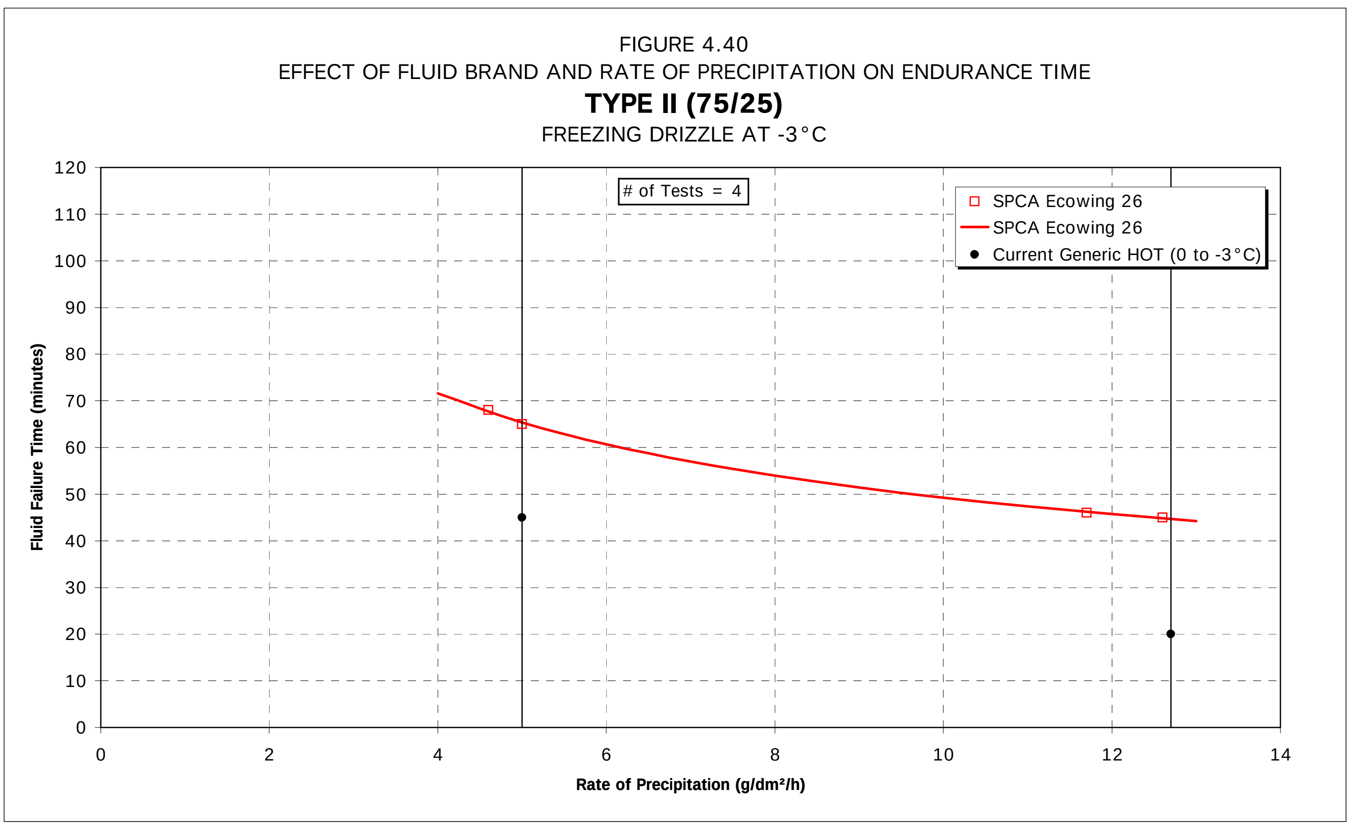
The holdover times in these cells have remained unchanged from last year. The Clariant fluid tested in 1999-2000 has an upper holdover time equal to the upper generic value.

TABLE 4.41

Holdover Time Guidelines for 75/25 Fluid, Above 0°C and 0°C to -3°C, Freezing Drizzle

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:20-0:45			
	1998-99 Endurance Time Test Results		0:30-1:00		
	1999-2000 HOT Table Values	0:20-0:45	0:30-1:00		
	1999-2000 Endurance Time Test Results			0:25-0:45	
	2000-01 HOT Table Values	0:20-0:45	0:30-1:00	0:25-0:45	
CURRENT	2000-01 Endurance Time Test Results				0:45-1:05
	2001-02 HOT Table Values	0:20-0:45	0:30-1:00	0:25-0:45	0:45-1:05





M\Groups\CM1680 (exBM3833)\Analysis\HOT\type II\HOT summary FD
AT: fig 4.39-4.40

4.3.2.1.3 50/50 fluid, above 0°C and 0°C to -3°C, freezing drizzle (Figure 4.41)

The holdover times in these cells have remained unchanged from last year. Both the Clariant MP II 1951 and the Kilfrost ABC-II Plus have lower holdover times equal to the lower generic value.

TABLE 4.42
Holdover Time Guidelines for 50/50 Fluid, Above 0°C and 0°C to -3°C, Freezing Drizzle

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:10-0:20			
	1998-99 Endurance Time Test Results		0:05-0:25		
	1999-2000 HOT Table Values	0:05-0:20	0:05-0:25		
	1999-2000 Endurance Time Test Results			0:05-0:15	
	2000-01 HOT Table Values	0:05-0:15	0:05-0:25	0:05-0:15	
CURRENT	2000-01 Endurance Time Test Results				0:15-0:25
	2001-02 HOT Table Values	0:05-0:15	0:05-0:25	0:05-0:15	0:15-0:25

4.3.2.1.4 Neat fluid, -3°C to -10°C, freezing drizzle (Figure 4.42)

The lower and upper generic holdover time limits for neat fluid in this temperature range for this precipitation type have remained unchanged from the generic values since 1999-2000 and are based on results of tests conducted with Kilfrost ABC-II Plus in 1998-99.

TABLE 4.43
Holdover Time Guidelines for Neat Fluid, -3°C to -10°C, Freezing Drizzle

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:30-1:00			
	1998-99 Endurance Time Test Results		0:15-0:45		
	1999-2000 HOT Table Values	0:15-0:45	0:15-0:45		
	1999-2000 Endurance Time Test Results			0:25-0:50	
	2000-01 HOT Table Values	0:15-0:45	0:15-0:45	025-0:50	
CURRENT	2000-01 Endurance Time Test Results				0:30-1:10
	2001-02 HOT Table Values	0:15-0:45	0:15-0:45	025-0:50	0:30-1:10

FIGURE 4.41
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (50/50)
FREEZING DRIZZLE AT -3°C

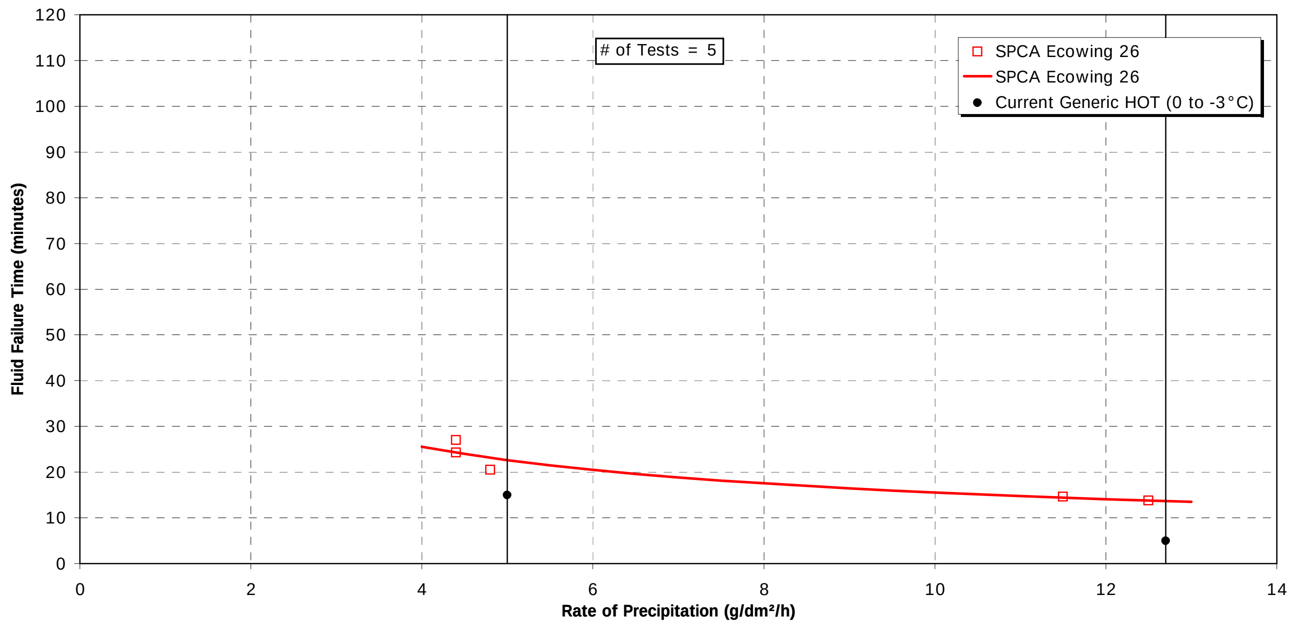
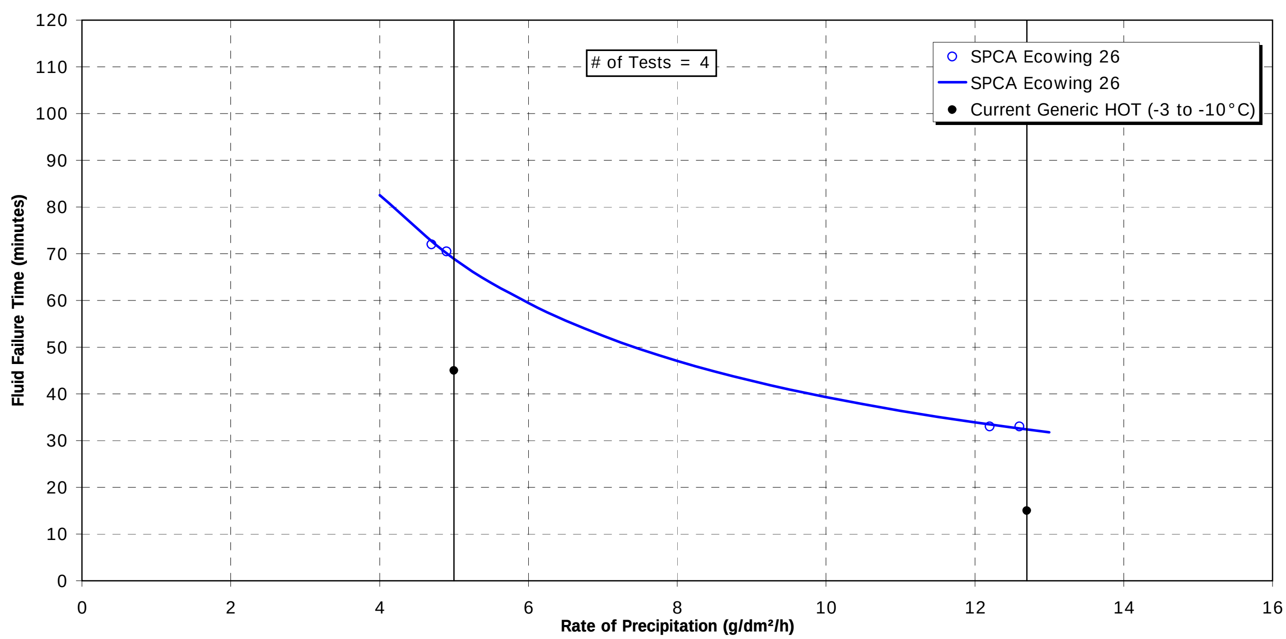


FIGURE 4.42
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (NEAT)
FREEZING DRIZZLE AT -10°C



M\Groups\CM1680 (exBM3833)\Analysis\HOT\type II\HOT summary FD
AT: fig 4.41-4.42

4.3.2.1.5 75/25 fluid, -3°C to -10°C, freezing drizzle (Figure 4.43)

The upper and lower generic holdover times for 75/25 fluid in freezing drizzle have not changed from the previous year and are based on the results of testing with Kilfrost ABC-II Plus.

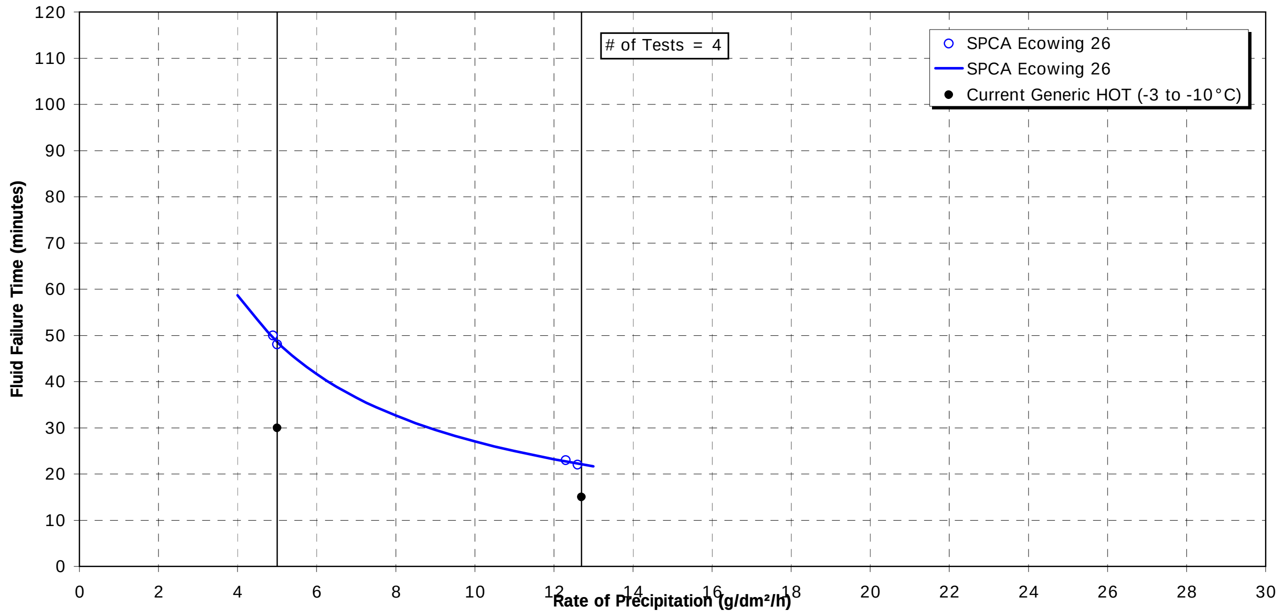
TABLE 4.44
Holdover Time Guidelines for 75/25 Fluid, -3°C to -10°C, Freezing Drizzle

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:20-0:45			
	1998-99 Endurance Time Test Results		0:15-0:30		
	1999-2000 HOT Table Values	0:15-0:30	0:15-0:30		
	1999-2000 Endurance Time Test Results			0:20-0:35	
	2000-01 HOT Table Values	0:15-0:30	0:15-0:30	0:20-0:35	
CURRENT	2000-01 Endurance Time Test Results				0:20-0:50
	2001-02 HOT Table Values	0:15-0:30	0:15-0:30	0:20-0:35	0:20-0:50

4.3.2.2 Overall perspective on freezing drizzle results

No changes were made to the freezing drizzle column of the generic Type II table from last year.

FIGURE 4.43
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (75/25)
FREEZING DRIZZLE AT -10°C



M\Groups\CM1680 (exBM3833)\Analysis\HOT\type II\HOT summary FD
AT: fig 4.43

This page intentionally left blank.

4.3.3 Light Freezing Rain

The light freezing rain endurance time data were derived from tests conducted by APS at the NRC test facility in Ottawa. Subsections 4.3.3.1.1 to 4.3.3.1.5 contain the Type II fluid holdover time results in the light freezing rain column. Results are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom. Because it was not possible to simulate light freezing rain above 0°C, the holdover time results for the category of precipitation above 0°C are identical to those in the range of 0°C to -3°C.

4.3.3.1 Changes to Type II fluid holdover times for light freezing rain

The tables presented in this subsection show columns containing the generic and fluid-specific holdover time results of testing with Type II fluids. The first horizontal row of values contains the generic holdover time values used in 1998-99. The second line contains the endurance time results from 1998-99 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1999-2000. The fourth set of values is the endurance time results from 1999-2000 testing. The fifth row contains the generic and fluid-specific holdover time values accepted for use in 2000-01 winter operations. The sixth set of values is the endurance time test results from 2000-01 testing. The seventh and final line contains the generic and fluid-specific holdover time values for use in 2001-02 winter operations. The underlined holdover time values indicate the fluids responsible for the generic holdover time.

4.3.3.1.1 *Neat fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.44)*

The holdover times have remained unchanged in these cells of the Type II table for light freezing rain. The upper holdover time of the Clariant fluid is equal to the generic value.

TABLE 4.45

Holdover Time Guidelines for Neat Fluid, Above 0°C and 0ºC to -3°C, Light Freezing Rain

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:30			
	1998-99 Endurance Time Test Results		0:30-0:40		
	1999-2000 HOT Table Values	0:15-0:30	0:30-0:40		
	1999-2000 Endurance Time Test Results			0:20-0:30	
	2000-01 HOT Table Values	0:15-0:30	0:30-0:40	0:20-0:30	
CURRENT	2000-01 Endurance Time Test Results				0:40-0:50
	2001-02 HOT Table Values	0:15-0:30	0:30-0:40	0:20-0:30	0:40-0:50

4.3.3.1.2 *75/25 fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.45)*

The holdover times have remained unchanged in these cells of the Type II table for light freezing rain. The upper holdover time of the Clariant fluid is equal to the generic value.

TABLE 4.46

Holdover Time Guidelines for 75/25 Fluid, Above 0°C and 0ºC to -3°C, Light Freezing Rain

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	998-99 HOT Table Values	0:10-0:25			
	1998-99 Endurance Time Test Results		0:20-0:40		
	1999-2000 HOT Table Values	0:10-0:25	0:20-0:40		
	1999-2000 Endurance Time Test Results			015-0:25	
	2000-01 HOT Table Values	0:10-0:25	0:20-0:40	0:15-0:25	
CURRENT	2000-01 Endurance Time Test Results				0:25-0:35
	2001-02 HOT Table Values	0:10-0:25	0:20-0:40	0:15-0:25	0:25-0:35

FIGURE 4.44
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (NEAT)
LIGHT FREEZING RAIN AT -3°C

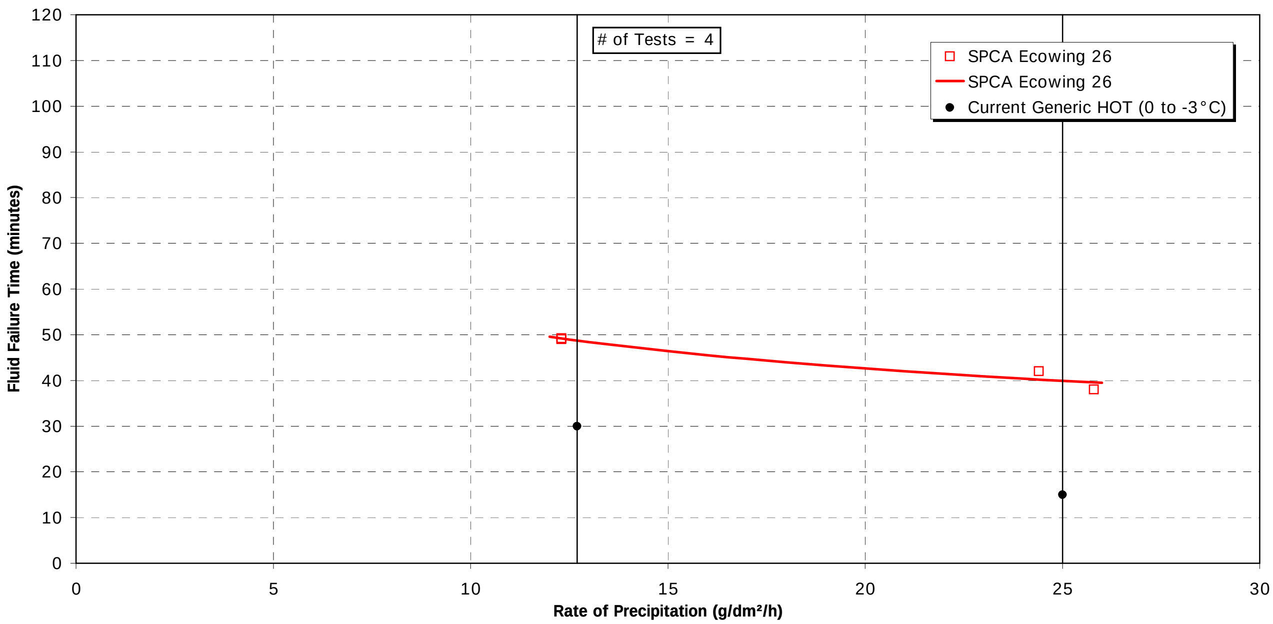
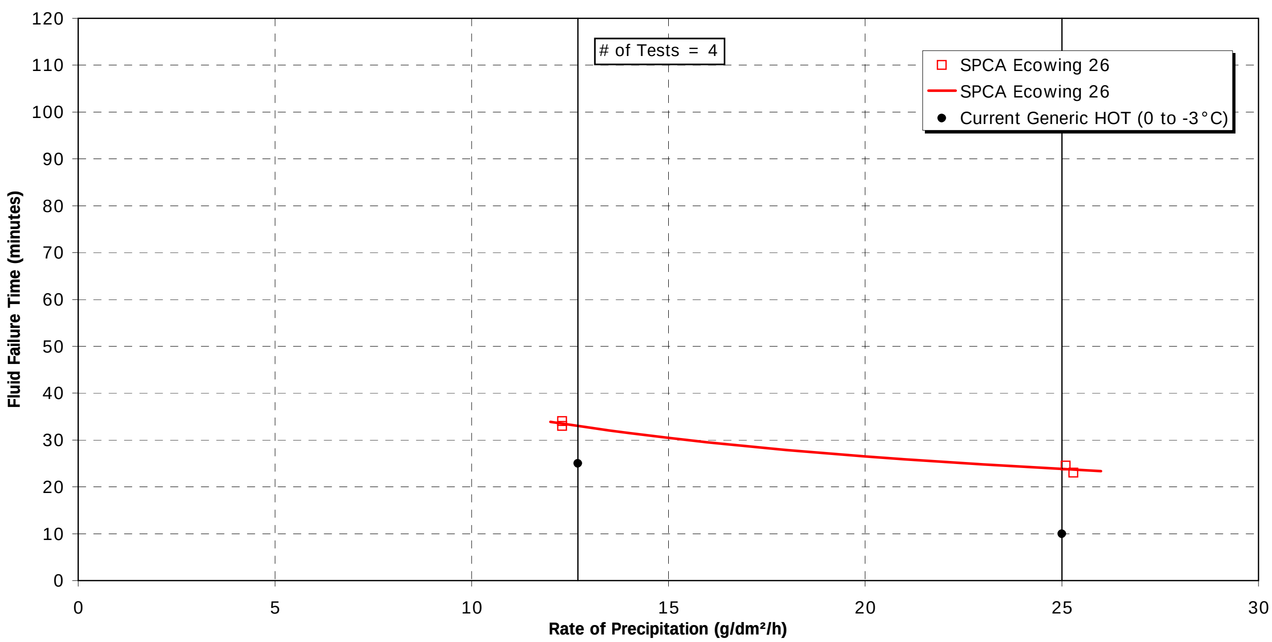


FIGURE 4.45
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (75/25)
LIGHT FREEZING RAIN AT -3°C



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary ZR
At:fig 4.44-4.45

4.3.3.1.3 50/50 fluid, above 0°C and 0ºC to -3°C, light freezing rain (Figure 4.46)

The generic holdover time values have not changed in these two cells. All three fluids tested have lower holdover time values equal to the generic values in these cells. The upper holdover time values obtained from tests using the Clariant and SPCA fluids are also equal to the generic values.

TABLE 4.47
Holdover Time Guidelines for 50/50 Fluid, Above 0°C and 0ºC to -3°C, Light Freezing Rain

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:05-0:10			
	1998-99 Endurance Time Test Results		0:05-0:15		
	1999-2000 HOT Table Values	0:05-0:10	0:05-0:15		
	1999-2000 Endurance Time Test Results			0:05-0:10	
	2000-01 HOT Table Values	0:05-0:10	0:05-0:15	0:05-0:10	
CURRENT	2000-01 Endurance Time Test Results				0:05:0:10
	2001-02 HOT Table Values	0:05-0:10	0:05-0:15	0:05-0:10	0:05:0:10

4.3.3.1.4 Neat fluid, -3°C to -10°C, light freezing rain (Figure 4.47)

The upper generic holdover time value has been reduced by five minutes to match the performance of Type IV fluids in this cell.

TABLE 4.48
Holdover Time Guidelines for Neat Fluid, -3°C to -10°C, Light Freezing Rain

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:10-0:30			
	1998-99 Endurance Time Test Results		0:10-0:30		
	1999-2000 HOT Table Values	0:10-0:30	0:10-0:30		
	1999-2000 Endurance Time Test Results			0:15-0:30	
	2000-01 HOT Table Values	0:10-0:30	0:10-0:30	0:15-0:30	
CURRENT	2000-01 Endurance Time Test Results				0:15-0:35
	2001-02 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:15-0:35

FIGURE 4.46

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II (50/50)

LIGHT FREEZING RAIN AT -3°C

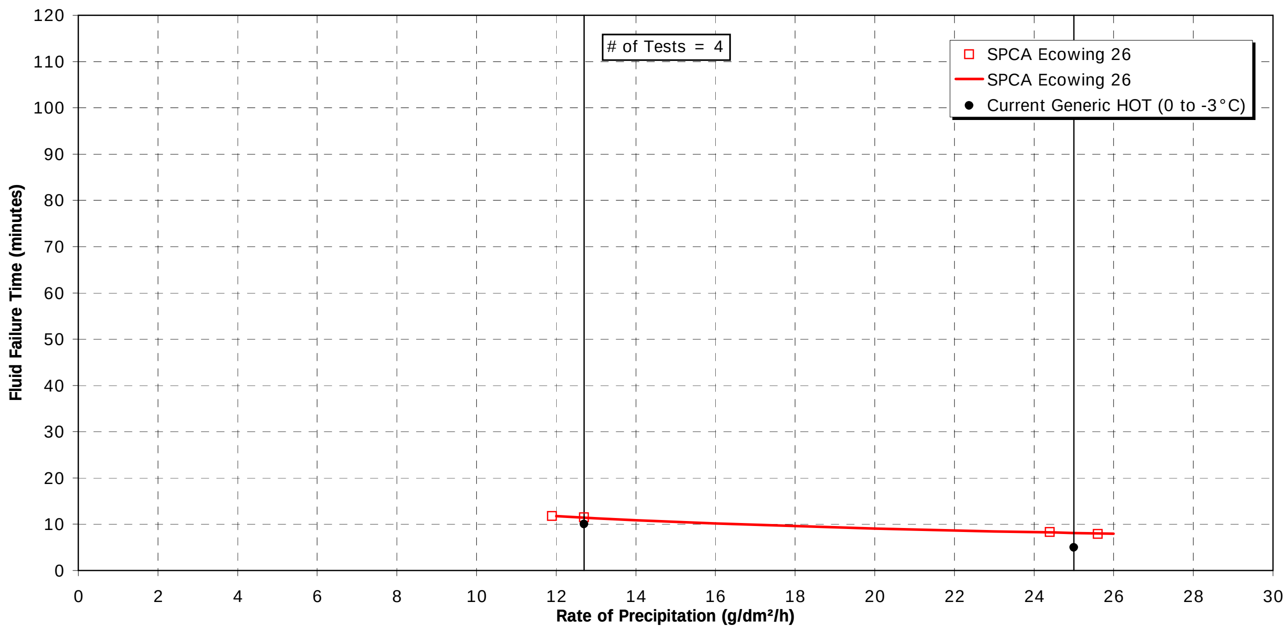
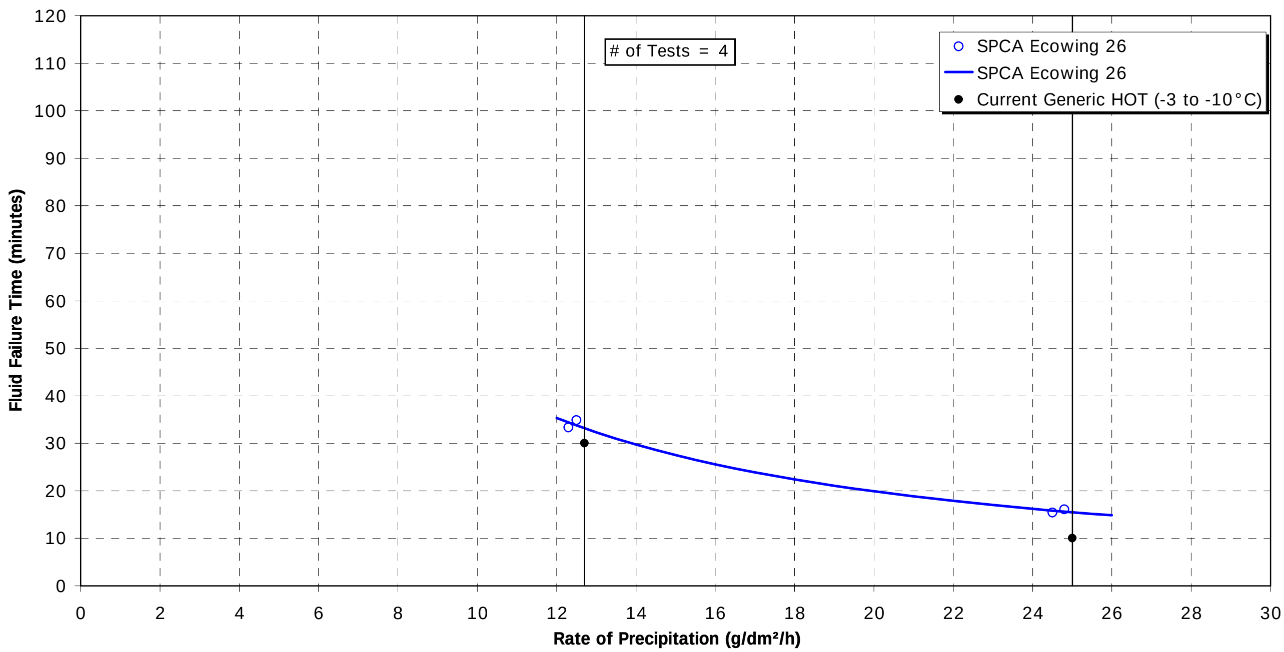


FIGURE 4.47

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II (NEAT)

LIGHT FREEZING RAIN AT -10°C



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary ZR
At:fig 4.46-4.47

4.3.3.1.5 75/25 fluid, -3°C to -10°C, light freezing rain (Figure 4.48)

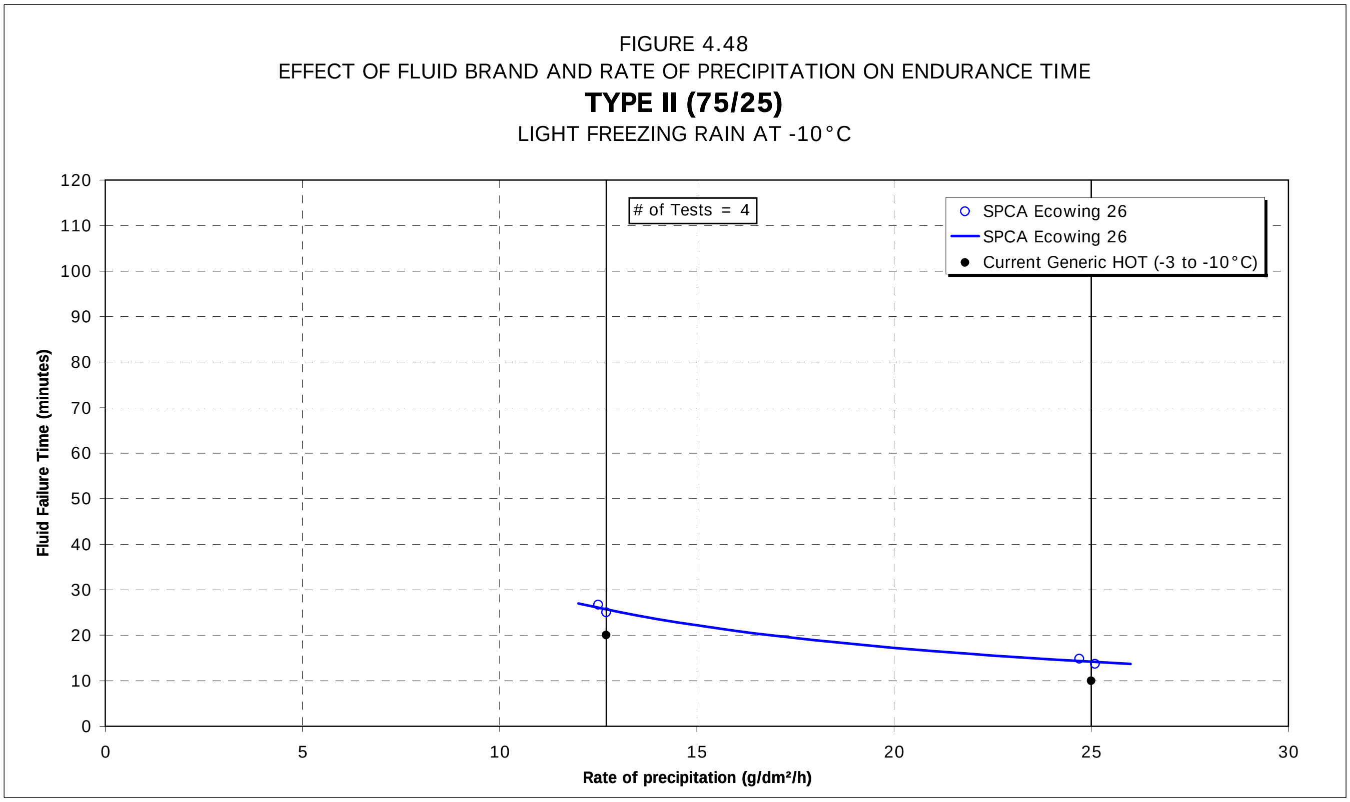
The upper and lower generic holdover times in this cell has remained unchanged from last year. The Clariant and Kilfrost fluids have upper holdover times equal to the generic value. The Kilfrost fluid used in 1998-99 testing is also responsible for the lower generic value.

TABLE 4.49
Holdover Time Guidelines for 75/25 Fluid, -3°C to -10°C, Light Freezing Rain

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:10-0:25			
	1998-99 Endurance Time Test Results		0:10-0:20		
	1999-2000 HOT Table Values	0:10-0:20	0:10-0:20		
	1999-2000 Endurance Time Test Results			0:15-0:20	
	2000-01 HOT Table Values	0:10-0:20	0:10-0:20	0:15-0:20	
CURRENT	**2000-01 Endurance Time Test Results**				0:15-0:25
	2001-02 HOT Table Values	0:10-0:20	0:10-0:20	0:15-0:20	0:15-0:25

4.3.3.2 Overall perspective on light freezing rain results

One change was made to the generic Type II table as a result of tests conducted in 2000-01 with Type IV fluid.



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary ZR
At:fig 4.48

4.3.4 Freezing Fog

The freezing fog endurance time data originated from tests conducted by APS at the NRC test facility in Ottawa. The freezing fog category is divided into nine cells. The data were collected under precipitation rates of 2 and 5 g/dm²/h. The lower precipitation rate limit of 2 g/dm²/h was not set for tests conducted prior to 1998-99; therefore, several reductions were made to the 1999-2000 Type II generic table.

Subsections 4.3.4.1.1 to 4.3.4.1.9 contain the Type II fluid endurance time results in the freezing fog column. Results are arranged in tabular form and follow the sequence of temperature ranges as they appear in the holdover time tables, from top to bottom. Failure times were measured at three different temperatures: -3°C, -14°C, and -25°C. In previous years, the holdover times for freezing fog above 0°C were superior to those from 0°C to -3°C, despite the fact that it is not possible to simulate freezing fog above 0°C. At the SAE meeting in Toulouse, it was agreed that the holdover times using Type II fluids above 0°C should be reduced to match the 0°C to -3°C results. For the purpose of this report, the above 0°C and the 0°C to -3°C cells are treated separately to properly document the changes that have occurred over the years.

4.3.4.1 Changes to Type II fluid holdover times for freezing fog

The tables presented in this subsection show columns containing the generic and fluid-specific holdover time results of testing with Type II fluids. The first horizontal row of values contains the generic holdover time values used in 1998-99. The second line in each table contains the endurance time results from 1998-99 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1999-2000. The fourth set of values is the endurance time results from 1999-2000 testing. The fifth row contains the generic and fluid-specific holdover time values accepted for use in 2000-01 winter operations. The sixth set of values is the endurance time test results from 2000-01 testing. The seventh and final line contains the generic and fluid-specific holdover time values for use in 2001-02 winter operations. The underlined holdover time values indicate the fluids responsible for the generic holdover time.

4.3.4.1.1 Neat fluid, above 0°C, freezing fog

The fog holdover time limits were reduced substantially in 1999-2000 to match the holdover times in the 0°C to -3°C cell for neat fluid, since fog cannot be produced in a laboratory at temperatures exceeding 0°C. No tests were conducted in this temperature range in 2000-01.

TABLE 4.50
Holdover Time Guidelines for Neat Fluid, Above 0°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	1:15-3:00			
	1998-99 Endurance Time Test Results		1:10-2:25		
	1999-2000 HOT Table Values	1:05-2:15	1:10-2:25		
	1999-2000 Endurance Time Test Results			0:55-1:40	
	2000-01 HOT Table Values	0:35-1:30	1:10-2:25	0:55-1:40	
CURRENT	2000-01 Endurance Time Test Results				1:25-2:35
	2001-02 HOT Table Values	0:35-1:30	1:10-2:25	0:55-1:40	1:25-2:35

4.3.4.1.2 75/2 fluid, above 0°C, freezing fog

The above 0°C fog holdover time limits were reduced substantially in 1999-2000 to match the holdover times in the 0°C to -3°C cell, since fog cannot be produced in a laboratory at temperatures exceeding 0°C. No tests were conducted in this temperature range in 2000-01.

TABLE 4.51
Holdover Time Guidelines for 75/25 Fluid, Above 0°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:50-2:00			
	1998-99 Endurance Time Test Results		1:10-2:25		
	1999-2000 HOT Table Values	0:50-1:45	1:10-2:25		
	1999-2000 Endurance Time Test Results			0:45-1:15	
	2000-01 HOT Table Values	0:25-1:00	1:10-2:25	0:45-1:15	
CURRENT	2000-01 Endurance Time Test Results				1:05-1:55
	2001-02 HOT Table Values	0:25-1:00	1:10-2:25	0:45-1:15	1:05-1:55

4.3.4.1.3 50/50 fluid, above 0°C, freezing fog

The generic holdover times in this cell have remained unchanged from last year. In 1999-2000, the upper generic holdover time limit was reduced by five minutes due to the result of Clariant tests between 0°C and -3°C. No tests were conducted in this temperature range in 2000-01.

TABLE 4.52

Holdover Time Guidelines for 50/50 Fluid, Above 0°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:20-0:45			
	1998-99 Endurance Time Test Results		0:15-0:45		
	1999-2000 HOT Table Values	0:15-0:35	0:15-0:45		
	1999-2000 Endurance Time Test Results			0:20-0:30	
	2000-01 HOT Table Values	0:15-0:30	0:15-0:45	0:20-0:30	
CURRENT	2000-01 Endurance Time Test Results				0:30-0:45
	2001-02 HOT Table Values	0:15-0:30	0:15-0:45	0:20-0:30	0:30-0:45

4.3.4.1.4 Neat fluid, 0°C to -3°C, freezing fog (Figure 4.49)

The current holdover time limits have not been reduced based on recent testing.

TABLE 4.53

Holdover Time Guidelines for Neat Fluid, 0°C to -3°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:35-1:30			
	1998-99 Endurance Time Test Results		1:10-2:25		
	1999-2000 HOT Table Values	0:35-1:30	1:10-2:25		
	1999-2000 Endurance Time Test Results			0:55-1:40	
	2000-01 HOT Table Values	0:35-1:30	1:10-2:25	0:55-1:40	
CURRENT	2000-01 Endurance Time Test Results				1:25-2:35
	2001-02 HOT Table Values	0:35-1:30	1:10-2:25	0:55-1:40	1:25-2:35

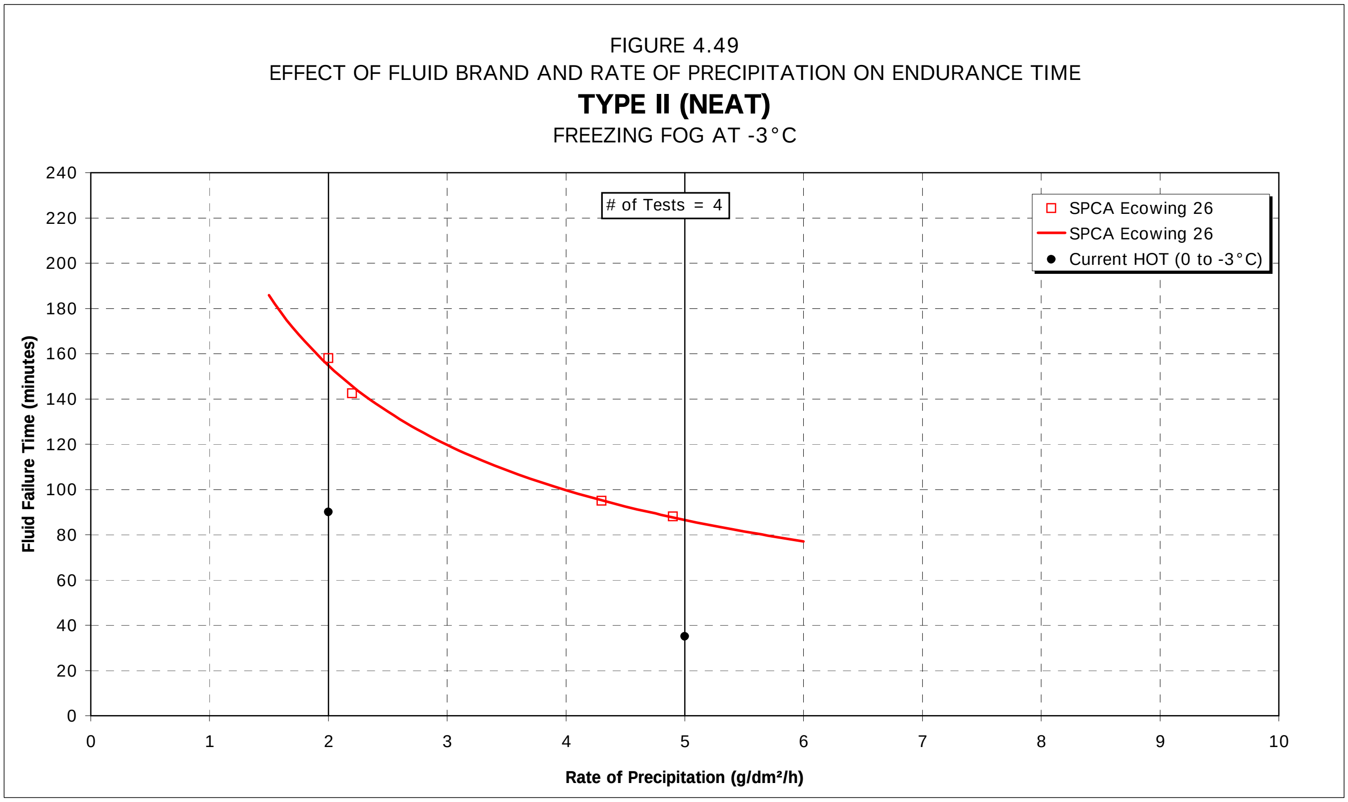


FIGURE 4.49
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (NEAT)
FREEZING FOG AT -3°C
# of Tests = 4
SPCA Ecowing 26
SPCA Ecowing 26
Current HOT (0 to -3°C)
Fluid Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
20
40
60
80
100
120
140
160
180
200
220
240
0
1
2
3
4
5
6
7
8
9
10

4.3.4.1.5 75/25 fluid, 0°C to -3°C, freezing fog (Figure 4.50)

The current holdover time limits have not been reduced based on recent testing.

TABLE 4.54
Holdover Time Guidelines for 75/25 Fluid, 0°C to -3°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:25-1:00			
	1998-99 Endurance Time Test Results		1:10-2:25		
	1999-2000 HOT Table Values	0:25-1:00	1:10-2:25		
	1999-2000 Endurance Time Test Results			0:45-1:15	
	2000-01 HOT Table Values	0:25-1:00	1:10-2:25	0:45-1:15	
CURRENT	2000-01 Endurance Time Test Results				1:05-1:55
	2001-02 HOT Table Values	0:25-1:00	1:10-2:25	0:45-1:15	1:05-1:55

4.3.4.1.6 50/50 fluid, 0°C to -3°C, freezing fog (Figure 4.51)

The current holdover time limits have not been reduced based on recent testing.

TABLE 4.55
Holdover Time Guidelines for 50/50 Fluid, 0°C to -3°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:15-0:45			
	1998-99 Endurance Time Test Results		0:15-0:45		
	1999-2000 HOT Table Values	0:15-0:35	0:15-0:45		
	1999-2000 Endurance Time Test Results			0:20-0:30	
	2000-01 HOT Table Values	0:15-0:30	0:15-0:45	0:20-0:30	
CURRENT	2000-01 Endurance Time Test Results				0:30-0:45
	2001-02 HOT Table Values	0:15-0:30	0:15-0:45	0:20-0:30	0:30-0:45

FIGURE 4.50
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (75/25)
FREEZING FOG AT -3°C

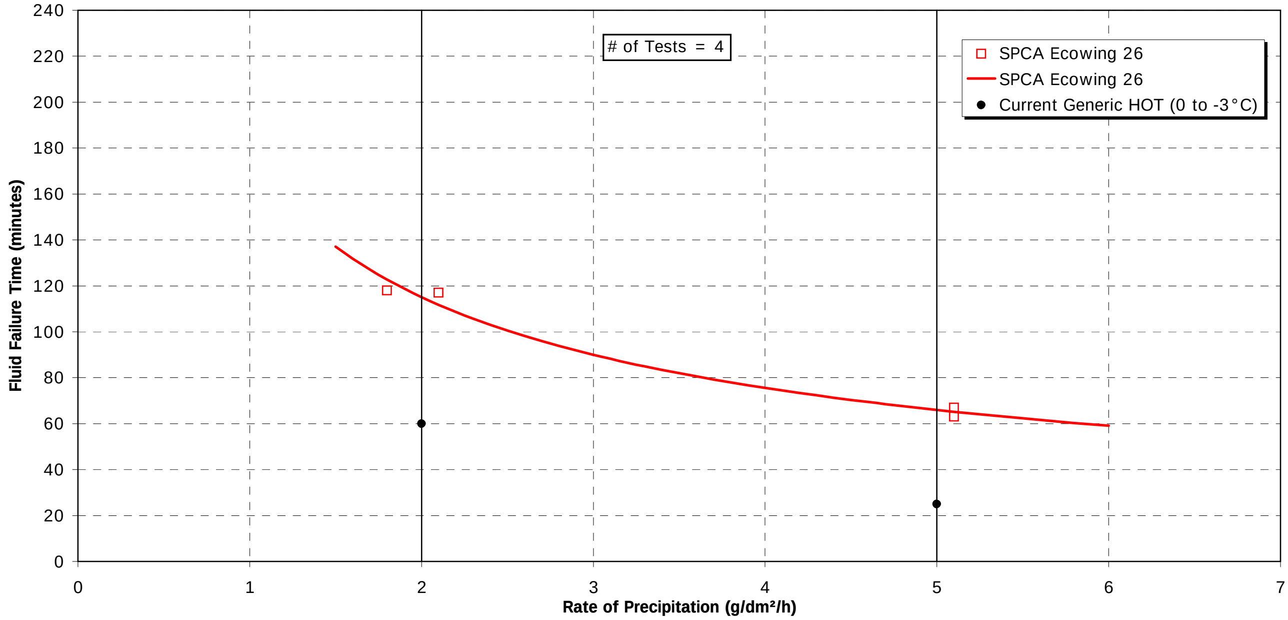
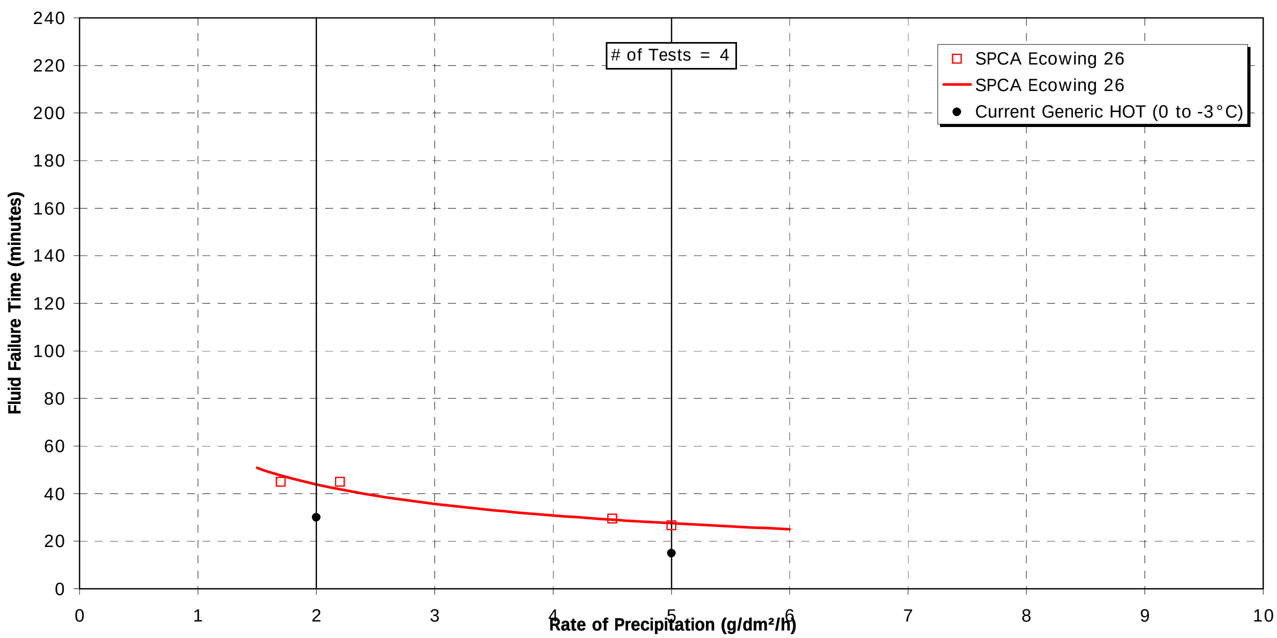


FIGURE 4.51
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (50/50)
FREEZING FOG AT -3°C



4.3.4.1.7 *Neat fluid, -3ºC to -14°C, freezing fog (Figure 4.52)*

The holdover times have remained unchanged in these cells of the Type II table for freezing fog.

TABLE 4.56
Holdover Time Guidelines for Neat Fluid, -3°C to -14°C, Freezing Fog

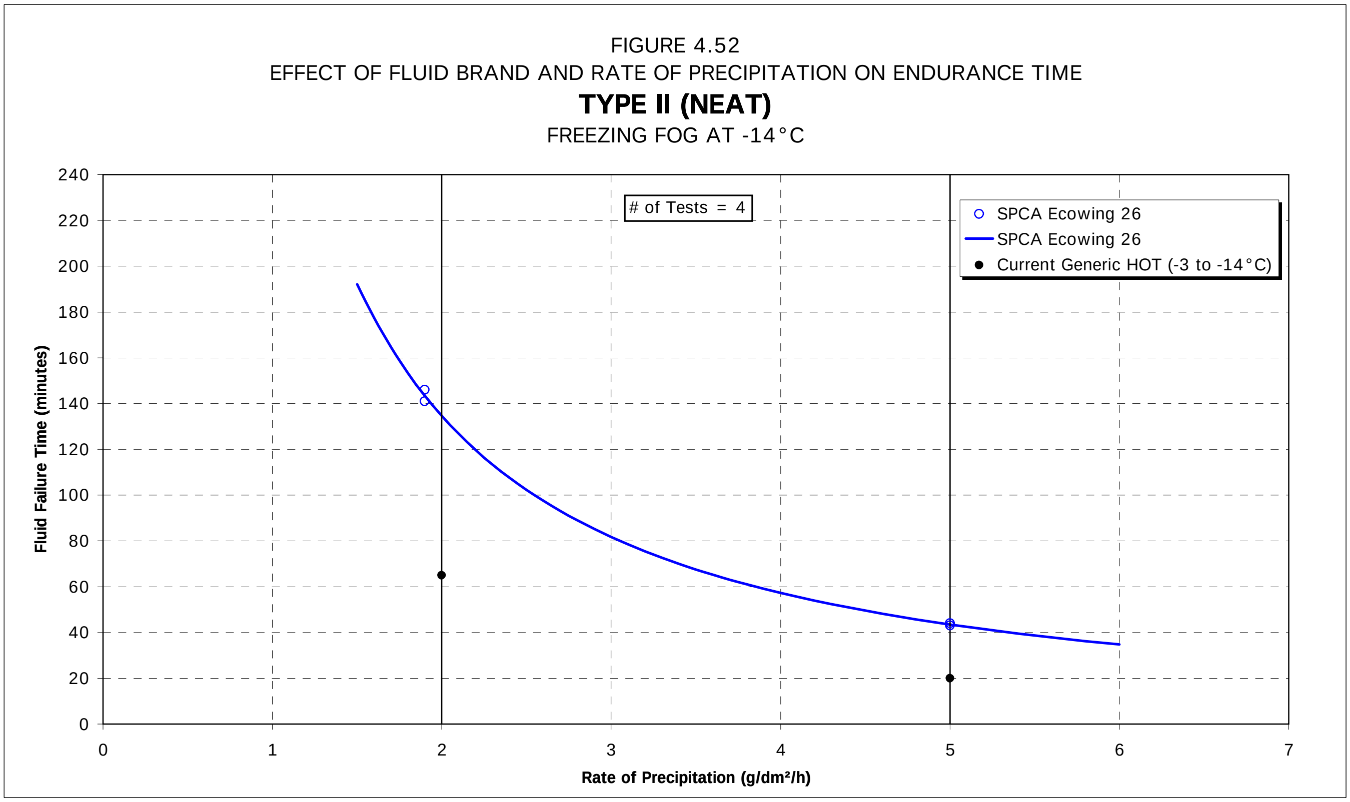
		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:35-1:30			
	1998-99 Endurance Time Test Results		0:30-1:05		
	1999-2000 HOT Table Values	0:30-1:05	0:30-1:05		
	1999-2000 Endurance Time Test Results			0:45-1:25	
	2000-01 HOT Table Values	0:20-1:05	0:30-1:05	0:45-1:25	
CURRENT	**2000-01 Endurance Time Test Results**				0:45-2:15
	2001-02 HOT Table Values	0:20-1:05	0:30-1:05	0:45-1:25	0:45-2:15

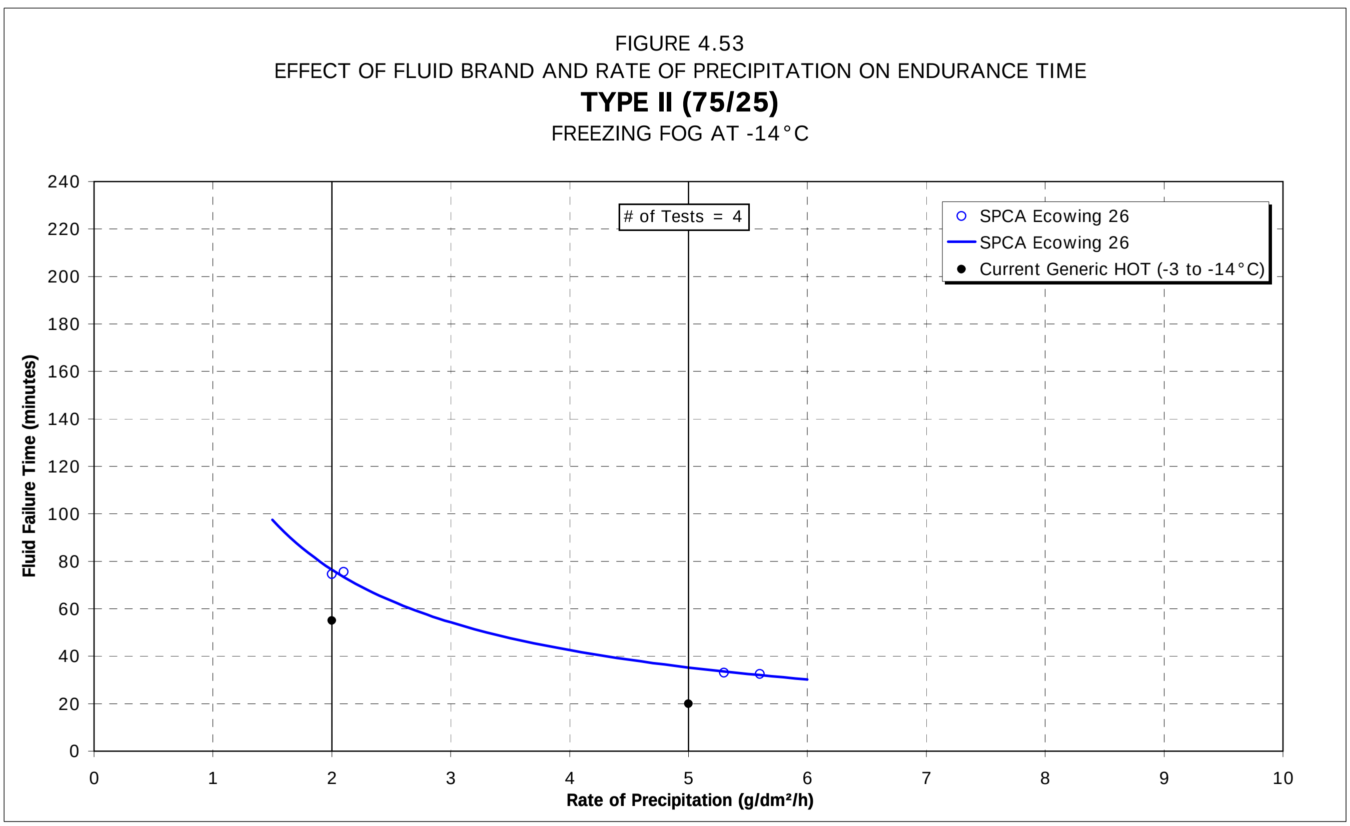
4.3.4.1.8 *75/25 fluid, -3ºC to -14°C, freezing fog (Figure 4.53)*

The upper and lower generic holdover times in this cell have remained unchanged from last year.

TABLE 4.57
Holdover Time Guidelines for 75/25 Fluid, -3°C to -14°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:25-1:00			
	1998-99 Endurance Time Test Results		0:20-0:55		
	1999-2000 HOT Table Values	0:20-0:55	0:20-0:55		
	1999-2000 Endurance Time Test Results			0:35-1:00	
	2000-01 HOT Table Values	0:20-0:55	0:20-0:55	0:35-1:00	
CURRENT	**2000-01 Endurance Time Test Results**				0:35-1:15
	2001-02 HOT Table Values	0:20-0:55	0:20-0:55	0:35-1:00	0:35-1:15





ICM1680(exBM3833)\Analysis\HOT\type II\HOT summary ZF
At:fig 4.52-4.53

4.3.4.1.9 Neat fluid, -14°C to -25°C, freezing fog (Figure 4.54)

The upper and lower generic holdover times in this cell have remained unchanged from last year and are based on the results using the Kilfrost fluid in tests performed in 1998-99.

TABLE 4.58
Holdover Time Guidelines for Neat Fluid, -14°C to -25°C, Freezing Fog

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	**1998-99 HOT Table Values**	0:20-1:30			
	1998-99 Endurance Time Test Results		0:15-0:20		
	1999-2000 HOT Table Values	0:15-0:20	0:15-0:20		
	1999-2000 Endurance Time Test Results			0:20-0:40	
	2000-01 HOT Table Values	0:15-0:20	0:15-0:20	0:20-0:40	
CURRENT	**2000-01 Endurance Time Test Results**				0:25-0:45
	2001-02 HOT Table Values	0:15-0:20	0:15-0:20	0:20-0:40	0:25-0:45

4.3.4.2 Overall perspective on freezing fog results

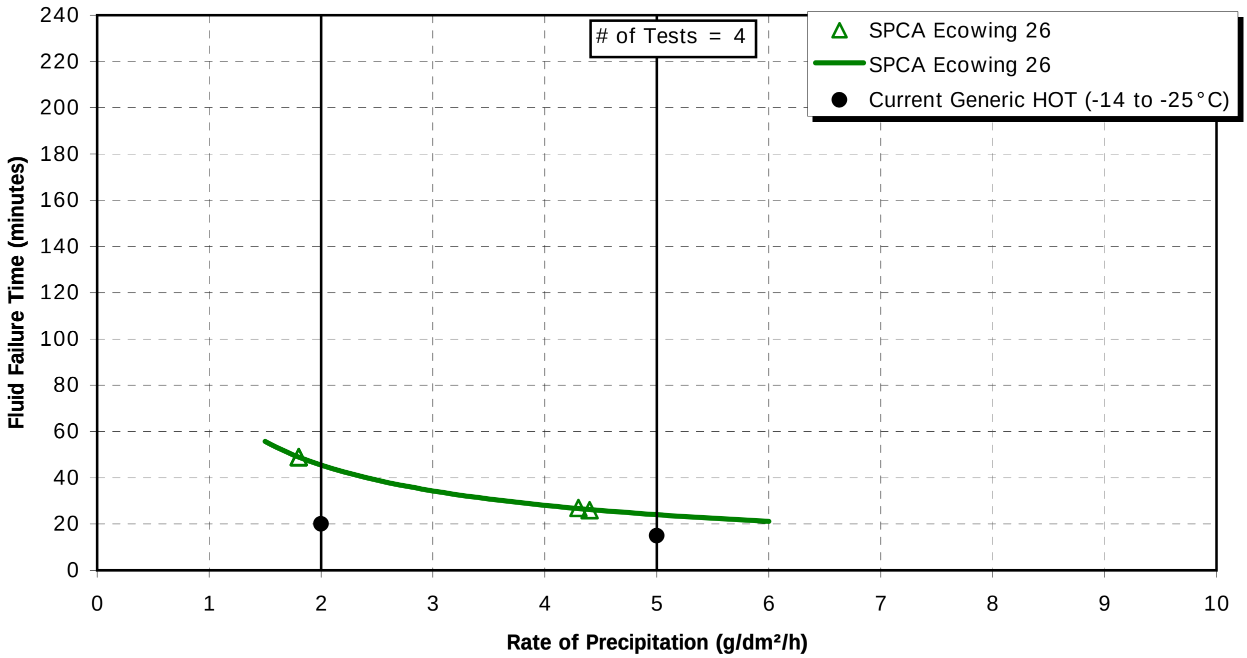
No changes were made to the freezing fog column in the generic Type II table based on the tests conducted with SPCA Ecowing 26 in 2000-01.

FIGURE 4.54

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE II (NEAT)

FREEZING FOG AT -25°C



This page intentionally left blank.

4.3.5 Rain on a Cold-Soaked Wing

The rain on cold-soaked wing endurance time data were derived from tests conducted by APS at the NRC test facility in Ottawa. The data used to evaluate the endurance times for this category of precipitation covered precipitation rates ranging from 5 g/dm^2/h to 76 g/dm^2/h. These rates encompass heavy drizzle (5 to 12.7 g/dm^2/h), light rain (12.7 to 25 g/dm^2/h), and moderate rain (25 to 76 g/dm^2/h). The box temperature prior to the start of testing was -10°C. Test data are plotted for two Type II fluid concentrations: neat fluid and 75/25 fluid.

Subsections 4.3.5.1.1 and 4.3.5.1.2 contain the Type II fluid holdover time results in the rain on a cold-soaked wing column.

4.3.5.1 Changes to Type II fluid holdover times for rain on a cold-soaked wing

The tables presented in this subsection show columns containing the generic and fluid-specific holdover time results with testing of Type II fluids. The first horizontal row of values contains the generic holdover time values used in 1998-99. The second line contains the endurance time results from 1998-99 testing. The third line contains the generic and fluid-specific holdover time values that were used in winter operations in 1999-2000. The fourth set of values is the endurance time results from 1999-2000 testing. The fifth row contains the generic and fluid-specific holdover time values accepted for use in 2000-01 winter operations. The sixth set of values is the endurance time test results from 2000-01 testing. The seventh and final line contains the generic and fluid-specific holdover time values for use in 2001-02 winter operations. The underlined holdover time values indicate the fluids responsible for the generic holdover time.

4.3.5.1.1 *Neat fluid, above 0°C, rain on a cold-soaked wing (Figure 4.55)*

The generic holdover times have not changed from last year. The Kilfrost fluid used in 1998-99 testing is responsible for the lower generic limit.

TABLE 4.59
Holdover Time Guidelines for Neat Fluid, Above 0°C, ROCSW

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:10-0:40			
	1998-99 Endurance Time Test Results		0:05-1:00		
	1999-2000 HOT Table Values	0:05-0:40	0:05-1:00		
	1999-2000 Endurance Time Test Results			0:10-0:50	
	2000-01 HOT Table Values	0:05-0:40	0:05-1:00	0:10-0:50	
CURRENT	2000-01 Endurance Time Test Results				0:20-1:25
	2001-02 HOT Table Values	0:05-0:40	0:05-1:00	0:10-0:50	0:20-1:25

4.3.5.1.2 *75/25 fluid, above 0°C, rain on a cold-soaked wing (Figure 4.56)*

The generic times in this cell remain unchanged from last year.

TABLE 4.60
Holdover Time Guidelines for 75/25 Fluid, Above 0°C, ROCSW

		SAE	ABC-II +	C-1951	S E26
HISTORICAL	1998-99 HOT Table Values	0:05-0:25			
	1998-99 Endurance Time Test Results		0:05-0:50		
	1999-2000 HOT Table Values	0:05-0:25	0:05-0:50		
	1999-2000 Endurance Time Test Results			0:05-0:40	
	2000-01 HOT Table Values	0:05-0:25	0:05-0:50	0:05-0:40	
CURRENT	2000-01 Endurance Time Test Results				0:10-1:00
	2001-02 HOT Table Values	0:05-0:25	0:05-0:50	0:05-0:40	0:10-1:00

4.3.5.2 *Overall perspective on rain on a cold-soaked wing results*

No changes were made to the rain on a cold-soaked wing holdover times based on the results of tests conducted in 1999-2000.

FIGURE 4.55
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (NEAT)
RAIN ON A COLD-SOAKED WING

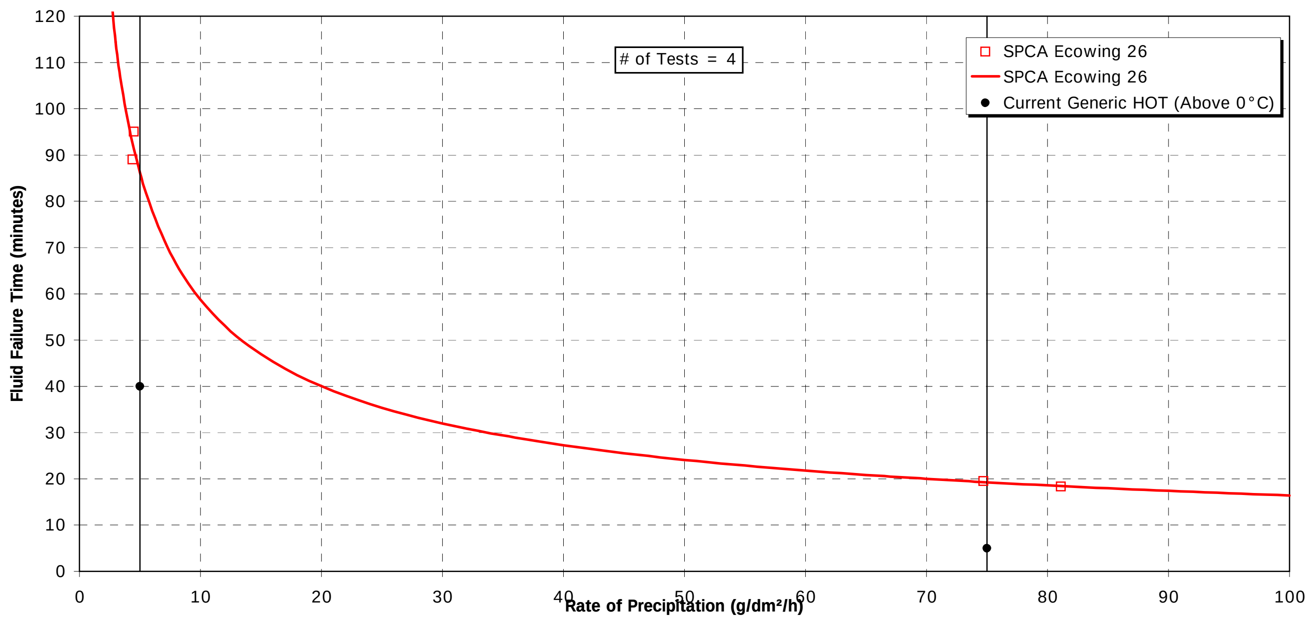
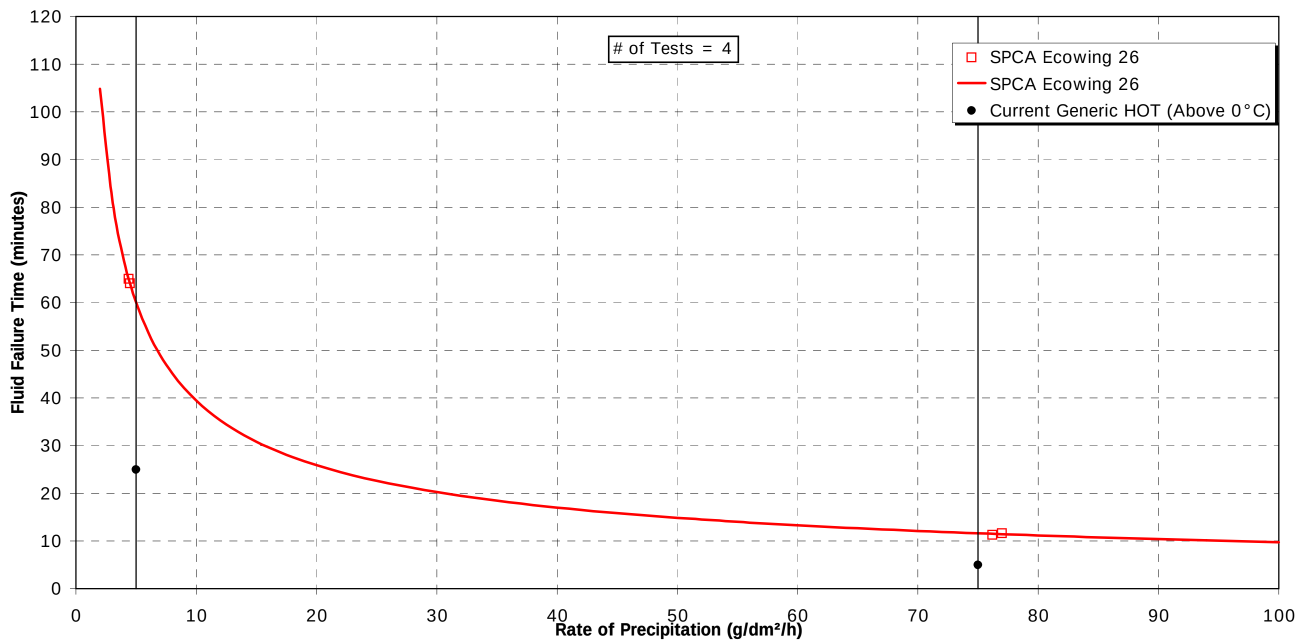


FIGURE 4.56
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE II (75/25)
RAIN ON A COLD-SOAKED WING



CM1680(exBM3833)\Analysis\HOT\type II\HOT summary CS
At:fig 4.55-4.56

4.3.6 Changes to the Generic Type II Table

One change was made to the generic Type II table for use in 2001-02 winter operations. In light freezing rain for Neat Type II fluid between -3°C and -10°C, the upper generic value was reduced by five minutes based on the results of Type IV fluid tests from 2000-01. No changes in the Type II table were made as a result of the most recent Type II fluid tests.

4.4 Type I Fluid Holdover Time Tests

Type I fluids are deicing fluids. They are not rheologically modified fluids, but rather exhibit Newtonian fluid properties. Type I fluids are used primarily to remove ice and snow from aircraft surfaces. They are applied at high pressures and elevated temperatures. These fluids do not offer the extended protection of thickened fluids. Depending on weather conditions, anticipated taxi times, or other pre-takeoff delays, an operator can choose to extend the time of fluid protection by application of Type II or Type IV anti-icing fluid on top of the Type I fluid.

Although the Type I holdover time table has been substantiated by tests conducted prior to 1996, several new Type I fluids have become available on an annual basis since the 1998-99 test season. Two Type I fluids, Newave Aerochemical FCY-1A and an experimental Type I product from Lyondell, were tested during the 2000-01 winter in natural and simulated conditions. Three additional fluids, Clariant EG I 1996, Clariant MP I 1938, and Lyondell ArcoPlus, were tested in natural snow conditions only.

The results of WSET tests with these Type I fluids are displayed in Table 4.61. A significant amount of time was required to prepare the various samples required for testing. Because fluids need to be diluted, freeze point curves (dilution curves) and lowest operational use temperatures (LOUTs) were obtained for each fluid. Fluid concentrations were lowered by adding hard water and the resultant freeze points were verified using calibrated Brix-scale refractometers.

TABLE 4.61

WSET VALUES OF SAMPLES TESTED (FIRST ICE EVENT)

FLUIDS TESTED IN 2000-01

FLUID	MINUTES
Clariant Safewing MPIV 2012 Protect	131
Octagon Max-Flight	120
SPCA Ecowing 26	56

Type I tests were carried out at three temperatures: +1°C, -10°C, and -25°C. Because testing required fluids diluted to a 10°C buffer, fluid samples were prepared with freeze points of -9°C, -20°C, and -35°C, respectively. Attempts were made to conduct tests at the LOUT for each fluid.

Due to procedural and logistical problems and complications related to maintaining chamber capabilities at extremely cold temperatures, -25°C was selected as the test temperature in cold conditions. No significant holdover time fluctuations were anticipated at a LOUT of -25°C due to the 10°C buffer. The information necessary for the preparation of the diluted Type I fluid samples is contained within Appendix E, and the procedure is described in Subsection 2.7.2.

The data from the Type fluid I tests (diluted to a 10°C buffer) conducted in 2000-01 are shown in Figures 4.57 to 4.62. For clarity, the regression curves for each of the Type I fluids have been omitted. It is important to note, however, that the regression method of analysis was used to determine the holdover times of the Type I fluids. The figures for each individual fluid, including the regression curves, appear in Appendix G.

Despite several changes that were made to the generic Type I table at the SAE G-12 Subcommittee meeting in Toulouse in May 2000, Transport Canada and the Federal Aviation Administration elected to publish the old Type I numbers in their tables for use during 2000-01 winter operations.

4.4.1 Freezing Drizzle

The following is a cell-by-cell summary of the holdover time performance of all Type I fluid brands tested under conditions of simulated freezing drizzle. The results are arranged according to the sequence of temperature ranges (from top to bottom) that appear in the corresponding columns of the holdover time tables. Because it was not possible to simulate freezing drizzle above 0°C, the holdover time results for the category of precipitation above 0°C are identical to those in the range of 0°C to -10°C.

4.4.1.1 Type I diluted fluid, above 0°C and 0°C to -10°C, freezing drizzle (Figure 4.57)

The generic holdover times in this cell are 5 to 8 minutes. Two Type I fluids tested, Newave Aerochemical FCY-1A and the experimental Type I from Lyondell, both had holdover times similar to fluids tested during the 1999-2000 winter test season.

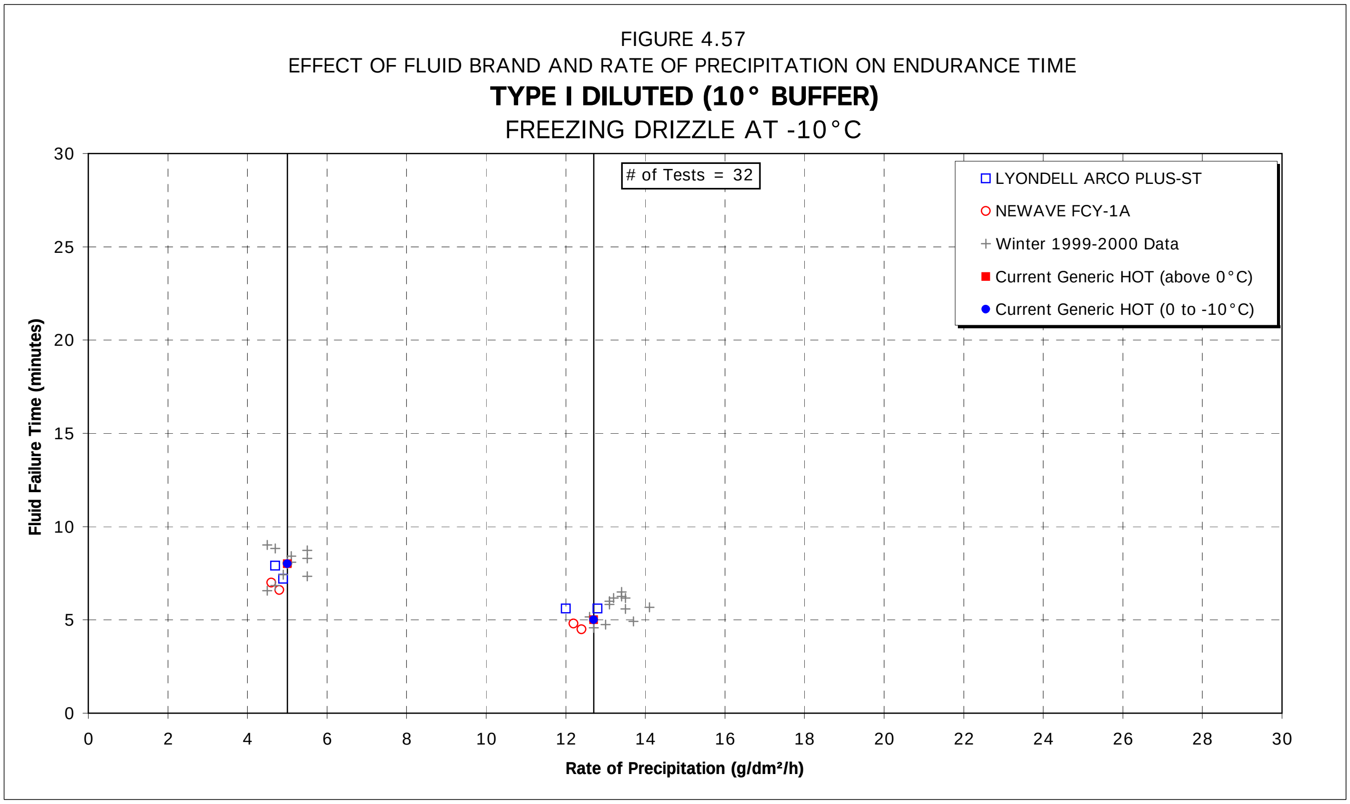


FIGURE 4.57
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE I DILUTED (10° BUFFER)
FREEZING DRIZZLE AT -10°C
# of Tests = 32
LYONDELL ARCO PLUS-ST
NEWAVE FCY-1A
Winter 1999-2000 Data
Current Generic HOT (above 0°C)
Current Generic HOT (0 to -10°C)
Fluid Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

4.4.2 Light Freezing Rain

The following is a cell-by-cell summary of the holdover time performance of the new Type I fluids tested under conditions of simulated light freezing rain. Because it was not possible to simulate freezing precipitation above 0°C, the holdover time results for the category of precipitation above 0°C are identical to those in the range of 0°C to -10°C.

4.4.2.1 Type I diluted fluid, above 0°C and 0ºC to -10°C, light freezing rain (Figure 4.58)

The generic holdover times of 2 to 5 minutes in these cells are appropriate, based on the results of the recent Type I tests. Both of the Type I fluids exhibit similar holdover times.

4.4.3 Freezing Fog

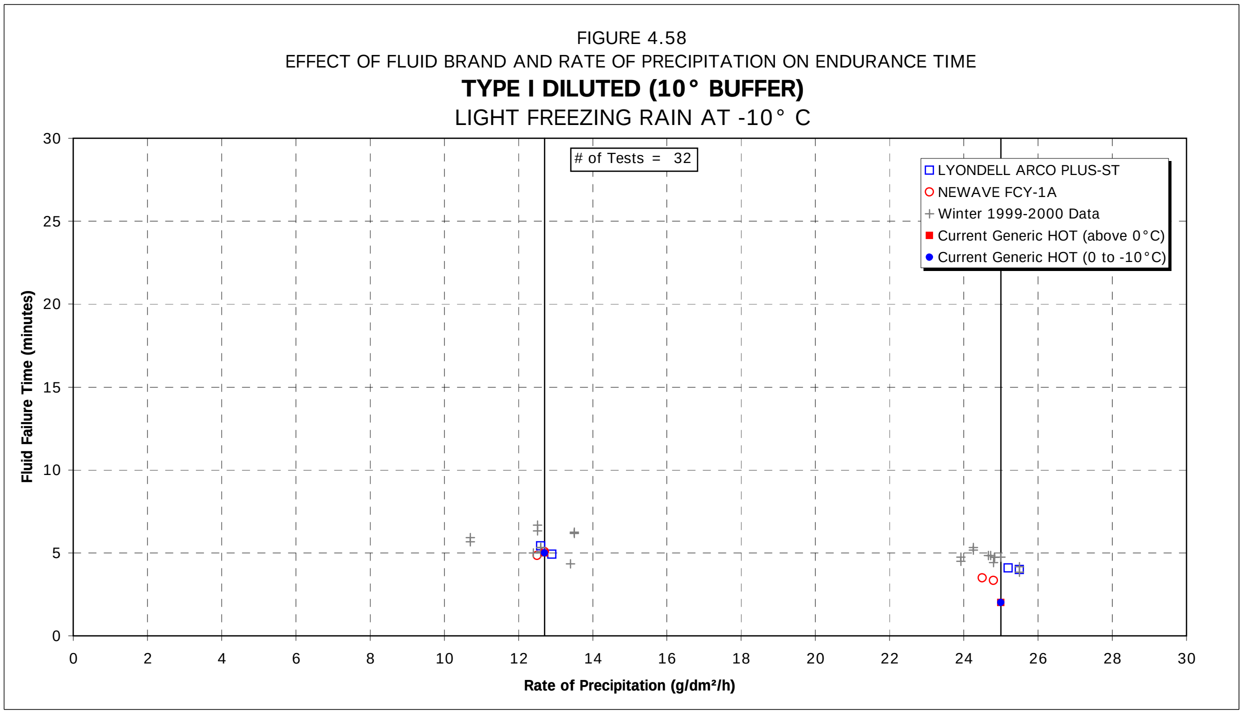
The freezing fog category is divided into three cells. The data were collected under precipitation rates of 2 and 5 g/dm^2/h. Failure times were measured at two temperatures: -10°C and -25°C. Although it was not possible to create freezing fog at temperatures above 0°C, the holdover times in the Type I holdover time tables differ in the two temperature ranges, above 0°C and 0°C to -10°C.

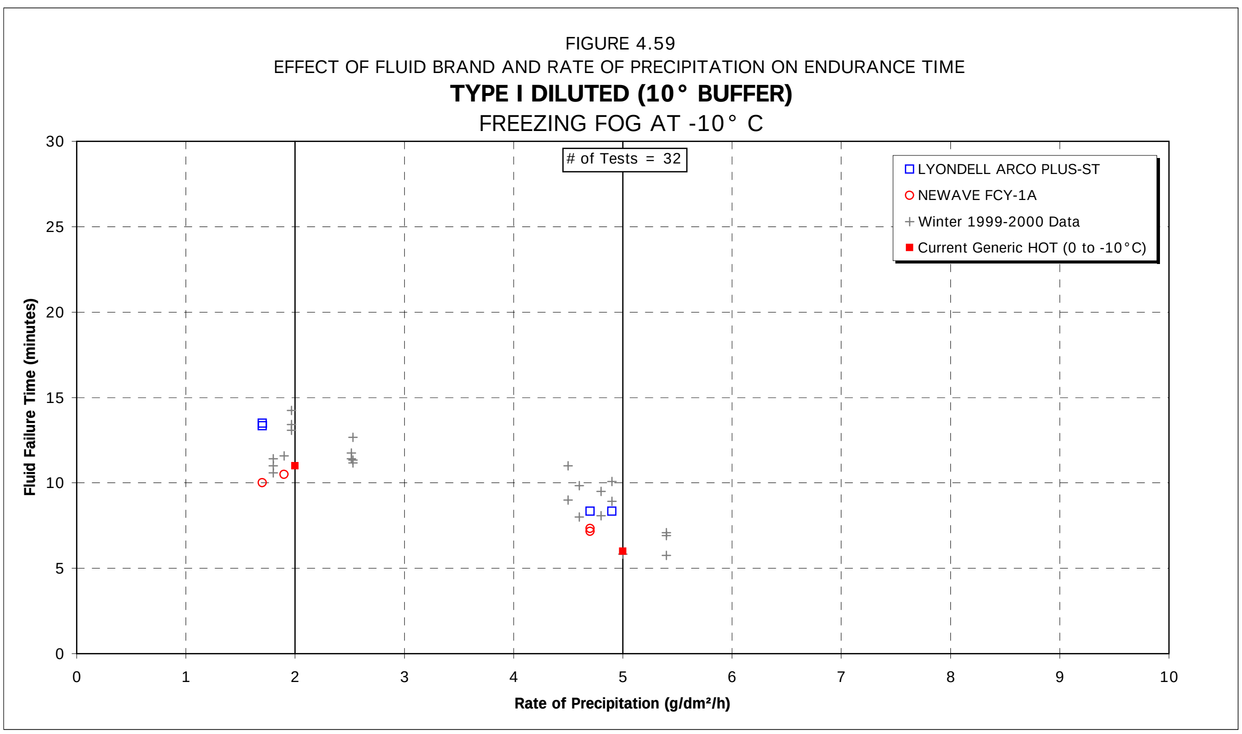
4.4.3.1 Type I diluted fluid, above 0°C, freezing fog

No testing was conducted during the past year in this temperature range, since it was not possible to generate freezing fog at temperatures above 0°C.

4.4.3.2 Type I diluted fluid, 0°C to -10°C, freezing fog (Figure 4.59)

At the SAE G-12 Holdover Time Subcommittee meeting in Toulouse, the holdover time range in this cell was reduced to 6 - 11 min, based on the results from testing in July 1999. All the fluids tested in April 2001 exhibited a holdover time performance in excess of the new generic values.





CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - Combined Charts
At: 10° chart

4.4.3.3 Type I diluted fluid, -25°C, freezing fog (Figure 4.60)

At the SAE G-12 Holdover Time Subcommittee meeting in Toulouse, the holdover time range in this cell was reduced to 6 – 9 min, based on the results from testing in July 1999.

Both fluids tested in April 2001 had endurance time performance similar to the generic values.

4.4.4 Rain on a Cold-Soaked Wing

The data used to evaluate the holdover times for this category of precipitation covered precipitation rates ranging from 5 $g/dm^2/h$ to 76 $g/dm^2/h$. This encompasses heavy drizzle (5 to 12.7 $g/dm^2/h$), light rain (12.7 to 25 $g/dm^2/h$), and moderate rain (25 to 76 $g/dm^2/h$). The box temperature prior to the start of testing was -10°C.

4.4.4.1 Type I diluted fluid, 1°C, rain on a cold-soaked wing (Figure 4.61)

The generic holdover time of 2 to 5 minutes in this cell is appropriate, based on the results of the recent Type I tests. All the new Type I fluids exhibit holdover times similar to the generic values.

4.4.5 Natural Snow

Natural snow tests were conducted at the Dorval Airport test site during the 2000-01 winter months. The results of these tests appear in Figure 4.62.

Regression analysis of the Type I data from testing in 1999-2000 in natural snow revealed that the holdover times using Type I in the snow cells of the current generic Type I Table were far superior to the results obtained in testing.

In Toulouse, the Type I snow data were presented to the SAE G-12 Holdover Time Subcommittee. AMIL had also conducted snow tests (simulated) with one Type I fluid, and the results of these tests were combined with values obtained by APS for the purpose of analysing the data set. The test data obtained by APS and AMIL showed that Type I holdover times for snow were as follows:

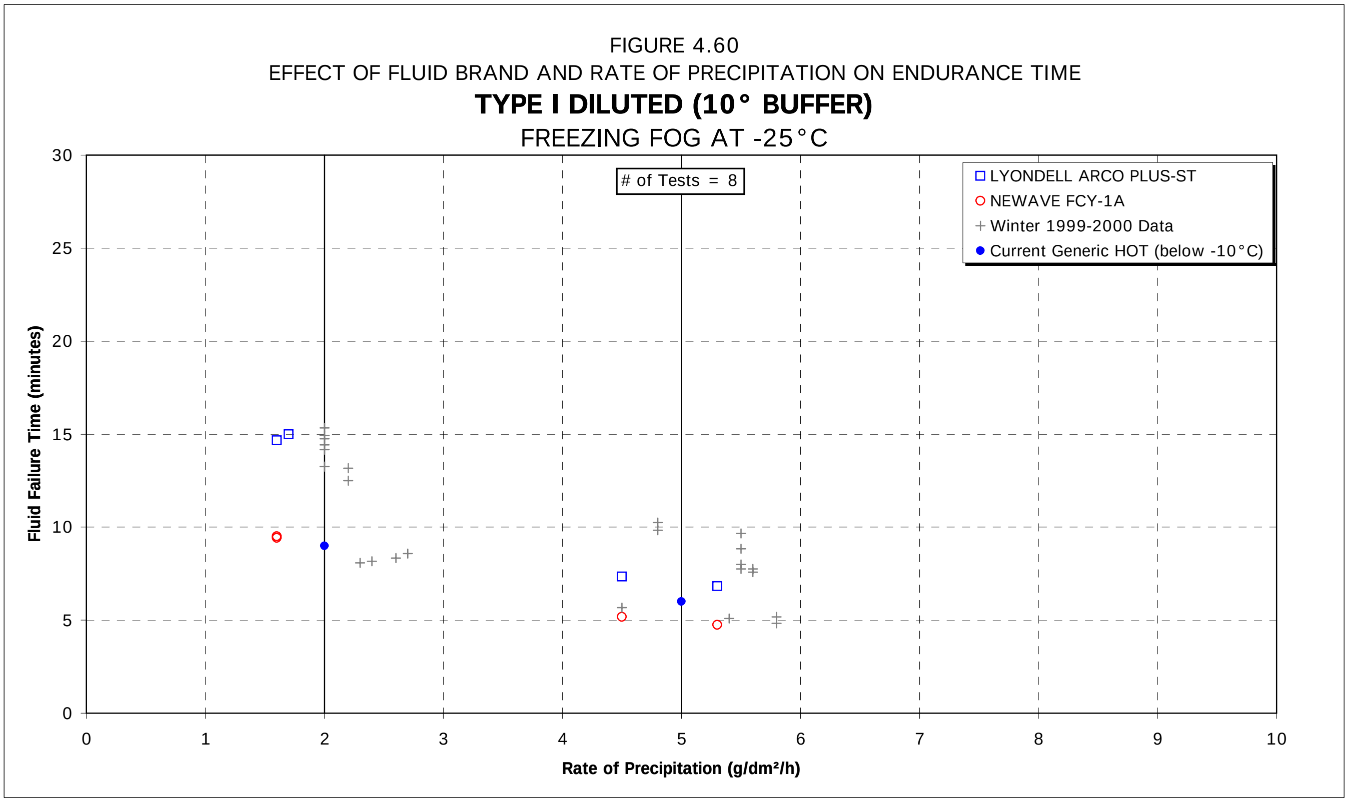


FIGURE 4.60
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE I DILUTED (10° BUFFER)
FREEZING FOG AT -25°C
# of Tests = 8
LYONDELL ARCO PLUS-ST
NEWAVE FCY-1A
Winter 1999-2000 Data
Current Generic HOT (below -10°C)
Fluid Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
9
10

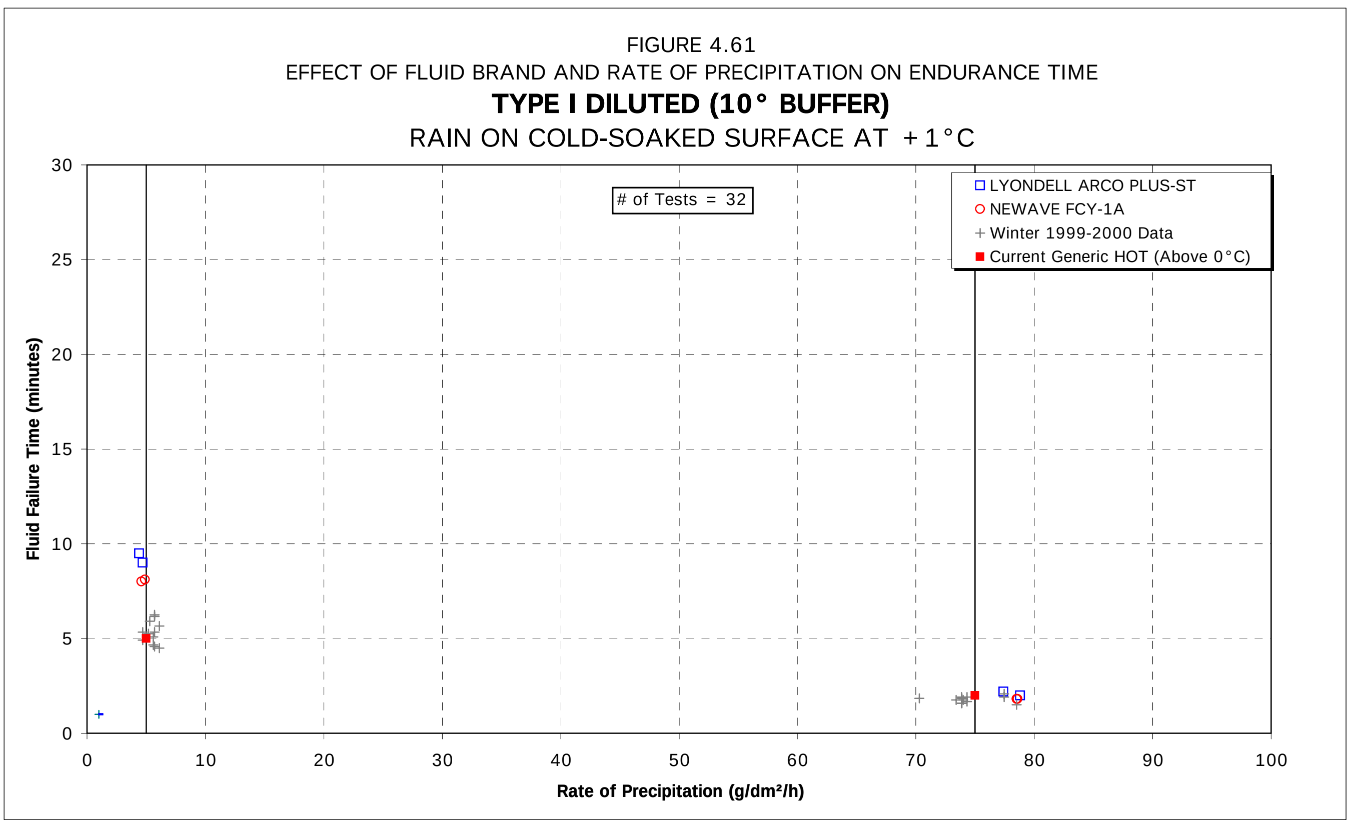
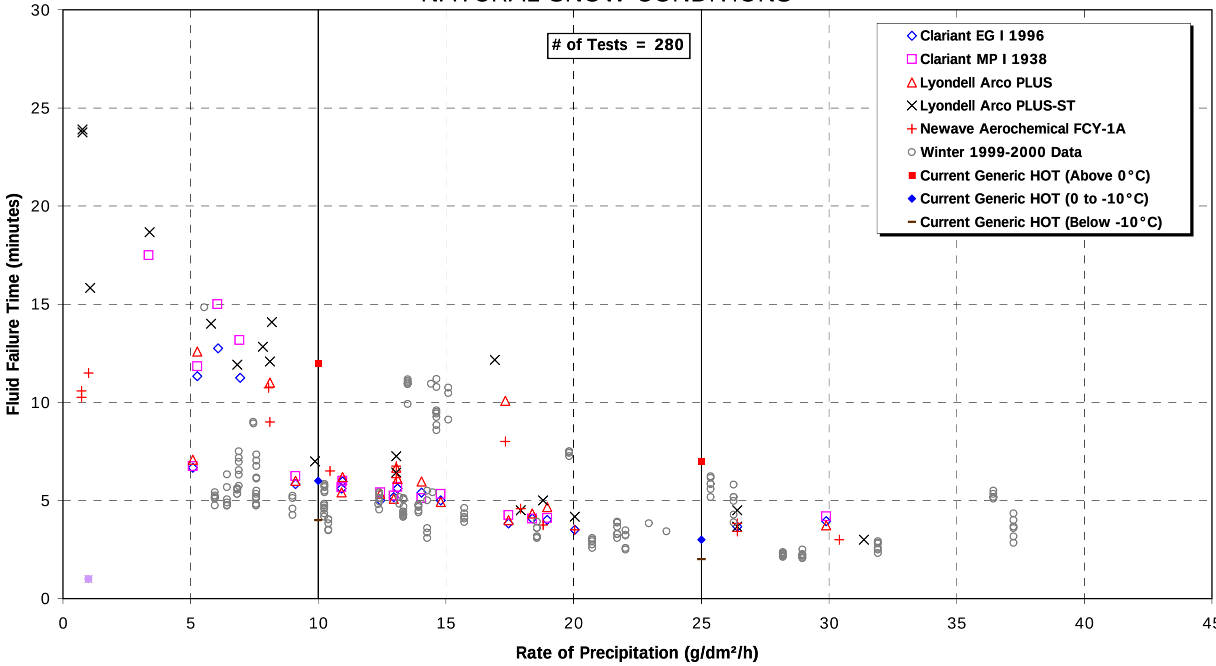


FIGURE 4.61
EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE I DILUTED (10° BUFFER)
RAIN ON COLD-SOAKED SURFACE AT +1°C
# of Tests = 32
LYONDELL ARCO PLUS-ST
NEWAVE FCY-1A
Winter 1999-2000 Data
Current Generic HOT (Above 0°C)
Fluid Failure Time (minutes)
Rate of Precipitation (g/dm²/h)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100

FIGURE 4.62
EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME
TYPE I (Diluted)
NATURAL SNOW CONDITIONS



CM1680(exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS (Type I only)
At: Sheet1

- 7 to 12 minutes for Type I above 0°C;
- 3 to 6 minutes for Type I between 0°C and -10°C; and
- 2 to 4 minutes for Type I fluid below -10°C.

After considerable discussion, it was decided that the new regression-generated holdover times for Type I fluid would be adopted in the various snow cells of the generic table, despite the fact that several members, including the co-chairs of the Holdover Time Subcommittee, were severely opposed to these changes. Because the holdover time of Type I fluid is influenced primarily by the heat of the fluid at application, many people believe that the new holdover times in the snow column are not indicative of real-life values.

In general, the endurance times of the Type I fluids tested in 2000-01 in natural snow conditions were similar to the results of 1999-2000 tests, which resulted in reductions to the snow column of the generic Type I table.

4.4.6 Overall Perspective on Type I Results

In general, the Type I endurance time results from 2000-01 tests agree with the current generic Type I holdover time guidelines and were approved by the SAE G-12 Holdover Time Subcommittee meeting in Toulouse in May 2000.

4.5 Type III Fluid

Type III fluid is a thickened anti-icing fluid that exhibits shear, flow, and anti-icing properties that lie between Type I and Type IV fluids. The fluid was designed specifically for use on aircraft with lower rotation speeds.

The earliest holdover time tests with a Type III fluid were carried out during the 1991-92 season (see Transport Canada report TP 11454E [12]). The next series of Type III fluid tests were conducted during the 1992-93 season and are documented in Transport Canada report TP 11836E [13]. These data are somewhat obsolete, as the fluid tested is no longer commercially available. The Type III fluid data cited in TP 11836E were combined with 75/25 Type IV fluid data and provided the basis for a proposed Type III fluid holdover time table. The first holdover time table for Type III fluid appeared in 1996 in Transport Canada report TP 12896E [8].

The latest Type III fluid test data were acquired during the 1996-97 test season using one fluid from one fluid manufacturer. The Type III fluid data were subject to the same regression method of analysis used to determine holdover times for Type IV fluids. The Type III fluid used in the 1996-97 holdover time tests has since been removed from the market.

No Type III fluids were available during the past test season and, therefore, no testing with Type III fluids was performed by APS. A Type III holdover time table does exist; however, no qualified Type III fluids are currently available. The values in the Type III table would need to be substantiated if new fluids become available.

4.6 Official Holdover Time Tables for 2001-02

The officially accepted generic holdover time tables for Type I, Type II, and Type IV fluids are presented in this section. These tables are proposed for use worldwide during the 2001-02 winter season.

The viscosity of the fluid sample used in holdover time testing, as measured by APS personnel, appears on the fluid-specific holdover time table for any given anti-icing fluid. The instrument spindle, chamber size, temperature, and rpm are documented with the viscosity measurement. For the fluid-specific values of a fluid to be valid, operators must ensure that the viscosity of the fluid used is superior to the published viscosity of that fluid, and use the same published viscosity measurement method.

Table 4.62 presents the accepted generic holdover time guidelines for Type I fluids and provides a summary of the material discussed in Subsection 4.4. Because it is believed that the holdover time of Type I fluid is influenced primarily by the heat of the fluid at application and the thermal mass of the receiving wing, the regulatory agencies contend that the new generic holdover times in the snow column are not indicative of real-life values. Table 4.62 displays the holdover time guidelines for Type I fluids published by Transport Canada for use in 2001-02 winter operations.

Table 4.64 presents the accepted holdover time table for generic Type II fluids and provides a summary of the material discussed in Subsection 4.3. The fluid-specific holdover time tables for Kilfrost ABC-II Plus, Clariant MP II 1951, and SPCA Ecowing 26 are given in Tables 4.65, 4.66, and 4.67, respectively.

There are eight Type IV fluid holdover time tables. The new generic Type IV fluid holdover time table is provided in Table 4.66. Tables 4.69 to 4.76 display the fluid-specific Type IV holdover time tables and correspond to Clariant Safewing MPIV 1957, Clariant Safewing MPIV 2001, Clariant Safewing Four, Clariant Safewing MP IV 2012 Protect, Kilfrost ABC-S, Octagon Max-Flight, SPCA AD-480, and Union Carbide Ultra+ fluids, respectively. These tables provide a summary of the material presented in Section 4.2.

The Transport Canada and FAA generic and fluid-specific holdover time guidelines are found in Appendices I and J. This section includes the same tables but in a format that facilitates viewing of the individual holdover time cells. This format contains only a small portion of the notes listed at the bottom of the tables intended for official use.

4.6.1 Methodology to Re-Categorize Fluid Holdover Time Tables

As new products are constantly being introduced into the market, the number of fluid-specific tables continues to increase. This has caused some concern in the industry. In addition, the generic fluid holdover time guidelines are annually changed to encompass the new fluids that are introduced into the market.

APS conducted a preliminary evaluation in 2001 aimed at providing a method that would reduce the number of holdover time guidelines that exist in the industry. This preliminary evaluation appears in Appendix L.

TABLE 4.62

GENERIC TYPE I FLUID HOLDOVER TIME GUIDELINES

For Use in 2001-02

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	*FROST	FREEZING FOG	SNOW ①	**FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER***
above 0°	above 32°	0:45	0:12-0:30	0:07-0:12	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	32 to 14	0:45	0:06-0:11	0:03-0:06	0:05-0:08	0:02-0:05		**CAUTION No holdover time guidelines exist**
below -10	below 14	0:45	0:06-0:09	0:02-0:04				

* During conditions that apply to aircraft protection for ACTIVE FROST.

** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

*** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.63

SAE TYPE I[5] FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002

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

OAT		**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**						
°C	**°F**	**FROST[2]**	**FREEZING FOG**	**SNOW**	**FREEZING DRIZZLE[3]**	**LIGHT FREEZING RAIN**	**RAIN ON COLD-SOAKED WING**	**OTHER[4]**
above 0	above 32	0:45	0:12-0:30	0:06-0:15[1] *0:07-0:12*	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	32 to 14	0:45	0:06-0:15[1] *0:06-0:11*	0:06-0:15[1] *0:03-0:16*	0:05-0:08	0:02-0:05	**CAUTION:**	
below -10	below 14	0:45	0:06-0:15[1] *0:06-0:09*	0:06-0:15[1] *0:02-0:04*	**No holdover time guidelines exist**			

° C = Degrees Celsius **OAT = Outside Air Temperature**

° F = Degrees Fahrenheit **FP = Freezing Point**

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gal./100 ft²) must be applied to deiced surfaces, OTHERWISE THE ITALICIZED TIMES MUST BE USED.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

4 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain and hail.

5 Type I Fluid / Water Mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.**

- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**

- **Fluids used during ground deicing do not provide ice protection during flight.**

TABLE 4.64

GENERIC TYPE II FLUID HOLDOVER TIME GUIDELINES

For Use in 2001-02

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0°	above 32°	100/0	12:00	0:35-1:30	0:20-0:55	0:30-0:55	0:15-0:30	0:05-0:40	CAUTION No holdover time guidelines exist
		75/25	6:00	0:25-1:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20-1:05	0:15-0:35	**0:15-0:45	**0:10-0:25		
		75/25	5:00	0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.65

"*FLUID-SPECIFIC* " TYPE II FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

KILFROST ABC-II PLUS

Viscosity of Neat 100% Fluid Tested 3 600 cP

20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, guard leg

OAT °C	OAT °F	Type II Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0º	above 32º	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15	CAUTION No holdover time guidelines exist	
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:35	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.66

"*FLUID-SPECIFIC* " TYPE II FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

CLARIANT SAFEWING MPII 1951

Viscosity of Neat 100% Fluid Tested 8 700 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	12:00	0:55-1:40	0:30-0:55	0:35-0:55	0:20-0:30	0:10-0:50	
		75/25	6:00	0:45-1:15	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:40	
		50/50	4:00	0:20-0:30	0:05-0:20	0:05-0:15	0:05-0:10		
0 to -3	32 to 27	**100/0**	8:00	0:55-1:40	0:25-0:45	0:35-0:55	0:20-0:30	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	0:45-1:15	0:15-0:35	0:25-0:45	0:15-0:25		
		50/50	3:00	0:20-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	8:00	0:45-1:25	0:20-0:40	**0:25-0:50	**0:15-0:30		
		75/25	5:00	0:35-1:00	0:15-0:25	**0:20-0:35	**0:15-0:20		
below -14 to -25	below 7 to -13	**100/0**	8:00	0:20-0:40	0:20-0:35				
below -25	below -13	**100/0**	SAE TYPE II fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.67
"*FLUID-SPECIFIC*" TYPE II FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

SPCA Ecowing 26

Viscosity of Neat 100% Fluid Tested 4 900 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0°	above 32°	**100/0**	12:00	1:25-2:35	0:40-1:05	0:50-1:35	0:40-0:50	0:20-1:25	**CAUTION No holdover time guidelines exist**
		75/25	6:00	1:05-1:55	0:30-0:50	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	4:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:10		
0 to -3	32 to 27	**100/0**	8:00	1:25-2:35	0:40-1:00	0:50-1:35	0:40-0:50		
		75/25	5:00	1:05-1:55	0:25-0:45	0:45-1:05	0:25-0:35		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	8:00	0:45-2:15	0:35-0:55	**0:30-1:10	**0:15-0:35		
		75/25	5:00	0:35-1:15	0:25-0:40	**0:20-0:50	**0:15-0:25		
below -14 to -25	below 7 to -13	**100/0**	8:00	0:25-0:45	0:30-0:50				
below -25	below -13	**100/0**	SAE TYPE II fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.68

GENERIC TYPE IV FLUID HOLDOVER TIME GUIDELINES

For Use in 2001-02

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
			Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
above 0º	above 32º	**100/0**	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:25-0:40	0:10-0:50	
		75/25	6:00	1:05-1:45	0:30-1:05	0:35-0:50	0:15-0:30	0:05-0:35	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
0 to -3	32 to 27	**100/0**	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:25-0:40	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	1:05-1:45	0:25-0:50	0:35-0:50	0:15-0:30		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:20-1:20	0:20-0:40	**0:20-0:45	**0:10-0:25		
		75/25	5:00	0:25-0:50	0:15-0:25	0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:15-0:40	0:15-0:30				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

TABLE 4.69

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

CLARIANT SAFEWING MPIV 1957

Viscosity of Neat 100% Fluid Tested 16 200 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	**CAUTION No holdover time guidelines exist**
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15		
0 to -3	32 to 27	**100/0**	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40		
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:45-1:30	0:30-0:50	**0:35-0:55	**0:20-0:35		
		75/25	5:00	0:25-1:10	0:20-0:40	**0:25-0:55	**0:15-0:30		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

cm1680\reports\holdover time\HOT tables (2001-02)
At:Clariant 1957

TABLE 4.70

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

CLARIANT SAFEWING MPIV 2001

Viscosity of Neat 100% Fluid Tested 18 000 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	1:20-3:20	1:55-2:00	0:55-1:55	0:40-1:00	0:15-2:00	CAUTION No holdover time guidelines exist
		75/25	6:00	1:20-2:00	0:50-1:25	0:35-1:10	0:25-0:35	0:10-1:25	
		50/50	4:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
0 to -3	32 to 27	100/0	12:00	1:20-3:20	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:20-2:00	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:35	0:30-0:50	**0:55-1:35	**0:30-0:45		
		75/25	5:00	0:30-1:00	0:20-0:35	**0:40-1:10	**0:20-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:35				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

TABLE 4.71

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

CLARIANT SAFEWING FOUR

Viscosity of Neat 100% Fluid Tested 6 400 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:50-2:45	0:45-1:45	1:05-1:45	0:50-1:05	0:10-1:20	
		75/25	6:00	1:45-2:25	0:40-1:25	0:50-1:30	0:30-0:45	0:15-1:25	
		50/50	4:00	0:30-0:45	0:15-0:25	0:15-0:25	0:10-0:15		
0 to -3	32 to 27	100/0	12:00	1:50-2:45	0:35-1:20	1:05-1:45	0:50-1:05	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	1:45-2:25	0:30-1:05	0:50-1:30	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:30-1:30	0:25-0:55	**0:25-1:05	**0:15-0:30		
		75/25	5:00	0:30-1:05	0:20-0:45	**0:20-0:50	**0:15-0:25		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.72

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-2002

CLARIANT SAFEWING MP IV PROTECT 2012

Viscosity of Neat 100% Fluid Tested 7 800 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	18:00	1:15-2:30	1:05-2:00	0:40-1:10	0:25-0:45	0:10-1:05	
		75/25	6:00	1:10-2:05	0:35-1:10	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	4:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10		
0 to -3	32 to 27	**100/0**	12:00	1:15-2:30	0:40-1:15	0:40-1:10	0:25-0:45	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	1:10-2:05	0:25-0:55	0:35-0:50	0:15-0:30		
		50/50	3:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:45-1:45	0:20-0:40	**0:25-0:45	**0:15-0:25		
		75/25	5:00	0:25-1:05	0:20-0:40	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:20-0:45	0:15-0:30				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

cm1680\reports\holdover time\fluid-specific table c2012
At:Clariant 2012

TABLE 4.73

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

KILFROST ABC-S

Viscosity of Fluid Tested 17 000 cP

20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, guard leg

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	**100/0**	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10		
0 to -3	32 to 27	**100/0**	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25	CAUTION No holdover time guidelines exist	
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:45-2:05	0:45-1:20	**0:20-1:00	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:25-0:50	**0:20-1:10	**0:10-0:35		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

TABLE 4.74

"*FLUID-SPECIFIC*" TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

OCTAGON MAX-FLIGHT

Viscosity of Neat 100% Fluid Tested 5 540 cP

20°C, 0.3 rpm, Spindle LV1, 600 mL beaker, 500 mL fluid, 33 min 20 sec, guard leg

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
			Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
above 0º	above 32º	**100/0**	18:00	2:40-4:00	1:15-2:00	0:55-2:00	0:35-1:00	0:15-1:15	
		75/25	6:00	2:05-3:15	1:20-2:00	1:15-2:00	0:35-1:10	0:10-0:40	
		50/50	4:00	0:55-1:45	0:40-1:20	0:35-1:00	0:15-0:30		
0 to -3	32 to 27	**100/0**	12:00	2:40-4:00	0:50-1:35	0:55-2:00	0:35-1:00	**CAUTION No holdover time guidelines exist**	
		75/25	5:00	2:05-3:15	0:45-1:45	1:15-2:00	0:35-1:10		
		50/50	3:00	0:55-1:45	0:25-1:15	0:35-1:00	0:15-0:30		
below -3 to -14	below 27 to 7	**100/0**	12:00	0:50-2:30	0:25-0:50	**0:25-1:10	**0:20-0:40		
		75/25	5:00	0:30-1:05	0:20-0:50	**0:20-1:00	**0:15-0:30		
below -14 to -25	below 7 to -13	**100/0**	12:00	0:20-0:45	0:20-0:40				
below -25	below -13	**100/0**	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

cm1680\report\HOT\fluid-specific table maxflight

TABLE 4.75

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

SPCA AD-480

Viscosity of Neat 100% Fluid Tested 15 200 cP

20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min

OAT		Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
°C	°F		*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	2:00-3:30	0:55-1:50	0:50-1:30	0:35-0:55	0:15-1:35	
		75/25	6:00	1:30-2:45	0:40-1:20	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	4:00	0:30-0:45	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55		
		75/25	5:00	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:30-0:55	**0:25-1:20	**0:15-0:30		
		75/25	5:00	0:25-0:50	0:20-0:45	**0:25-1:05	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:25-0:40				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

① Snow includes snow grains.

TABLE 4.76

"*FLUID-SPECIFIC* " TYPE IV FLUID HOLDOVER TIME GUIDELINES FOR 2001-02

DOW UCAR ULTRA+

Viscosity of Neat 100% Fluid Tested 36 000 cP

0°C, 0.3 rpm, Spindle SC4-31/13R, 10 mL fluid, 10 min

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
			*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD-SOAKED WING	OTHER****
above 0º	above 32º	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	CAUTION No holdover time guidelines exist
		75/25							
		50/50							
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	**0:45-1:25	**0:30-0:45		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40-2:10	0:20-0:45				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF), provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

* During conditions that apply to aircraft protection for ACTIVE FROST.

** The lowest use temperature is limited to -10ºC (14ºF).

*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

**** Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail

① Snow includes snow grains.

cm1680\reports\holdover time\HOT tables (2001-02)
At:Ultra+

5. SUPPLEMENTARY TESTS

In addition to tests performed to determine the holdover times for qualified fluids, APS conducted supplementary tests. The supplementary tests and their corresponding results are presented in this section. The twofold nature of these tests is as follows:

- The evaluation of the holdover time performance of Kilfrost Type IV ABC-S degraded viscosity fluid (Subsection 5.1) and

- A series of round-robin tests conducted at NRC observed differences in anti-icing fluid endurance times in natural and artificial snow. Tests were also performed in freezing drizzle and light freezing rain using common fluids to identify the differences in endurance times (Subsection 5.2).

5.1 Evaluation of the Holdover Time Performance of a Degraded Viscosity Sample of Kilfrost Type IV ABC-S

At the request of Kilfrost, APS was asked to conduct holdover time tests for a degraded viscosity sample of its Kilfrost ABC-S Type IV anti-icing fluid. The viscosity of the degraded fluid was 3 900 cP (20°C, 0.3 rpm, Spindle LV2, 150 mL beaker, 150 mL fluid, 10 minutes, guard leg), compared to 17 000 cP for the sample used to generate the fluid-specific holdover time table for Kilfrost ABC-S.

Testing was conducted in natural snow at Dorval Airport and in simulated conditions at NRC in Ottawa in March and April 2000. The results of these tests appear in TP 13659E [2].

Due to the late arrival of the fluid in 2000, all of the test data for the degraded ABC-S sample was collected between 0°C and -3°C. APS conducted additional testing with the degraded viscosity sample of ABC-S during the summer of 2000 using the prototype NCAR artificial snowmaking system. These results were presented to Kilfrost, and appear in TP 13659E [2].

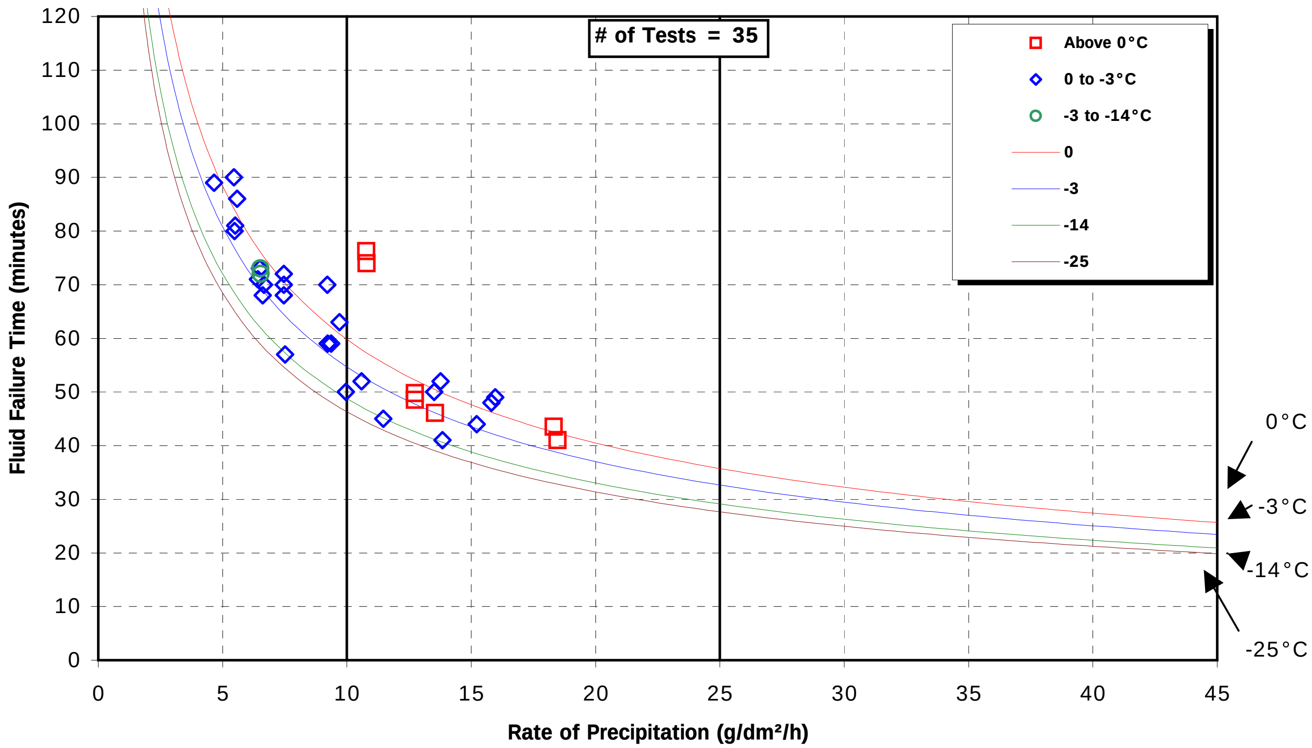
At Kilfrost's request, APS conducted additional testing with the ABC-S degraded sample in natural snow conditions above 0°C during the 2000-01 test season. In total, seven tests were conducted with the neat sample in natural snow conditions above 0°C. The results of 2000-01 tests were combined with results from tests conducted in 1999-2000 tests, and regression curves were drawn based on the combined data set. This information appears in Figure 5.1.

FIGURE 5.1

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

KILFROST ABS-S Deg. (NEAT)

NATURAL SNOW



CM1680(exBM3833)\Analysis\HOT\type IV\figure 5.1
At: Kilfrost ABC-S(Deg.)-Neat

5.2 Results of Round-Robin Testing Using Certified Type IV Fluids in Freezing Drizzle and Light Freezing Rain

Tests conducted by APS have provided holdover time guidelines to pilots and operators for several years. There is great concern in the industry that endurance times generated by the test procedures in the Proposed AS 5485 would not produce equivalent fluid endurance times.

As part of the 2000-01 test program, APS, AMIL, and NCAR laboratories, in a series of round-robin tests, attempted to examine and reconcile differences in anti-icing fluid endurance times in natural and artificial snow (see TP 13828E [14]). It was also proposed that APS and AMIL conduct tests in freezing drizzle and light freezing rain using common fluids to identify the differences in endurance times.

One ethylene glycol-based Type IV fluid and two propylene glycol-based Type IV fluids were tested in natural snow as part of the snow reconciliation test program. To ensure that all laboratories tested fluid of the same viscosity, test samples were delivered from the fluid manufacturers to the test facilities from the same production batches. The same fluids were used in freezing drizzle and light freezing rain tests.

The following fluids and dilutions were tested in 2000-01 round-robin testing:

- UCAR Ultra+ neat, viscosity 36 000 cP;
- Kilfrost ABC-S neat, viscosity 26 300 cP;
- Kilfrost ABC-S 75/25 fluid/water concentration, viscosity 23 200 cP;
- Kilfrost ABC-S 50/50 fluid/water concentration, viscosity 1 900 cP;
- SPCA AD-480 neat, viscosity 15 200 cP;
- SPCA AD-480 75/25 fluid/water concentration, viscosity 16 200 cP; and
- SPCA AD-480 50/50 fluid/water concentration, viscosity 7 000 cP;

APS personnel measured all Type IV fluid viscosities using the methods specified for each fluid by the respective fluid manufacturer. The manufacturer-specified methods for viscosity measurement are described in the 1999-2000 Transport Canada report, TP 13659E [2].

Round-robin tests were conducted in the following conditions at NRC in Ottawa using standard APS test procedures:

- Light freezing rain, -10°C, precipitation rate of 25 g/dm^2/h; and
- Freezing drizzle, -3°C, precipitation rate of 13 g/dm^2/h.

The results of the round-robin tests in light freezing rain and freezing drizzle appear in the test log in Table 5.1.

TABLE 5.1
ROUND-ROBIN TESTING

SIMULATED FREEZING PRECIPITATION AT NRC-CEF (2000-01)

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution (%)	Fluid Type	Fail Time (min)	Estimated Rate (g/dm²/hr)	Actual Rate of Precip (g/dm²/hr)	Ambient Temp (°C)	Precipitation (Type)
159	1	27-Mar-01	14:24:45	16:23:00	Kilfrost ABC-S	100	4	118.3	13	12.7	-3	Freezing Drizzle
160	2	27-Mar-01	15:56:30	17:53:00	Kilfrost ABC-S	100	4	116.5	13	12.6	-3	Freezing Drizzle
162	2	27-Mar-01	16:32:00	17:26:00	Kilfrost ABC-S	75	4b	54.0	13	12.9	-3	Freezing Drizzle
161	2	27-Mar-01	15:57:30	16:53:00	Kilfrost ABC-S	75	4b	55.5	13	12.7	-3	Freezing Drizzle
164	4	27-Mar-01	17:56:30	18:07:30	Kilfrost ABC-S	50	4a	11.0	13	12.8	-3	Freezing Drizzle
163	4	27-Mar-01	17:48:00	17:58:30	Kilfrost ABC-S	50	4a	10.5	13	12.6	-3	Freezing Drizzle
154	1	27-Mar-01	14:51:00	15:57:00	SPCA AD-480	100	4	66.0	13	13.1	-3	Freezing Drizzle
153	1	27-Mar-01	14:23:00	15:21:00	SPCA AD-480	100	4	58.0	13	12.3	-3	Freezing Drizzle
155	3	27-Mar-01	16:39:00	17:20:00	SPCA AD-480	75	4b	41.0	13	12.9	-3	Freezing Drizzle
156	3	27-Mar-01	16:52:00	17:37:00	SPCA AD-480	75	4b	45.0	13	12.7	-3	Freezing Drizzle
157	4	27-Mar-01	17:47:15	18:01:55	SPCA AD-480	50	4a	14.7	13	11.6	-3	Freezing Drizzle
158	4	27-Mar-01	18:00:15	18:13:15	SPCA AD-480	50	4a	13.0	13	11.9	-3	Freezing Drizzle
151	1	27-Mar-01	14:15:00	15:09	UCAR Ultra +	100	4	54.0	13	12.1	-3	Freezing Drizzle
152	3	27-Mar-01	16:46:00	17:36:00	UCAR Ultra +	100	4	50.0	13	13.1	-3	Freezing Drizzle
73	7	5-Jun-01	13:37:00	13:54:00	Kilfrost ABC-S	100	4	17.0	25	25.3	-10	Light Freezing Rain
74	7	5-Jun-01	14:03:00	14:19:45	Kilfrost ABC-S	100	4	16.8	25	25.6	-10	Light Freezing Rain
99	2	3-Apr-01	12:00:00	12:08:00	Kilfrost ABC-S	75	4b	8.0	25	24.8	-10	Light Freezing Rain
100	3	3-Apr-01	12:31:30	12:40:15	Kilfrost ABC-S	75	4b	8.8	25	24.2	-10	Light Freezing Rain
93	1	3-Apr-01	11:16:20	11:29:30	SPCA AD-480	100	4	13.2	25	24.6	-10	Light Freezing Rain
94	2	3-Apr-01	11:50:45	12:02:45	SPCA AD-480	100	4	12.0	25	24.4	-10	Light Freezing Rain
76	7	5-Jun-01	14:08:00	14:23:00	SPCA AD-480	75	4b	15.0	25	25.8	-10	Light Freezing Rain
75	7	5-Jun-01	13:33:30	13:48:00	SPCA AD-480	75	4b	14.5	25	25.4	-10	Light Freezing Rain
91	1	3-Apr-01	11:15:30	11:47:30	UCAR Ultra +	100	4	32.0	25	24.9	-10	Light Freezing Rain
92	2	3-Apr-01	11:51:30	12:26:00	UCAR Ultra +	100	4	34.5	25	24.1	-10	Light Freezing Rain

The results of APS endurance time tests in the two test conditions were to be compared with tests conducted by AMIL in its facility in Chicoutimi. The latter tests were never performed.

This page intentionally left blank

6. CONCLUSIONS

Generic holdover time guidelines are no longer endorsed and published by the SAE. For the upcoming winter operations season (2001-02), all generic and fluid-specific tables will be published by Transport Canada and the U.S. Federal Aviation Administration.

6.1 Type IV Fluids

The 2000-01 holdover time test program was developed in part to determine the holdover times for one new Type IV fluid (Clariant Safewing MPIV 2012 Protect), and to re-test one certified Type IV fluid (Octagon Max-Flight). Two additional Type IV fluids, one from Clariant and another from UCAR/Dow, were delivered for testing, although neither of these fluids will be manufactured for use in 2001-02.

The fluid viscosities of the Clariant Safewing MPIV 2012 Protect and Octagon Max-Flight were selected by the fluid manufacturers based on the sample selection procedures agreed upon at the SAE meeting in Toronto in 1999.

The results of Type IV endurance time tests revealed a wide variation in performance properties among the different fluid brands. In the determination of fluid holdover times, the data for each fluid and each cell of the tables were subjected to a regression analysis. From the results of the analyses, the generic Type IV fluid holdover time guidelines were devised. Each cell of the table contains the holdover times of the poorest performing fluid brand(s). Due to the wide variation in performance of the Type IV fluids tested, fluid-specific holdover time tables were developed. All categories of precipitation, with the exception of frost, were selected to take advantage of enhanced holdover times for individual fluids.

6.1.1 Snow

No reductions were made to the snow column of the generic Type IV holdover time tables based on the results of tests conducted in 2000-01.

Four holdover times in snow were increased following the 2001 SAE G-12 Holdover Time Subcommittee meeting in New Orleans, as a result of the elimination of Hoechst 1957 and diluted UCAR/Dow Ultra+ test data. Both the upper and lower holdover time limits for 75/25 fluid in two cells, above 0°C and 0°C to -3°C, were increased.

6.1.2 Freezing Drizzle

Several reductions and increases have been made to the freezing drizzle column of the generic Type IV holdover time table. The five reductions, which range from 5 to 20 minutes, were a result of tests conducted during the 2000-01 test season with Clariant Safewing MPIV Protect 2012 fluid. In addition to the five reductions, four increases were made to the freezing drizzle column of the generic Type IV holdover time table. The removal of obsolete test data from 1996-97 testing resulted in two 5-minute and two 10-minute increases to the generic numbers.

6.1.3 Light Freezing Rain

Two changes were made to the light freezing rain column of the generic Type IV holdover time table. The upper holdover time limits in the -3°C to -10°C cells for neat and 75/25 fluids were reduced by five minutes.

6.1.4 Freezing Fog

No changes were made to the freezing fog column of the generic Type IV fluid holdover time table for the upcoming year.

6.1.5 Rain on a Cold-Soaked Wing

No changes were made to the generic holdover times in the rain on a cold-soaked wing condition.

6.2 Type II Fluids

One Type II fluid, SPCA Ecowing 26, was tested extensively in all conditions during the 2000-01 winter season, and a fluid-specific holdover time table for this fluid was generated.

6.2.1 Natural Snow

No changes were made to the generic Type II table as a result of tests conducted in 2000-01 with the SPCA Ecowing 26 product.

6.2.2 Freezing Drizzle

No changes were made to the generic Type II table as a result of tests conducted in 2000-01 with the SPCA Ecowing 26 product.

6.2.3 Light Freezing Rain

One change was made to the generic Type II table as a result of tests conducted in 2000-01 with Type IV fluid. In the -3°C to -10°C cell for neat Type II fluid, the upper generic value was reduced by 5 minutes to match a reduction in the corresponding cell of the Type IV table.

6.2.4 Freezing Fog

No changes were made to the generic Type II table as a result of tests conducted in 2000-01 with the SPCA Ecowing 26 product.

6.2.5 Rain on a Cold-Soaked Wing

No changes were made to the generic Type II table as a result of tests conducted in 2000-01 with the SPCA Ecowing 26 product.

6.3 Type I Fluids

In general, the Type I holdover time results from tests conducted in 2000-01 agreed with the reduced generic Type I holdover time guidelines, and no changes were made to the generic Type I table.

6.4 Type III Fluids

No Type III fluids were available during the past season; therefore, no Type III tests were performed. A Type III holdover time table exists; however, the values need to be substantiated since the table was generated using a fluid that is no longer commercially available.

6.5 Supplementary Tests

Natural snow testing was conducted with a degraded viscosity sample of Kilfrost ABC-S in natural snow conditions above 0°C during the 2000-01 test season. The results of 2000-01 tests were combined with 1999-2000 tests, and regression curves were drawn based on the combined data set.

APS also conducted round-robin testing in light freezing rain and freezing drizzle during the past test season. The results of APS endurance time tests in the two test conditions were to be compared with tests conducted by AMIL in their facility in Chicoutimi. The latter tests were never performed.

7. RECOMMENDATIONS

Based on past test results and conclusions, it is recommended that:

- Any new Type I, Type II or Type IV fluids be evaluated over the entire range of conditions of the holdover time tables;
- The holdover time table for Type III fluids be re-evaluated if new Type III fluids become available for testing in the 2001-02 test season;
- Type II fluid-specific tables be generated for previously certified Type II fluids; and
- A new endurance time test procedure aimed at simulating a real-world Type I application to a wing be developed for Type I fluids.

This page intentionally left blank.

REFERENCES

1. Society of Automotive Engineers (SAE) Proposed Aerospace Standard AS 5485, *Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids: SAE Type I, II, III, and IV,* October 2000 (unpublished).

2. Chaput, M., Hanna, M., Hunt, M., *Aircraft Ground De/Anti-icing Fluid Holdover Time and Endurance Time Testing Program for the 1999-2000 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2000, TP 13659E (to be published).

3. Alwaid, A., *Endurance Time Tests in Simulated Frost Conditions*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2001, TP 13831E (to be published).

4. *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (see page 17 of report).

5. American Meteorological Society, *Glossary of Meteorology WSDH #7 Manual of Surface Weather Observations* (MANOBS).

6. *NCAR & TDC Snow Visibility Chart Reference* (see page 19 of report).

7. www.tc.gc.ca/tdc/

8. D'Avirro, J., *Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1995-1996 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 1996, TP 12896E, 172.

9. Moc, N., *Winter Weather Data Evaluation (1995-2001)*, APS Aviation Inc., Transportation Development Centre, Montreal, September 2001, TP 13830E (to be published).

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

11. D’Avirro, J., Peters, A., Hanna, M., Dawson, P., Chaput, M., *Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1996/97 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 1997, TP 13131E, 232.

12. D'Avirro, J., Foo, H., Guy, C., Hoppe, A., McConachie, E., Spicer, S., *Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1991-1992 Winter*, Aviation Planning Services Ltd., Transportation Development Centre, Montreal, August 1992, TP 11454E, 83.

13. Bilgen, E., Chan, G., Cleary, C., D'Avirro, J., Foo, H., *Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1992-1993 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, October 1993, TP 11836E, 122.

14. Chaput, M., Campbell, R., *Endurance Time Testing in Snow: Reconciliation of Indoor and Outdoor Snow Data*, APS Aviation Inc., Transportation Development Centre, Montreal, October 2001, TP 13828E (to be published).

15. Myers, Barry B., *Aircraft Anti-Icing Fluid Endurance, Holdover, and Failure Times Under Winter Precipitation Conditions: A Glossary of Terms*, Transportation Development Centre, Montreal, November 2001, TP 13832.

APPENDIX A

EXCERPT FROM THE TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT 2000-01

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE

WORK STATEMENT
DC 187
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING
2000-2001
(January 2001)

5.1 Holdover Time Testing

5.1.1 Holdover Time Testing and Evaluation of De/Anti-Icing Fluids for SAE

5.1.1.1 **Natural Snow Tests at Dorval**

5.1.1.1.1 The contractor shall prepare a test procedure.

5.1.1.1.2 Conduct flat plate tests under conditions of natural snow at the Dorval Airport test site to record fluid holdover times. All testing will be performed using the methodology developed in the conduct of similar tests for Transport Canada in past years.

5.1.1.1.3 Develop individual fluid holdover times for snow, based on samples of newly certified or re-certified Type I, Type II, Type III and Type IV fluids supplied by fluid manufacturers, under as wide a range of temperature, precipitation rate, precipitation type, and wind conditions as can be experienced. Testing is anticipated for two new Type IV fluids, two Type II fluids, as well as one Type I fluid.

5.1.1.1.4 Analyze the data collected and report the findings.

5.1.1.2 **Holdover Time Tests in Simulated Precipitation at NRC**

5.1.1.2.1 Prepare a test procedure for the conduct of holdover time tests in simulated precipitation at NRC.

5.1.1.2.2 Conduct flat plate tests under conditions of freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface at the National Research Council Climatic Engineering Facility in Ottawa to record fluid holdover times. All testing will be performed using the methodology developed in the conduct of similar tests for Transport Canada in past years.

5.1.1.2.3 Develop individual fluid holdover times for all simulated precipitation conditions, based on samples of newly certified or re-certified fluids supplied by fluid manufacturers, under defined test parameters, such as temperature and precipitation rate. Two Type IV fluids, two Type II fluids, as well as one Type I fluid are anticipated for testing.

5.1.1.2.4 Analyze the data collected and report the findings.

5.1.2 Testing in Natural Snow for Comparison with Simulated Snow Tests

5.1.2.1 Prepare a test procedure for the conduct of Type I holdover time tests in natural precipitation.

5.1.2.2 Conduct further testing in natural snow conditions, using the same fluids as tested in simulated conditions during the last test season in order to compare the holdover times in natural and simulated conditions using the NCAR artificial snow generation system.

5.1.2.3 Re-evaluate Type I holdover times in natural snow with the new fluids using both the current test method and the newly proposed Type I fluid test protocol.

5.1.2.4 Conduct all holdover time trials in natural snow with Type I fluids at the Dorval test site at the same time as tests with new fluids to reduce costs.

5.1.2.5 Analyze the data collected and report the findings.

5.1.3 Holdover Time Testing in Simulated Frost at IREQ

The need to carry out frost testing has been expressed by several members of the SAE G-12 Holdover Time Subcommittee. During the 1999-2000 winter test season, APS conducted preliminary calibration tests in simulated frost conditions at the Institut de Recherche d'Hydro-Québec (IREQ) cold chamber in Varennes. Results of the calibration trials revealed that frost was producible at IREQ, and that the rates of deposition obtained at two temperatures (-3°C and -25°C) were similar to those proposed for use in future endurance time trials in simulated frost. Endurance time tests were conducted as part of these calibration trials with selected fluids, and in some cases, the endurance times obtained were significantly below the numbers approved for use in the various SAE holdover time tables.

5.1.3 1 Prepare a test procedure for the conduct of frost calibration and frost holdover time tests in simulated frost conditions.

5.1.3.2 Conduct additional frost calibration trials to fully determine the exact parameters required to perform holdover time tests in all the frost conditions. Trials will be performed to create a set of rate correction curves to relate the decreasing frost rate obtained on a bare surface during a long test, to the actual frost rate on the fluid covered surface. The required parameters will be identified and all the calibration trials will be performed as part of this set of trials. It is anticipated that two days of calibration is required at each of the five test temperatures, 0°C, -3°C, -10°C, -14°C, and -25°C, for a total of ten days.

5.1.3.3 Conduct holdover time testing in frost conditions at IREQ as part of the winter holdover time test program. Individual fluid holdover times for frost based on samples of newly certified or re-certified fluids supplied by the fluid manufacturers, will be obtained under defined test parameters, such as temperature, frost deposition rate, and relative humidity. Testing shall be conducted over a ten-day period at IREQ with three anti-icing fluids and two deicing fluids.

5.1.3.4 Analyze the data collected and report the findings.

5.1.4 Round Robin Holdover Time Testing

Tests conducted by TDC have provided holdover time guidelines to pilots and operators for several years. Round Robin testing of Type IV fluid must be performed to reconcile the differences in anti-icing fluid failure times in natural and simulated snow. Results of recent TDC holdover time tests using the NCAR artificial snow generation system indicate that the failure times for several Type IV fluids were up to 50% shorter than the times obtained from natural snow trials. Furthermore, the results of APS tests in natural and simulated snow are not in accordance with results obtained using AMIL’s artificial snow method. In addition, APS and AMIL shall carry out testing under conditions of freezing rain and drizzle.

In 1998-99, a reference fluid (Fluid X) was proposed by the SAE to allow a comparison of different laboratory snowmaking methods. Unfortunately, the viscosity of Fluid X was found to be unstable, and use of the fluid was discontinued.

At the SAE G-12 Fluids Subcommittee meeting in Toulouse, it was proposed that certified fluids be used in the future to compare natural and simulated snow test data obtained from various sources.

5.1.4.1 Prepare a test procedure for the conduct of round-robin testing in snow and also for freezing rain and freezing drizzle.

5.1.4.2 Conduct natural snow tests in conjunction with outdoor testing of new fluids. Simulated snow testing will be completed using the NCAR system at one of several climatic chambers, including NRC, PMG Technologies, Centre du Recherche Industrielle du Québec (CRIQ) or IREQ. A total of 10 days of climatic chamber use will be planned for these trials. It is anticipated that tests will be conducted with three Type IV fluids (one ethylene and two propylene) of the same batch to obtain similar results in natural snow and using both artificial snow methods.

5.1.4.3 Collect a minimum of 20 data points per fluid dilution in natural snow under the widest possible range of temperatures, precipitation rates, precipitation types, and wind conditions.

5.1.4.4 Conduct a minimum of two tests in simulated snow for each fluid dilution, at each of the snow rate limits, for each cell of the snow column.

5.1.4.5 Travel to AMIL on two occasions during natural snow events to aid AMIL personnel in the determination of fluid failures in order to minimize the impact of the fluid failure call variable.

5.1.4.6 Conduct round robin testing in other simulated conditions covered by the various holdover time tables.

5.1.4.7 Aanalyze the data collected and report the findings.

5.1.5 Evaluation of the IREQ Chamber for Freezing Fog Holdover Time Testing

Aircraft de/anti-icing fluid holdover time testing in freezing fog has been conducted by APS at the National Research Council's Climatic Engineering Facility in Ottawa for several years. While the NRC facility has yielded good results for trials involving freezing fog, the daily calibration required for the conduct of tests in freezing fog is often excessive.

During the 1999-2000 test season, APS conducted preliminary calibration tests at the IREQ facility in Varennes. The results of these trials indicated that freezing fog could be produced at the facility, but several changes would need to be made to the current set-up in order to produce freezing fog with precipitation rates and rate distributions in the range required by the proposed Aerospace Standard 5485.

5.1.5.1 Establish the costs of conducting freezing fog holdover time testing at IREQ vs. NRC, and identify the benefits of such testing. Discus with IREQ their capabilities and charges..

5.1.5.2 Prepare a test procedure for the conduct of freezing fog testing at IREQ.

5.1.5.3 Obtain the approval of Transport Canada to conduct the freezing fog tests

5.1.5.4 Conduct the freezing fog tests at IREQ.

5.1.5.5 Analyze the data collected and report the findings.

5.1.6 Evaluation of Winter Weather Data

A study of the snow weather data has been undertaken since 1995 to ascertain the suitability of the precipitation rate ranges used for fluid holdover time evaluation in snow. Winter weather data will be collected and examined from Environment Canada for six weather stations within Quebec (Dorval, Quebec City, Rouyn, Pointe-au-Père, Frelighsburg, and High Falls).

During the 1999-2000 test season, APS collected one fog deposition measurement in an attempt to determine typical fog deposition rates that occur in natural conditions. The observed rate of fog deposition was below the current lower precipitation rate used in the evaluation of fluid holdover times in this condition.

5.1.6.1 Snow Rates

5.1.6.1.1 Examine the precipitation rate/temperature data from the different stations to determine the variance of the data in warmer and colder regions.

5.1.6.1.2 Examine the various temperature ranges used to establish holdover times to determine the frequency of precipitation that occurs within each temperature range.

5.1.6.1.3 Analyze the data collected and report the findings.

5.1.6.2 Fog Deposition Rates

5.1.6.2.1 Prepare a procedure for the collection of fog deposition rates in natural fog conditions.

5.1.6.2.2 Collect fog deposition measurements on at least two occasions.

5.1.6.2.3 Analyze the data collected and report the findings.

5.1.7 Documentation of Fluid Failure Characteristics

The objective of this study will be to document the appearance and properties of anti-icing fluids when they reach their operational limits.

Laboratory trials were conducted in past years under controlled conditions of ambient temperature and artificial precipitation; and natural snow trials were conducted in conditions selected for the desired precipitation rates and ambient air temperature. Documentation included photographic and videotape records, visual description, readings from various ice detection sensors, and measurements of physical characteristics such as adherence, viscosity, fluid concentration, and film thickness

5.1.7.1 Prepare a procedure for the conduct of trials to document the appearance of fluid failure characteristics.

5.1.7.2 Conduct trials outdoors during holdover time snow testing to collect missing data at temperatures of 0ºC to -5ºC. It is anticipated that one session will be sufficient to collect the information.

5.1.7.3 Analyze the data collected and report the findings.

APPENDIX B

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
WINTER 2000-01

BM3833

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING

Winter 2000/2001

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Michael Chaput

Reviewed by: John D'Avirro

APS AVIATION INC.

November 9, 2000
Version 1.0

EXPERIMENTAL PROGRAM FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
2000/2001

This document provides the detailed procedures and equipment required for the conduct of natural precipitation flat plate tests at Dorval for the 2000/2001 winter season.

1. OBJECTIVE

To conduct tests on standard flat plates to validate the current holdover time tables and develop holdover time tables for new fluids.

2. TEST REQUIREMENTS (PLAN)

Table B-1 provides the test plan for fluid types to be tested at the Dorval test site located adjacent to the Atmospheric Environment Services. These tests shall be conducted during natural snow conditions.

3. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group. This equipment is listed in Attachment B-I.

4. PERSONNEL

The following personnel are required for the conduct of tests. The responsibility for each tester is provided in Attachment B-II.

For one stand	For two stands
1 x Test site Leader/video	1 x Test site leader/video
1 x End condition tester	2 x End condition tester
1 x Meteo tester	2 x Meteo tester

5. PROCEDURE

The modified test procedure is included in Attachment B-I. This procedure was developed several years ago and has been modified over the years to incorporate discussions at the SAE working group meetings. Attachment B-III contains a brief summary of the steps required to conduct a test.

6. DATA FORMS

The data forms are included at the end of this document. One data form was developed for the end-condition tester (Table B-3) and one data form for the Meteo/Video tester (Table B-4).

Table B-1

NATURAL SNOW PRECIPITATION TEST PLAN

NEW FLUIDS

Temperature Range	Type IV/II Neat	Type IV/II 75/25	Type IV/II 50/50	Type III	Type I Diluted
>0ºC	YES	YES	YES	YES	YES
0 to -3ºC	YES	YES	YES	YES	YES
-3 to -14ºC	YES	YES	NO	YES	YES
-14 to -25ºC	YES	NO	NO	NO	YES
below -25ºC	YES	NO	NO	NO	YES

This page intentionally left blank.

ATTACHMENT B-I

FLAT PLATE FIELD TEST EQUIPMENT AND PROCEDURE

2000/2001

This field test procedure has been developed by the SAE G-12 Holdover Time Subcommittee working group on aircraft ground de/anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests, which is aimed at substantiating the holdover time table entries for freezing point depressant fluids known as de/anti-icing fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant fluids provide protection to test panels during inclement weather such as freezing rain or snow.

2. EQUIPMENT

Environment Canada's READAC (Automated Weather Station) is located within 50 metres of the Dorval test stands. Data from this station will be acquired on a one minute basis. Temperature, total precipitation, visibility, wind speed and direction are among a few of the parameters measured.

2.1 Precipitation Rate Measurement

The following equipment or equivalent are recommended:

2.1.1 Plate Pan (see Figure B-1)

A plate pan, placed at a 10º inclination on the test stand will be used to collect and weigh snow. The procedure for the collection of precipitation rates using this method is described in Attachment B-V. A schematic of the plate pan is provided in Figure B-1.

Note: When this method is used 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. The plate pans should be carefully rotated every 5 minutes to prevent accumulating snow from blowing away. The time of rotation should be reduced to 2 minutes during heavy precipitation or high wind conditions.

2.2 Plate Temperature Monitoring

Type T Kapton insulated thermocouple probes have been embedded within the test plates to monitor plate temperatures during a test. The accuracy of the thermocouples is 1.0°C over the range +404 to -250°C. Data from the thermocouples will be recorded with a logger.

2.3 Test Stand

A typical test stand is illustrated in Figure B-2; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figures B-2 and B-3. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels.

2.4 Test Panels

2.4.1 Material and Dimensions

Alclad Aluminum 2024-T6 or 5052-H32 polished standard roll mill finish 30x50x0.32 cm (12x20x1/8"), for a working area of 25x40 cm (10x18"). Thicker aluminum stock may be needed when an instrument is mounted on the plate.

2.4.2 Markings

Each panel shall be marked as shown in Figure B-2 with lines at 2.5 and 15 cm (1 and 6") from the panel top edge, with 15 crosshair points and with vertical lines 2.5 cm (1") from each side; this marks off a working area of 25x40 cm (10x18") on each panel. All marks shall be made using a 0.3 cm (1/8") thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 2 cm (0.8") from the panel edge.

2.5 Fluid Application

The fluid should be poured onto the plates from a manageable container, until the entire test section surface is saturated and a consistent fluid thickness over the entire plate surface is obtained. Up to two litres of fluid may be applied to each panel for tests using anti-icing fluids. For Type I tests, 1 litre of fluid is sufficient.

Anti-icing fluids are applied to test surfaces at ambient outside air temperature. Type I fluids are applied at 20°C +/- 3°C, and diluted to a 10°C buffer. The mixing procedure for Type I fluids has been included in Attachment B-VII.

2.6 Film Thickness Gauge

Film thickness at the 15 cm (6") line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc., Pompano Beach, Florida.

2.7 Video Recording (Optional)

Tests may also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

2.8 Anemometer

Wind Minder Anemometer Model 2615 or equivalent. Available from Qualimetrics Inc., Princeton, New Jersey. To be mounted at 3 metres (10'). (For wind data and calibration sources, see TP12896E and TP12654E). Additional meteorological information is obtained from READAC.

2.9 Wind Vane

Model 2020 Qualimetrics or equivalent. To be mounted at 3 metres (10'). (For wind data and calibration sources, see TP12896E and TP12654E)

2.10 Relative Humidity Meter

Relative humidity will be provided by READAC on a minute-by-minute basis.

2.11 Ice Detection Sensors

Where feasible surface or remotely mounted ice detection sensors should be used during the tests.

3. DE/ANTI-ICING FLUIDS

3.1 Certification

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Test Fluids

Samples of deicing and anti-icing fluids for holdover time testing shall be prepared and delivered according to the sample selection procedures, intended for inclusion in Aerospace Standard 5485.

3.3 Dye

Fluids should be supplied for certification and for testing in the form to be used on aircraft.

4. PROCEDURE

Attachment B-III contains a summary of the major steps required for the conduct of flat plate tests. This should be mounted on the wall in the trailer at the site.

4.1 Start-up and Close-up

Attachment B-III provides a reference to enable testers to start the equipment at the beginning of a test session, and also provides reference on what should be closed at the end of a session.

4.2 Set-up

4.2.1 Panel Test Stand

If there is any wind, orient the test stand so that the test panels are facing into the wind direction at the beginning of the test and the wind is blowing up the panels,

i.e.----> /
wind panel

If the wind shifts during the test do not move the stand; simply note it on the data sheet.

4.2.2 Plate Pan Method

Coat the bottom of the plate pan, as well as the inner sides of the pan, with about 0.6cm (¼") of anti-icing fluid (Type IV). Weigh the wetted pan prior to testing to the nearest gram. Weigh the pan at 10-minute intervals over the course of the test (see Table B-3). Replace the pans on the test stand as long as the duration of the last test panel. Do not remove the contents of the pan until the test is complete. Weigh again after test completion of each panel to determine the true water content reading of the precipitation.

When using plate pans to measure precipitation rate, two plate pans shall be used. Care must be taken to ensure that snow or ice does not fall into the pans when transporting them into the trailer. The complete description of this method is included in Attachment B-V.

4.3 Test Panel Preparation

4.3.1 Before the start of each day's testing, ensure the panels are clean.

4.3.2 Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather).

4.3.3 Allow the panels to cool to outside air temperature.

4.4 Fluid Preparation and Application

4.4.1 Fluid Temperature

Anti-icing fluids should be placed outside (cold-soaked to ambient temperature conditions) prior to the start of the test session. Deicing fluids should be applied to test surfaces at 20°C +/- 5°C. Deicing fluids should be stored in the trailer at all times.

4.4.2 Cleaning Panels

Before applying test fluid to a panel, squeegee the surface to remove any precipitation or moisture. Fluid being used for the test could be used to help remove snow or ice from the test panel.

4.4.3 Order of Application

Apply the fluid to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete coverage by applying the fluid in a flooding manner. Start with the top left panel U, then cover panel X in the second row with the same fluid, then flood the second test fluid on panel V followed by panel Y, etc. (see Figure B-1).

4.5 Holdover Time Testing

4.5.1 Commence recording the test until the test reaches the END CONDITION. See Section 5 for definition of end condition.

4.5.2 Record the elapsed time (holdover time) required for the fluid to achieve the test END CONDITION.

4.6 Video Recording (not performed routinely)

Video record test (if required) with a hand-held camera in the following sequences:

1. General outdoor condition prior to test (get good view of snow falling).
2. Video record the data forms.
3. Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchronized).
4. Record pans being weighed and brought out.
5. Record establishing shot of test stand (all the plates).
6. Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then returning to wide shot of the plate. Repeat this with each plate in sequence, beginning from left to right, top to bottom. Always follow the same sequence. Ensure that each plate has a tag marked with the type of fluid used on the plate and that the plate itself is marked with its corresponding letter (X, Y, Z...). Record the clock/timer often.
7. For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming in into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.
8. Ensure that the lighting is appropriate for video purposes.
9. Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

4.7 Plate Pan Measurements

Measure the quantity (rate) of precipitation using at least two plate pans mounted on the test stand. Record these measurements on the Form (Table B-4) at the following times:

- At the start of the test;
- Every 10 minutes;
- When there is a significant change in the rate (intensity) for more than one minute;
- After failure of each panel (measure only once if two panels fail at almost the same time); and
- At the end of the test.

4.8 Meteorological Observations

Meteorological observations must be recorded at the same times as in Subsection 4.7, and when there are changes in the type and category of precipitation. Significant changes in wind speed and direction should also be noted.

4.8.1 Type of Precipitation

Note the type of precipitation (refer to Figure B-5 for the codes). This is a subjective determination. If two or three forms of precipitation co-exist, then note all of these.

4.8.2 Classification of Precipitation

While many different classifications are available, a simple classification of ten forms of solid precipitation is shown in Figure B-4. Use of black velvet to collect the snow and inspect it, will facilitate the identification.

4.8.3 Determination of Wet or Dry Snow

While this is usually temperature and humidity level dependant, determination of wet or dry snow could be determined by collecting snow in a dry plate pan on a stand not being used. If in the course of a test, the snow in the pan can be combined and formed into a *snow-ball*, then this will be identified as wet snow. If the snow does not form into a *snow-ball* or if the snow does not even accumulate, then this is considered dry snow. Note that the time to form a *snow-ball*, when collecting with gloves, should be less then five seconds. One other method to determine whether the snow is wet or dry would be to measure the depth of the snow in the pan and compare it to the liquid equivalent depth. If the ratio is >10, then it would be dry snow.

4.8.4 Temperature and Wind Measurements

These are to be recorded from the computer monitor at the site at the start of the test. READAC information will also be used for data analysis.

4.9 Video Organization

The video equipment cassettes should be marked sequentially for the panning camera and the Hi 8 cameras. These numbers should be recorded on the data form at the time of testing. When these are full, then they should be marked as full.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when the accumulating precipitation fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

- When precipitation or frosting produces a *loss of gloss* (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to grey or greyish appearance at any five crosshairs, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

As these determinations are subjective in nature, the following is **very important**:

- Whenever possible, have the same individual make the determination that a crosshair has failed.

- When making such a determination, ensure consistency in the criteria used to call the end of a test.

- Under light snow conditions or when the precipitation rate decreases, snow may sometimes build up on the fluid and then be absorbed later as the fluid accommodates (absorbs) it. If this occurs, record the first time snow builds up and note (in the comments sections) that there was an *un-failure* at a specific crosshair.

Updated definitions of fluid failure in natural snow conditions, along with photographs of the various failure conditions, have been included in Attachment B-VI.

6. REPORTING AND OBSERVATIONS

Calculate and record test data, observations and comments in the format of Tables B-3 and B-4. Each test must be conducted in duplicate. Detailed definitions and descriptions of meteorological phenomena are available in the Manual of Surface Weather Observation (MANOBS) - a copy is available at APS offices.

ATTACHMENT B-II
PERSONNEL RESPONSIBILITY

Test Site Leader

- Call personnel to conduct tests;
- Ensure test site is safe, functional and operational at all times;
- Supervise site personnel during the conduct of tests;
- Ensure site is opened and closed properly;
- Monitor weather forecasts on a daily basis and during test period;
- Report to project manager on site activities on daily basis;
- Review data forms upon completion of test for completeness and correctness;
- Decide what fluids should be tested;
- Ensure results are reasonable;
- Ensure all clocks are synchronized at all times;
- Ensure fluids are available and verify fluids being used for test are correct;
- Ensure computers are all operational;
- Ensure electronic data is being collected for all tests;
- Ensure proper documentation of tapes, diskettes, cassettes;
- Verify test procedure is correct (eg. stand into wind);
- Ensure all materials are available (pens, paper, batteries, etc.); and
- Fill in end of testing checklist for every session (see Attachment B-IV).

End Condition Tester

- Monitor the progression of failures on the plates;
- Record end condition times for each crosshair;
- Communicate to video operator the end condition times;
- Apply fluids onto test panels;
- Complete and sign Data Form (Table B-3); and
- Prepare fluids for each test.

Meteo Tester

- Record meteo for both stands;
- Rotate and measure plate pan weights;
- Squeegee plates prior the fluid application;
- Complete and sign Data Form (Table B-4);
- Assist end condition tester when failure times occur quickly; and
- Place stop-watch and start stop-watch on test stand.

Video Tester

- Sign and fill in cassette #'s, etc. in data form (Table B-4);
- Video all tests (see procedure);
- Verify all equipment is on;
- Document and mark all cassettes used for all electronic equipment;
- Ensure camera batteries are recharged and available;
- Ensure lighting is appropriate; and
- Video fluid application (capture fluid name on container).

This page intentionally left blank.

ATTACHMENT B-III

SUMMARY OF STEPS TO CONDUCT TESTS

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

Upon Entering Trailer

1. Turn on lights (outside and inside) and sign-in.
2. Determine tests to be conducted and fluids (Type II, III, IV to be placed outdoors).
3. Remove snow and clear access to stands.
4. Turn on C/FIMS computers.
5. Synchronize all clocks on all equipment in 4) and stop watches.

For Each Test

1. Fill in general material on Tables 1 and 2 (Tables B-3 and B-4), and prepare plate pans for start of test.
2. Place fluids by stand.
3. Ensure stand is into wind.
4. Start logging C/FIMS computers.
5. Record end condition times of all panels **(care to be taken for the 5th crosshair of each panel)**.
6. Measure plate pan weights over the course of the test.
7. Video record start of test, progression of failures, and when the end condition (5 of 15 crosshairs) is being called on each panel.
8. Ensure forms are properly completed and signed.
9. Save C/FIMS data.
10. Start a new test.

To Close Trailer

1. Replenish fluids.
2. Log and document date, times, test #'s, etc. on all media
3. After major events (more than 10 tests), start new tapes for next occasion.
4. Place all media and test forms in large envelope for delivery to office.
5. Shut off the C/FIMS.
6. Clean trailer and all garbage.
7. Ensure outdoor is left clean and presentable.
8. Close lights and sign-out.

This page intentionally left blank.

ATTACHMENT B-IV

CHECKLIST FOR SITE LEADER FOR END OF TESTING

ITEM	ENTER DATE										
ALL FLUIDS BROUGHT IN											
ALL FLUIDS REPLENISHED											
WASTE FLUIDS BROUGHT IN											
HANDHELD CAMERAS BROUGHT IN											
OUTDOOR AND STAND LIGHTS TURNED OFF											
WRIST WATCHES HANDED IN											
ALL TEST MEDIA PROPERLY LABELED (HI 8, RVSI, C/FIMS)											
DATA FORMS CHECKED AND SIGNED											
ALL PERSONNEL SIGNED OUT											
TRAILER CLEANED UP											
TRAILER HEATER KEPT AT 20°C											
SITE LEADER INITIALS											

BM3833/procedures/holdover time/natural snow/checklist

This page intentionally left blank.

ATTACHMENT B-V
PROCEDURE FOR THE COLLECTION OF PRECIPITATION

GENERAL

1. Two large timepieces should be installed in the trailer (one above the rate station, the other in the window adjacent to the door), to insure that accurate collection times are recorded. Both timepieces should be synchronized;

2. Rates should be collected every 10 minutes in normal conditions and every 5 minutes in periods of high precipitation rates and high winds.

3. In the event of error (dropped pan, lost fluid…), the error and time should be recorded on the data form. When fluid has been lost from the plate pans, pans should be re-weighed prior to being placed on the test stand; and

4. The start time of the rate collection period is recorded from the timepiece above the rate station prior to exiting the trailer. The time required to get from the rate station to outside the trailer door should also be recorded. This value (in sec.) should be included in the buffer column in Table 3 (Table B-4), and eventually deducted from the rate collection time. When entering the trailer following a rate collection period, record the time from the timepiece in the window near the door.

PROCEDURE

1. Ensure that both plate pans are marked (*upper* and *lower*);

2. The bottom and sides of the pan must be wetted with Type IV anti-icing fluid to prevent blowing snow from escaping the pan;

3. Tare the scale, then weigh the wetted pan to the nearest gram;

4. Record the start time (hr/min/sec) from the timepiece located near the rate station before leaving the trailer to place the pans on the test stand, taking into consideration the time delay necessary to proceed outside from the rate station;

5. Ensure that the pans are placed in the proper location (upper and lower locations);

6. Prior to removing the plate pans from the test stand for re-weighing, carefully wipe away any accumulated precipitation from the lips of the plate pans (ensure that the precipitation does not fall into the plate pan). Carefully remove the plate pans from the stand and proceed **immediately** to the trailer to re-weigh the pans. Do not rest the pans on top of one another while transporting. Once inside the trailer, rest the pans on a clean dry table surface;

7. Upon entering the trailer, record the end time (hr/min/sec) from the timepiece in the window near the door;

8. Carefully wipe the bottom, sides and lips of the pans prior to weighing;

9. Weigh the plate pan. Plate pans should be re-weighed until consistent measurements are obtained;

10. Record the new weight (do not tare scale again), and bring the pans back outside;

11. Start time from the timepiece near the rate station; and

12. Continue this procedure until the final plate on the test stand has failed.

ATTACHMENT B-VI

UPDATED DEFINITIONS OF PLATE FAILURE IN NATURAL SNOW CONDITIONS

In all natural snow tests, regardless of the method of fluid failure, an accumulation of snow is apparent in the failed areas. Type IV fluid failures in natural snow tests normally occur when:

- The fluid has eroded due to dilution and snow begins to accumulate on the plate surface (dilution failure); and

- The fluid no longer absorbs the snow and it begins to rest on top of the fluid (snow-bridging failure).

A typical dilution-style failure is shown in Photo B-1. In this case, the fluid has been diluted due to ongoing precipitation and the fluid film has eroded substantially. Failures have reached just beyond the 3″ line on the plate (white snow is visible in the failed area). Dilution failures normally occur from top-to-bottom on the test surface, and are common at warm temperatures and low rates of precipitation. Ethylene-based Type IV fluids usually fail in this manner.

A snow-bridging failure is shown in Photo B-2. In this case, the fluid resists dilution and a thick film of fluid remains on the entire plate surface. Plate failure has occurred in this test because snow, resting on top of the fluid, covers more than 1/3 of the plate surface. Snow-bridging failures do not always occur in top-to-bottom fashion, and are common at cold temperatures and high rates of precipitation. Propylene-based Type IV fluids usually fail in this manner.

ATTACHMENT B-VII

UPDATED DEFINITIONS OF PLATE FAILURE IN NATURAL SNOW CONDITIONS

Photo B-1
Dilution Failure

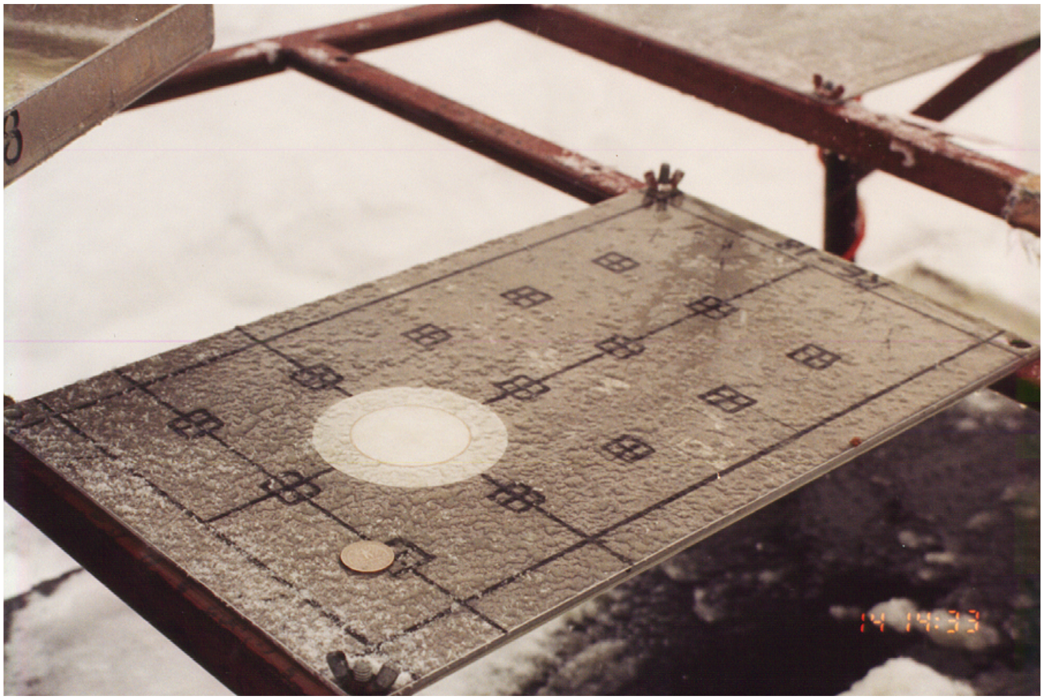


Photo B-2
Snow-bridging Failure

ATTACHMENT B-VII
TYPE I FLUID HOLDOVER TIME TEST MIXING PROCEDURE FOR NATURAL SNOW TESTS
Winter 2000/2001

In order to conduct Type I fluid holdover time tests, fluids must be pre-mixed to a 10°C buffer. This signifies that the fluid freeze point must be 10°C below the ambient air temperature. For example, if tests are conducted at an outside air temperature of -2°C, the fluid freeze point must be -22°C.

All Type I fluids must be diluted from their concentrated forms with HARD WATER. The procedure for the preparation of hard water is included in Attachment B-VIIA. Plastic containers (20-litre) of hard water will be pre-mixed and placed on the large shelf near the fluid mixing station.

The fluid dilutions and fluid freeze point measurements (°brix) for each Type I fluid at various temperatures are shown in Table B-2. Using the information in this table, Type I fluids should be prepared prior to the start of each test period. Fluid concentrations should also be adjusted using this information during any given test period if the ambient air temperature fluctuates by more than 1°C.

The following is an example of Type I fluid preparation for holdover time testing:

The ambient air temperature is -10°C. Type I fluids will be mixed to a freeze point of -20°C. In the case of Lyondell Arco+ Type I, the required glycol concentration of the -20°C freeze point fluid is 55%. Using a graduated cylinder, measure out the required amount of the Lyondell Arco+ concentrate. If mixing into an eight-litre container, the required amount of Lyondell Arco+ concentrate would be 4.4 litres. Add this amount to the container. The remainder of the eight-litre container will be filled with hard water (3.6 litres). The mixture should be shaken prior to measuring the refractive index (°Brix). The brix of the diluted fluid should be 26.5, based on the information in Table B-2. If the brix is below 26.5, additional concentrate should be added to the container. If the brix is above 26.5, hard water should be added. The mixture is deemed acceptable for testing when the refractive index of the fluid (°brix) is within 0.25 of the value stated in Table B-2. A summary for the testers is provided as Attachment B-VIIB.

Fluids for Type I testing should be applied to the test plates at 20°C +/-5°C. One litre of fluid is required for each individual test plate, and will be poured from one-litre containers. Prior to the start of each test run, the brix and temperature of each test fluid should be indicated on the End Condition Data Form (Table B-3).

In order to ensure that Type I fluids are sufficiently warm for holdover time testing, the containers of concentrated fluids should be replenished and stored in the trailer following each test period.

This page intentionally left blank.

ATTACHMENT B-VIIA
PROCEDURE FOR PREPARING HARD WATER

Hard water is required to dilute Type I fluids for holdover time testing. The following procedure outlines the steps required to produce 1 litre of hard water.

Hard Water =	Distilled (deionized) water	+	calcium acetate monohydrate or anhydrous calcium acetate	+	magnesium sulfate heptahydrate

In order to produce 1 liter of hard water:

1. Take 1 liter of Distilled Water.
2. Dissolve 400mg of the calcium acetate monohydrate or anhydrous calcium acetate.
3. Dissolve 280mg of the magnesium sulfate heptahydrate.

Requirements:

The distilled water must conform to specifications of Type IV water outlined in D 1193-91.

Electrical conductivity at 25°C = 5
Electrical resistance = 0.2
pH = 5.0 - 8.0
Total organic carbon = no limit
Sodium = 50 ug
Chlorides = 50 ug
Total silica = no limit

This page intentionally left blank.

ATTACHMENT B-VIIB
SUMMARY PROCEDURE FOR MIXING OF TYPE I FLUIDS FOR 10°C BUFFER

An example is included below in brackets using Lyondell Arco+:

1. Determine the outside air temperature (for example, -10°C).
2. Find the volume of the fluid and hard water (see below) to be mixed in Table A. (Mix 4.4 l glycol and 3.6 l hard water for Lyondell).
3. Shake the container and measure the refractive index in Brix and compare the value with that in Table A (for Safetemp, it should be 26.5).
4. If the Brix value is off by more than 0.25, adjust mixture by adding hard water to decrease Brix, or fluid to increase Brix. Redo Step 3.

As a general rule of thumb, add 150 ml of water or fluid for every 1 Brix value that the mixture is off (in the example, if the Brix was 28, then add 300 ml of water to reduce the Brix to about 26.5).

To produce 1 litre of hard water:

1. Take 1 litre of Distilled Water.
2. Dissolve 400 mg of the calcium acetate monohydrate or anhydrous calcium acetate.
3. Dissolve 280 mg of the magnesium sulfate heptahydrate.

TABLE B-2
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Clariant EG I 1996				Clariant MPI 1938 TF (310)				Lyondell Arco Plus / Lyondell Arco Plus-ST				FCY-1A			
		% 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	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5																
1	-9	28	14	2.2	5.8	28.5	16.5	2.3	5.7	31.25	20.5	2.5	5.5	19.9	12.80	1.6	6.4
0	-10	29.5	14.75	2.4	5.6	31.5	18.5	2.5	5.5	32.25	21.25	2.6	5.4	22.0	14.01	1.8	6.2
-1	-11	31	15.5	2.5	5.5	34	19.75	2.7	5.3	33.25	21.8	2.7	5.3	23.7	15.18	1.9	6.1
-2	-12	33	16.5	2.6	5.4	37.5	21.5	3.0	5.0	34.25	22.5	2.7	5.3	26.0	16.50	2.1	5.9
-3	-13	35	17.5	2.8	5.2	39.25	22.5	3.1	4.9	35.25	23	2.8	5.2	27.2	17.37	2.2	5.8
-4	-14	36.5	18.25	2.9	5.1	40.5	23.5	3.2	4.8	36	23.5	2.9	5.1	29.0	18.90	2.3	5.7
-5	-15	38	19	3.0	5.0	42	24.25	3.4	4.6	37	24	3.0	5.0	30.5	19.38	2.4	5.6
-6	-16	39.5	19.75	3.2	4.8	43	24.75	3.4	4.6	38	24.75	3.0	5.0	32.0	20.10	2.6	5.4
-7	-17	41	20.5	3.3	4.7	44.25	25.5	3.5	4.5	39	25.5	3.1	4.9	33.5	21.22	2.7	5.3
-8	-18	42.5	21.25	3.4	4.6	45.5	26	3.6	4.4	40.25	26.25	3.2	4.8	35.0	22.50	2.8	5.2
-9	-19	44	22	3.5	4.5	46.5	26.5	3.7	4.3	41.25	26.75	3.3	4.7	36.4	22.91	2.9	5.1
-10	-20	45	22.5	3.6	4.4	47.75	27.5	3.8	4.2	42.5	27.5	3.4	4.6	38.0	23.60	3.0	5.0
-11	-21	46	23	3.7	4.3	49	28	3.9	4.1	43.5	28	3.5	4.5	39.0	24.44	3.1	4.9
-12	-22	47.5	23.75	3.8	4.2	50	28.75	4.0	4.0	44.5	28.5	3.6	4.4	40.3	25.16	3.2	4.8
-13	-23	48.5	24.25	3.9	4.1	51	29.25	4.1	3.9	45.5	29.25	3.6	4.4	41.5	25.84	3.3	4.7
-14	-24	50	25	4.0	4.0	52.25	29.75	4.2	3.8	46.5	30	3.7	4.3	42.6	26.48	3.4	4.6
-15	-25	50.5	25.25	4.0	4.0	53.5	30.25	4.3	3.7	47.5	30.5	3.8	4.2	44.0	27.10	3.5	4.5
-16	-26	52	26	4.2	3.8	54.5	30.75	4.4	3.6	48.75	31.25	3.9	4.1	44.8	27.69	3.6	4.4
-17	-27	53	26.5	4.2	3.8	55.5	31.25	4.4	3.6	50	32	4.0	4.0	45.9	28.24	3.7	4.3
-18	-28	54	27	4.3	3.7	56.5	31.75	4.5	3.5	50.75	32.5	4.1	3.9	46.9	28.77	3.8	4.2
-19	-29	55	27.5	4.4	3.6	57.75	32.25	4.6	3.4	51.75	33	4.1	3.9	47.9	29.27	3.8	4.2
-20	-30	56	28	4.5	3.5	58.75	32.75	4.7	3.3	52.75	33.5	4.2	3.8	49.0	30.50	3.9	4.1
-22	-32	58	29	4.6	3.4	61	33.75	4.9	3.1	55	34.5	4.4	3.6	50.6	30.64	4.0	4.0
-25	-35	61.5	30.75	4.9	3.1	64.5	35.25	5.2	2.8	56.75	35.75	4.5	3.5	53.5	32.70	4.3	3.7
-30	-40	66.5	33.25	5.3	2.7	70	37.75	5.6	2.4	60	37.25	4.8	3.2	58.0	34.90	4.6	3.4
Standard Mix																	

Bm3833/proc/hot/nat snw/Fcy-1a

FIGURE B-1
SCHEMATICS OF PLATE PAN AND TEST STAND

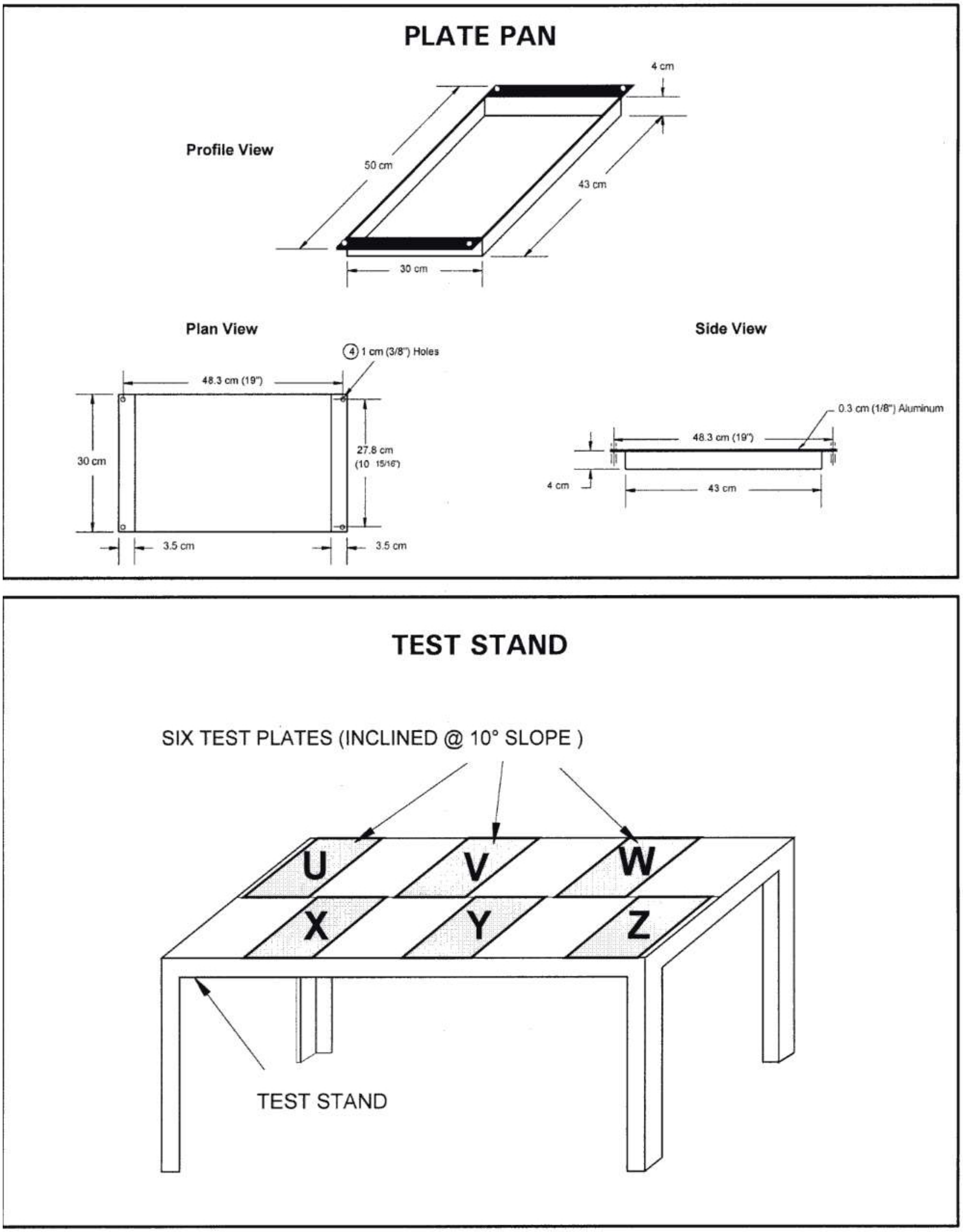


FIGURE B-2
TEST STAND

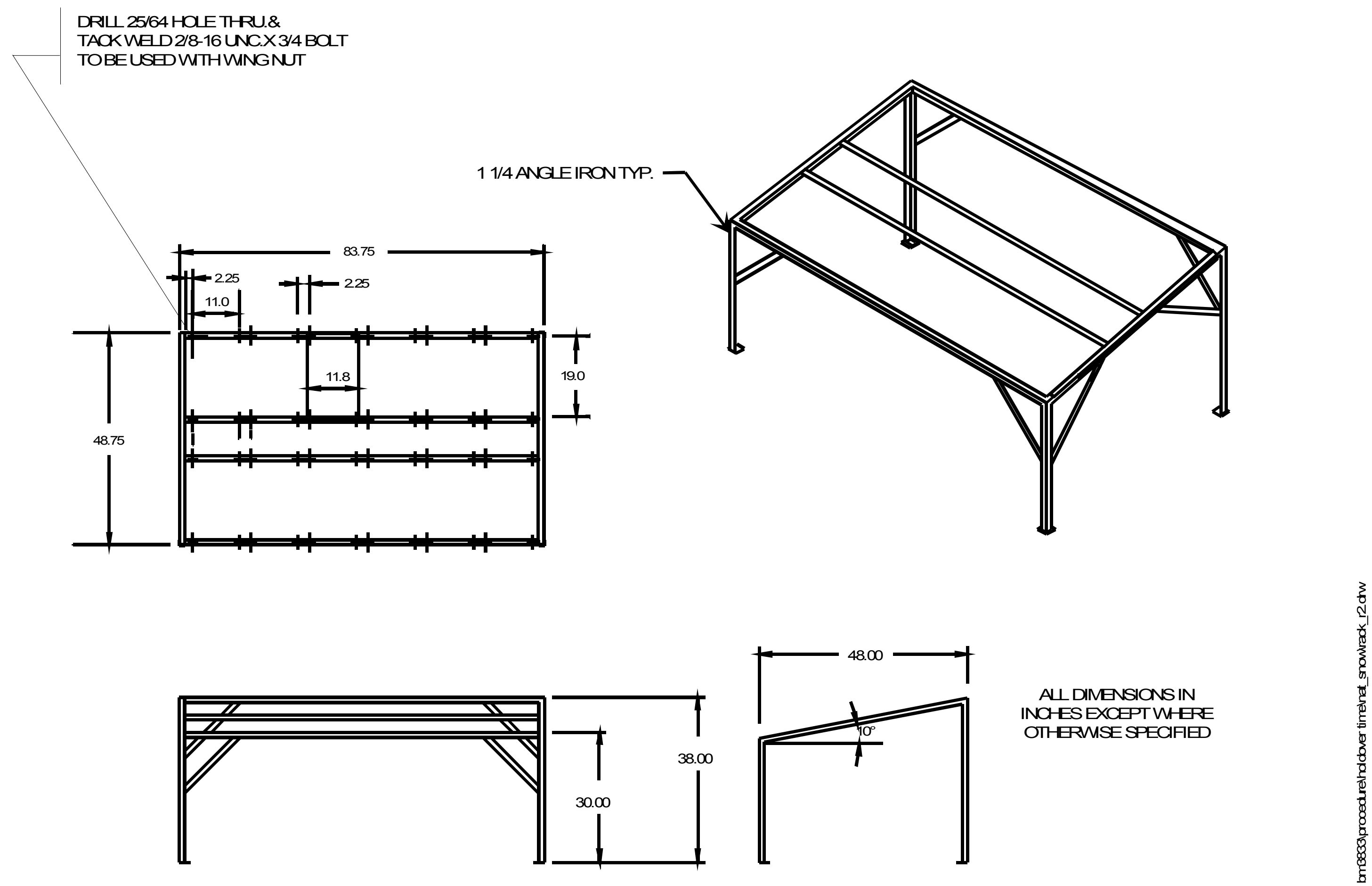


FIGURE B-3

TYPICAL ICE SENSOR FLAT PLATE MARKINGS

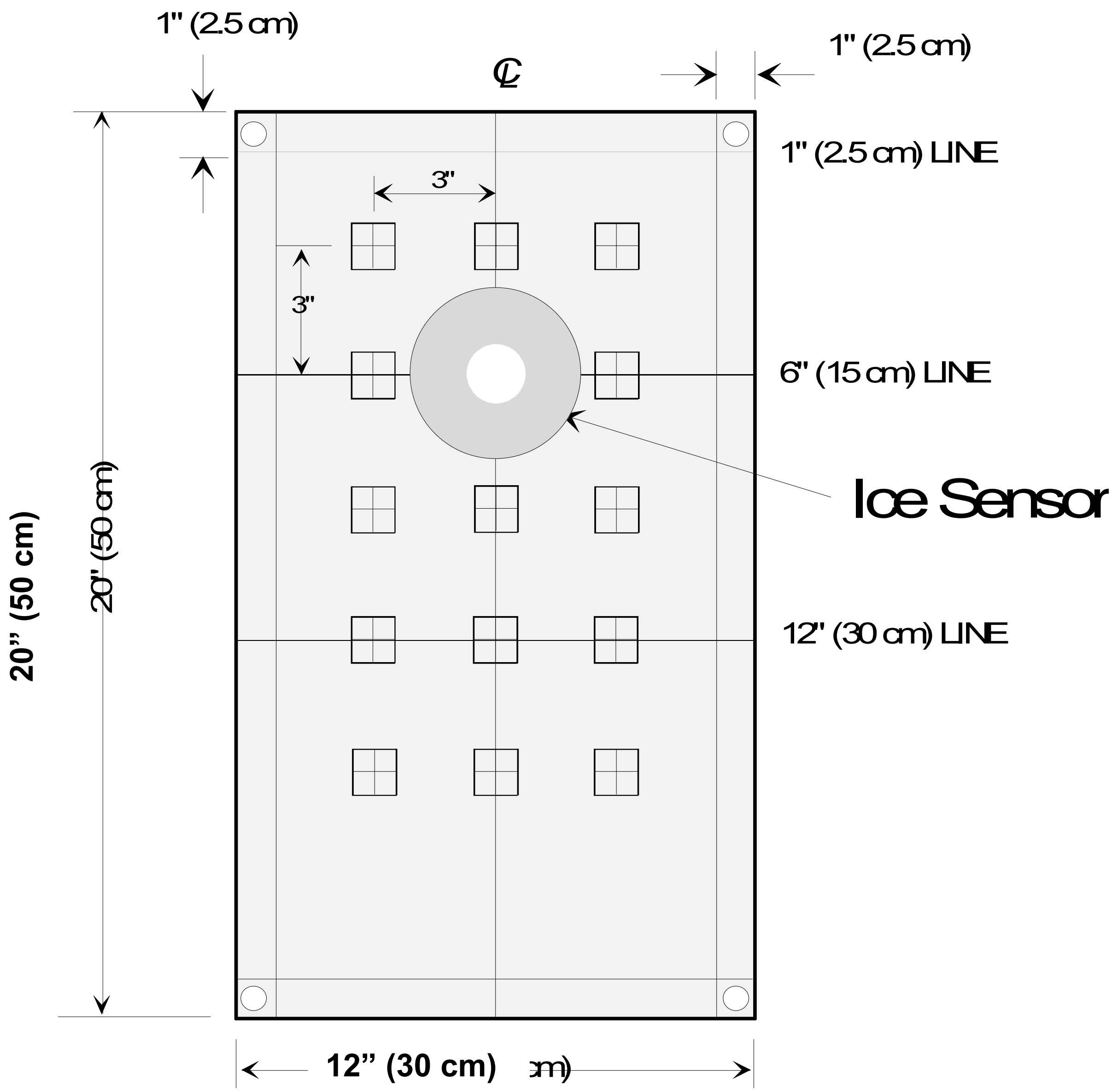
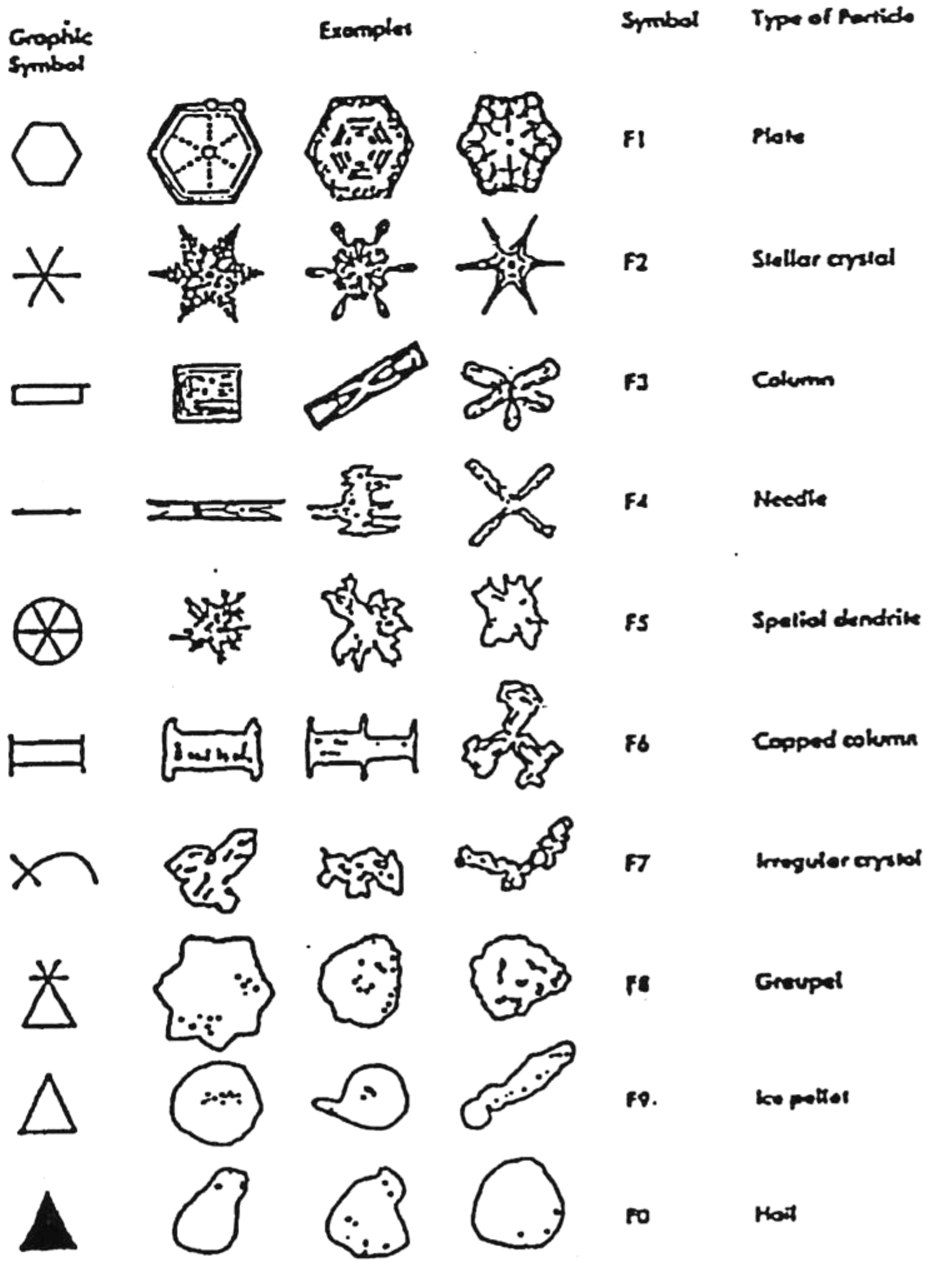


FIGURE B-4
INTERNATIONAL CLASSIFICATION FOR SOLID PRECIPITATION



4. A pictorial summary of the International Snow Classification for solid precipitation. This classification applies to falling snow.

Source: International Commission on Snow and Ice, 1951

FIGURE B-5
WEATHER PHENOMENA AND SYMBOLS

General Category	Specific Phenomena	Symbol
Tornadoes and Thunderstorms	Tornado	Tornado
	Waterspout	Waterspout
	Funnel Cloud	Funnel Cloud
	Thunderstorm	T, T+
Precipitation	Rain	R--, R-, R, R+
	Rain Showers	RW--, RW-, RW, RW+
	Drizzle	L--, L-, L, L+
	Freezing Rain	ZR--, ZR-, ZR, ZR+
	Freezing Drizzle	ZL--, ZL-, ZL, ZL+
	Snow	S--, S-, S, S+
	Snow Grains	SG--, SG-, SG, SG+
	Ice Crystals	IC
	Ice Pellets	IP--, IP-, IP, IP+
	Ice Pellet Showers	IPW--, IPW-, IPW, IPW+
	Snow Showers	SW--, SW-, SW, SW+
	Snow Pellets	SP--, SP-, SP, SP+
	Hail	A--, A-, A, A+
Obstructions to Vision (visibility 6 miles or less)	Fog	F
	Ice Fog	IF
	Haze	H
	Smoke	K
	Blowing Snow	BS
	Blowing Sand	BN
	Blowing Dust	BD
	Dust Haze	D

TABLE B-3
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

VERSION 6.0 Winter 1999/2000

LOCATION:	DATE:	RUN # :	STAND # :

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NUMBER: ___ ___ ___ ___ ___ ___

DIRECTION OF STAND: _____ °

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

____

____

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

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

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

	Plate U			Plate V			Plate W		
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 / TEMPERATURE AT START	/			/			/		

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

	Plate X			Plate Y			Plate Z		
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 / TEMPERATURE AT START	/			/			/		

Groups\CM1680 (exBM3833)\Procedures\Holdover Time\Natural snow\Data Form V6.xls

TABLE B-4
METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME VERSION 6.0 Winter 1999/2000

LOCATION:	DATE:	RUN # :	STAND # :
HAND HELD VIDEO CASSETTE #:			

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 (Δ w*4.7/ Δt) ($g/dm^2/h$)

*measurements every 15 min. and at failure time of each test panel.

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See Fig. 3)	If SNOW, WET or DRY

**observations at beginning, end, and every 10 min. intervals. Additional observations when there are significant changes.

TEMPERATURE AT START OF TEST ________ ºC

WIND SPEED AT START OF TEST ________ kph

WIND DIRECTION AT START OF TEST ________ º

COMMENTS : ____

____

____

____

	PRINT	SIGN
WRITTEN & PERFORMED BY :	__________	________________
VIDEO BY :	__________	________________
TEST SITE LEADER :	__________	________________

Groups\CM1680 (exBM3833)\Procedures\Holdover Time\Natural snow\Data Form V6.xls

This page intentionally left blank.

APPENDIX C

DETAILED PLAN OF NRC COLD CHAMBER TESTING WINTER 2000-01

BM3833.001

DETAILED PLAN OF NRC COLD CHAMBER TESTING

Winter 2000/01

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

Prepared by: Michael Chaput

Reviewed by: John D'Avirro

April 2001
Version 1.0

APS AVIATION INC.

DETAILED PLAN OF NATIONAL RESEARCH COUNCIL COLD CHAMBER TESTING

Winter 2000/01

This document provides the detailed procedures and equipment required for the conduct of simulated freezing fog, freezing drizzle, light freezing rain and rain on a cold-soaked surface holdover time tests. Procedures for supplemental tests, such as the evaluation of an artificial snowmaking machine, are also provided in this document. These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa.

1. OBJECTIVES

The objective of the current holdover time test program is to establish holdover times for Type I deicing fluids and Type II and Type IV anti-icing fluids over the full range of HOT table conditions. Scheduling of the indoor tests will be coordinated with the NRC. Duration of tests will be 15 working days, including set-up time. Fluid failure will be determined by visual observation and supported by any ice detection instruments if these are made available.

The anticipated schedule of tests is provided in Attachment C-ll

2. PERSONNEL

An indication of the personnel required is provided in Attachment C-IV.

HOT Manager: Overall management of HOT tests;
Determine test fluids and positioning of tests on stand; and
Determine failure times.

Spreadsheet 1/2: Management of rate spreadsheets;
Bring in / take out rate pans;
Measure droplet sizes (once per condition);
Measure rate distribution (once per condition);
Measure continuous rates (2 plates per stand);
Data entry / Chart preparation;
Fill in / modify recipe sheet; and
Printing of rate summaries.

Rate Manager: Manage rate pan entry / exit (rate management form); and
Bring in / take out rate pans (as required).

Fluids: Ensure fluid temperature and brix are correct prior to testing;
Pour fluids on test plates;
Mark stand position in each condition;
Ensure stand is level (10°);
Ensure temperature loggers are operational;
Ensure Type I fluids are mixed to proper freeze points; and
Ensure video is operational.

3. PROCEDURES

- The procedures for indoor holdover time trials are shown in Attachment C-1;
- The detailed rate collection procedure appears in Attachment C-VI;
- The cold soak box preparation procedure appears in Attachment C-VII;
- The hard water preparation procedure for Type I tests in Attachment C-VIII.

4. TEST PLAN

Attachment C-II provides the test schedule for CEF tests while the detailed test plan is included in Attachment C-III.

5. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the Society of Automotive Engineers (SAE) working group on ground deicing. A description of some important equipment appears in Attachment C-1. The complete equipment list for CEF tests is shown in Attachment C-V

6. DATA FORMS

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

- De/anti-icing data form for freezing precipitation, Table C-2;
- De/anti-icing data form for cold-soak box, Table C-2A;
- Precipitation rate measurement, Table C-3;
- Detailed precipitation rate measurement form, Table C-3A;
- Continuous precipitation measurement form, Table C3B;
- Cold-soak precipitation rate measurement, Table C-4; and
- Rate management form, Table C-5.

ATTACHMENT C-1

INDOOR FLAT PLATE TEST EQUIPMENT AND PROCEDURE
2000/01

This indoor test procedure has been developed by the SAE G-12 Holdover Time Subcommittee working group on aircraft ground de/anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests. The aim of this procedure is the development of holdover time table entries for freezing point depressant fluids known as de/anti-icing fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant fluids provide protection to test panels during simulated winter conditions.

2. EQUIPMENT

The following equipment is required:

2.1 Plate Pans

Plate pans (27.7cm x 54cm), placed at a 10º inclination on the test stand, will be used to collect and weigh freezing precipitation. The procedure for the collection of precipitation rates using this method is described in 4.1 and in Attachment C-VI.

2.2 Temperature Gauge for Panels

Plate temperatures will be measured using thermocouples embedded within the test plate. All thermocouples are capable of measuring panel temperatures to an accuracy of 0.5ºC (1ºF) over the range +10 to -30ºC (+50 to -20ºF), and will be linked to an electronic data acquisition system.

2.3 Test Stand

A typical test stand is illustrated in Figure C-2; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figure C-2. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels. Test panels should be positioned on the test stand at a 10° ± 0.2° angle from the horizontal.

2.4 Test Panels

2.4.1 Material and Dimensions

Test panels are made of Alclad Aluminum, 2024-T6 or 5052-H32, polished standard roll mill finish. The test panel dimensions are 300 x 500 x 3.2 mm, with a working area of 250 x 450 mm. Thicker aluminum stock may be needed when an instrument is mounted on the plate (CFIMS Sensor required 6.4 mm). Typical plate roughness used in APS Holdover time trials is 0.4 microns, measured parallel to the long axis of the plate.

2.4.2 Markings

Each panel shall be marked (as shown in Figure C-1) with lines at 25 and 150 mm from the panel top edge, with 15 crosshair points and with vertical lines 25 mm from each side; this marks off a working area of 250 x 450 mm on each panel. All marks shall be made using a 30 mm thick black marker or silkscreen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment of Test Panels

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 20 mm (0.8") from the panel edge.

2.5 Fluid Application

One litre of fluid per test should be poured onto the plates from one-litre pour containers, ensuring that the entire test section surface is saturated and a consistent fluid thickness over the entire plate surface is obtained.

2.6 Film Thickness Gauge

Film thickness at the 15 cm (6") line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc., Pompano Beach, Florida.

2.7 Video recording (optional)

Tests may also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

2.8 Relative Humidity Meter

Relative humidity in the test chamber will be recorded using a Vaisala RH Meter attached to an electronic data acquisition system.

2.9 Ice Detection Sensors

Where feasible, surface or remotely mounted ice detection sensors should be used during the tests.

2.10 Addition Equipment

- Squeegee/scraper
- Extension power cords
- Floodlights
- Watches/stopwatches

2.11 Test Chamber

Tests in simulated conditions will be conducted at the NRC, Climatic Engineering Facility in Ottawa. The chamber air temperature control is 0.5°C (+ standard deviation) based on the average air temperature measured at one-minute intervals. Temperature data is stored on the CEF data acquisition system. A minimum of three thermocouples are mounted in close proximity to the test stands and are monitored throughout the test set-up. The distance between nozzle and test plate is 6.5 to 6.7 meters, depending on the location of the plate on the test stand. The test chamber is equipped with artificial lighting arranged as such that it does not interfere with the precipitation nor with the air, fluid and plate temperatures

2.12 Spray Equipment

2.12.1 Characteristics of 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:

- Freezing Drizzle:
  High precipitation rate: 12.7 g/dm²/hr;
  Droplet median volume diameter: 350 μm;
  Droplets produced with two # 23 hypodermic needles; and
  Air temperature: -3 and –10°C.

  Low Precipitation rate: 5 g/dm²/hr;
  Droplet median volume diameter: 250 μm;
  Droplets produced with two # 24 hypodermic needles; and
  Air temperature: -3 and –10°C.

- Light Freezing Rain:
  High precipitation rate: 25 g/dm²/hr;
  Droplet median volume diameter: 1 000 μm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and –10°C.

  Low precipitation rate: 12.7 g/dm²/hr;
  Droplet median volume diameter: 1 000 μm;
  Droplets produced with two # 20 hypodermic needles; and
  Air temperature: -3 and –10°C.

- Drizzle on Cold-Soaked Surface:
  Precipitation rate: 5 g/dm²/hr;
  Droplet median volume diameter: 250 μm;
  Droplets produced with two # 24 hypodermic needles; and
  Air temperature: +1°C.

- Moderate Rain on Cold-Soaked Surface:
  Precipitation rate: 76 g/dm²/hr;
  Droplet median volume diameter: 1 400 μm;
  Droplets produced with two # 17 hypodermic needles; and
  Air temperature: +1°C.

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

2.12.2 Droplet Size Determination

The droplet size determination and distribution can be determined using the Dye Stain Method. The Dye Stain Method technique consists of dusting filter paper disks with water activated, very finely divided, powder form of methylene blue dye. The prepared disks are manually positioned under precipitation for a fixed time in order to acquire a droplet size pattern. A calibration curve is then used to convert from the measured diameter of the droplets ton the pattern to the experimental median volume diameter. This method of droplet size determination has been used for several years (see Transport Canada Reports TP 12654E, TP 12896E, TP 13131E, TP 13318E).

2.12.3 Spray Distribution

The water spray shall be evenly distributed over the entire area of each test plate. Even distribution is verified by exposing either a clean test plate or sheet of paper briefly to the spray. Drop distribution on the plate or paper is visually evaluated. Uneven distribution requires that the spray equipment be adjusted (step size and spray head speed) until even distribution is achieved.

2.13 Calibration of Test Equipment

All temperature sensors, humidity sensors, electronic balances, anemometers, and timing devices shall be maintained in a known state of calibration. Our experience indicates that a one-year calibration interval is sufficient.

3. DE/ANTI-ICING FLUIDS

3.1 Test Fluids

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Certification

Type IV fluids shall be pre-sheared by each manufacturer to a viscosity level selected by the manufacturer using the sample selection procedures outlined in the proposed Aerospace Standard 5485. Each manufacturer shall provide samples and a certificate of compliance showing the viscosity of their test sample of fluid before and after shearing, as well as information pertaining to the freeze point and refractive index of the fluid and other fluid parameters as usually provided to the end users. Viscosity and refractive index verifications of each fluid shall be made by the test organization upon receipt of fluid from the manufacturer.

3.3 Fluid Dye

Fluids should be supplied for certification and for holdover time testing in the form to be used on aircraft.

4. PROCEDURE

4.1 Rate Calculation Procedure

Rate calculation is performed by placing ice catch pans (27.7 cm x 54 cm) on the test plate support at each test location (maximum of 12 locations). Each pan is marked with a number identifying the collection location on the test plate support. The individual pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are then placed on the test plate support for a pre-determined period. The pans are re-weighed following this period and the precipitation rate for each pan is calculated (R1).

$R1 = (W_{a1}-W_{b1})/\text{Area-of-pan} * (T_{a1}-T_{b1})$
where,
W_{a1} = weight after of the 1st measurement
W_{b1} = weight before of the 1st measurement
T_{a1} = time after of the 1st measurement
T_{b1} = time before of the 1st measurement

The pans are then weighed and placed on the test plate support for a second collection period (R2). After the second collection period has expired, the pans are again re-weighed and the rates computed. A test may begin following the second rate collection period.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval (R3). It is then re-weighed and placed again (R4) on the stand in order to collect a minimum of two rates before and two rates after each test 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. In order for the test to be valid, the average rate must be within the set limits.

Water Spray Intensity Calculation

$$\text{Average intensity:} \quad \frac{R1 + R2 + R3 + R4}{4}$$

The average intensity calculated must be within the specified tolerance.

The detailed rate procedure appears in Attachment F.

4.2 Continuous Rate Monitoring

During a test, rates will continuously be monitored in order to ensure that no rate fluctuations occur. One continuous monitoring pan is required when conducting 1 to 6 fluid tests, and two continuous monitoring pans are required for 7 to 12 tests. For this purpose, ice collection pans will be weighed and placed on each designated location. The continuous monitoring pans will be re-weighed at 15-minute intervals during the test.

4.3 Rate Distribution

Clean test plates are placed on the test stand, prior to the rate collection period, and are exposed to the precipitation in order to verify that even ice formation occurs over the surface of the test plates. If this visual inspection proves satisfactory, the rate collection period will begin. If this visual inspection proves unsatisfactory, the test stand is repositioned under the spray device.

In order to verify the rate distribution on the test stand, a continuous rate monitoring pan will be replaced with a detailed rate distribution pan, which consists of 4 small pans of equivalent size. The area of the 4 small pans combined is similar to that of a standard rate collection pan. The small pans will be weighed and placed at these locations and re-weighed at fixed intervals. The typical collection period for rate distribution is 60 minutes, however this interval may be shorter if all tests have completed within 60 minutes. The variation between the rate of any of the 4 small pans and that of the average rate of that location should not be greater than 10%.

4.4 Test Panel Preparation

4.4.1

Before the start of each day's testing, ensure the panels are clean using the procedure outlined in 4.5.4.

4.4.2

Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather).

4.4.3

Allow the panels to cool to chamber temperature. The temperature may be verified using the thermistors attached to each plate.

4.5 Fluid Preparation and Application

4.5.1 Procedure for Type I Fluid Application

- Position plate covers over plates to protect from precipitation;
- Prepare 1 litre of test fluid and place it in a premarked pitcher. Fluid temperature must be 20°C ± 3°C. Measure and record Brix;
- Scrape up and squeegee any ice off the plate;
- Apply 1/3 litre to fully cleanse the plate and squeegee; and
- Apply remaining 2/3 litre on plate for test. Application should be consistent for each test to ensure consistent heat transfer to the plate,

4.5.2 Procedure for Anti-icing Fluid Application (Type II and IV)

Apply the fluids at ambient test temperature ±1.0°C to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete and consistent coverage by applying 1 litre of fluid from the prepared containers. Start time of the test begins immediately following completion of the fluid application.

4.5.3 Fluid Temperature

Except for Type I fluids, all fluids should be cold-soaked to ambient temperature conditions prior to the start of the test session.

4.5.4 Cleaning Panels

The test panels must be clean of all contamination prior to the start of any test. This is accomplished by scrapping off contamination, or when a different type of fluid is to be tested, a hot water wash is used to remove traces of the previous fluid. Before applying test fluid to any test panel, apply a small quantity of the fluid being used for the test and spread it over the entire test surface. Squeegee off any remaining fluid from the plate surface prior to the start of the test. Fluid for test is applied following procedure outlined in 4.5.1 and 4.5.2.

4.6 Holdover Time Testing

4.6.1

Record the elapsed time (holdover time) required for the fluid to achieve the test END CONDITION. See Section 5 for definition of end condition.

4.6.2 Fluid Holdover Time Determination

The test is dynamic by nature, and small variations can be expected. Each test condition shall be tested on at least two panels. Two tests will be conducted at the low rate limit and two tests will be conducted at the high rate limit, for each test temperature and precipitation type. If the variation of the anti-icing endurance time at one of the specified rate limits is more than 10%, repeat testing on two additional panels, for a total of 4 data points.

The holdover time values at the required precipitation rates are obtained by producing a “best fit” regression curve through the points using a power law transformation based on the test points collected at the lower and upper rate limits.

The equation used to treat the data is given by the expression below:

$$t = cR^a$$

where

t = Time (minutes)

R = Rate of precipitation (g/dm2/hr)

a,c = Coefficients determined from the regression

4.7 Video Recording (not performed routinely)

Video record test (if required) with a hand-held camera in the following sequences:

1) General laboratory conditions prior to test.
2) Video record the data forms.
3) Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchronized).
4) Record pans being weighed and brought out.
5) Record establishing shot of test stand (all the plates).
6) Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then returning to wide shot of the plate. Repeat this with each plate in sequence. Record the clock/timer often.
7) For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming in into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.
8) Ensure that the lighting is appropriate for video purposes.

9) Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when precipitation fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

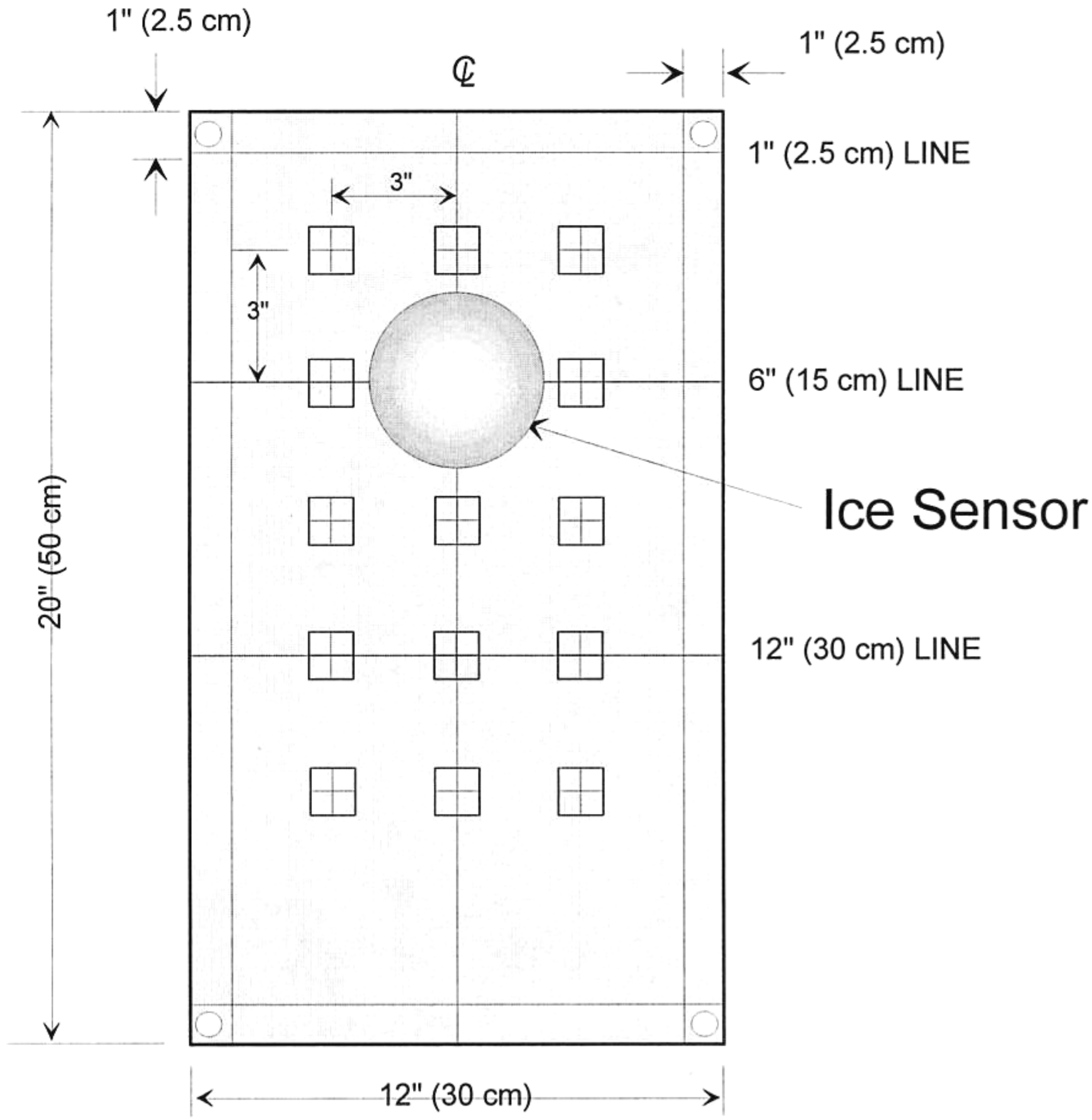
- When precipitation or frosting produces a loss of gloss (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to grey or grayish appearance at any five crosshairs, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

As these determinations are subjective in nature, the following is very important:

- Whenever possible, have the same individual make the determination that a crosshair has failed.
- When making such a determination, ensure consistency in the criteria used to call the end of a test.

FIGURE C-1

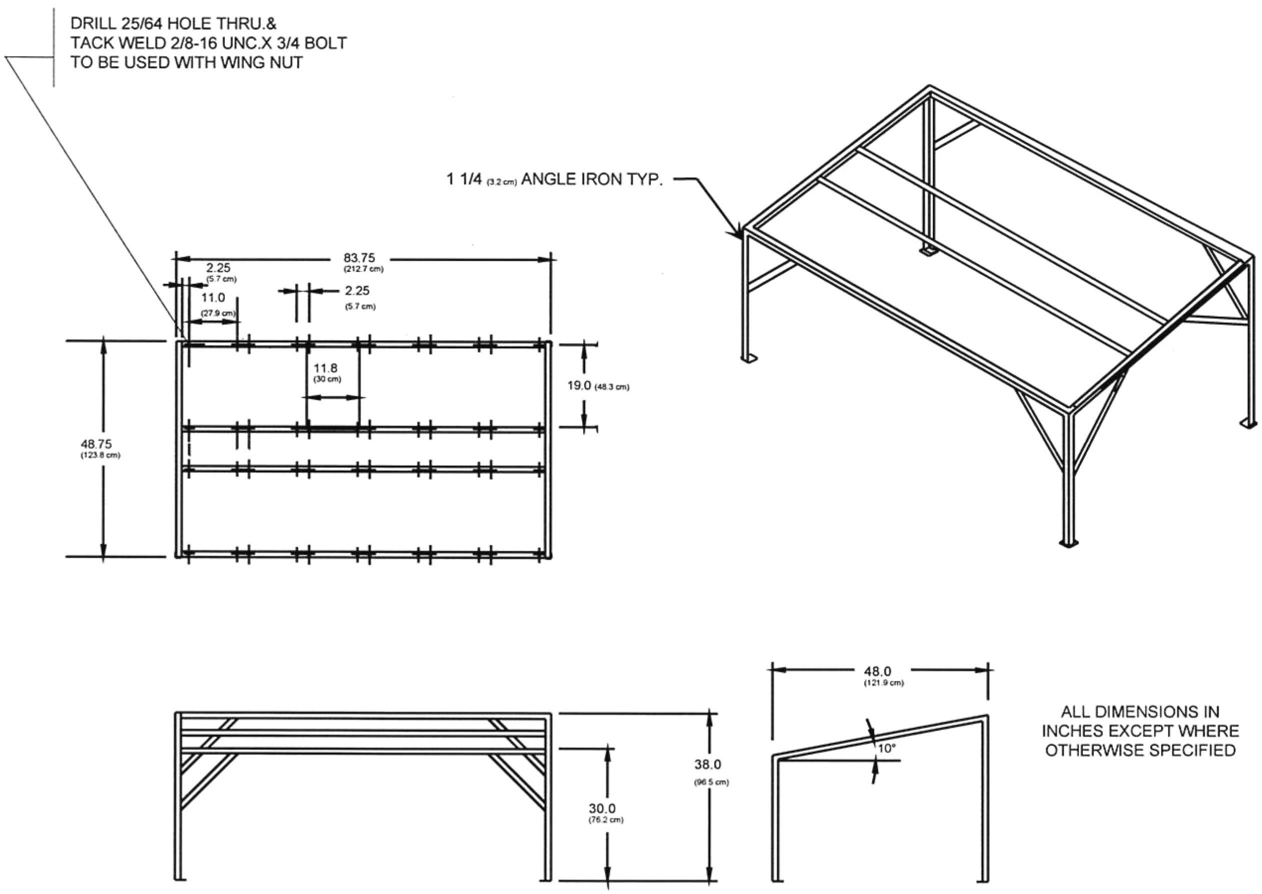
TYPICAL ICE SENSOR FLAT PLATE MARKINGS



1589\procedur\nat_snowplate.ch4

FIGURE C-2

TEST STAND



ALL DIMENSIONS IN
INCHES EXCEPT WHERE
OTHERWISE SPECIFIED

cm1589\proce\nat_snow\rack_r2.ch4

ATTACHMENT C-II

March 2001

March 2001

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

April 2001

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
			March 1 Memorial Day (Canada) Memorial Day (Canada)	2	3 4
5	6	7	8	9	10 11
12	13	14	15	16	17 Saint Patrick's Day (Canada) Saint Patrick's Day (Canada) 18
19	20	21	22	23	24 25
26	27 ZD 3H (6H)	28 ZD 3L (7H)	29 ZFog 3L (13H)	30 ZFog 3H (10H)	31

ATTACHMENT C-II

April 2001

April 2001						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

May 2001						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Z Fog 10H (3) Z Fog 10L (3)	Z Fog 14L (9)	Z Fog 14H (6)	ZD 10L (6) ZD 10H (4)	ZR 10L (4) ZR 10H (3)	 April 1
2 Z Fog 25H (4) Z Fog 25L (4)	3 ZR 3L (4) ZR 3H (3)	4 CSW L (7)	5 CSW H (5)	6	7 8
9	10	11	12	13 Good Friday (Canada) Good Friday (Canada)	14 15 Easter (Canada) Easter (Canada)
16 Easter Monday (Canada) Easter Monday (Canada)	17	18	19	20	21 22
23	24	25	26	27	28 29
30					

ATTACHMENT C-III

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	HOT	HOT Est.
1	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	100		60
2	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	100		60
3	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	75		60
4	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	75		60
5	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	50		15
6	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (TIV)	50		15
7	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	100		60
8	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	100		60
9	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	75		60
10	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	75		60
11	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	50		15
12	Light Freezing Rain	-3	13	CLAR SF MPIV 2015 TF (TIV)	50		15
13	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	100		70
14	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	100		70
15	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	75		50
16	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	75		50
17	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	50		25
18	Light Freezing Rain	-3	13	UCAR Dieth. (TIV)	50		25
19	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	100		30
20	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	100		30
21	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	75		25
22	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	75		25
23	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	50		10
24	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (COATED)	100		60
25	Light Freezing Rain	-3	13	CLAR SF PRO 2012 (COATED)	100		60
26	Light Freezing Rain	-3	13	SPCA Ecowing 26 (TII)	50		10
27	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	100		40
28	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	100		40
29	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	75		25
30	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	75		25
31	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	50		5
32	Light Freezing Rain	-3	25	CLAR SF PRO 2012 (TIV)	50		5
33	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	100		40
34	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	100		40
35	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	75		25
36	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	75		25
37	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	50		5
38	Light Freezing Rain	-3	25	CLAR SF MPIV 2015 TF (TIV)	50		5
39	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	100		50
40	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	100		50
41	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	75		35
42	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	75		35
43	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	50		10
44	Light Freezing Rain	-3	25	UCAR Dieth. (TIV)	50		10
45	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	100		15
46	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	100		15
47	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	75		10
48	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	75		10
49	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	50		5
50	Light Freezing Rain	-3	25	SPCA Ecowing 26 (TII)	50		5
51	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (TIV)	100		45
52	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (TIV)	100		45
53	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (COATED)	100		45
54	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (COATED)	100		45
55	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (TIV)	75		30
56	Light Freezing Rain	-10	13	CLAR SF PRO 2012 (TIV)	75		30
57	Light Freezing Rain	-10	13	CLAR SF MPIV 2015 TF (TIV)	100		45
58	Light Freezing Rain	-10	13	CLAR SF MPIV 2015 TF (TIV)	100		45

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate $g/dm^2/hr$	Fluid Brand	Dilution	HOT	HOT Est.	
59	Light Freezing Rain	-10	13	CLAR SF MPIV 2015 TF (TIV)	75		30	
60	Light Freezing Rain	-10	13	CLAR SF MPIV 2015 TF (TIV)	75		30	
61	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100		40	
62	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100		40	
63	Light Freezing Rain	-10	13	UCAR Dieth. (COATED)	100		40	
64	Light Freezing Rain	-10	13	UCAR Dieth. (COATED)	100		40	
65	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	75		35	
66	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	75		35	
67	Light Freezing Rain	-10	13	SPCA Ecowing 26 (TII)	100		30	
68	Light Freezing Rain	-10	13	SPCA Ecowing 26 (TII)	100		30	
69	Light Freezing Rain	-10	13	SPCA Ecowing 26 (TII)	75		20	
70	Light Freezing Rain	-10	13	SPCA Ecowing 26 (TII)	75		20	
71	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100 / 25°C		40	
72	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100 / 25°C		40	
73	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100 / 15°C		40	
74	Light Freezing Rain	-10	13	UCAR Dieth. (TIV)	100 / 15°C		40	
75	Light Freezing Rain	-10	13	LYON. ARCO PLUS-ST. (TI)	10°		5	
76	Light Freezing Rain	-10	13	LYON. ARCO PLUS-ST. (TI)	10°		5	
77	Light Freezing Rain	-10	13	NEWAVE AEROCH. FCY-1A (TI)	10°		5	
78	Light Freezing Rain	-10	13	NEWAVE AEROCH. FCY-1A (TI)	10°		5	**15**
79	Light Freezing Rain	-10	25	CLAR SF PRO 2012 (TIV)	100		30	
80	Light Freezing Rain	-10	25	CLAR SF PRO 2012 (TIV)	100		30	
81	Light Freezing Rain	-10	25	CLAR SF PRO 2012 (TIV)	75		20	
82	Light Freezing Rain	-10	25	CLAR SF PRO 2012 (TIV)	75		20	
83	Light Freezing Rain	-10	25	CLAR SF MPIV 2015 TF (TIV)	100		30	
84	Light Freezing Rain	-10	25	CLAR SF MPIV 2015 TF (TIV)	100		30	
85	Light Freezing Rain	-10	25	CLAR SF MPIV 2015 TF (TIV)	75		20	
86	Light Freezing Rain	-10	25	CLAR SF MPIV 2015 TF (TIV)	75		20	
87	Light Freezing Rain	-10	25	UCAR Dieth. (TIV)	100		20	
88	Light Freezing Rain	-10	25	UCAR Dieth. (TIV)	100		20	
89	Light Freezing Rain	-10	25	UCAR Dieth. (TIV)	75		20	
90	Light Freezing Rain	-10	25	UCAR Dieth. (TIV)	75		20	
91	Light Freezing Rain	-10	25	UCAR Ultra+	100		20	
92	Light Freezing Rain	-10	25	UCAR Ultra+	100		20	
93	Light Freezing Rain	-10	25	SPCA AD-480	100		20	
94	Light Freezing Rain	-10	25	SPCA AD-480	100		20	
95	Light Freezing Rain	-10	25	SPCA AD-480	75		20	
96	Light Freezing Rain	-10	25	SPCA AD-480	75		20	
97	Light Freezing Rain	-10	25	Kilfrost ABC-S	100		20	
98	Light Freezing Rain	-10	25	Kilfrost ABC-S	100		20	
99	Light Freezing Rain	-10	25	Kilfrost ABC-S	75		20	
100	Light Freezing Rain	-10	25	Kilfrost ABC-S	75		20	
101	Light Freezing Rain	-10	25	SPCA Ecowing 26 (TII)	100		10	
102	Light Freezing Rain	-10	25	SPCA Ecowing 26 (TII)	100		10	
103	Light Freezing Rain	-10	25	SPCA Ecowing 26 (TII)	75		10	
104	Light Freezing Rain	-10	25	SPCA Ecowing 26 (TII)	75		10	
105	Light Freezing Rain	-10	25	LYON. ARCO PLUS-ST. (TI)	10°		2	
106	Light Freezing Rain	-10	25	LYON. ARCO PLUS-ST. (TI)	10°		2	
107	Light Freezing Rain	-10	25	NEWAVE AEROCH. FCY-1A (TI)	10°		2	
108	Light Freezing Rain	-10	25	NEWAVE AEROCH. FCY-1A (TI)	10°		2	**9**
							3038	
							51	

Rates: 156 Tests x 30 minutes = 78 hours
Hours required for testing = 155 hours (78 +77)
Total Chamber time required = 16 hours (155 hours /10 plates at a time)

Estimated time in chamber to complete Zr- tests = 2 days

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	HOT	HOT Est.
109	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	100		120
110	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	100		120
111	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	75		70
112	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	75		70
113	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	50		20
114	Freezing Drizzle	-3	5	CLAR SF PRO 2012 (TIV)	50		20
115	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	100		120
116	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	100		120
117	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	75		70
118	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	75		70
119	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	50		20
120	Freezing Drizzle	-3	5	CLAR SF MPIV 2015 TF (TIV)	50		20
121	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	100		120
122	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	100		120
123	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	75		80
124	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	75		80
125	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	50		35
126	Freezing Drizzle	-3	5	UCAR Dieth. (TIV)	50		35
127	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	100		60
128	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	100		60
129	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	75		45
130	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	75		45
131	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	50		20
132	Freezing Drizzle	-3	5	SPCA Ecowing 26 (TII)	50		20
133	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	100		55
134	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	100		55
135	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	75		55
136	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	75		55
137	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	50		10
138	Freezing Drizzle	-3	13	CLAR SF PRO 2012 (TIV)	50		10
139	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	100		55
140	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	100		55
141	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	75		55
142	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	75		55
143	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	50		10
144	Freezing Drizzle	-3	13	CLAR SF MPIV 2015 TF (TIV)	50		10
145	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	100		65
146	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	100		65
147	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	75		55
148	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	75		55
149	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	50		15
150	Freezing Drizzle	-3	13	UCAR Dieth. (TIV)	50		15
151	Freezing Drizzle	-3	13	UCAR Ultra+	100		65
152	Freezing Drizzle	-3	13	UCAR Ultra+	100		65
153	Freezing Drizzle	-3	13	SPCA AD-480	100		65
154	Freezing Drizzle	-3	13	SPCA AD-480	100		65
155	Freezing Drizzle	-3	13	SPCA AD-480	75		55
156	Freezing Drizzle	-3	13	SPCA AD-480	75		55
157	Freezing Drizzle	-3	13	SPCA AD-480	50		15
158	Freezing Drizzle	-3	13	SPCA AD-480	50		15
159	Freezing Drizzle	-3	13	Kilfrost ABC-S	100		65
160	Freezing Drizzle	-3	13	Kilfrost ABC-S	100		65
161	Freezing Drizzle	-3	13	Kilfrost ABC-S	75		55
162	Freezing Drizzle	-3	13	Kilfrost ABC-S	75		55
163	Freezing Drizzle	-3	13	Kilfrost ABC-S	50		15
164	Freezing Drizzle	-3	13	Kilfrost ABC-S	50		15
165	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	100		30
166	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	100		30

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	HOT	HOT Est.	
167	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	75		20	
168	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	75		20	
169	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	50		5	
170	Freezing Drizzle	-3	13	SPCA Ecowing 26 (TII)	50		5	
171	Freezing Drizzle	-10	5	CLAR SF PRO 2012 (TIV)	100		95	
172	Freezing Drizzle	-10	5	CLAR SF PRO 2012 (TIV)	100		95	
173	Freezing Drizzle	-10	5	CLAR SF PRO 2012 (TIV)	75		70	
174	Freezing Drizzle	-10	5	CLAR SF PRO 2012 (TIV)	75		70	
175	Freezing Drizzle	-10	5	CLAR SF MPIV 2015 TF (TIV)	100		95	
176	Freezing Drizzle	-10	5	CLAR SF MPIV 2015 TF (TIV)	100		95	
177	Freezing Drizzle	-10	5	CLAR SF MPIV 2015 TF (TIV)	75		70	
178	Freezing Drizzle	-10	5	CLAR SF MPIV 2015 TF (TIV)	75		70	
179	Freezing Drizzle	-10	5	UCAR Dieth. (TIV)	100		80	
180	Freezing Drizzle	-10	5	UCAR Dieth. (TIV)	100		80	
181	Freezing Drizzle	-10	5	UCAR Dieth. (TIV)	75		75	
182	Freezing Drizzle	-10	5	UCAR Dieth. (TIV)	75		75	
183	Freezing Drizzle	-10	5	SPCA Ecowing 26 (TII)	100		45	
184	Freezing Drizzle	-10	5	SPCA Ecowing 26 (TII)	100		45	
185	Freezing Drizzle	-10	5	SPCA Ecowing 26 (TII)	75		30	
186	Freezing Drizzle	-10	5	SPCA Ecowing 26 (TII)	75		30	
187	Freezing Drizzle	-10	5	LYON. ARCO PLUS-ST. (TI)	10°		8	
188	Freezing Drizzle	-10	5	LYON. ARCO PLUS-ST. (TI)	10°		8	
189	Freezing Drizzle	-10	5	LYON. ARCO PLUS-ST. (COATED)	10°		8	
190	Freezing Drizzle	-10	5	LYON. ARCO PLUS-ST. (COATED)	10°		8	
191	Freezing Drizzle	-10	5	NEWAVE AEROCH. FCY-1A (TI)	10°		8	
192	Freezing Drizzle	-10	5	NEWAVE AEROCH. FCY-1A (TI)	10°		8	**19**
193	Freezing Drizzle	-10	13	CLAR SF PRO 2012 (TIV)	100		55	
194	Freezing Drizzle	-10	13	CLAR SF PRO 2012 (TIV)	100		55	
195	Freezing Drizzle	-10	13	CLAR SF PRO 2012 (TIV)	75		40	
196	Freezing Drizzle	-10	13	CLAR SF PRO 2012 (TIV)	75		40	
197	Freezing Drizzle	-10	13	CLAR SF MPIV 2015 TF (TIV)	100		55	
198	Freezing Drizzle	-10	13	CLAR SF MPIV 2015 TF (TIV)	100		55	
199	Freezing Drizzle	-10	13	CLAR SF MPIV 2015 TF (TIV)	75		40	
200	Freezing Drizzle	-10	13	CLAR SF MPIV 2015 TF (TIV)	75		40	
201	Freezing Drizzle	-10	13	UCAR Dieth. (TIV)	100		30	
202	Freezing Drizzle	-10	13	UCAR Dieth. (TIV)	100		30	
203	Freezing Drizzle	-10	13	UCAR Dieth. (TIV)	75		30	
204	Freezing Drizzle	-10	13	UCAR Dieth. (TIV)	75		30	
205	Freezing Drizzle	-10	13	SPCA Ecowing 26 (TII)	100		15	
206	Freezing Drizzle	-10	13	SPCA Ecowing 26 (TII)	100		15	
207	Freezing Drizzle	-10	13	SPCA Ecowing 26 (TII)	75		15	
208	Freezing Drizzle	-10	13	SPCA Ecowing 26 (TII)	75		15	
209	Freezing Drizzle	-10	13	LYON. ARCO PLUS-ST. (TI)	10°		5	
210	Freezing Drizzle	-10	13	LYON. ARCO PLUS-ST. (TI)	10°		5	
211	Freezing Drizzle	-10	13	NEWAVE AEROCH. FCY-1A (TI)	10°		5	
212	Freezing Drizzle	-10	13	NEWAVE AEROCH. FCY-1A (TI)	10°		5	**10**
							4838	
							81	

Rates: 136 Tests x 30 minutes = 68 hours
Hours required for testing = 167 hours (68 +99)
Total Chamber time required = 21 hours (167 hours /8 plates at a time)

Estimated time in chamber to complete Zd tests = 3 days

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	HOT	HOT Est.
213	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	100		240
214	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	100		240
215	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	75		180
216	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	75		180
217	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	50		35
218	Freezing Fog	-3	2	CLAR SF PRO 2012 (TIV)	50		35
219	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	100		240
220	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	100		240
221	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	75		180
222	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	75		180
223	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	50		35
224	Freezing Fog	-3	2	CLAR SF MPIV 2015 TF (TIV)	50		35
225	Freezing Fog	-3	2	UCAR Dieth. (TIV)	100		180
226	Freezing Fog	-3	2	UCAR Dieth. (TIV)	100		180
227	Freezing Fog	-3	2	UCAR Dieth. (TIV)	75		120
228	Freezing Fog	-3	2	UCAR Dieth. (TIV)	75		120
229	Freezing Fog	-3	2	UCAR Dieth. (TIV)	50		50
230	Freezing Fog	-3	2	UCAR Dieth. (TIV)	50		50
231	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	100		90
232	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	100		90
233	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	75		60
234	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	75		60
235	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	50		35
236	Freezing Fog	-3	2	SPCA Ecowing 26 (TII)	50		35
237	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	100		150
238	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	100		150
239	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	75		120
240	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	75		120
241	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	50		20
242	Freezing Fog	-3	5	CLAR SF PRO 2012 (TIV)	50		20
243	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	100		150
244	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	100		150
245	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	75		120
246	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	75		120
247	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	50		20
248	Freezing Fog	-3	5	CLAR SF MPIV 2015 TF (TIV)	50		20
249	Freezing Fog	-3	5	UCAR Dieth. (TIV)	100		180
250	Freezing Fog	-3	5	UCAR Dieth. (TIV)	100		180
251	Freezing Fog	-3	5	UCAR Dieth. (TIV)	75		120
252	Freezing Fog	-3	5	UCAR Dieth. (TIV)	75		120
253	Freezing Fog	-3	5	UCAR Dieth. (TIV)	50		20
254	Freezing Fog	-3	5	UCAR Dieth. (TIV)	50		20
255	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	100		35
256	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	100		35
257	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	75		25
258	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	75		25
259	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	50		15
260	Freezing Fog	-3	5	SPCA Ecowing 26 (TII)	50		15
261	Freezing Fog	-10	2	LYON. ARCO PLUS-ST. (TI)	10°		15
262	Freezing Fog	-10	2	LYON. ARCO PLUS-ST. (TI)	10°		15
263	Freezing Fog	-10	2	NEWAVE AEROCH. FCY-1A (TI)	10°		15
264	Freezing Fog	-10	2	NEWAVE AEROCH. FCY-1A (TI)	10°		15
265	Freezing Fog	-10	5	LYON. ARCO PLUS-ST. (TI)	10°		6
266	Freezing Fog	-10	5	LYON. ARCO PLUS-ST. (TI)	10°		6
267	Freezing Fog	-10	5	NEWAVE AEROCH. FCY-1A (TI)	10°		6
268	Freezing Fog	-10	5	NEWAVE AEROCH. FCY-1A (TI)	10°		6
269	Freezing Fog	-14	2	CLAR SF PRO 2012 (TIV)	100		120
270	Freezing Fog	-14	2	CLAR SF PRO 2012 (TIV)	100		120

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate $g/dm^2/hr$	Fluid Brand	Dilution	HOT	HOT Est.	
271	Freezing Fog	-14	2	CLAR SF PRO 2012 (TIV)	75		70	
272	Freezing Fog	-14	2	CLAR SF PRO 2012 (TIV)	75		70	
273	Freezing Fog	-14	2	CLAR SF MPIV 2015 TF (TIV)	100		120	
274	Freezing Fog	-14	2	CLAR SF MPIV 2015 TF (TIV)	100		120	
275	Freezing Fog	-14	2	CLAR SF MPIV 2015 TF (TIV)	75		70	
276	Freezing Fog	-14	2	CLAR SF MPIV 2015 TF (TIV)	75		70	
277	Freezing Fog	-14	2	UCAR Dieth. (TIV)	100		120	
278	Freezing Fog	-14	2	UCAR Dieth. (TIV)	100		120	
279	Freezing Fog	-14	2	UCAR Dieth. (TIV)	75		70	
280	Freezing Fog	-14	2	UCAR Dieth. (TIV)	75		70	
281	Freezing Fog	-14	2	SPCA Ecowing 26 (TII)	100		65	
282	Freezing Fog	-14	2	SPCA Ecowing 26 (TII)	100		65	
283	Freezing Fog	-14	2	SPCA Ecowing 26 (TII)	75		55	
284	Freezing Fog	-14	2	SPCA Ecowing 26 (TII)	75		55	
285	Freezing Fog	-14	5	CLAR SF PRO 2012 (TIV)	100		45	
286	Freezing Fog	-14	5	CLAR SF PRO 2012 (TIV)	100		45	
287	Freezing Fog	-14	5	CLAR SF PRO 2012 (TIV)	75		30	
288	Freezing Fog	-14	5	CLAR SF PRO 2012 (TIV)	75		30	
289	Freezing Fog	-14	5	CLAR SF MPIV 2015 TF (TIV)	100		45	
290	Freezing Fog	-14	5	CLAR SF MPIV 2015 TF (TIV)	100		45	
291	Freezing Fog	-14	5	CLAR SF MPIV 2015 TF (TIV)	75		30	
292	Freezing Fog	-14	5	CLAR SF MPIV 2015 TF (TIV)	75		30	
293	Freezing Fog	-14	5	UCAR Dieth. (TIV)	100		45	
294	Freezing Fog	-14	5	UCAR Dieth. (TIV)	100		45	
295	Freezing Fog	-14	5	UCAR Dieth. (TIV)	75		30	
296	Freezing Fog	-14	5	UCAR Dieth. (TIV)	75		30	
297	Freezing Fog	-14	5	SPCA Ecowing 26 (TII)	100		30	
298	Freezing Fog	-14	5	SPCA Ecowing 26 (TII)	100		30	
299	Freezing Fog	-14	5	SPCA Ecowing 26 (TII)	75		20	
300	Freezing Fog	-14	5	SPCA Ecowing 26 (TII)	75		20	
301	Freezing Fog	-25	2	CLAR SF PRO 2012 (TIV)	100		40	
302	Freezing Fog	-25	2	CLAR SF PRO 2012 (TIV)	100		40	
303	Freezing Fog	-25	2	CLAR SF MPIV 2015 TF (TIV)	100		40	
304	Freezing Fog	-25	2	CLAR SF MPIV 2015 TF (TIV)	100		40	
305	Freezing Fog	-25	2	UCAR Dieth. (TIV)	100		40	
306	Freezing Fog	-25	2	UCAR Dieth. (TIV)	100		40	
307	Freezing Fog	-25	2	SPCA Ecowing 26 (TII)	100		20	
308	Freezing Fog	-25	2	SPCA Ecowing 26 (TII)	100		20	
309	Freezing Fog	-25	2	LYON. ARCO PLUS-ST. (TI)	10°		15	
310	Freezing Fog	-25	2	LYON. ARCO PLUS-ST. (TI)	10°		15	
311	Freezing Fog	-25	2	NEWAVE AEROCH. FCY-1A (TI)	10°		15	
312	Freezing Fog	-25	2	NEWAVE AEROCH. FCY-1A (TI)	10°		15	**6**
313	Freezing Fog	-25	5	CLAR SF PRO 2012 (TIV)	100		25	
314	Freezing Fog	-25	5	CLAR SF PRO 2012 (TIV)	100		25	
315	Freezing Fog	-25	5	CLAR SF MPIV 2015 TF (TIV)	100		25	
316	Freezing Fog	-25	5	CLAR SF MPIV 2015 TF (TIV)	100		25	
317	Freezing Fog	-25	5	UCAR Dieth. (TIV)	100		25	
318	Freezing Fog	-25	5	UCAR Dieth. (TIV)	100		25	
319	Freezing Fog	-25	5	SPCA Ecowing 26 (TII)	100		15	
320	Freezing Fog	-25	5	SPCA Ecowing 26 (TII)	100		15	
321	Freezing Fog	-25	5	LYON. ARCO PLUS-ST. (TI)	10°		6	
322	Freezing Fog	-25	5	LYON. ARCO PLUS-ST. (TI)	10°		6	
323	Freezing Fog	-25	5	NEWAVE AEROCH. FCY-1A (TI)	10°		6	
324	Freezing Fog	-25	5	NEWAVE AEROCH. FCY-1A (TI)	10°		6	**3**
							7398	
							123	

Rates: 200 Tests x 30 minutes = 100 hours
Hours required for testing = 311 hours (100 + 211)
Total Chamber time required = 39 hours (311 hours /8 plates at a time)

Estimated time in chamber to complete Zfog tests = 6 days

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	HOT	HOT Est.	
325	Cold Soak Box	1	5	CLAR SF PRO 2012 (TIV)	100		115	
326	Cold Soak Box	1	5	CLAR SF PRO 2012 (TIV)	100		115	
327	Cold Soak Box	1	5	CLAR SF PRO 2012 (TIV)	75		55	
328	Cold Soak Box	1	5	CLAR SF PRO 2012 (TIV)	75		55	
329	Cold Soak Box	1	5	CLAR SF MPIV 2015 TF (TIV)	100		115	
330	Cold Soak Box	1	5	CLAR SF MPIV 2015 TF (TIV)	100		115	
331	Cold Soak Box	1	5	CLAR SF MPIV 2015 TF (TIV)	75		55	
332	Cold Soak Box	1	5	CLAR SF MPIV 2015 TF (TIV)	75		55	
333	Cold Soak Box	1	5	UCAR Dieth. (TIV)	100		70	
334	Cold Soak Box	1	5	UCAR Dieth. (TIV)	100		70	
335	Cold Soak Box	1	5	UCAR Dieth. (TIV)	75		60	
336	Cold Soak Box	1	5	UCAR Dieth. (TIV)	75		60	
337	Cold Soak Box	1	5	SPCA Ecowing 26 (TII)	100		40	
338	Cold Soak Box	1	5	SPCA Ecowing 26 (TII)	100		40	
339	Cold Soak Box	1	5	SPCA Ecowing 26 (TII)	75		25	
340	Cold Soak Box	1	5	SPCA Ecowing 26 (TII)	75		25	
341	Cold Soak Box	1	5	LYON. ARCO PLUS-ST. (TI)	10°		5	
342	Cold Soak Box	1	5	LYON. ARCO PLUS-ST. (TI)	10°		5	
343	Cold Soak Box	1	5	NEWAVE AEROCH. FCY-1A (TI)	10°		5	
344	Cold Soak Box	1	5	NEWAVE AEROCH. FCY-1A (TI)	10°		5	**18**
345	Cold Soak Box	1	75	CLAR SF PRO 2012 (TIV)	100		15	
346	Cold Soak Box	1	75	CLAR SF PRO 2012 (TIV)	100		15	
347	Cold Soak Box	1	75	CLAR SF PRO 2012 (TIV)	75		5	
348	Cold Soak Box	1	75	CLAR SF PRO 2012 (TIV)	75		5	
349	Cold Soak Box	1	75	CLAR SF MPIV 2015 TF (TIV)	100		15	
350	Cold Soak Box	1	75	CLAR SF MPIV 2015 TF (TIV)	100		15	
351	Cold Soak Box	1	75	CLAR SF MPIV 2015 TF (TIV)	75		5	
352	Cold Soak Box	1	75	CLAR SF MPIV 2015 TF (TIV)	75		5	
353	Cold Soak Box	1	75	UCAR Dieth. (TIV)	100		15	
354	Cold Soak Box	1	75	UCAR Dieth. (TIV)	100		15	
355	Cold Soak Box	1	75	UCAR Dieth. (TIV)	75		10	
356	Cold Soak Box	1	75	UCAR Dieth. (TIV)	75		10	
357	Cold Soak Box	1	75	SPCA Ecowing 26 (TII)	100		5	
358	Cold Soak Box	1	75	SPCA Ecowing 26 (TII)	100		5	
359	Cold Soak Box	1	75	SPCA Ecowing 26 (TII)	75		5	
360	Cold Soak Box	1	75	SPCA Ecowing 26 (TII)	75		5	
361	Cold Soak Box	1	75	LYON. ARCO PLUS-ST. (TI)	10°		2	
362	Cold Soak Box	1	75	LYON. ARCO PLUS-ST. (TI)	10°		2	
363	Cold Soak Box	1	75	NEWAVE AEROCH. FCY-1A (TI)	10°		2	
364	Cold Soak Box	1	75	NEWAVE AEROCH. FCY-1A (TI)	10°		2	**3**
							1248	
							21	

Rates: 56 Tests x 30 minutes = 28 hours
Hours required for testing = 58 hours (28 +30)
Total Chamber time required = 15 hours (58 hours /4 boxes at a time)
Estimated time in chamber to complete CSW tests = 2 days

ATTACHMENT C-IV

		ZR3H	ZR3L	ZR10H ZR10L	CSWL	CSWH	ZFOG25H ZFOG25L	ZFOG14H ZFOG14L	ZFOG14L ZFOG10H ZFOG10L	ZFOG3L	ZFOG3H	ZD10H	ZD10L	ZD3H	ZD3L	
		27-Mar	**28-Mar**	**29-Mar**	**30-Mar**	**31-Mar**	***3-Apr***	***4-Apr***	***5-Apr***	***6-Apr***	***7-Apr***	**10-Apr**	**11-Apr**	**12-Apr**	**13-Apr**	**14-Apr**
HOT MGR		MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	
Fluids Prep.		JM	JM	JM	JM	JM	JM	JM	JM	JM	JM	JM	JM	JM	JM	
Fluids / NCAR		MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	
Rate SS	Manage SS, change pans, detail rates, data entry, charts	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	Rob	
Rate SS	Manage SS, change pans, detail rates, data entry, charts	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	YOW2	
Rate Mgr	Manage/change pans	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	PL	
CSW Mgr					JD	JD										
CSW box					RC	RC										
CSW box					?	?										
Procedure		YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	YOW3	
CHARTS		NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	
NCAR		NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	

ATTACHMENT C-V

NRC COLD CHAMBER TESTS MARCH 2000

TEST EQUIPMENT CHECKLIST

TASK	*NRC Cold Chamber*	
	Resp.	**Status**
Logistics for Every Test		
Make Hotel reservations	CD	
Rent Mini-Van/Cube truck	CD	
Personnel Advances	All	
Personnel Transportation	MC	
Prior to Testing		
Install thermocouples on plates	NB	
Coordinate drop-off of truck in Ottawa	MC	
Install thermocouples in boxes	NB	
Follow-up on Kilfrost shipment	MC	
Mark crosshairs on all new plates	NB	
Order refrigerators	JD	
Test Equipment		
New Stand x 4 (individual stands)	MC	
2 x 3-plate stand	MC	
Desktop Computer x 1 (MC's computer)	MC	
Diskettes	MC	
Rags	MC	
Time Cards, Invoices, Expense forms	MC	
Video Tapes	JD	
Batteries AA, 9V	JD	
Laptop Computer x 2 Micron and IBM	NM	
Still Photo Camera and still digital camera	MC	
Fluid for cold-soak boxes	MC	
Digital Microscope + forensic scales	MC	
Weigh Scale x 2 (sartorius) + wiring	MC	
Digital Video camera	MC	
Time lapse video camera	MC / JM	
Boards for cold-soak test	MC	
Clamps x 12	MC	
VCR for time lapse	MC / JM	
Monitor for time lapse	MC / JM	
Reg. Plates (wing nuts) X 22 (with logging capability)	MC	
1 litre pour containers from office	MC	
Red containers	MC	
Data Forms for plates	MC	
Precipitation rate Data Forms	MC	
Insulation for weigh scale	MC	
Reports + HOT Tables	MC	
Dilution curves for Type I fluids	MC	
Large Precipitation Pans x 100	MC	
Metal cold-soak box covers	MC	
Microscope (with oil) for droplet sizes	MC	
Rate distribution pans	MC	
Large calculator	MC	
Fluids	MC	
Clipboards x 5	MC	
Pencils + pens	MC	
Paper Towels	MC	
Rubber squeegees x 4	MC	
Waste containers x 20	MC	
Plastic Refills(red containers) for Fluids and funnels	MC	
Electrical Extension Cords	MC	
Lighting x 3	MC	
Stop watches x 4	MC	
Storage bins for small equipment	MC	
Protective clothing (6)	MC	
Brixometer X 3	MC	
Tie wraps	MC	
Funnels	MC	
Hand-held Temperture Probes x 2 (Barnant and Wahl)	MC	
Thickness Gauges x 5 (both types)	MC	
Scrapers	MC	
RH meter	MC	

ATTACHMENT C-IV

AMENDED PROCEDURE FOR THE COLLECTION OF PRECIPITATION FOR HOLDOVER TIME TRIALS

The precipitation rate procedure outlined below is for use in 2000/01 holdover time trials. A concentrated effort has been made on an annual basis to improve this procedure based on the experiences gained through testing.

Below is an example of a typical test stand used for the conduct of holdover time tests. Each number represents a test location (plate location) on the test stand.

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

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spraying device, and the various pressure settings 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 collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are re-weighed following this 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 close to the precipitation rate required for the condition, then the pouring of fluids may begin at this location.

Rates will continuously be 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 in order to collect a minimum of two 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.

The following is an example of a test run conducted in light freezing rain conditions. The desired rate of precipitation for this run is 25 $g/dm^2/h$.

Prior to the start of the test, collection pans are placed at each of the locations on the stand. Following a collection period, the pans are re-weighed. The following rates were recorded.

Rate collection #1

1 24.5 $g/dm^2/hr$	2 24.6 $g/dm^2/hr$	3 24.2 $g/dm^2/hr$	4 23.9 $g/dm^2/hr$	5 25.0 $g/dm^2/hr$	6 26.4 $g/dm^2/hr$
7 26.2 $g/dm^2/hr$	8 25.6 $g/dm^2/hr$	9 25.3 $g/dm^2/hr$	10 25.1 $g/dm^2/hr$	11 25.7 $g/dm^2/hr$	12 26.1 $g/dm^2/hr$

The rates are deemed to be acceptable, and therefore the pans are immediately returned to the test stand and a second rate collection period is initiated. Following the collection period, the pans are again re-weighed.

Rate collection #2

1 25.1 $g/dm^2/hr$	2 24.8 $g/dm^2/hr$	3 24.9 $g/dm^2/hr$	4 25.9 $g/dm^2/hr$	5 25.8 $g/dm^2/hr$	6 25.4 $g/dm^2/hr$
7 25.9 $g/dm^2/hr$	8 25.3 $g/dm^2/hr$	9 25.2 $g/dm^2/hr$	10 25.0 $g/dm^2/hr$	11 25.1 $g/dm^2/hr$	12 26.4 $g/dm^2/hr$

A calculation of the precipitation rates reveals that the rates are consistent As a result, holdover time tests will be conducted on plates 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11. Collection pans will be re-weighed and placed on locations 7 and 12 in order to provide continuous monitoring of the rates during the test period.

Following the failure of the plates, the collection pans are weighed and once again placed on the test stand at their respective locations. Following the precipitation collection period, the pans are re-weighed.

Rate collection #3 (following plate failure)

1 25.4 g/dm^2/hr	2 24.9 g/dm^2/hr	3 25.5 g/dm^2/hr	4 26.7 g/dm^2/hr	5 25.2 g/dm^2/hr	6 26.5 g/dm^2/hr
7 26.3 g/dm^2/hr	8 25.4 g/dm^2/hr	9 24.6 g/dm^2/hr	10 25.5 g/dm^2/hr	11 24.3 g/dm^2/hr	12 26.3 g/dm^2/hr

The pans are returned to the stand. Following another collection period, they are re-weighed for the final time.

Rate collection #4 (following plate failure)

1 25.2 g/dm^2/hr	2 25.7 g/dm^2/hr	3 25.1 g/dm^2/hr	4 24.3 g/dm^2/hr	5 25.7 g/dm^2/hr	6 26.9 g/dm^2/hr
7 26.7 g/dm^2/hr	8 25.4 g/dm^2/hr	9 24.6 g/dm^2/hr	10 25.5 g/dm^2/hr	11 24.3 g/dm^2/hr	12 26.3 g/dm^2/hr

The rate of precipitation for any location on the stand may be calculated by averaging the four rates obtained for this location. Below are the calculated precipitation rates for the example run.

Average Precipitation Rates

1 25.1 $g/dm^2/hr$	2 25.0 $g/dm^2/hr$	3 24.9 $g/dm^2/hr$	4 25.2 $g/dm^2/hr$	5 25.4 $g/dm^2/hr$	6 26.3 $g/dm^2/hr$
7 26.3 $g/dm^2/hr$	8 25.4 $g/dm^2/hr$	9 24.9 $g/dm^2/hr$	10 25.3 $g/dm^2/hr$	11 24.9 $g/dm^2/hr$	12 26.3 $g/dm^2/hr$

The normal procedure is to conduct two tests at about 25 $g/dm^2/hr$ and two tests at about 13 $g/dm^2/hr$ for light freezing rain. Each of these tests are conducted at the same temperature (i.e. –3°C). The average values obtained for precipitation rate at each position is used for each test. The HOT value at the required precipitation rate (for example at 25 $g/dm^2/hr$) is obtained by producing a "best fit" regression curve through the points using a "log-log" transformation based on the test points collected at around 13 $g/dm^2/hr$ and 25 $g/dm^2/hr$. Similarly, the HOT value at 13 $g/dm^2/h$ is obtained using the same curve. This method is repeated for all other conditions and associated temperatures described in 2.12.1., for each fluid.

ATTACHMENT C-VII

COLD SOAK BOX PREPARATION PROCEDURE

Winter 2000/01

1. Put six containers (20 L) of CSW box fluid (propylene 65/35) in cold (-30 ± 5°C) freezer overnight. Freezers to be kept in large chamber.

2. Put all filled CSW boxes in warmer (-12 ± 1°C) freezer overnight.

3. Next morning, if freezer in step (2) does not provide fluid and box temperature of -12 ± 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 -12°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 -12 ± 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 -12 ± 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 to warm 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).

The process shall be managed as per the attached form (Figure C-3).

FIGURE C-3

CSW PROCESS MANAGEMENT FORM

1	*2*	*3*	*4*	*5*
6	*7*	*8*	*9*	*10*

1. A typical box position can be in one of the following stages:

- **Rate**
- **Not used**
- **Available for test (approx. Rate)**
- **Warming**
- **Test**

2. Denote the stage in the appropriate square

ATTACHMENT C-VIII

PROCEDURE FOR PREPARING HARD WATER

Hard water is required to dilute Type I fluids for holdover time testing. The following procedure outlines the steps required to produce 1 litre of hard water.

Hard Water =

Distilled (deionized) water + calcium acetate monohydrate or anhydrous calcium acetate + magnesium sulfate heptahydrate.

In order to produce 1 litre of hard water:

Take 1 litre of Distilled Water
Dissolve 400mg of the calcium acetate monohydrate or anhydrous calcium acetate
Dissolve 280mg of the magnesium sulfate heptahydrate

Requirements

The distilled water must conform to specifications of type IV water outlined in D 1193-91.

Electrical conductivity at 25°C = 5
Electrical resistance = 0.2
pH = 5.0 – 8.0
Total organic carbon = no limit
Sodium = 50 ug
Chlorides = 50 ug
Total silica = no limit

TABLE C-I

FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Clariant EG I 1996				Clariant MPI 1938 TF (310)				Lyondell Arco+				Inland Duragly-P			
		% 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	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5																
1	-9	28	14	2.2	5.8	28.5	16.5	2.3	5.7	31.25	20.5	2.5	5.5	30	21.25	2.4	5.6
0	-10	29.5	14.75	2.4	5.6	31.5	18.5	2.5	5.5	32.25	21.25	2.6	5.4	31	21.5	2.5	5.5
-1	-11	31	15.5	2.5	5.5	34	19.75	2.7	5.3	33.25	21.8	2.7	5.3	32	22	2.6	5.4
-2	-12	33	16.5	2.6	5.4	37.5	21.5	3.0	5.0	34.25	22.5	2.7	5.3	33	22.5	2.6	5.4
-3	-13	35	17.5	2.8	5.2	39.25	22.5	3.1	4.9	35.25	23	2.8	5.2	33	22.5	2.6	5.4
-4	-14	36.5	18.25	2.9	5.1	40.5	23.5	3.2	4.8	36	23.5	2.9	5.1	34	22.5	2.7	5.3
-5	-15	38	19	3.0	5.0	42	24.25	3.4	4.6	37	24	3.0	5.0	35	23	2.8	5.2
-6	-16	39.5	19.75	3.2	4.8	43	24.75	3.4	4.6	38	24.75	3.0	5.0	36	23.5	2.9	5.1
-7	-17	41	20.5	3.3	4.7	44.25	25.5	3.5	4.5	39	25.5	3.1	4.9	37	24	3.0	5.0
-8	-18	42.5	21.25	3.4	4.6	45.5	26	3.6	4.4	40.25	26.25	3.2	4.8	38.5	25	3.1	4.9
-9	-19	44	22	3.5	4.5	46.5	26.5	3.7	4.3	41.25	26.75	3.3	4.7	40	26	3.2	4.8
-10	-20	45	22.5	3.6	4.4	47.75	27.5	3.8	4.2	42.5	27.5	3.4	4.6	41.5	27	3.3	4.7
-11	-21	46	23	3.7	4.3	49	28	3.9	4.1	43.5	28	3.5	4.5	43.5	28	3.5	4.5
-12	-22	47.5	23.75	3.8	4.2	50	28.75	4.0	4.0	44.5	28.5	3.6	4.4	45	29	3.6	4.4
-13	-23	48.5	24.25	3.9	4.1	51	29.25	4.1	3.9	45.5	29.25	3.6	4.4	46	29.5	3.7	4.3
-14	-24	50	25	4.0	4.0	52.25	29.75	4.2	3.8	46.5	30	3.7	4.3	47	30	3.8	4.2
-15	-25	50.5	25.25	4.0	4.0	53.5	30.25	4.3	3.7	47.5	30.5	3.8	4.2	47.5	30.5	3.8	4.2
-16	-26	52	26	4.2	3.8	54.5	30.75	4.4	3.6	48.75	31.25	3.9	4.1	48.5	31	3.9	4.1
-17	-27	53	26.5	4.2	3.8	55.5	31.25	4.4	3.6	50	32	4.0	4.0	49	31.5	3.9	4.1
-18	-28	54	27	4.3	3.7	56.5	31.75	4.5	3.5	50.75	32.5	4.1	3.9	50	32	4.0	4.0
-19	-29	55	27.5	4.4	3.6	57.75	32.25	4.6	3.4	51.75	33	4.1	3.9	51	32.5	4.1	3.9
-20	-30	56	28	4.5	3.5	58.75	32.75	4.7	3.3	52.75	33.5	4.2	3.8	51.75	33	4.1	3.9
-22	-32	58	29	4.6	3.4	61	33.75	4.9	3.1	55	34.5	4.4	3.6	53	34	4.2	3.8
-25	-35	61.5	30.75	4.9	3.1	64.5	35.25	5.2	2.8	56.75	35.75	4.5	3.5	56	35.5	4.5	3.5
-30	-40	66.5	33.25	5.3	2.7	70	37.75	5.6	2.4	60	37.25	4.8	3.2	60	37	4.8	3.2
Standard Mix																	

TABLE C-2
DE/ANTI-ICING DATA FORM FOR FREEZING PRECIPIATION

REMEMBER TO SYNCHRONIZE TIME　　　　VERSION 5.0　　　　1997/98

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

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application:						
Initial Brix						
Initial Fluid Temperatrure						
	Plate 1	**Plate 2**	**Plate 3**	**Plate 4**	**Plate 5**	**Plate 6**
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
C/FIMS						

Time of Fluid Application:						
Initial Brix						
Initial Fluid Temperatrure						
	Plate 7	**Plate 8**	**Plate 9**	**Plate 10**	**Plate 11**	**Plate 12**
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
C/FIMS						

PRECIP:　　**ZF , ZD , ZR-, MOD**　　**AMBIENT TEMPERATURE:** ________ °C

COMMENTS: ______________________________　　**FAILURES CALLED BY :** ______________

____

______________________________　　**HAND WRITTTEN BY :** ______________　　**LEADER:** ______________

TABLE C-2A
DE/ANTI-ICING DATA FORM FOR COLD SOAK BOX

REMEMBER TO SYNCHRONIZE TIME

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

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application	______	______	______	______	______
Initial Brix	______	______	______	______	______
Fluid Temperature	______	______	______	______	______
Intial Box Temperature	______	______	______	______	______
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	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
Final Box Temperature	______	______	______	______	______

Time of Fluid Application	______	______	______	______	______
Initial Brix	______	______	______	______	______
Fluid Temperature	______	______	______	______	______
Intial Box Temperature	______	______	______	______	______
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	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
Final Box Temperature	______	______	______	______	______

AMBIENT TEMPERATURE: ________ °C

COMMENTS: ______________________________

FAILURES CALLED BY : ______________

HAND WRITTTEN BY : ______________

TABLE C-3

PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________ **Needles used:** __________

Start Time: ____________________ **Flow Rate of Water:** __________

Run # : ____________________ **Line Air Pressure:** __________

Stand: ____________________ **Line Air Temperature:** __________

Precip Type: ____________________ (ZD, ZR-, FZF, S) **Line Water Pressure:** __________

Line Water Temperature: __________

Pan Location:

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

Collection Pan:

Pan #	Area of Pan (dm²)	Location	Weight of Pan (g) Before	Weight of Pan (g) After	Collection Time (hr:mm:ss) Start	Collection Time (hr:mm:ss) End	Rate
1	14.56	1					
2	14.56	2					
3	14.56	3					
4	14.56	4					
5	14.56	5					
6	14.56	6					
7	14.56	7					
8	14.56	8					
9	14.56	9					
10	14.56	10					
11	14.56	11					
12	14.56	12					
13	14.56	13					
14	14.56	14					
15	14.56	15					
16	14.56	16					

Comments: ____

____

____

____

Handwritten by: ____________________

Measured by: ____________________

TABLE C-3A

DETAILED PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

PLATE

1	2
3	4

Date: ____________________

Start Time: ____________________

Run # : ____________________

Stand: ____________________

Precip Type: ____________________ (ZD, ZR-)

Pan Location (Circle):

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

Collection Pan:

Pan/ #	Area of Pan (dm^2)	Weight of Pan (g) Before	Weight of Pan (g) After	Collection Time (hr:mm:ss) Start	Collection Time (hr:mm:ss) End	Rate
1						
2						
3						
4						

Comments: ____________________

Handwritten by: ____________________

Measured by: ____________________

TABLE C-3B

CONTINUOUS PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ____________________

Start Time: ____________________

Run # : ____________________

Stand: ____________________

Precip Type: ____________________ (ZD, ZR-, FZF, S, CS)

Pan Location:

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

Collection Pan:

Pan #	Area of Pan (dm²)	Location	Weight of Pan (g)		Collection Time (hr:mm:ss)		Rate
			Before	After	Start	End	
1	14.56						
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							
1							
2							

Comments: ____________________

Handwritten by: ____________________

Measured by: ____________________

TABLE C-4

COLD SOAK PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ______________________

Start Time: ______________________

Run # : ______________________

Precip Type: ______________________ (Drizzle, Light Rain, Moderate Rain, Heavy Rain)

Pan Location:

1	**2**	**3**	**4**	**5**
6	**7**	**8**	**9**	**10**

Collection Pan:

Pan #	Area of Pan (dm²)	Location		Weight of Pan (g) Before	After	Collection Time (hr:mm:ss) Start	End	RATE
1	14.56	1	=					
2	14.56	2	=					
3	14.56	3	=					
4	14.56	4	=					
5	14.56	5	=					
6	14.56	6	=					
7	14.56	7	=					
8	14.56	8	=					
9	14.56	9	=					
10	14.56	10	=					

Comments: ______________________

Handwritten by: ______________________

Measured by: ______________________

TABLE C-5

RATE MANAGEMENT FORM

DATE: ________________ **PERFORMED BY:** ________________

PAN #	TIME OUT	PAN #	TIME OUT	PAN #	TIME OUT

APPENDIX D

NRC TEST PROCEDURE OCTAGON MAXFLIGHT
JUNE 2001

NRC Test Procedure Octagon Max-Flight
June 2001

The detailed procedure and equipment list for these tests can be found in Appendix C. The following are the changes to the procedure found in Appendix C.

June 04 - June 10

June 2001

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

July 2001

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Monday, June 04

SETUP AT NRC

10:00- 14:00 **CSW +1° C**
14:00-19:00 **ZD -3° C**

SETUP NCAR MACHINE IN SMALL CHAMBER

Tuesday, June 05

8:00-12:00 **ZR – 10° C**
12:00-16:00 **ZD – 10° C**
16:00-20:00 **ZR – 3 ° C**

NCAR 8:00-10:30 TEST# 15,16

NCAR 16-19 :30 TEST# 9,10,11

Wednesday, June 06

8:00-14:00 **Zfog – 25° C**
14:00-18:00 **Zfog – 14° C**
AMIL 8:00-14:00
TEST# 9,11,33,35,57,59

NCAR 14:00-19:00 TEST# 17,18

AMIL ALTERNATES
TEST# 29,53, 5, 7

Thursday, June 07

8:00-18:00 **Zfog – 3° C**

NCAR 8:-12:45 TEST# 12,13,14

AMIL 13:00-20:00
TEST#1,13,17,21, 23,37,43,45,47

Friday, June 08

Saturday, June 09

Sunday, June 10

CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
1	Cold Soak Box	1	5	O MaxF	100		50
2	Cold Soak Box	1	5	O MaxF	100		50
3	Cold Soak Box	1	5	O MaxF	75		40
4	Cold Soak Box	1	5	O MaxF	75		40
5	Cold Soak Box	1	75	O MaxF	100		10
6	Cold Soak Box	1	75	O MaxF	100		10
7	Cold Soak Box	1	75	O MaxF	75		10
8	Cold Soak Box	1	75	O MaxF	75		10
9	Freezing Drizzle	-10	5	O MaxF	100		70
10	Freezing Drizzle	-10	5	O MaxF	100		70
11	Freezing Drizzle	-10	5	O MaxF	75		60
12	Freezing Drizzle	-10	5	O MaxF	75		60
13	Freezing Drizzle	-10	13	O MaxF	100		30
14	Freezing Drizzle	-10	13	O MaxF	100		30
15	Freezing Drizzle	-10	13	O MaxF	75		30
16	Freezing Drizzle	-10	13	O MaxF	75		30
17	Freezing Drizzle	-3	5	O MaxF	100		120
18	Freezing Drizzle	-3	5	O MaxF	100		120
19	Freezing Drizzle	-3	5	O MaxF	75		120
20	Freezing Drizzle	-3	5	O MaxF	75		120
21	Freezing Drizzle	-3	5	O MaxF	50		60
22	Freezing Drizzle	-3	5	O MaxF	50		60
23	Freezing Drizzle	-3	13	O MaxF	100		60
24	Freezing Drizzle	-3	13	O MaxF	100		60
25	Freezing Drizzle	-3	13	O MaxF	75		80
26	Freezing Drizzle	-3	13	O MaxF	75		80
27	Freezing Drizzle	-3	13	O MaxF	50		30
28	Freezing Drizzle	-3	13	O MaxF	50		30
29	Light Freezing Rain	-10	13	O MaxF	100		40
30	Light Freezing Rain	-10	13	O MaxF	100		40
31	Light Freezing Rain	-10	13	O MaxF	75		30
32	Light Freezing Rain	-10	13	O MaxF	75		30
33	Light Freezing Rain	-10	25	O MaxF	100		20
34	Light Freezing Rain	-10	25	O MaxF	100		20
35	Light Freezing Rain	-10	25	O MaxF	75		20
36	Light Freezing Rain	-10	25	O MaxF	75		20
37	Light Freezing Rain	-3	13	O MaxF	100		60
38	Light Freezing Rain	-3	13	O MaxF	100		60
39	Light Freezing Rain	-3	13	O MaxF	75		70
40	Light Freezing Rain	-3	13	O MaxF	75		70
41	Light Freezing Rain	-3	13	O MaxF	50		30
42	Light Freezing Rain	-3	13	O MaxF	50		30
43	Light Freezing Rain	-3	25	O MaxF	100		40
44	Light Freezing Rain	-3	25	O MaxF	100		40
45	Light Freezing Rain	-3	25	O MaxF	75		40
46	Light Freezing Rain	-3	25	O MaxF	75		40
47	Light Freezing Rain	-3	25	O MaxF	50		20
48	Light Freezing Rain	-3	25	O MaxF	50		20
49	Freezing Fog	-25	2	O MaxF	100		120
50	Freezing Fog	-25	2	O MaxF	100		120
51	Freezing Fog	-25	5	O MaxF	100		20
52	Freezing Fog	-25	5	O MaxF	100		20
53	Freezing Fog	-14	2	O MaxF	100		180
54	Freezing Fog	-14	2	O MaxF	100		180

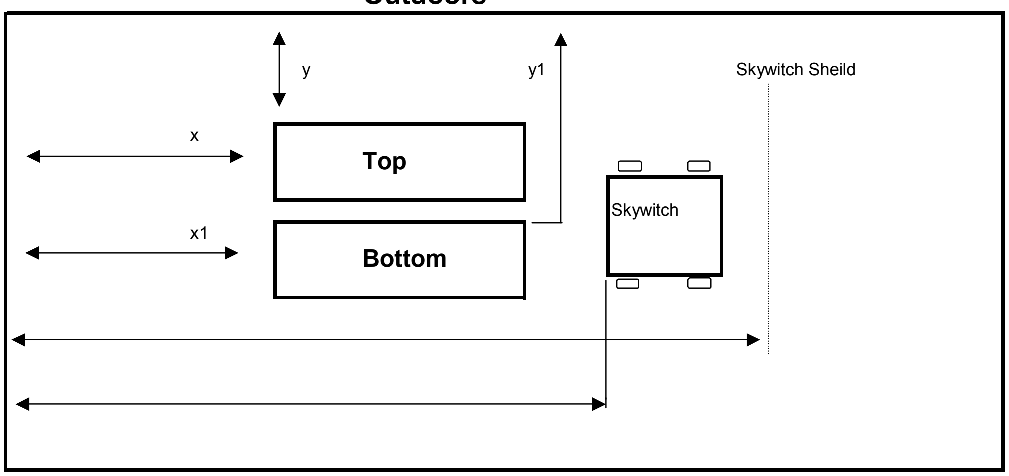
CEF DETAILED TEST PLAN

Test #	Precip Type	Temp. °C	Precip Rate g/dm²/hr	Fluid Brand	Dilution	Viscosity	HOT Est.
55	Freezing Fog	-14	2	O MaxF	75		120
56	Freezing Fog	-14	2	O MaxF	75		120
57	Freezing Fog	-14	5	O MaxF	100		40
58	Freezing Fog	-14	5	O MaxF	100		40
59	Freezing Fog	-14	5	O MaxF	75		30
60	Freezing Fog	-14	5	O MaxF	75		30
61	Freezing Fog	-3	2	O MaxF	100		180
62	Freezing Fog	-3	2	O MaxF	100		180
63	Freezing Fog	-3	2	O MaxF	75		120
64	Freezing Fog	-3	2	O MaxF	75		120
65	Freezing Fog	-3	2	O MaxF	50		50
66	Freezing Fog	-3	2	O MaxF	50		50
67	Freezing Fog	-3	5	O MaxF	100		120
68	Freezing Fog	-3	5	O MaxF	100		120
69	Freezing Fog	-3	5	O MaxF	75		70
70	Freezing Fog	-3	5	O MaxF	75		70
71	Freezing Fog	-3	5	O MaxF	50		20
72	Freezing Fog	-3	5	O MaxF	50		20

Test Stand Location at NRC Chamber

Test	Date of Final Position	Condition	Stand Position x	x1	y	y1	Sky Witch Position	Skywitch Sheild Position	Nozzle Position	Rate	height	Comments
1	4-Apr-01	ZR3H	24' 2"	22' 7"	7'	9' 10"				Very Good		Top Stand 19' from snow fence
2	4-Apr-01	ZR3L	24' 2"	22' 7"	7'	9' 10"				Very Good		Top Stand 19' from snow fence
3	4/2/2001	ZR10H	24'	24' 5"	6' 9"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	2-Apr-01	ZR10L	24'	24' 5"	6' 9"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
5	27-Mar-01	ZD3H	24' 5"	22'	6'6"	10'4" to north wall				Very Good		
6	28-Mar-01	ZD3L	25' 3"	25' 3"	7'3"	9' 6" to north wall				Good		
7	2-Apr-01	ZD10H	24'	25' 3"	7'11"	9' 6"				Very Good		
8	2-Apr-01	ZD10L	24'	24' 7"	7' 7"	9' 11"				Good		20 ft. from Snow Fence
9	10-Apr-01	ZFog3H	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
10	10-Apr-01	ZFog3L	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
11	10-Apr-01	ZFog10H	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
12	10-Apr-01	ZFog10L	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
13	9-Apr-01	ZFog14H	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
14	9-Apr-01	ZFog14L	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
15	6-Apr-01	ZFog25H	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
16	6-Apr-01	ZFog25L	24'	21'11"	6'6"	8'10"	34' 2"from x	40'2" from x	top of 11	Good	144"	
17	29-Mar-01	CSWH	25'3"	25'3"		9' 6" to north wall						
18	29-Mar-01	CSWL	23'11"	25'3"	7'3"	9' 6" to north wall						

Outdoors



APPENDIX E

DILUTIONS FOR TYPE I FLUIDS

FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Clariant EG I 1996				Clariant MPI 1938 TF (310)				Lyondell Arco Plus / Lyondell Arco Plus-ST				FCY-1A			
		% 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	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5																
1	-9	28	14	2.2	5.8	28.5	16.5	2.3	5.7	31.25	20.5	2.5	5.5	19.9	12.80	1.6	6.4
0	-10	29.5	14.75	2.4	5.6	31.5	18.5	2.5	5.5	32.25	21.25	2.6	5.4	22.0	14.01	1.8	6.2
-1	-11	31	15.5	2.5	5.5	34	19.75	2.7	5.3	33.25	21.8	2.7	5.3	23.7	15.18	1.9	6.1
-2	-12	33	16.5	2.6	5.4	37.5	21.5	3.0	5.0	34.25	22.5	2.7	5.3	26.0	16.50	2.1	5.9
-3	-13	35	17.5	2.8	5.2	39.25	22.5	3.1	4.9	35.25	23	2.8	5.2	27.2	17.37	2.2	5.8
-4	-14	36.5	18.25	2.9	5.1	40.5	23.5	3.2	4.8	36	23.5	2.9	5.1	29.0	18.90	2.3	5.7
-5	-15	38	19	3.0	5.0	42	24.25	3.4	4.6	37	24	3.0	5.0	30.5	19.38	2.4	5.6
-6	-16	39.5	19.75	3.2	4.8	43	24.75	3.4	4.6	38	24.75	3.0	5.0	32.0	20.10	2.6	5.4
-7	-17	41	20.5	3.3	4.7	44.25	25.5	3.5	4.5	39	25.5	3.1	4.9	33.5	21.22	2.7	5.3
-8	-18	42.5	21.25	3.4	4.6	45.5	26	3.6	4.4	40.25	26.25	3.2	4.8	35.0	22.50	2.8	5.2
-9	-19	44	22	3.5	4.5	46.5	26.5	3.7	4.3	41.25	26.75	3.3	4.7	36.4	22.91	2.9	5.1
-10	-20	45	22.5	3.6	4.4	47.75	27.5	3.8	4.2	42.5	27.5	3.4	4.6	38.0	23.60	3.0	5.0
-11	-21	46	23	3.7	4.3	49	28	3.9	4.1	43.5	28	3.5	4.5	39.0	24.44	3.1	4.9
-12	-22	47.5	23.75	3.8	4.2	50	28.75	4.0	4.0	44.5	28.5	3.6	4.4	40.3	25.16	3.2	4.8
-13	-23	48.5	24.25	3.9	4.1	51	29.25	4.1	3.9	45.5	29.25	3.6	4.4	41.5	25.84	3.3	4.7
-14	-24	50	25	4.0	4.0	52.25	29.75	4.2	3.8	46.5	30	3.7	4.3	42.6	26.48	3.4	4.6
-15	-25	50.5	25.25	4.0	4.0	53.5	30.25	4.3	3.7	47.5	30.5	3.8	4.2	44.0	27.10	3.5	4.5
-16	-26	52	26	4.2	3.8	54.5	30.75	4.4	3.6	48.75	31.25	3.9	4.1	44.8	27.69	3.6	4.4
-17	-27	53	26.5	4.2	3.8	55.5	31.25	4.4	3.6	50	32	4.0	4.0	45.9	28.24	3.7	4.3
-18	-28	54	27	4.3	3.7	56.5	31.75	4.5	3.5	50.75	32.5	4.1	3.9	46.9	28.77	3.8	4.2
-19	-29	55	27.5	4.4	3.6	57.75	32.25	4.6	3.4	51.75	33	4.1	3.9	47.9	29.27	3.8	4.2
-20	-30	56	28	4.5	3.5	58.75	32.75	4.7	3.3	52.75	33.5	4.2	3.8	49.0	30.50	3.9	4.1
-22	-32	58	29	4.6	3.4	61	33.75	4.9	3.1	55	34.5	4.4	3.6	50.6	30.64	4.0	4.0
-25	-35	61.5	30.75	4.9	3.1	64.5	35.25	5.2	2.8	56.75	35.75	4.5	3.5	53.5	32.70	4.3	3.7
-30	-40	66.5	33.25	5.3	2.7	70	37.75	5.6	2.4	60	37.25	4.8	3.2	58.0	34.90	4.6	3.4
Standard Mix																	

APPENDIX F

REGRESSION ANALYSIS PERFORMED FOR ALL FLUIDS

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
Clariant Safewing Protect 2012 TYPE IV NEAT (#1)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.848609101
R Square	0.720137407
Adjusted R Square	0.704589485
Standard Error	0.11640313
Observations	39

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.255169372	0.627584686	46.31727732	1.10919E-10
Residual	36	0.487788791	0.013549689		
Total	38	1.742958163			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.92612771	0.138720318	21.09372118	7.45545E-22	2.644790235	3.207465184	2.644790235	3.207465184
X Variable 1	-0.672516229	0.069874323	-9.624654666	1.70911E-11	-0.814227738	-0.530804721	-0.814227738	-0.530804721
X Variable 2	-0.539913491	0.097964342	-5.511326651	3.12786E-06	-0.738594125	-0.341232858	-0.738594125	-0.341232858

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
Clariant Safewing Protect 2012 TYPE IV 75/25 (#2)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.897090785
R Square	0.804771876
Adjusted R Square	0.788502866
Standard Error	0.109595936
Observations	27

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.188312187	0.594156093	49.46655395	3.06555E-09
Residual	24	0.28827046	0.012011269		
Total	26	1.476582646			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.724035362	0.140721475	19.35763792	3.75207E-16	2.433600572	3.014470152	2.433600572	3.014470152
X Variable 1	-0.776760145	0.07815721	-9.938432407	5.5449E-10	-0.938068665	-0.615451626	-0.938068665	-0.615451626
X Variable 2	-0.301958715	0.117109401	-2.578432744	0.016487747	-0.543660589	-0.06025684	-0.543660589	-0.06025684

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

Clariant Safewing Protect 2012 TYPE IV 50/50 (#3)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.884860767
R Square	0.782978576
Adjusted R Square	0.762309869
Standard Error	0.078918004
Observations	24

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.471866071	0.235933035	37.88232018	1.07964E-07
Residual	21	0.130789078	0.006228051		
Total	23	0.602655149			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.960979108	0.1137476	17.23974046	7.14479E-14	1.724427983	2.197530233	1.724427983	2.197530233
X Variable 1	-0.606501552	0.070623486	-8.587816659	2.59435E-08	-0.753371157	-0.459631946	-0.753371157	-0.459631946
X Variable 2	0.007987971	0.141755097	0.056350503	0.955595303	-0.286807942	0.302783884	-0.286807942	0.302783884

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
OCTAGON MAXFLIGHT TYPE IV NEAT (#4)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.901416722
R Square	0.812552106
Adjusted R Square	0.793807317
Standard Error	0.105978918
Observations	23

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.973732379	0.48686619	43.34815884	5.35557E-08
Residual	20	0.22463062	0.011231531		
Total	22	1.198362999			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.46342965	0.197924849	17.49871062	1.36098E-13	3.050565842	3.876293458	3.050565842	3.876293458
X Variable 1	-0.740666821	0.079578545	-9.307368259	1.04298E-08	-0.906664679	-0.574668962	-0.906664679	-0.574668962
X Variable 2	-0.727451643	0.144566748	-5.031943065	6.38674E-05	-1.029012454	-0.425890832	-1.029012454	-0.425890832

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
OCTAGON MAXFLIGHT TYPE IV 75/25 (#5)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.950091225
R Square	0.902673336
Adjusted R Square	0.890507503
Standard Error	0.075209269
Observations	19

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.839385563	0.419692782	74.19741278	8.05109E-09
Residual	16	0.090502947	0.005656434		
Total	18	0.92988851			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.23189607	0.126578623	25.53271627	2.15248E-14	2.963561437	3.500230704	2.963561437	3.500230704
X Variable 1	-0.794605147	0.071462654	-11.11916646	6.15793E-09	-0.946099172	-0.643111122	-0.946099172	-0.643111122
X Variable 2	-0.432014864	0.11909428	-3.627503034	0.002263785	-0.684483403	-0.179546324	-0.684483403	-0.179546324

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
OCTAGON MAXFLIGHT TYPE IV 50/50 (#6)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.96627079
R Square	0.93367924
Adjusted R Square	0.91709905
Standard Error	0.062289884
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.436991753	0.218495877	56.31293983	1.93463E-05
Residual	8	0.031040237	0.00388003		
Total	10	0.46803199			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.415473277	0.384115609	8.891784649	2.0253E-05	2.529700521	4.301246032	2.529700521	4.301246032
X Variable 1	-1.178585299	0.154584248	-7.624226375	6.1636E-05	-1.535057444	-0.822113154	-1.535057444	-0.822113154
X Variable 2	-0.505766837	0.449389609	-1.125452894	0.293025887	-1.542061805	0.530528131	-1.542061805	0.530528131

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

SPCA Ecowing 26 TYPE II NEAT (#7)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.923362966
R Square	0.852599166
Adjusted R Square	0.841680586
Standard Error	0.079753992
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.993375822	0.496687911	78.08699891	5.95318E-12
Residual	27	0.171738878	0.006360699		
Total	29	1.165114701			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.359820524	0.103272698	22.85038117	3.38926E-19	2.147922591	2.571718456	2.147922591	2.571718456
X Variable 1	-0.509783809	0.051083643	-9.979394214	1.48406E-10	-0.614598716	-0.404968902	-0.614598716	-0.404968902
X Variable 2	-0.097821725	0.068495936	-1.428139118	0.164717855	-0.238363682	0.042720232	-0.238363682	0.042720232

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

SPCA Ecowing 26 TYPE II 75/25 (#8)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.875173255
R Square	0.765928226
Adjusted R Square	0.742521049
Standard Error	0.101698378
Observations	23

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.676857233	0.338428616	32.7219388	4.93731E-07
Residual	20	0.206851201	0.01034256		
Total	22	0.883708434			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.348508166	0.10813041	21.71921998	2.22466E-15	2.122952188	2.574064145	2.122952188	2.574064145
X Variable 1	-0.601564504	0.075656502	-7.951259814	1.28091E-07	-0.759381128	-0.443747879	-0.759381128	-0.443747879
X Variable 2	-0.104311588	0.088235312	-1.182197753	0.250992465	-0.288367138	0.079743963	-0.288367138	0.079743963

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
SPCA Ecowing 26 TYPE II 50/50 (#9)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.923123113
R Square	0.852156282
Adjusted R Square	0.839835972
Standard Error	0.089666887
Observations	27

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.112222804	0.556111402	69.1667897	1.09052E-10
Residual	24	0.192963613	0.008040151		
Total	26	1.305186417			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.017841297	0.115060376	17.53723885	3.45307E-15	1.780368401	2.255314193	1.780368401	2.255314193
X Variable 1	-0.69433267	0.059577645	-11.65424825	2.28376E-11	-0.817294861	-0.571370479	-0.817294861	-0.571370479
X Variable 2	0.029819409	0.164816418	0.18092499	0.857945645	-0.31034489	0.369983707	-0.31034489	0.369983707

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

Newave Aerochemical FCY-1A TYPE I (#10)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.884445599
R Square	0.782244018
Adjusted R Square	0.745951354
Standard Error	0.104941543
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.474731768	0.237365884	21.55377803	0.000106616
Residual	12	0.13215273	0.011012727		
Total	14	0.606884498			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.508199858	0.164300854	9.179501007	8.95823E-07	1.150219054	1.866180661	1.150219054	1.866180661
X Variable 1	-0.42661168	0.068017205	-6.27211421	4.11575E-05	-0.574808437	-0.278414923	-0.574808437	-0.278414923
X Variable 2	-0.384881843	0.134243224	-2.86704856	0.014167226	-0.677372698	-0.092390989	-0.677372698	-0.092390989

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

Clariant EG I 1996 TYPE I (#11)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.933229937
R Square	0.870918116
Adjusted R Square	0.853707198
Standard Error	0.065030908
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.427999167	0.213999583	50.60265347	2.14531E-07
Residual	15	0.063435285	0.004229019		
Total	17	0.491434452			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.748409892	0.114360548	15.28857566	1.48295E-10	1.504656004	1.99216378	1.504656004	1.99216378
X Variable 1	-0.660585464	0.069970722	-9.440883927	1.05946E-07	-0.80972462	-0.511446309	-0.80972462	-0.511446309
X Variable 2	-0.327220109	0.099679766	-3.282713461	0.0050342	-0.539682631	-0.114757587	-0.539682631	-0.114757587

MULTI-VARIABLE REGRESSION OUTPUT

NATURAL SNOW CONDITIONS

Clariant MP I 1938 TYPE I (#12)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.936913575
R Square	0.877807047
Adjusted R Square	0.86035091
Standard Error	0.076520779
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.58889749	0.294448745	50.28644581	4.06746E-07
Residual	14	0.081976015	0.00585543		
Total	16	0.670873505			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.799431607	0.106735396	16.85880851	1.07494E-10	1.570506746	2.028356468	1.570506746	2.028356468
X Variable 1	-0.632918803	0.083822908	-7.550666275	2.66627E-06	-0.812701219	-0.453136386	-0.812701219	-0.453136386
X Variable 2	-0.39185275	0.11912729	-3.289361741	0.005374859	-0.647355603	-0.136349897	-0.647355603	-0.136349897

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
Lyondell Arco Plus TYPE I (#13)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.878956
R Square	0.77256365
Adjusted R Square	0.740072743
Standard Error	0.075783318
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.273117582	0.136558791	23.7778418	3.14789E-05
Residual	14	0.080403558	0.005743111		
Total	16	0.353521139			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.802033717	0.14977721	12.03142795	9.04445E-09	1.480793264	2.12327417	1.480793264	2.12327417
X Variable 1	-0.571039008	0.097767262	-5.84079983	4.28704E-05	-0.780729117	-0.361348899	-0.780729117	-0.361348899
X Variable 2	-0.468064116	0.108394917	-4.318137128	0.000708262	-0.700548299	-0.235579934	-0.700548299	-0.235579934

MULTI-VARIABLE REGRESSION OUTPUT
NATURAL SNOW CONDITIONS
Lyondell Arco Plus - ST TYPE I (#14)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.956225763
R Square	0.914367709
Adjusted R Square	0.903663673
Standard Error	0.087934934
Observations	19

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.321071089	0.660535544	85.42270185	2.89135E-09
Residual	16	0.123720843	0.007732553		
Total	18	1.444791932			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.901464038	0.102096043	18.62426777	2.86285E-12	1.685030145	2.117897931	1.685030145	2.117897931
X Variable 1	-0.634000683	0.048966358	-12.947679	6.7888E-10	-0.737804701	-0.530196665	-0.737804701	-0.530196665
X Variable 2	-0.48530765	0.088989525	-5.453536807	5.30725E-05	-0.673956972	-0.296658327	-0.673956972	-0.296658327

CM1680 (exBM3833)\Analysis\HOT\Snow\Snow Regression Lyondell ST
AT: regr.

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -3 °C

Clariant Safewing Protect 2012 TYPE IV NEAT (#1)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998715349
R Square	0.997432348
Adjusted R Square	0.996148523
Standard Error	0.009810414
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.074774246	0.074774246	776.9218695	0.001284651
Residual	2	0.000192488	9.62442E-05		
Total	3	0.074966735			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.672758496	0.040597596	65.83538867	0.000230638	2.498081018	2.847435974	2.498081018	2.847435974
log_rate	-0.902431626	0.032376182	-27.87331824	0.001284651	-1.041735192	-0.763128061	-1.041735192	-0.763128061

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -3 °C

Clariant Safewing Protect 2012 TYPE IV 75/25 (#2)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.88294821
R Square	0.779597541
Adjusted R Square	0.735517049
Standard Error	0.067399181
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.080340267	0.080340267	17.68577231	0.00844516
Residual	5	0.022713248	0.00454265		
Total	6	0.103053515			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.31049647	0.215194033	10.73680549	0.000121447	1.757323503	2.863669438	1.757323503	2.863669438
log_rate	-0.765860492	0.182111617	-4.205445555	0.00844516	-1.233992543	-0.297728441	-1.233992543	-0.297728441

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -3 °C
Clariant Safewing Protect 2012 TYPE IV 50/50 (#3)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.973251642
R Square	0.947218759
Adjusted R Square	0.920828138
Standard Error	0.033323034
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.039855636	0.039855636	35.89225024	0.026748358
Residual	2	0.002220849	0.001110425		
Total	3	0.042076486			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.749854869	0.133867615	13.07153245	0.005801692	1.17386861	2.325841128	1.17386861	2.325841128
log_rate	-0.640335548	0.106882664	-5.991014124	0.026748358	-1.100214852	-0.180456243	-1.100214852	-0.180456243

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -10 °C
Clariant Safewing Protect 2012 TYPE IV NEAT (#4)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998114413
R Square	0.996232381
Adjusted R Square	0.994348571
Standard Error	0.008306707
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.036490632	0.036490632	528.8391828	0.001885587
Residual	2	0.000138003	6.90014E-05		
Total	3	0.036628635			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.121678557	0.034751335	61.05315326	0.000268169	1.972155529	2.271201586	1.972155529	2.271201586
log_rate	-0.637421547	0.027718194	-22.99650371	0.001885587	-0.756683392	-0.518159702	-0.756683392	-0.518159702

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -10 °C
Clariant Safewing Protect 2012 TYPE IV 75/25 (#5)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.962948304
R Square	0.927269436
Adjusted R Square	0.890904155
Standard Error	0.04541636
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.052594899	0.052594899	25.49875568	0.037051696
Residual	2	0.004125291	0.002062646		
Total	3	0.056720191			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.182453852	0.203271929	10.73662195	0.008563631	1.307844724	3.057062979	1.307844724	3.057062979
log_rate	-0.817806891	0.161953848	-5.049629261	0.037051696	-1.514638543	-0.120975239	-1.514638543	-0.120975239

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#6)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.991494984
R Square	0.983062304
Adjusted R Square	0.974593456
Standard Error	0.010789675
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.013513673	0.013513673	116.0798135	0.008505016
Residual	2	0.000232834	0.000116417		
Total	3	0.013746507			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.41169022	0.047815823	50.43707486	0.000392866	2.205955198	2.617425243	2.205955198	2.617425243
X Variable 1	-0.412418393	0.03827892	-10.77403423	0.008505016	-0.577119407	-0.247717379	-0.577119407	-0.247717379

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV 75/25 (#7)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.978794615
R Square	0.958038898
Adjusted R Square	0.937058347
Standard Error	0.019197463
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.016828829	0.016828829	45.66319019	0.021205385
Residual	2	0.000737085	0.000368543		
Total	3	0.017565915			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.400992745	0.084365349	28.45946544	0.001232376	2.037997691	2.763987798	2.037997691	2.763987798
X Variable 1	-0.456050024	0.067488435	-6.757454416	0.021205385	-0.746429526	-0.165670522	-0.746429526	-0.165670522

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV 50/50 (#8)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.989491156
R Square	0.979092747
Adjusted R Square	0.968639121
Standard Error	0.017269005
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.027931321	0.027931321	93.66058364	0.010508844
Residual	2	0.000596437	0.000298219		
Total	3	0.028527759			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.173350366	0.072014885	30.17918266	0.001096151	1.863495109	2.483205623	1.863495109	2.483205623
X Variable 1	-0.556450006	0.057497336	-9.677839823	0.010508844	-0.803841247	-0.309058765	-0.803841247	-0.309058765

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -10 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#9)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999354983
R Square	0.998710382
Adjusted R Square	0.998065573
Standard Error	0.008529739
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.112688605	0.112688605	1548.847078	0.000645017
Residual	2	0.000145513	7.27564E-05		
Total	3	0.112834118			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.852933031	0.036757383	77.61523772	0.000165958	2.694778666	3.011087396	2.694778666	3.011087396
X Variable 1	-1.142860392	0.029039485	-39.35539452	0.000645017	-1.267807299	-1.017913485	-1.267807299	-1.017913485

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -10 °C
OCTAGON MAXFLIGHT TYPE IV 75/25 (#10)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99977177
R Square	0.999543593
Adjusted R Square	0.999315389
Standard Error	0.00467568
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.095756627	0.095756627	4380.051562	0.00022823
Residual	2	4.3724E-05	2.1862E-05		
Total	3	0.095800351			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.609589157	0.019894479	131.1715275	5.81143E-05	2.523990064	2.69518825	2.523990064	2.69518825
X Variable 1	-1.039607209	0.015708317	-66.18195798	0.00022823	-1.107194691	-0.972019726	-1.107194691	-0.972019726

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -3 °C
SPCA Ecowing 26 TYPE II NEAT (#11)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.962421873
R Square	0.926255862
Adjusted R Square	0.889383794
Standard Error	0.018225182
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.008344056	0.008344056	25.12079993	0.037578127
Residual	2	0.000664315	0.000332157		
Total	3	0.009008371			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.013091618	0.073725356	27.3052817	0.001338548	1.695876792	2.330306444	1.695876792	2.330306444
log_rate	-0.294594169	0.058777	-5.012065435	0.037578127	-0.547491364	-0.041696974	-0.547491364	-0.041696974

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -3 °C
SPCA Ecowing 26 TYPE II 75/25 (#12)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.990836265
R Square	0.981756504
Adjusted R Square	0.972634756
Standard Error	0.014429436
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.0224091	0.0224091	107.6281107	0.009163735
Residual	2	0.000416417	0.000208209		
Total	3	0.022825518			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.048837841	0.058150595	35.23330815	0.000804579	1.798635849	2.299039832	1.798635849	2.299039832
log_rate	-0.480564854	0.046322197	-10.37439688	0.009163735	-0.679873319	-0.281256389	-0.679873319	-0.281256389

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -3 °C
SPCA Ecowing 26 TYPE II 50/50 (#13)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998345731
R Square	0.996694198
Adjusted R Square	0.995041297
Standard Error	0.006367583
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.024449179	0.024449179	602.9968724	0.001654269
Residual	2	8.10922E-05	4.05461E-05		
Total	3	0.024530271			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.61661094	0.025815537	62.62162722	0.000254909	1.505535571	1.727686308	1.505535571	1.727686308
log_rate	-0.505800365	0.020597837	-24.55599463	0.001654269	-0.594425764	-0.417174965	-0.594425764	-0.417174965

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN, T = -10 °C
SPCA Ecowing 26 TYPE II NEAT (#14)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99707024
R Square	0.994149063
Adjusted R Square	0.991223594
Standard Error	0.018161415
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.112087045	0.112087045	339.8255758	0.00292976
Residual	2	0.000659674	0.000329837		
Total	3	0.112746719			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.758664183	0.076155078	36.22429727	0.000761209	2.4309951	3.086333265	2.4309951	3.086333265
log_rate	-1.121716464	0.060849227	-18.43435857	0.00292976	-1.383529737	-0.85990319	-1.383529737	-0.85990319

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED LIGHT FREEZING RAIN, T = -10 °C

SPCA Ecowing 26 TYPE II 75/25 (#15)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99500397
R Square	0.990032899
Adjusted R Square	0.985049349
Standard Error	0.018388389
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.067173529	0.067173529	198.6601617	0.00499603
Residual	2	0.000676266	0.000338133		
Total	3	0.067849794			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.376026107	0.0781129	30.41784529	0.001079045	2.039933191	2.712119024	2.039933191	2.712119024
log_rate	-0.875870298	0.062141883	-14.09468559	0.00499603	-1.143245425	-0.608495171	-1.143245425	-0.608495171

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN
NEWAVE AEROCHEMICAL FCY-1A TYPE I (#16)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.990609794
R Square	0.981307764
Adjusted R Square	0.971961646
Standard Error	0.015772922
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.026121509	0.026121509	104.9962959	0.009390206
Residual	2	0.00049757	0.000248785		
Total	3	0.026619079			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.305183627	0.067880745	19.22759718	0.002693967	1.01311615	1.597251105	1.01311615	1.597251105
log_rate	-0.55441585	0.054106401	-10.24677003	0.009390206	-0.787217067	-0.321614633	-0.787217067	-0.321614633

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED LIGHT FREEZING RAIN
LYONDELL ARCO PLUS-ST TYPE I (#17)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.968204874
R Square	0.937420677
Adjusted R Square	0.906131016
Standard Error	0.019534386
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.011432289	0.011432289	29.95943835	0.031795126
Residual	2	0.000763184	0.000381592		
Total	3	0.012195473			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.108908349	0.082663126	13.41478838	0.005511003	0.753237374	1.464579323	0.753237374	1.464579323
log_rate	-0.358077536	0.065419955	-5.473521568	0.031795126	-0.63955708	-0.076597991	-0.63955708	-0.076597991

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE, T = -3 °C
Clariant Safewing Protect 2012 TYPE IV NEAT (#1)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.977724903
R Square	0.955945986
Adjusted R Square	0.941261315
Standard Error	0.034401221
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.077040103	0.077040103	65.09822192	0.003977469
Residual	3	0.003550332	0.001183444		
Total	4	0.080590435			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.261685449	0.071637594	31.57120896	6.98282E-05	2.033702439	2.489668459	2.033702439	2.489668459
log_rate	-0.605754981	0.075077954	-8.068346914	0.003977469	-0.844686764	-0.366823199	-0.844686764	-0.366823199

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE, T = -3 °C
Clariant Safewing Protect 2012 TYPE IV 75/25 (#2)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.996522099
R Square	0.993056293
Adjusted R Square	0.98958444
Standard Error	0.009783697
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.027379056	0.027379056	286.0305972	0.003477901
Residual	2	0.000191441	9.57207E-05		
Total	3	0.027570497			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.013977772	0.023481406	85.76904391	0.00013591	1.912945365	2.11501018	1.912945365	2.11501018
log_rate	-0.425299666	0.025147151	-16.91243913	0.003477901	-0.533499201	-0.317100131	-0.533499201	-0.317100131

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE, T = -3 °C
Clariant Safewing Protect 2012 TYPE IV 50/50 (#3)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.957055542
R Square	0.915955311
Adjusted R Square	0.873932967
Standard Error	0.032836069
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.02350154	0.02350154	21.79686363	0.042944458
Residual	2	0.002156415	0.001078207		
Total	3	0.025657955			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.583825324	0.075692111	20.92457593	0.002276155	1.258148229	1.909502419	1.258148229	1.909502419
log_rate	-0.391334308	0.08382063	-4.668711132	0.042944458	-0.751985622	-0.030682995	-0.751985622	-0.030682995

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -10 °C

Clariant Safewing Protect 2012 TYPE IV NEAT (#4)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.996648261
R Square	0.993307756
Adjusted R Square	0.989961634
Standard Error	0.014012416
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.058286519	0.058286519	296.853424	0.003351739
Residual	2	0.000392696	0.000196348		
Total	3	0.058679214			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.055905751	0.029608767	69.43570879	0.000207348	1.928509418	2.183302083	1.928509418	2.183302083
log_rate	-0.561898994	0.032612735	-17.22943481	0.003351739	-0.702220366	-0.421577622	-0.702220366	-0.421577622

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE, T = -10 °C
Clariant Safewing Protect 2012 TYPE IV 75/25 (#5)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.987499188
R Square	0.975154646
Adjusted R Square	0.962731969
Standard Error	0.035789522
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.100547228	0.100547228	78.49794662	0.012500812
Residual	2	0.00256178	0.00128089		
Total	3	0.103109008			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.04688673	0.082430766	24.83158678	0.001617842	1.692215521	2.401557939	1.692215521	2.401557939
log_rate	-0.803426755	0.090681176	-8.859906694	0.012500812	-1.193596634	-0.413256875	-1.193596634	-0.413256875

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#6)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.618919992
R Square	0.383061957
Adjusted R Square	0.177415942
Standard Error	0.007496994
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.000104694	0.000104694	1.862724923	0.265658995
Residual	3	0.000168615	5.62049E-05		
Total	4	0.000273309			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.094930354	0.014637075	143.1249294	7.52053E-07	2.048348605	2.141512104	2.048348605	2.141512104
X Variable 1	-0.022391758	0.01640642	-1.364816809	0.265658995	-0.074604359	0.029820843	-0.074604359	0.029820843

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -3 °C

OCTAGON MAXFLIGHT TYPE IV 75/25 (#7)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.995275754
R Square	0.990573826
Adjusted R Square	0.987431768
Standard Error	0.002040438
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.001312561	0.001312561	315.2627328	0.000389515
Residual	3	1.24902E-05	4.16339E-06		
Total	4	0.001325051			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.137571439	0.004104394	520.8007821	1.56117E-08	2.124509415	2.150633464	2.124509415	2.150633464
X Variable 1	-0.081744565	0.004603865	-17.75563946	0.000389515	-0.096396132	-0.067092999	-0.096396132	-0.067092999

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV 50/50 (#8)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.985671733
R Square	0.971548765
Adjusted R Square	0.962065021
Standard Error	0.031024005
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.098600807	0.098600807	102.4435789	0.002054418
Residual	3	0.002887467	0.000962489		
Total	4	0.101488273			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.309869722	0.059161894	39.04320082	3.69666E-05	2.121589993	2.498149451	2.121589993	2.498149451
X Variable 1	-0.673260777	0.06651827	-10.12144154	0.002054418	-0.884951796	-0.461569757	-0.884951796	-0.461569757

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -10 °C
OCTAGON MAXFLIGHT TYPE IV 75/25 (#10)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999441425
R Square	0.998883162
Adjusted R Square	0.998324742
Standard Error	0.011793489
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.248793455	0.248793455	1788.769254	0.000558575
Residual	2	0.000278173	0.000139086		
Total	3	0.249071628			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.576028581	0.024891378	103.4907988	9.33546E-05	2.468929552	2.683127611	2.468929552	2.683127611
X Variable 1	-1.128511161	0.026682634	-42.29384417	0.000558575	-1.243317349	-1.013704974	-1.243317349	-1.013704974

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -3 °C
SPCA Ecowing 26 TYPE II NEAT (#11)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997358295
R Square	0.994723569
Adjusted R Square	0.992085354
Standard Error	0.015261138
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.087814446	0.087814446	377.0441022	0.002641705
Residual	2	0.000465805	0.000232902		
Total	3	0.08828025			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.458913093	0.031978992	76.89151357	0.000169096	2.3213185	2.596507685	2.3213185	2.596507685
log_rate	-0.672327639	0.03462461	-19.4176235	0.002641705	-0.821305415	-0.523349863	-0.821305415	-0.523349863

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -3 °C

SPCA Ecowing 26 TYPE II 75/25 (#12)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999670666
R Square	0.99934144
Adjusted R Square	0.999012161
Standard Error	0.003002184
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.027354166	0.027354166	3034.931113	0.000329334
Residual	2	1.80262E-05	9.01311E-06		
Total	3	0.027372192			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.100885165	0.006714429	312.8911261	1.02143E-05	2.07199529	2.12977504	2.07199529	2.12977504
log_rate	-0.408507629	0.007415249	-55.09020887	0.000329334	-0.440412894	-0.376602364	-0.440412894	-0.376602364

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -3 °C

SPCA Ecowing 26 TYPE II 50/50 (#13)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.963002978
R Square	0.927374736
Adjusted R Square	0.903166315
Standard Error	0.040653924
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.063313122	0.063313122	38.30793936	0.008494916
Residual	3	0.004958225	0.001652742		
Total	4	0.068271347			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.732659897	0.074421302	23.28177359	0.000173598	1.495817879	1.969501916	1.495817879	1.969501916
log_rate	-0.541309632	0.087458366	-6.189340786	0.008494916	-0.819641447	-0.262977817	-0.819641447	-0.262977817

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -10 °C
SPCA Ecowing 26 TYPE II NEAT (#14)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999643236
R Square	0.999286599
Adjusted R Square	0.998929899
Standard Error	0.006313939
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.111683037	0.111683037	2801.47315	0.000356764
Residual	2	7.97316E-05	3.98658E-05		
Total	3	0.111762769			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.404392495	0.013941758	172.4597753	3.36204E-05	2.344405909	2.464379081	2.344405909	2.464379081
log_rate	-0.810087572	0.01530519	-52.92894435	0.000356764	-0.875940537	-0.744234606	-0.875940537	-0.744234606

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE, T = -10 °C
SPCA Ecowing 26 TYPE II 75/25 (#15)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999528371
R Square	0.999056964
Adjusted R Square	0.998585446
Standard Error	0.007351172
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.114499946	0.114499946	2118.810538	0.000471629
Residual	2	0.000108079	5.40397E-05		
Total	3	0.114608025			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.276825982	0.016824537	135.3277056	5.45998E-05	2.204435792	2.349216172	2.204435792	2.349216172
log_rate	-0.844528949	0.018347144	-46.03053919	0.000471629	-0.923470394	-0.765587503	-0.923470394	-0.765587503

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING DRIZZLE
NEWAVE AEROCHEMICAL FCY-1A TYPE I (#16)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99296812
R Square	0.985985688
Adjusted R Square	0.978978532
Standard Error	0.014121593
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.028060551	0.028060551	140.71125	0.00703188
Residual	2	0.000398839	0.000199419		
Total	3	0.02845939			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.101294018	0.030579022	36.01469104	0.000770085	0.969723015	1.232865021	0.969723015	1.232865021
log_rate	-0.400628254	0.033773585	-11.86217729	0.00703188	-0.545944363	-0.255312145	-0.545944363	-0.255312145

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING DRIZZLE

LYONDELL ARCO PLUS-ST TYPE I (#17)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.980154681
R Square	0.960703198
Adjusted R Square	0.941054797
Standard Error	0.018770575
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.017227298	0.017227298	48.8947268	0.019845319
Residual	2	0.000704669	0.000352334		
Total	3	0.017931966			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.094298827	0.04142552	26.41605504	0.001429986	0.916059075	1.27253858	0.916059075	1.27253858
log_rate	-0.318016327	0.045479785	-6.992476443	0.019845319	-0.513700185	-0.122332468	-0.513700185	-0.122332468

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C

CLARIANT SAFEWING PROTECT 2012 TYPE IV NEAT (#1)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997824364
R Square	0.995653461
Adjusted R Square	0.993480192
Standard Error	0.014141462
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.091618518	0.091618518	458.1362296	0.002175636
Residual	2	0.000399962	0.000199981		
Total	3	0.09201848			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.416213398	0.018828775	128.3255744	6.07203E-05	2.335199661	2.497227136	2.335199661	2.497227136
log_rate	-0.773950178	0.03615894	-21.40411712	0.002175636	-0.929529646	-0.618370709	-0.929529646	-0.618370709

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -3 °C
CLARIANT SAFEWING PROTECT 2012 TYPE IV 75/25 (#2)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.981555295
R Square	0.963450796
Adjusted R Square	0.945176194
Standard Error	0.033786144
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.060180927	0.060180927	52.72075429	0.018444705
Residual	2	0.002283007	0.001141504		
Total	3	0.062463934			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.281357703	0.044243294	51.56392059	0.000375892	2.09099404	2.471721366	2.09099404	2.471721366
log_rate	-0.603833243	0.083162246	-7.260905886	0.018444705	-0.961651758	-0.246014728	-0.961651758	-0.246014728

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C

CLARIANT SAFEWING PROTECT 2012 TYPE IV 50/50 (#3)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998889537
R Square	0.997780306
Adjusted R Square	0.996670459
Standard Error	0.01051126
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.099330232	0.099330232	899.0251777	0.001110463
Residual	2	0.000220973	0.000110487		
Total	3	0.099551205			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.879035045	0.013977377	134.4340242	5.53281E-05	1.818895203	1.939174886	1.818895203	1.939174886
log_rate	-0.741206823	0.024720285	-29.98374856	0.001110463	-0.847569701	-0.634843945	-0.847569701	-0.634843945

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -14 °C
CLARIANT SAFEWING PROTECT 2012 TYPE IV NEAT (#4)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999981716
R Square	0.999963432
Adjusted R Square	0.999945148
Standard Error	0.00197087
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.212436979	0.212436979	54690.77566	1.82841E-05
Residual	2	7.76866E-06	3.88433E-06		
Total	3	0.212444748			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.307042715	0.002256752	1022.284412	9.56877E-07	2.297332687	2.316752743	2.297332687	2.316752743
log_rate	-0.957719635	0.004095259	-233.8605902	1.82841E-05	-0.975340124	-0.940099147	-0.975340124	-0.940099147

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -14 °C
CLARIANT SAFEWING PROTECT 2012 TYPE IV 75/25 (#5)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998612911
R Square	0.997227747
Adjusted R Square	0.99584162
Standard Error	0.016083195
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.186095588	0.186095588	719.4347645	0.001387089
Residual	2	0.000517338	0.000258669		
Total	3	0.186612926			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.104451183	0.021386672	98.40012356	0.000103262	2.012431695	2.19647067	2.012431695	2.19647067
log_rate	-1.014534272	0.03782431	-26.82228112	0.001387089	-1.177279255	-0.851789288	-1.177279255	-0.851789288

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -25 °C
CLARIANT SAFEWING PROTECT 2012 TYPE IV NEAT (#6)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999042874
R Square	0.998086664
Adjusted R Square	0.997129996
Standard Error	0.007326884
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.056007439	0.056007439	1043.294791	0.000957126
Residual	2	0.000107366	5.36832E-05		
Total	3	0.056114806			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.872042332	0.012709754	147.2917834	4.60907E-05	1.817356636	1.926728027	1.817356636	1.926728027
log_rate	-0.760771199	0.023553234	-32.30007416	0.000957126	-0.862112655	-0.659429743	-0.862112655	-0.659429743

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#7)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997040199
R Square	0.994089158
Adjusted R Square	0.992611448
Standard Error	0.008257554
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.045871069	0.045871069	672.7225464	1.31277E-05
Residual	4	0.000272749	6.81872E-05		
Total	5	0.046143817			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.510208879	0.009041023	277.6465481	1.00959E-09	2.485106922	2.535310836	2.485106922	2.535310836
X Variable 1	-0.434325377	0.016745465	-25.93689547	1.31277E-05	-0.480818338	-0.387832417	-0.480818338	-0.387832417

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV 75/25 (#8)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.95570471
R Square	0.913371492
Adjusted R Square	0.896045791
Standard Error	0.03655488
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.070444543	0.070444543	52.71772058	0.000774397
Residual	5	0.006681296	0.001336259		
Total	6	0.07712584			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.446900141	0.039339992	62.19879678	2.03326E-08	2.345773638	2.548026643	2.345773638	2.548026643
X Variable 1	-0.505129455	0.069570381	-7.260696976	0.000774397	-0.683965521	-0.32629339	-0.683965521	-0.32629339

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C
OCTAGON MAXFLIGHT TYPE IV 50/50 (#9)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.858010247
R Square	0.736181585
Adjusted R Square	0.692211849
Standard Error	0.080185422
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.107651957	0.107651957	16.74291577	0.006416183
Residual	6	0.038578211	0.006429702		
Total	7	0.146230168			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.224680352	0.089800649	24.77354424	2.84631E-07	2.004945919	2.444414785	2.004945919	2.444414785
X Variable 1	-0.708919744	0.173253304	-4.091810817	0.006416183	-1.132855617	-0.284983871	-1.132855617	-0.284983871

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -14 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#10)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998406661
R Square	0.996815862
Adjusted R Square	0.995223792
Standard Error	0.020431949
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.261380139	0.261380139	626.1133982	0.001593339
Residual	2	0.000834929	0.000417465		
Total	3	0.262215068			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.538539893	0.025314998	100.2780984	9.94313E-05	2.429618171	2.647461616	2.429618171	2.647461616
X Variable 1	-1.194543076	0.04773922	-25.02225806	0.001593339	-1.399948503	-0.989137648	-1.399948503	-0.989137648

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -14 °C
OCTAGON MAXFLIGHT TYPE IV 75/25 (#11)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99270612
R Square	0.98546544
Adjusted R Square	0.97819816
Standard Error	0.02455688
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.081774122	0.081774122	135.6030641	0.00729388
Residual	2	0.001206081	0.00060304		
Total	3	0.082980203			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.043983797	0.034466709	59.30313154	0.000284223	1.895685412	2.192282181	1.895685412	2.192282181
X Variable 1	-0.765330207	0.065722504	-11.64487287	0.00729388	-1.048111516	-0.482548898	-1.048111516	-0.482548898

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -25 °C
OCTAGON MAXFLIGHT TYPE IV NEAT (#12)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999713585
R Square	0.999427253
Adjusted R Square	0.999140879
Standard Error	0.005260179
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.096564892	0.096564892	3489.941558	0.000286415
Residual	2	5.5339E-05	2.76695E-05		
Total	3	0.096620231			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.88041016	0.006990198	269.0067124	1.38186E-05	1.850333745	1.910486575	1.850333745	1.910486575
X Variable 1	-0.784341671	0.013276886	-59.07572732	0.000286415	-0.841467539	-0.727215803	-0.841467539	-0.727215803

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -3 °C
SPCA Ecowing 26 TYPE II NEAT (#13)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998150916
R Square	0.996305251
Adjusted R Square	0.994457877
Standard Error	0.009400981
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.047663273	0.047663273	539.3087712	0.001849084
Residual	2	0.000176757	8.83784E-05		
Total	3	0.04784003			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.381038511	0.01424849	167.1081279	3.58081E-05	2.319732163	2.442344858	2.319732163	2.442344858
log_rate	-0.635181171	0.027351357	-23.22302244	0.001849084	-0.752864643	-0.517497699	-0.752864643	-0.517497699

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -3 °C
SPCA Ecowing 26 TYPE II 75/25 (#14)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.992089205
R Square	0.984240991
Adjusted R Square	0.976361486
Standard Error	0.022904699
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.065531744	0.065531744	124.9115316	0.007910795
Residual	2	0.001049251	0.000524625		
Total	3	0.066580994			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.243926018	0.029393745	76.34025661	0.000171546	2.117454854	2.370397183	2.117454854	2.370397183
log_rate	-0.60734785	0.054342077	-11.17638276	0.007910795	-0.841163097	-0.373532602	-0.841163097	-0.373532602

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -3 °C
SPCA Ecowing 26 TYPE II 50/50 (#15)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.977903983
R Square	0.9562962
Adjusted R Square	0.934444299
Standard Error	0.030694974
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.04123232	0.04123232	43.7626106	0.022096017
Residual	2	0.001884363	0.000942181		
Total	3	0.043116683			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.795517899	0.040084242	44.79360989	0.000498016	1.623049206	1.967986593	1.623049206	1.967986593
log_rate	-0.509001701	0.076942736	-6.615331481	0.022096017	-0.840059803	-0.177943599	-0.840059803	-0.177943599

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -14 °C

SPCA Ecowing 26 TYPE II NEAT (#16)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999694258
R Square	0.999388609
Adjusted R Square	0.999082914
Standard Error	0.009065247
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.268661239	0.268661239	3269.231562	0.000305742
Residual	2	0.000164357	8.21787E-05		
Total	3	0.268825597			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.500620912	0.011478909	217.8448208	2.10713E-05	2.451231118	2.550010706	2.451231118	2.550010706
log_rate	-1.233472597	0.021572807	-57.17719442	0.000305742	-1.326292959	-1.140652234	-1.326292959	-1.140652234

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -14 °C
SPCA Ecowing 26 TYPE II 75/25 (#17)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998555307
R Square	0.997112701
Adjusted R Square	0.995669051
Standard Error	0.013674799
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.129158902	0.129158902	690.6888088	0.001444693
Residual	2	0.000374	0.000187		
Total	3	0.129532902			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.137950723	0.018184101	117.5725248	7.23338E-05	2.059710794	2.216190651	2.059710794	2.216190651
log_rate	-0.845202663	0.032160267	-26.28095905	0.001444693	-0.98357722	-0.706828105	-0.98357722	-0.706828105

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -25 °C
SPCA Ecowing 26 TYPE II NEAT (#18)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999688674
R Square	0.999377445
Adjusted R Square	0.999066167
Standard Error	0.004715618
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.071393547	0.071393547	3210.567544	0.000311326
Residual	2	4.44741E-05	2.2237E-05		
Total	3	0.071438021			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.868227936	0.005982548	312.279614	1.02543E-05	1.842487089	1.893968782	1.842487089	1.893968782
log_rate	-0.697178224	0.012304187	-56.66187028	0.000311326	-0.750118903	-0.644237545	-0.750118903	-0.644237545

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -10 °C

NEWAVE AEROCHEMICAL FCY-1A TYPE I (#19)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.982591177
R Square	0.965485421
Adjusted R Square	0.948228131
Standard Error	0.019862073
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.022071013	0.022071013	55.94652675	0.017408823
Residual	2	0.000789004	0.000394502		
Total	3	0.022860017			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.09978255	0.024110376	45.61449172	0.000480265	0.996043902	1.203521197	0.996043902	1.203521197
log_rate	-0.354657868	0.047415795	-7.479741089	0.017408823	-0.558671709	-0.150644028	-0.558671709	-0.150644028

MULTI-VARIABLE REGRESSION OUTPUT

SIMULATED FREEZING FOG, T = -25 °C

NEWAVE AEROCHEMICAL FCY-1A TYPE I (#20)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999886263
R Square	0.999772538
Adjusted R Square	0.999658807
Standard Error	0.003007976
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.079537391	0.079537391	8790.684526	0.000113737
Residual	2	1.80958E-05	9.04792E-06		
Total	3	0.079555487			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.093793921	0.003139798	348.3644381	8.24E-06	1.080284451	1.10730339	1.080284451	1.10730339
log_rate	-0.578839905	0.006173723	-93.75865041	0.000113737	-0.605403308	-0.552276502	-0.605403308	-0.552276502

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -10 °C
LYONDELL ARCO PLUS-ST TYPE I (#21)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999427111
R Square	0.998854549
Adjusted R Square	0.998281824
Standard Error	0.004950332
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.042739019	0.042739019	1744.037664	0.000572889
Residual	2	4.90116E-05	2.45058E-05		
Total	3	0.042788031			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.233216758	0.00558299	220.8882305	2.04947E-05	1.209195075	1.257238442	1.209195075	1.257238442
log_rate	-0.458512938	0.010979275	-41.76167698	0.000572889	-0.505752979	-0.411272898	-0.505752979	-0.411272898

MULTI-VARIABLE REGRESSION OUTPUT
SIMULATED FREEZING FOG, T = -25 °C
LYONDELL ARCO PLUS-ST TYPE I (#22)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997408721
R Square	0.994824156
Adjusted R Square	0.992236234
Standard Error	0.016383177
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.103179014	0.103179014	384.410412	0.002591279
Residual	2	0.000536817	0.000268408		
Total	3	0.103715831			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.317262223	0.017656677	74.60419919	0.000179621	1.241291622	1.393232824	1.241291622	1.393232824
log_rate	-0.676961036	0.034527577	-19.60638702	0.002591279	-0.825521313	-0.52840076	-0.825521313	-0.52840076

MULTI-VARIABLE REGRESSION OUTPUT

COLD-SOAKED BOXES

CLARIANT SAFEWING PROTECT 2012 TYPE IV NEAT (#1)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999354523
R Square	0.998709462
Adjusted R Square	0.998064194
Standard Error	0.018634964
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.537471762	0.537471762	1547.741854	0.000645477
Residual	2	0.000694524	0.000347262		
Total	3	0.538166286			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.226036756	0.022133213	100.5744952	9.88462E-05	2.13080516	2.321268353	2.13080516	2.321268353
log_rate	-0.613263647	0.015588271	-39.34135044	0.000645477	-0.680334612	-0.546192682	-0.680334612	-0.546192682

MULTI-VARIABLE REGRESSION OUTPUT

COLD-SOAKED BOXES

CLARIANT SAFEWING PROTECT 2012 TYPE IV 75/25 (#2)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999056532
R Square	0.998113953
Adjusted R Square	0.997485271
Standard Error	0.021708771
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.748203044	0.748203044	1587.628862	3.47827E-05
Residual	3	0.001413812	0.000471271		
Total	4	0.749616856			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.078860602	0.021609127	96.20289718	2.47592E-06	2.010090652	2.147630552	2.010090652	2.147630552
log_rate	-0.656075452	0.016465666	-39.8450607	3.47827E-05	-0.708476598	-0.603674305	-0.708476598	-0.603674305

MULTI-VARIABLE REGRESSION OUTPUT

COLD-SOAKED BOXES

OCTAGON MAXFLIGHT TYPE IV NEAT (#3)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998390663
R Square	0.996783917
Adjusted R Square	0.995175875
Standard Error	0.031261772
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.605802286	0.605802286	619.874433	0.001609337
Residual	2	0.001954597	0.000977298		
Total	3	0.607756883			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.642041685	0.03926962	67.27953219	0.000220846	2.473078029	2.811005342	2.473078029	2.811005342
X Variable 1	-0.695585658	0.027938222	-24.89727762	0.001609337	-0.815794206	-0.575377109	-0.815794206	-0.575377109

MULTI-VARIABLE REGRESSION OUTPUT
COLD-SOAKED BOXES
OCTAGON MAXFLIGHT TYPE IV 75/25 (#4)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999966813
R Square	0.999933628
Adjusted R Square	0.999900442
Standard Error	0.004860923
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.711955918	0.711955918	30131.1393	3.31866E-05
Residual	2	4.72572E-05	2.36286E-05		
Total	3	0.712003176			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.664526635	0.005997686	444.2591042	5.06669E-06	2.638720657	2.690332613	2.638720657	2.690332613
X Variable 1	-0.741173564	0.004269845	-173.5832345	3.31866E-05	-0.759545239	-0.72280189	-0.759545239	-0.72280189

MULTI-VARIABLE REGRESSION OUTPUT
COLD-SOAKED BOXES
SPCA Ecowing 26 TYPE II NEAT (#5)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999356744
R Square	0.998713902
Adjusted R Square	0.998070853
Standard Error	0.017459275
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.473423158	0.473423158	1553.091611	0.000643256
Residual	2	0.000609653	0.000304826		
Total	3	0.47403281			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.322404321	0.019855396	116.9659015	7.30859E-05	2.236973386	2.407835255	2.236973386	2.407835255
log_rate	-0.553495277	0.014044794	-39.40928331	0.000643256	-0.613925191	-0.493065362	-0.613925191	-0.493065362

MULTI-VARIABLE REGRESSION OUTPUT
COLD-SOAKED BOXES
SPCA Ecowing 26 TYPE II 75/25 (#6)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999933319
R Square	0.999866643
Adjusted R Square	0.999799964
Standard Error	0.00612832
Observations	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.563169242	0.563169242	14995.33251	6.66807E-05
Residual	2	7.51126E-05	3.75563E-05		
Total	3	0.563244355			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2.203204191	0.00698666	315.344406	1.0056E-05	2.173142998	2.233265384	2.173142998	2.233265384
log_rate	-0.607199385	0.004958534	-122.4554307	6.66807E-05	-0.628534249	-0.585864522	-0.628534249	-0.585864522

MULTI-VARIABLE REGRESSION OUTPUT
COLD-SOAKED BOXES
NEWAVE AEROCHEMICAL FCY-1A TYPE I (#7)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99953689
R Square	0.999073995
Adjusted R Square	0.998610993
Standard Error	0.014037251
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.425185614	0.425185614	2157.8161	0.00046311
Residual	2	0.000394089	0.000197044		
Total	3	0.425579702			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.267140651	0.016387809	77.3221503	0.000167218	1.196629549	1.337651752	1.196629549	1.337651752
log_rate	-0.534993384	0.011517049	-46.45229919	0.00046311	-0.584547279	-0.485439489	-0.584547279	-0.485439489

MULTI-VARIABLE REGRESSION OUTPUT
COLD-SOAKED BOXES
LYONDELL ARCO PLUS-ST TYPE I (#8)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999397343
R Square	0.998795049
Adjusted R Square	0.998192574
Standard Error	0.015911564
Observations	4

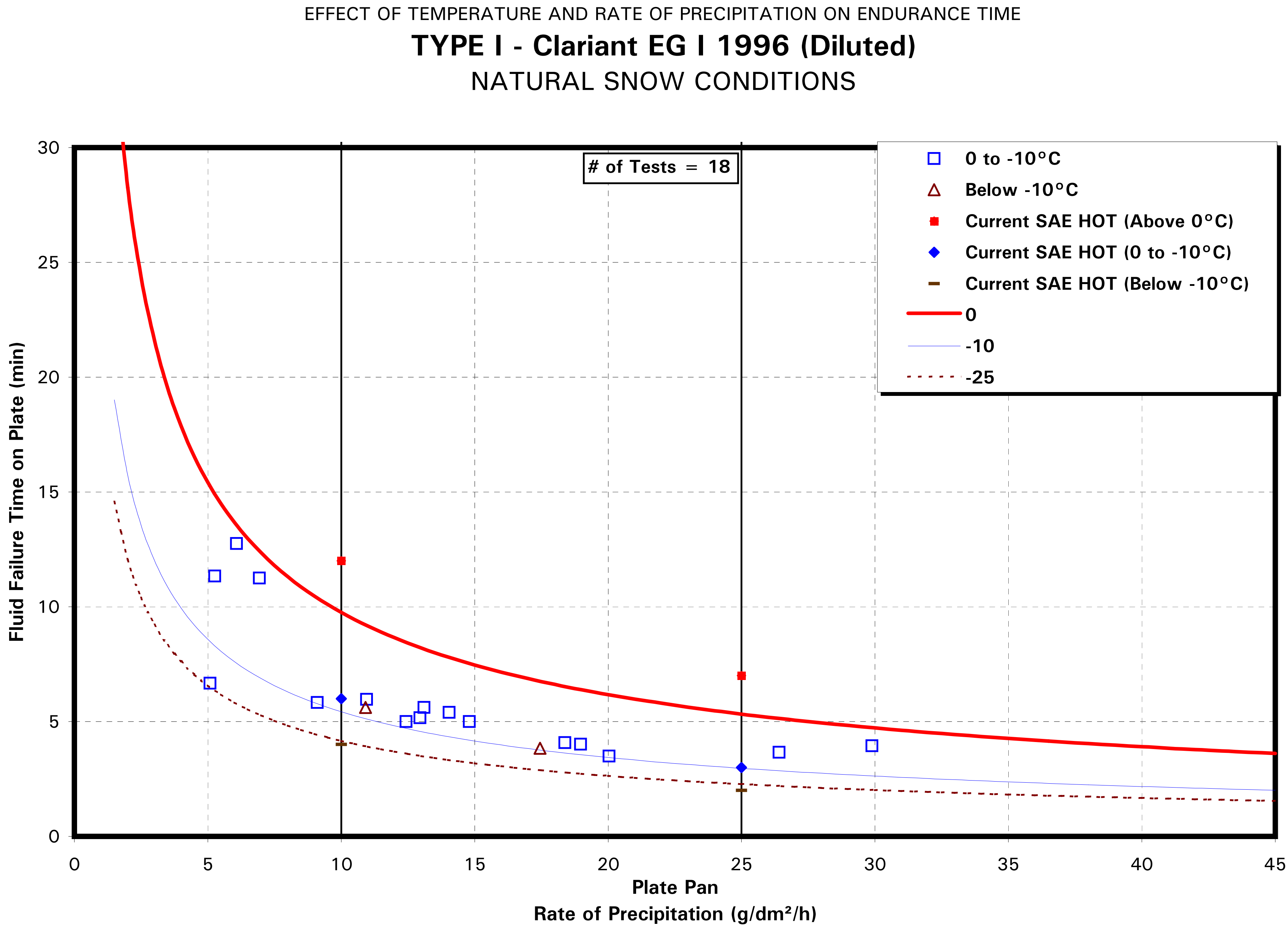
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.419723033	0.419723033	1657.818739	0.000602657
Residual	2	0.000506356	0.000253178		
Total	3	0.420229389			

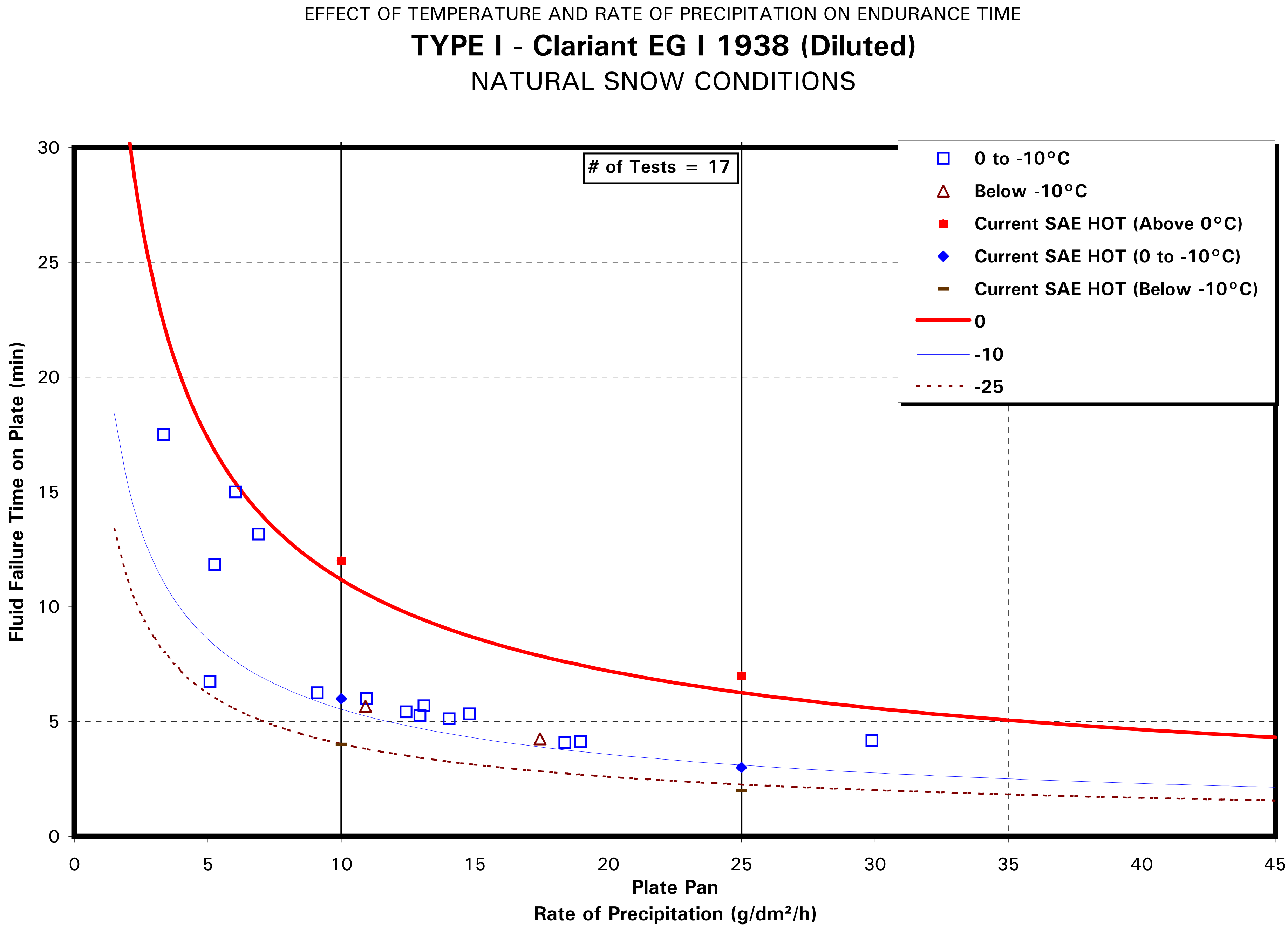
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.311128095	0.018254003	71.82688106	0.000193776	1.232587405	1.389668785	1.232587405	1.389668785
log_rate	-0.524567691	0.012883475	-40.71632031	0.000602657	-0.580000848	-0.469134534	-0.580000848	-0.469134534

APPENDIX G

EFFECT OF FLUID BRAND AND RATE OF PRECIPITATION ON HOLDOVER TIME
WINTER 2000-01



M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : C1996

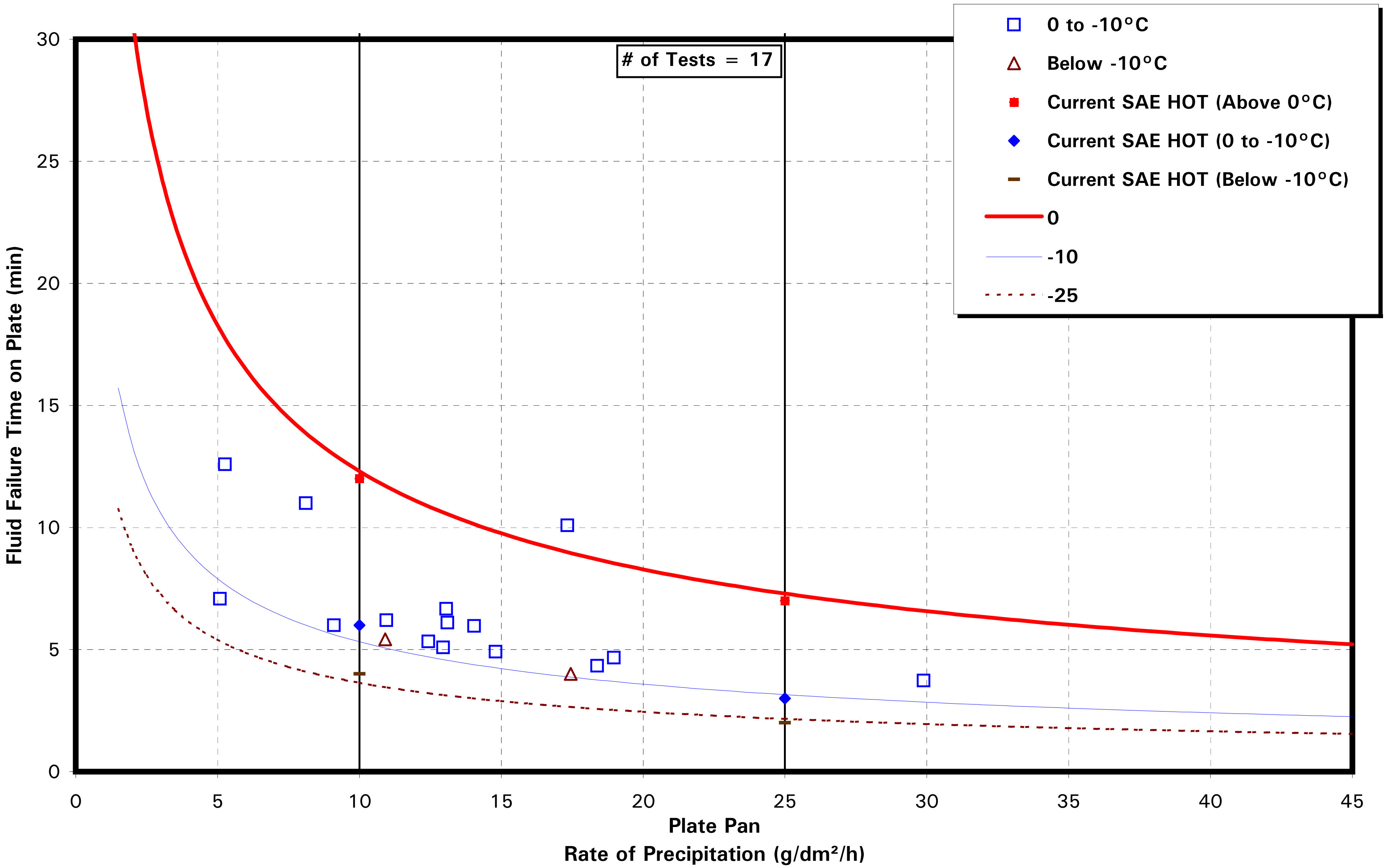


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : C1938

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I - Lyondell Arco Plus (Diluted)

NATURAL SNOW CONDITIONS

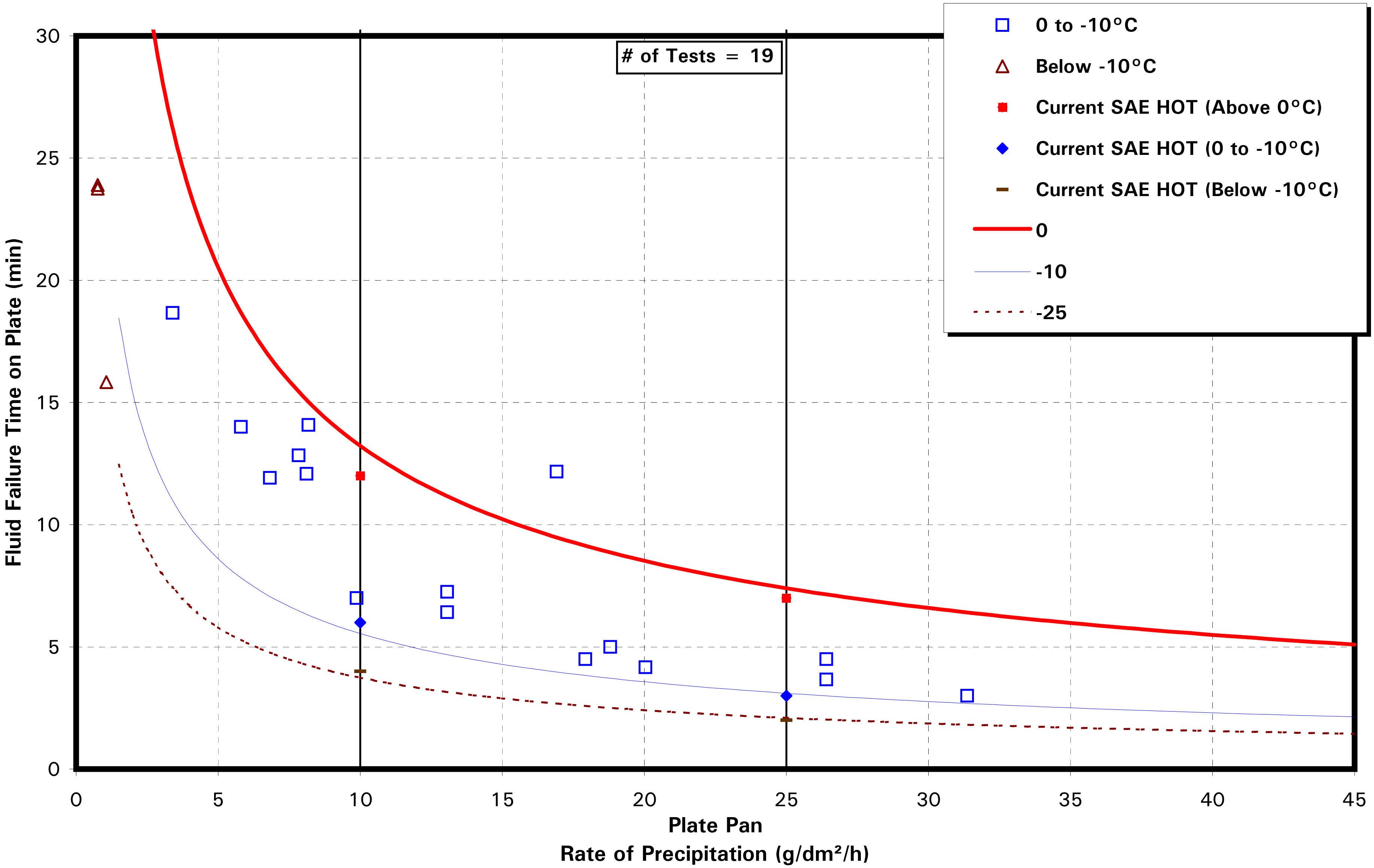


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : Lyondell

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I - Lyondell Arco Plus-ST (Diluted)

NATURAL SNOW CONDITIONS

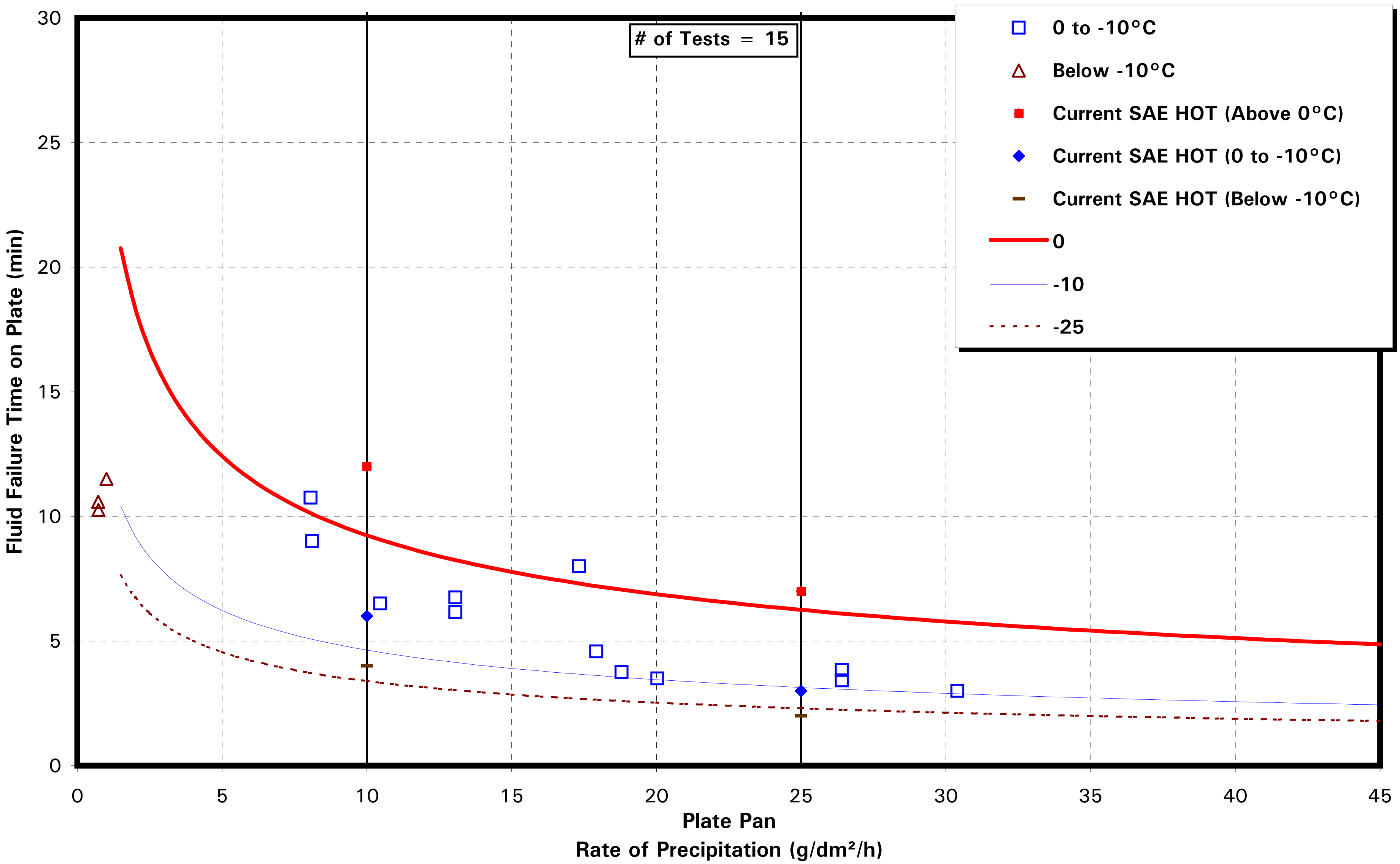


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : Lyondell-ST

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

TYPE I - Newave Aerochemical FCY-1A (Diluted)

NATURAL SNOW CONDITIONS

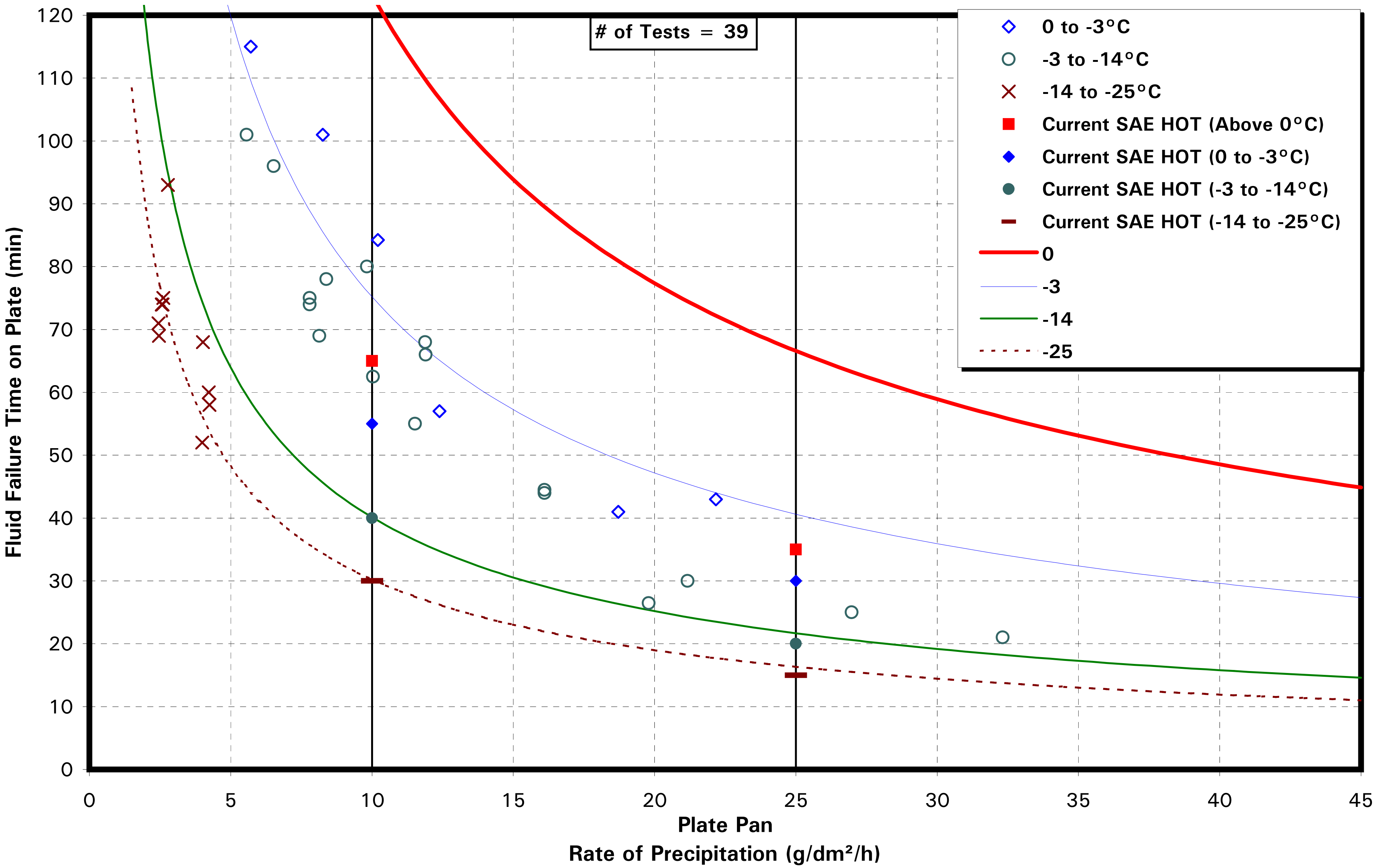


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : FCY-1A

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (NEAT)

NATURAL SNOW

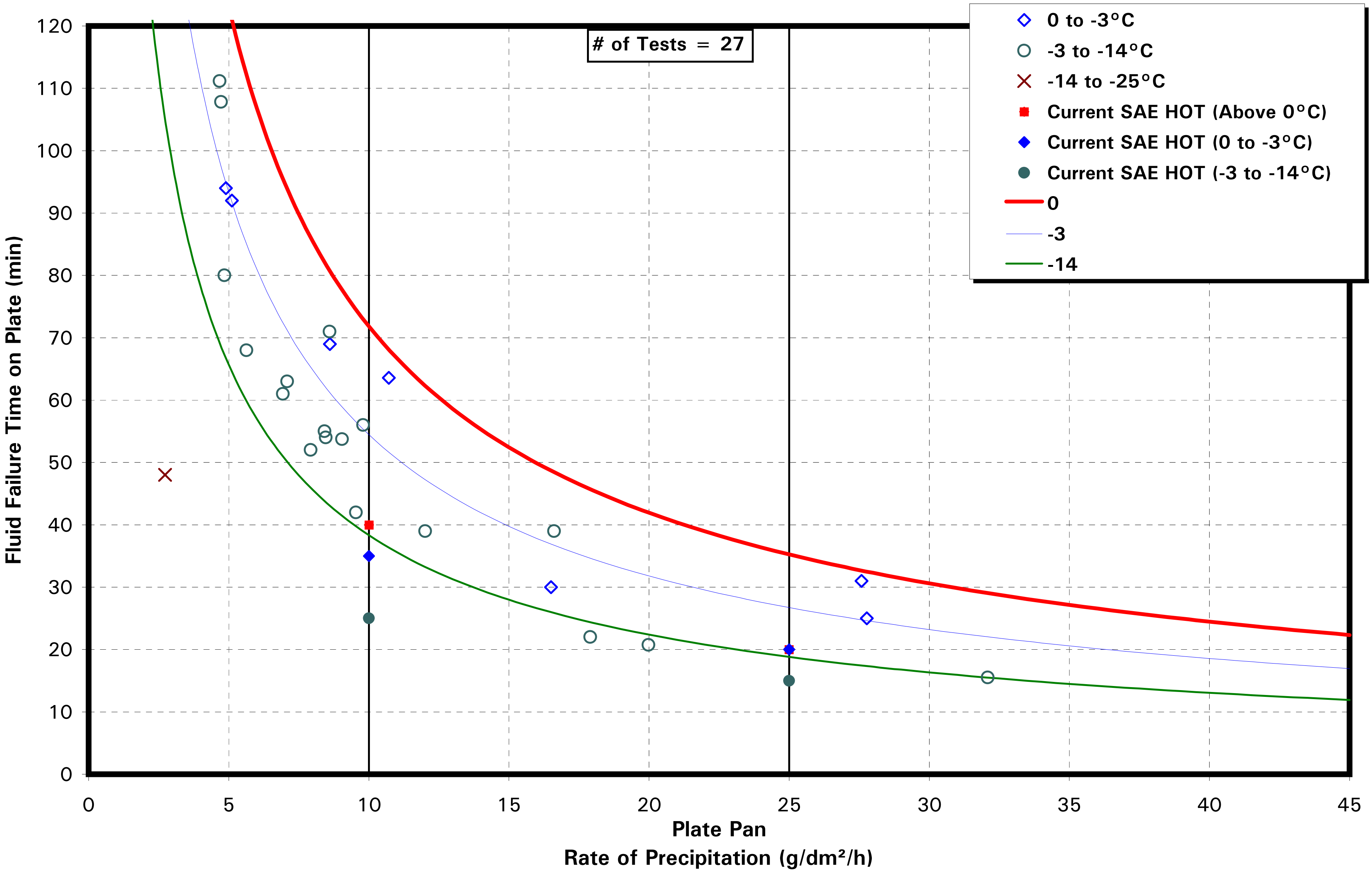


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : C2012-Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (75/25)

NATURAL SNOW

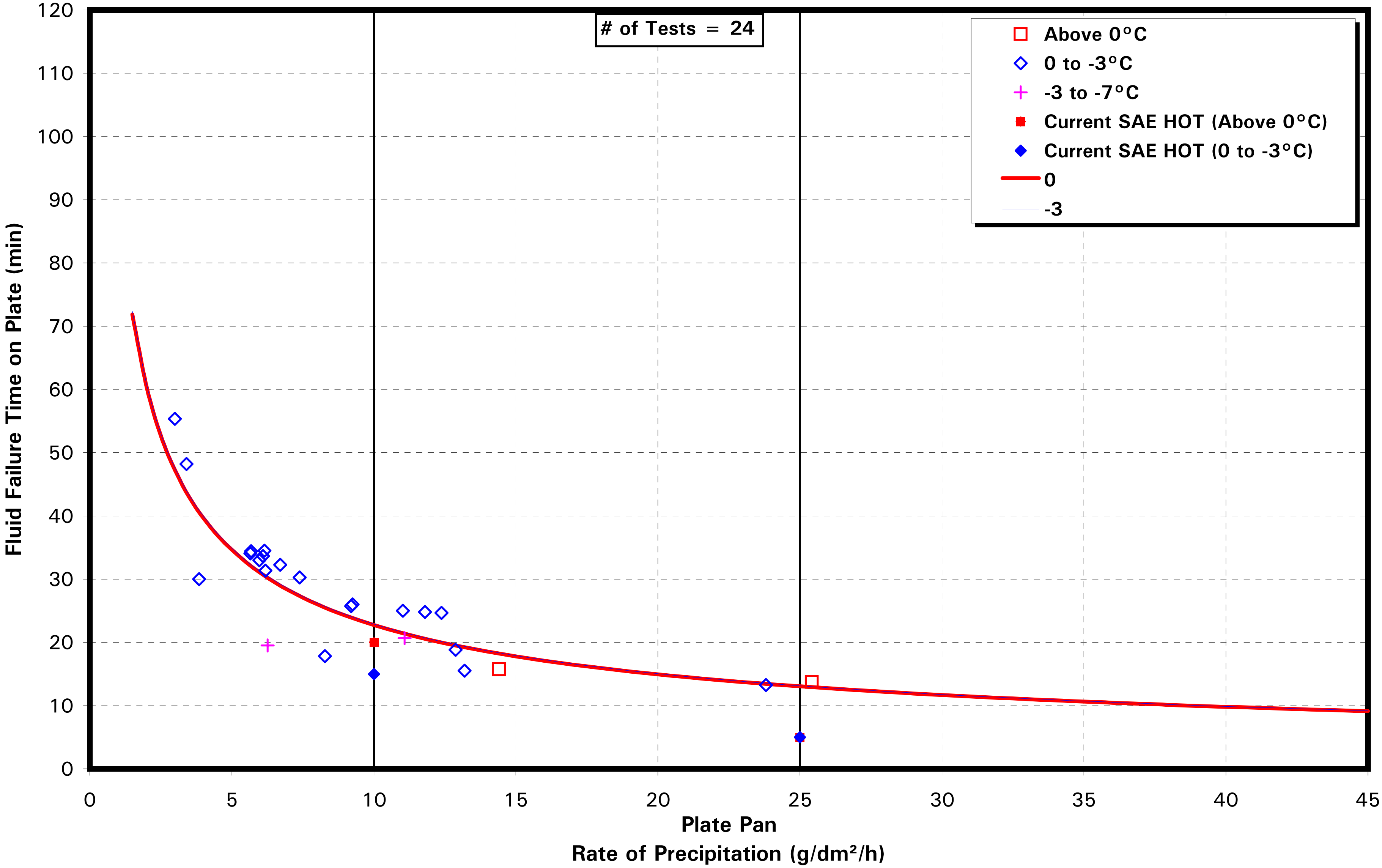


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : C2012-75%

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (50/50)

NATURAL SNOW

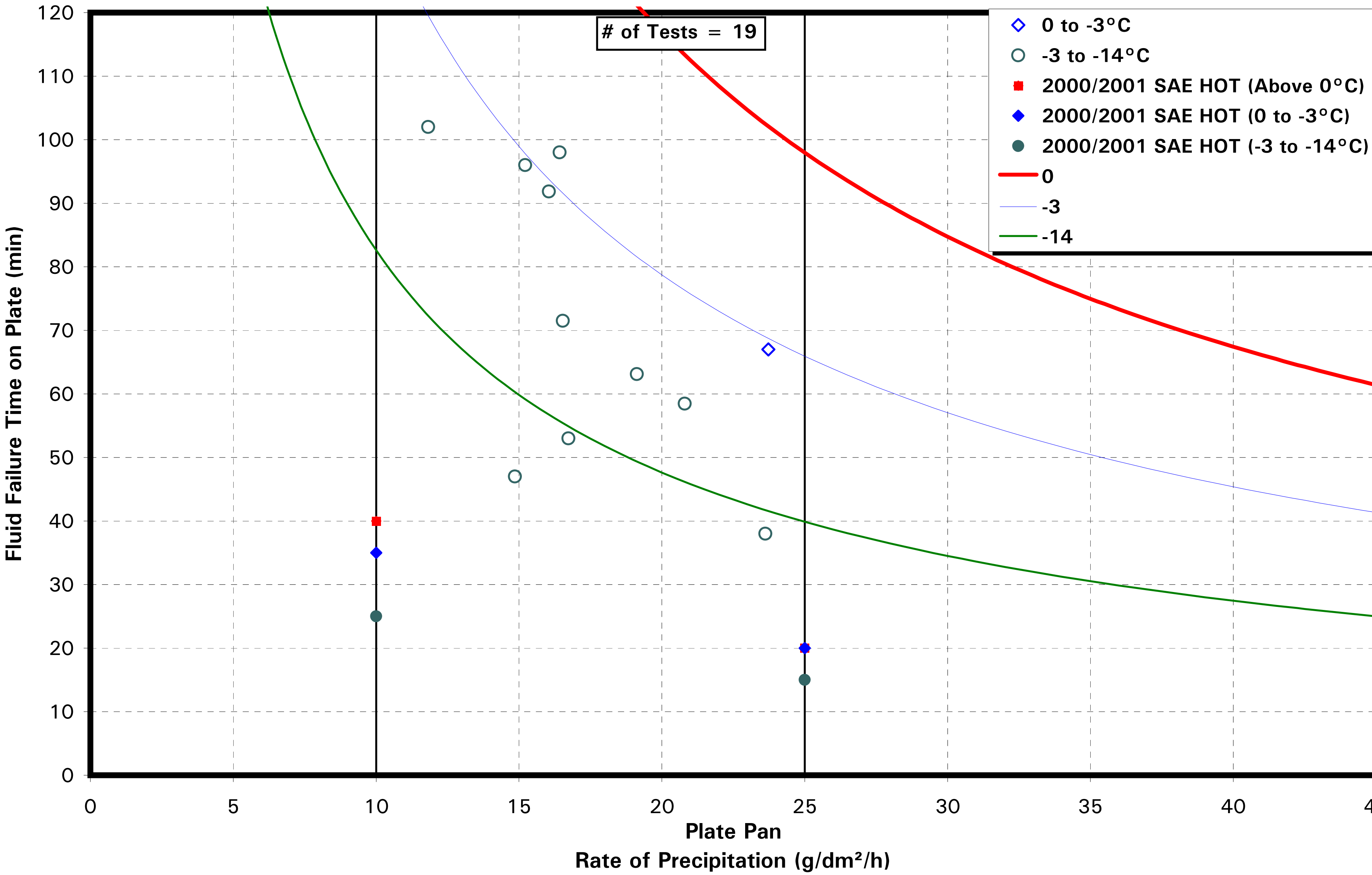


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT : C2012-50%

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (75/25)

BEFORE 28 FEBRUARY (VISCOSITY = 5990 cP) NATURAL SNOW

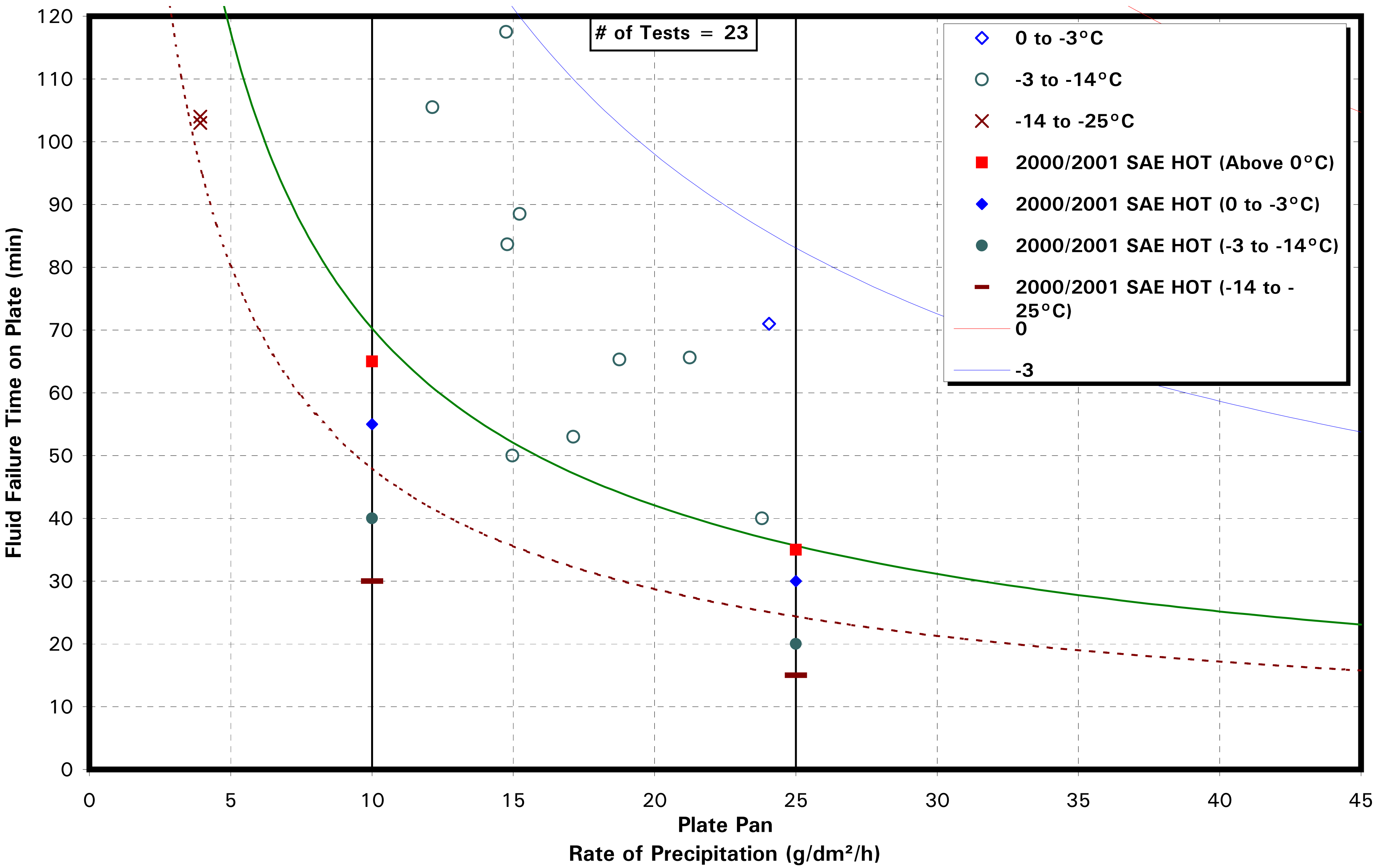


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS (OCTOGON)
AT: 75%(before)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (NEAT)

BEFORE 28 FEBRUARY (VISCOSITY = 5990 cP) NATURAL SNOW

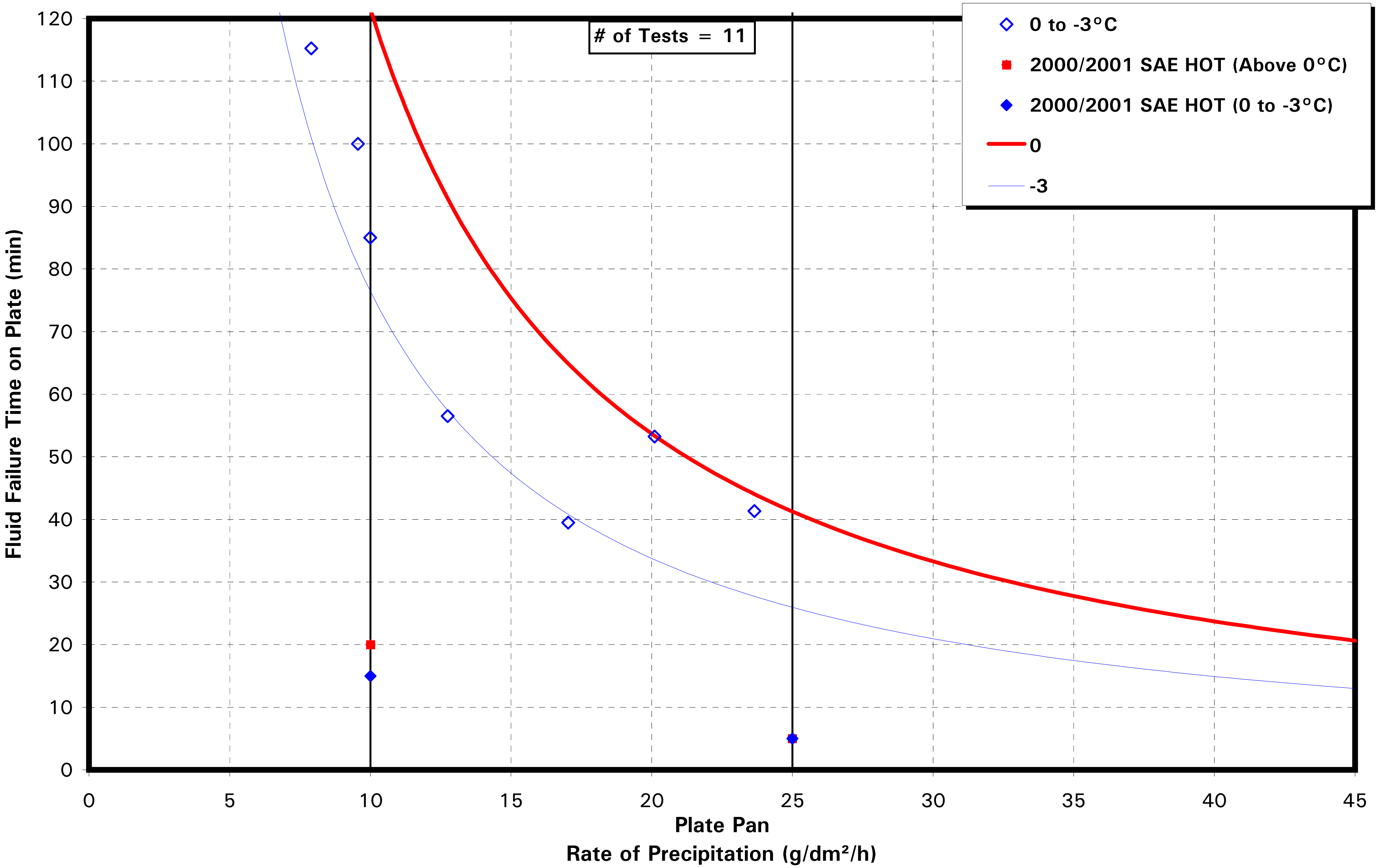


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS (OCTOGON)
AT: Neat(before)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (50/50)

NATURAL SNOW

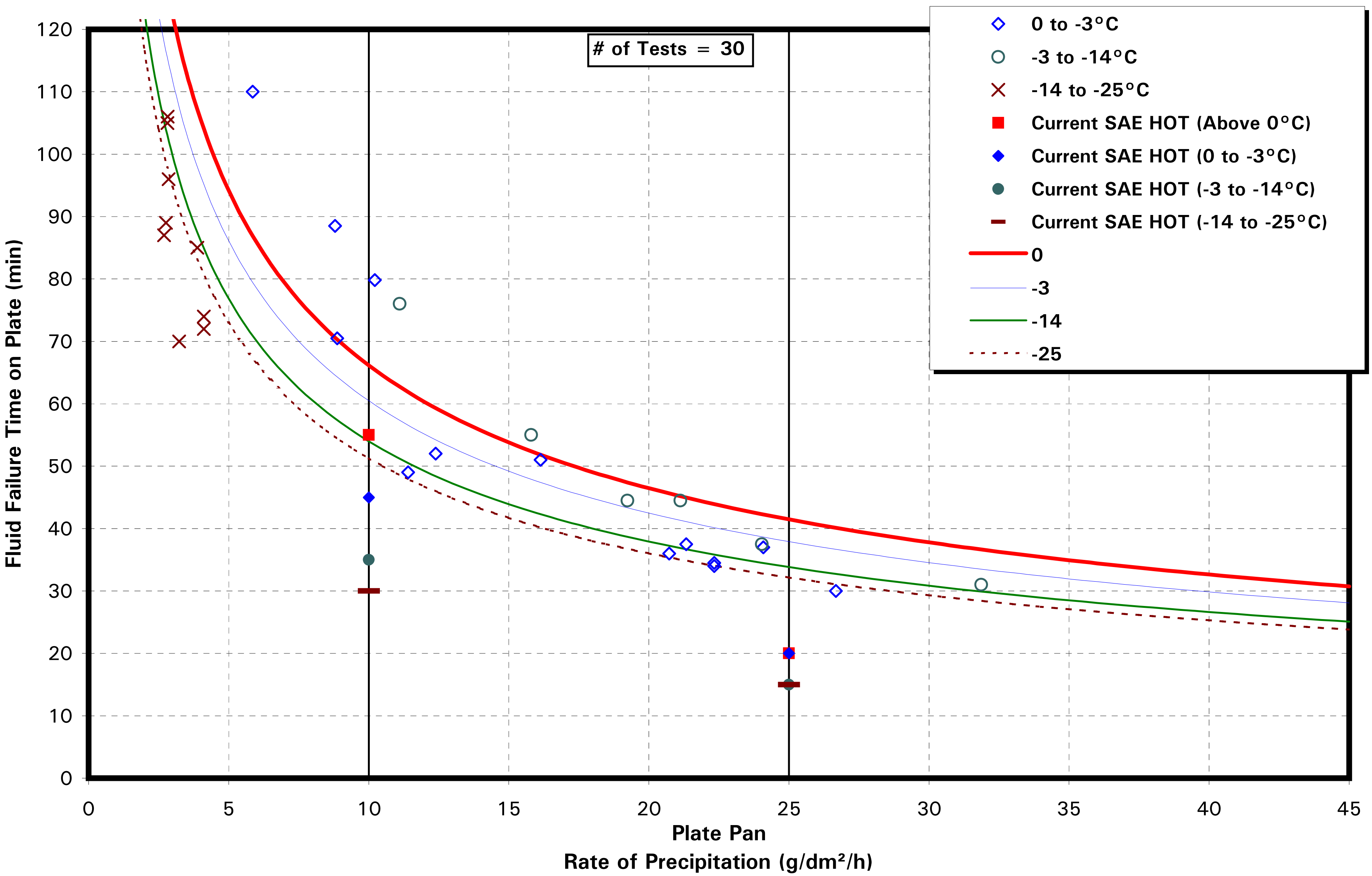


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS (OCTOGON)
AT: 50%

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA ECOWING 26 (NEAT)

NATURAL SNOW

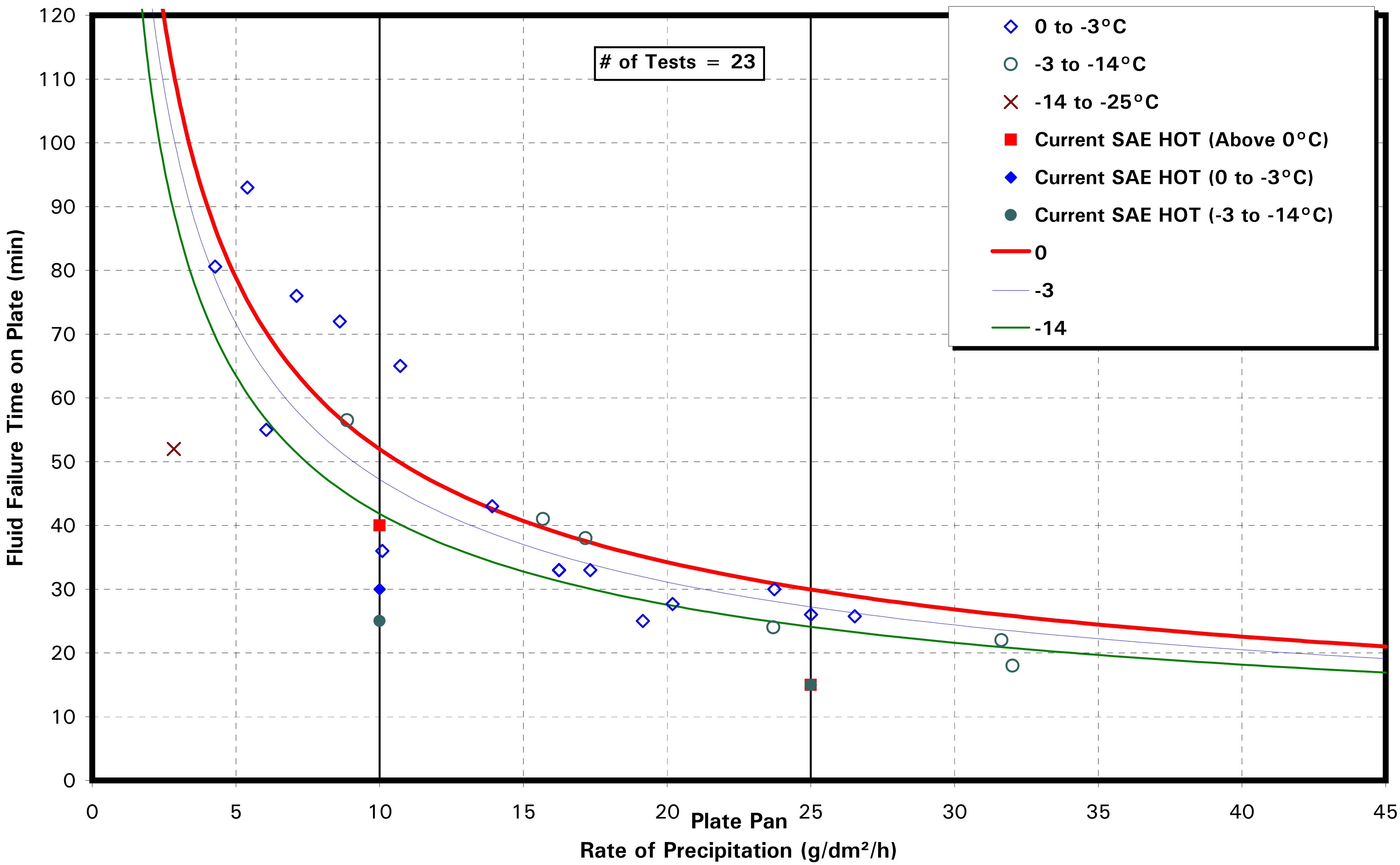


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT: SPCA E26-Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA ECOWING 26 (75/25)

NATURAL SNOW

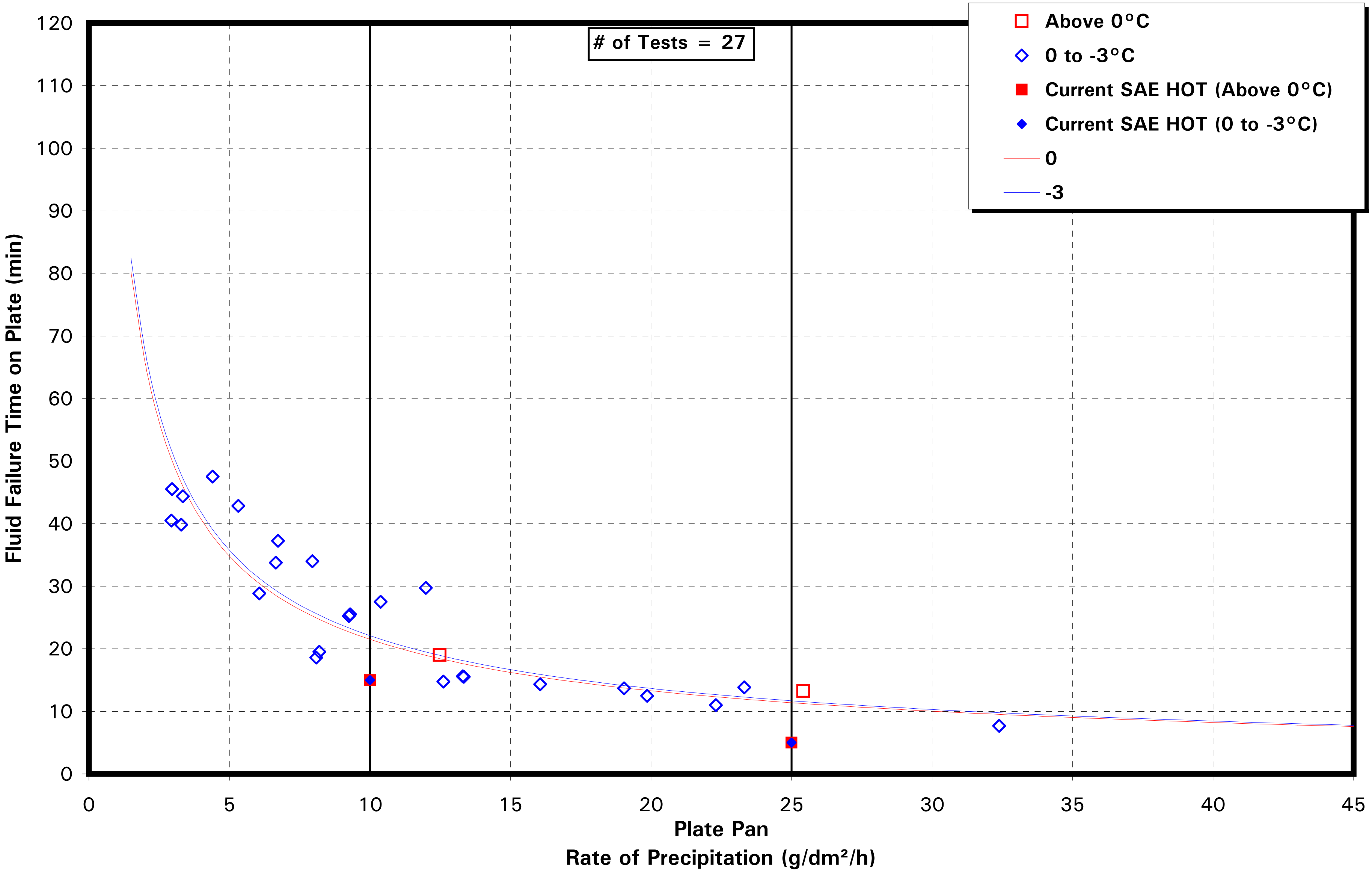


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT: SPCA E26-75%

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA ECOWING 26 (50/50)

NATURAL SNOW

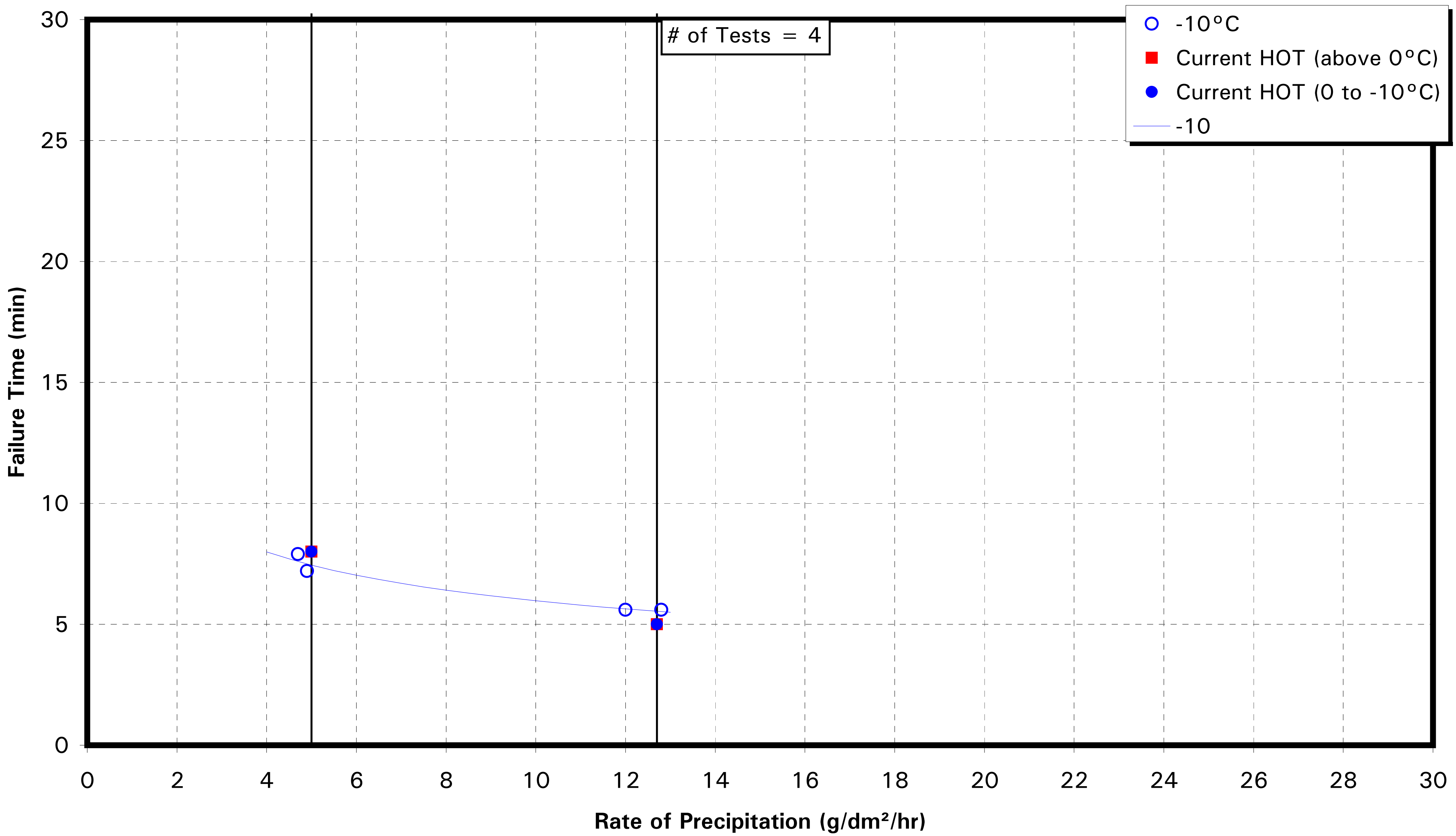


M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Fluid Rates CHARTS new
AT: SPCA E26-50%

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

LYONDELL ARCO PLUS - ST (10°)

FREEZING DRIZZLE

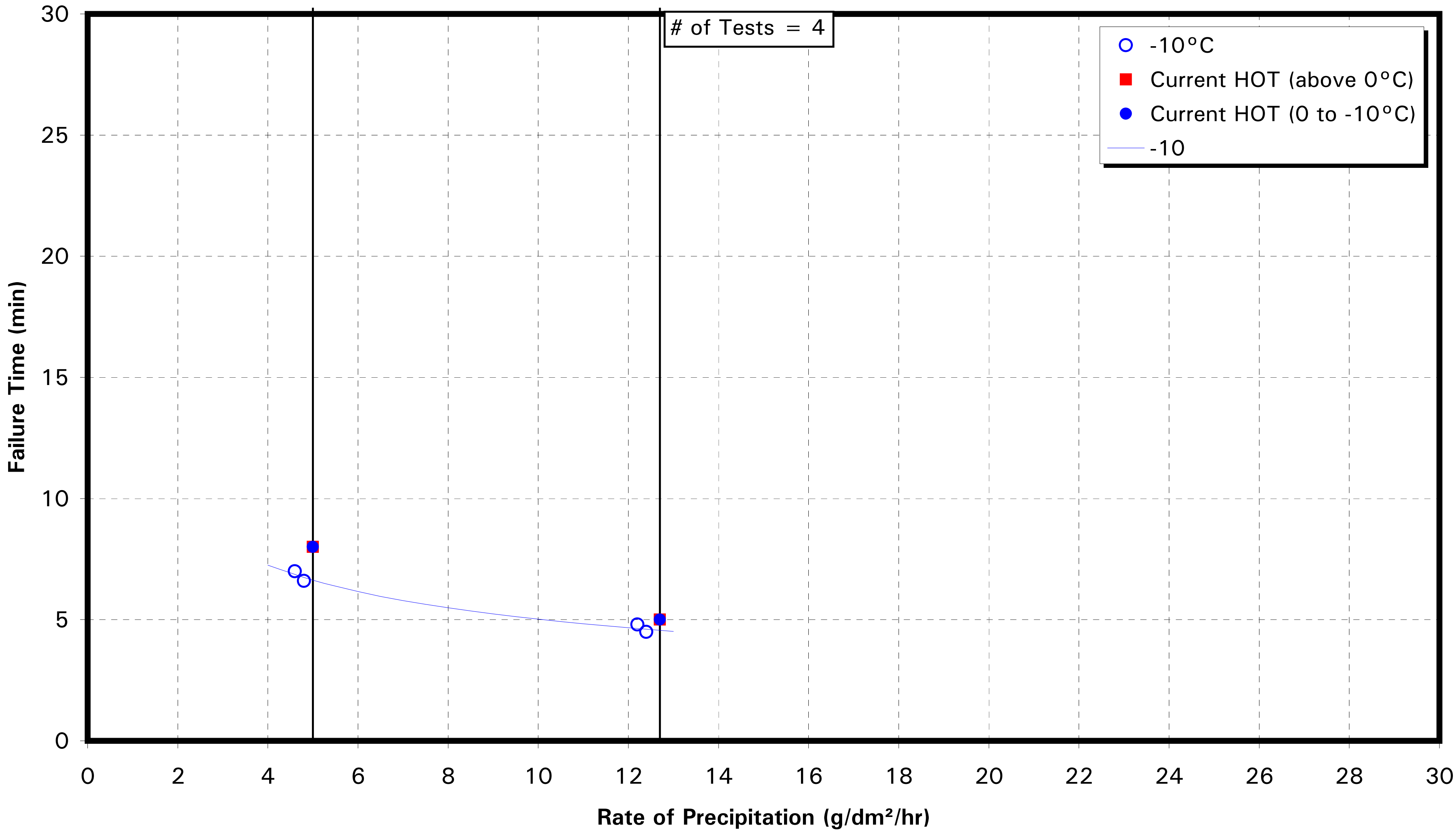


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - LYONDELL ARCO+
AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

NEWAVE AEROCH. FCY-1A (10°)

FREEZING DRIZZLE

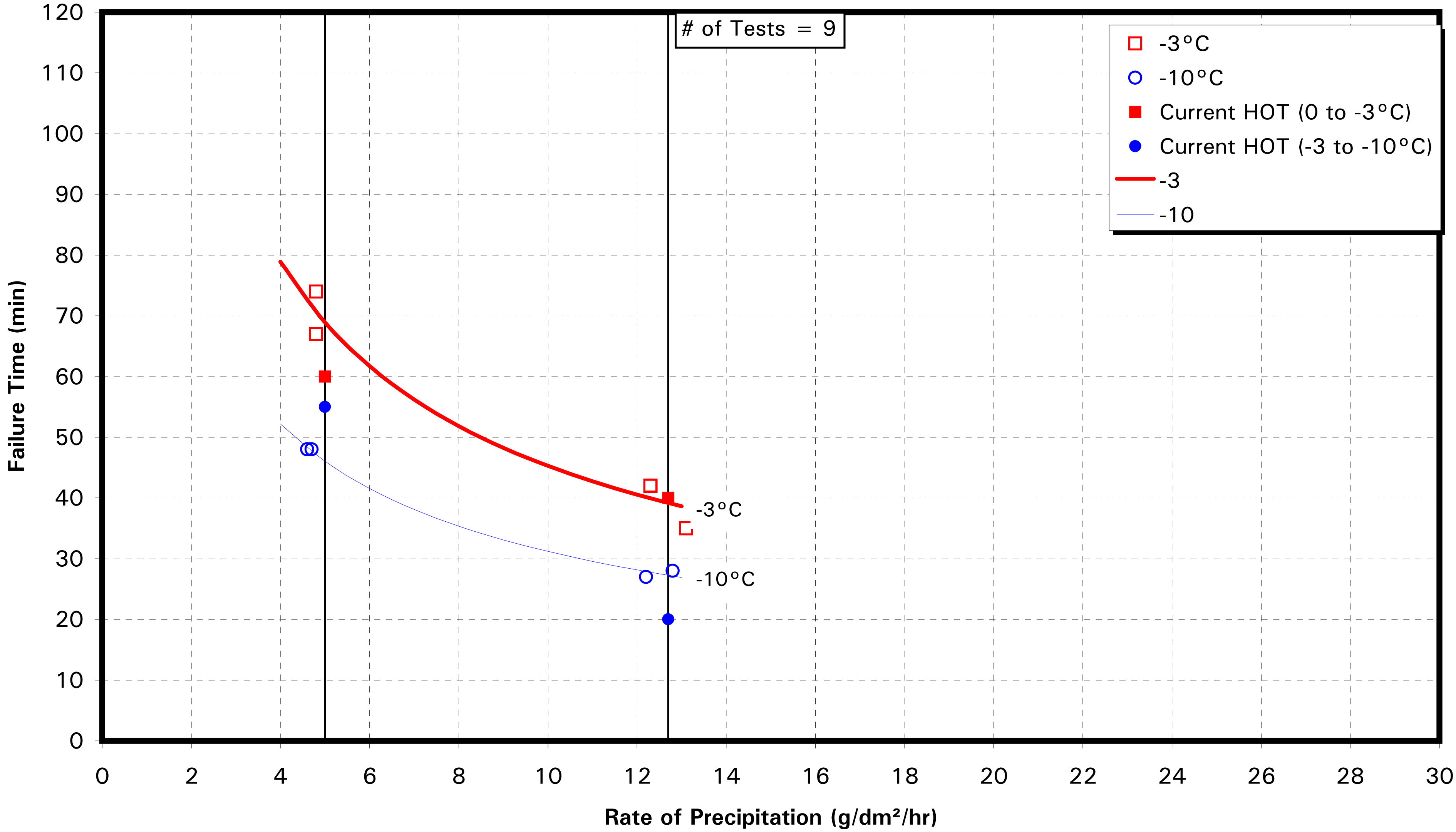


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - NEWAVE AEROCH FCY-1A
AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (NEAT)

FREEZING DRIZZLE

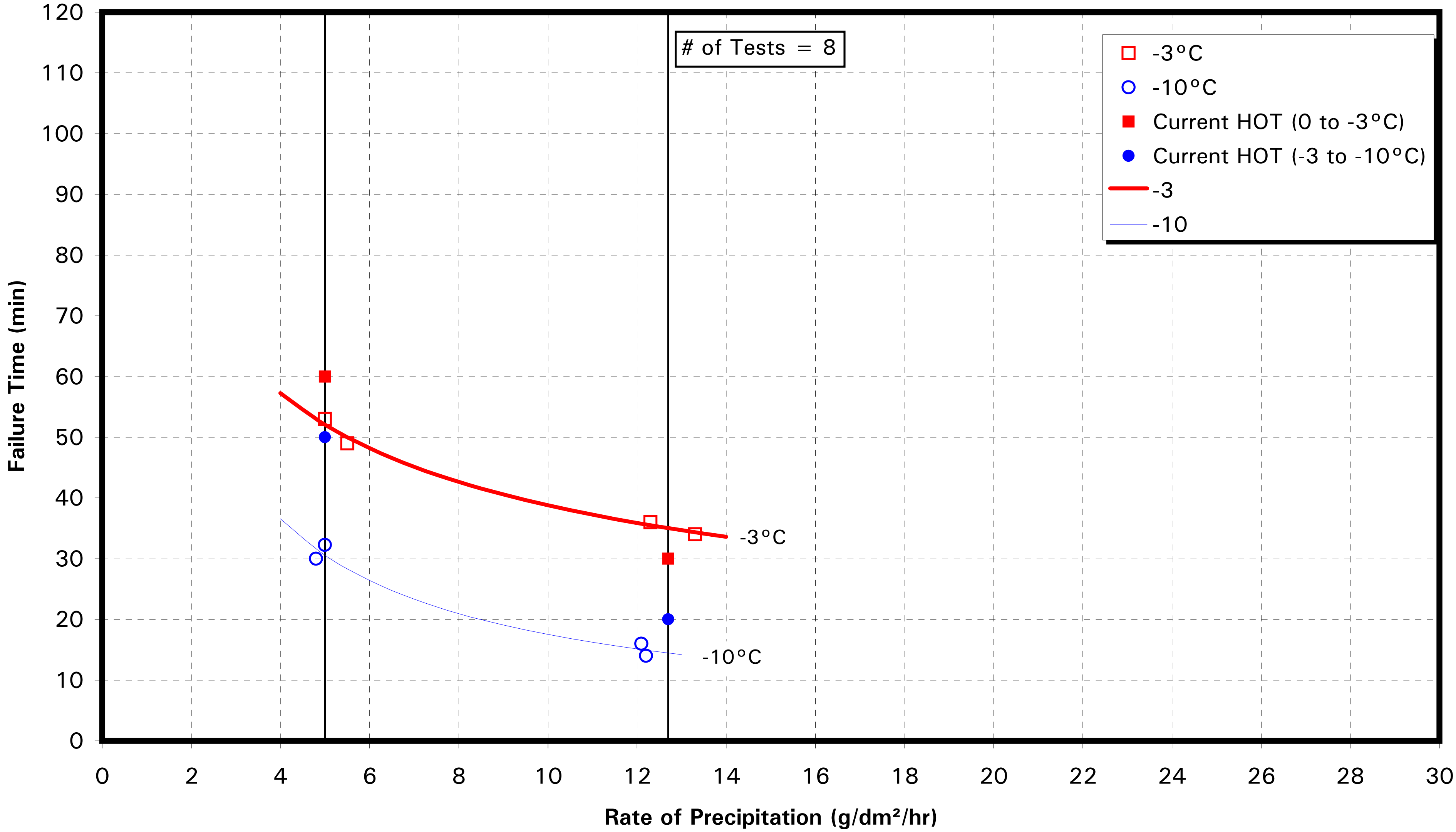


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - C2012
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (75/25)

FREEZING DRIZZLE

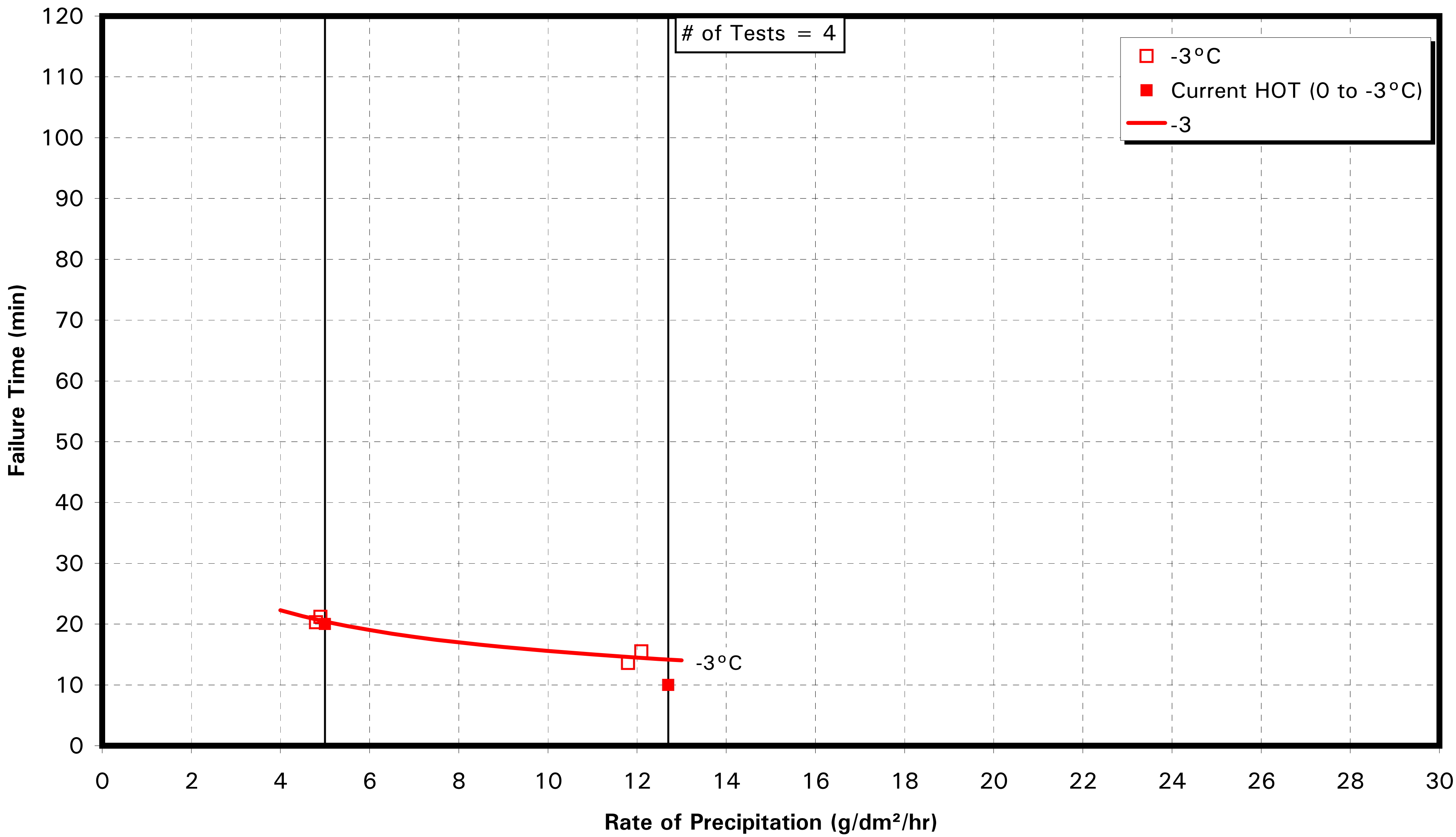


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - C2012
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT SAFEWING PROTECT 2012 (50/50)

FREEZING DRIZZLE

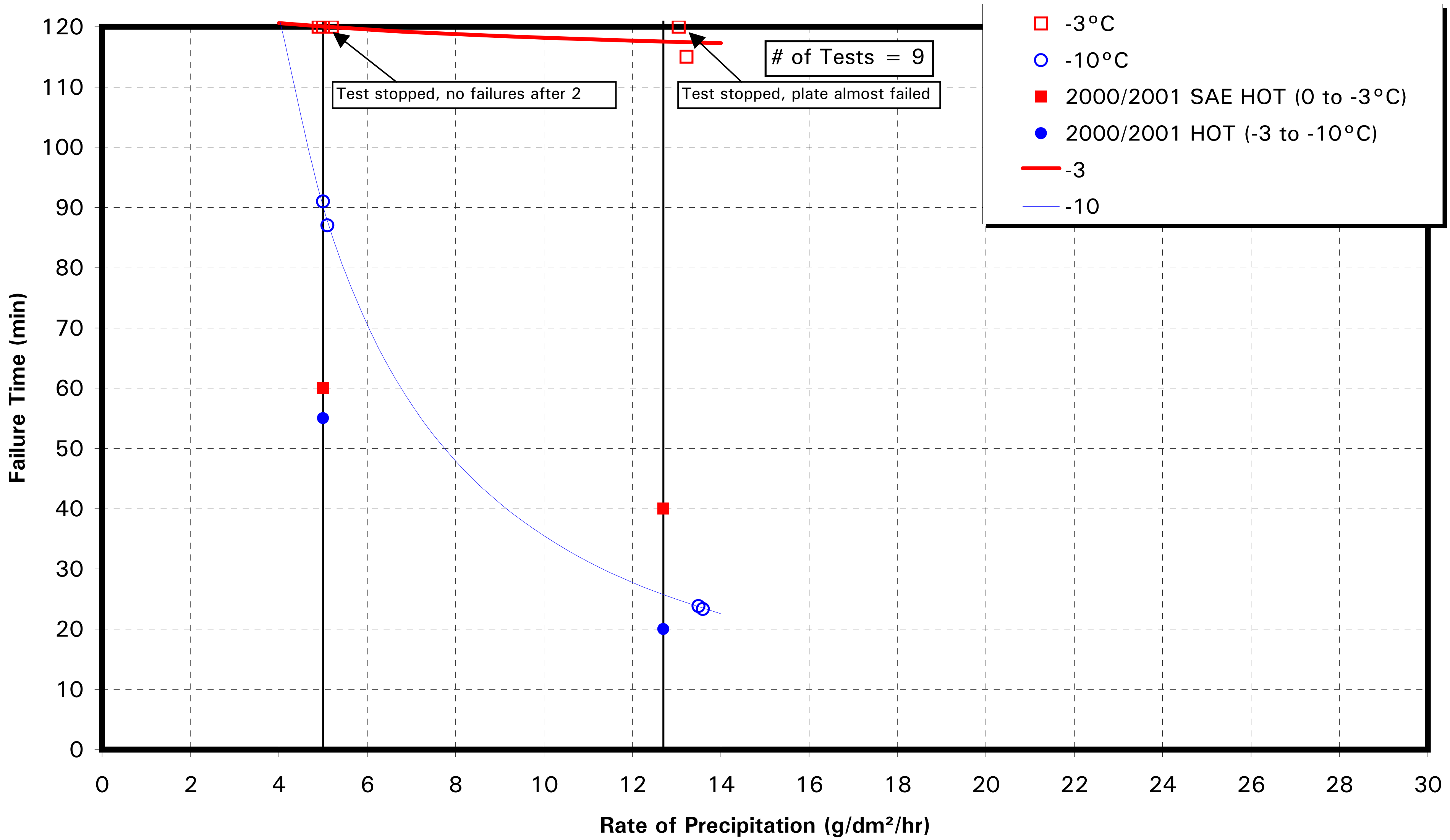


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - C2012
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (NEAT)

FREEZING DRIZZLE

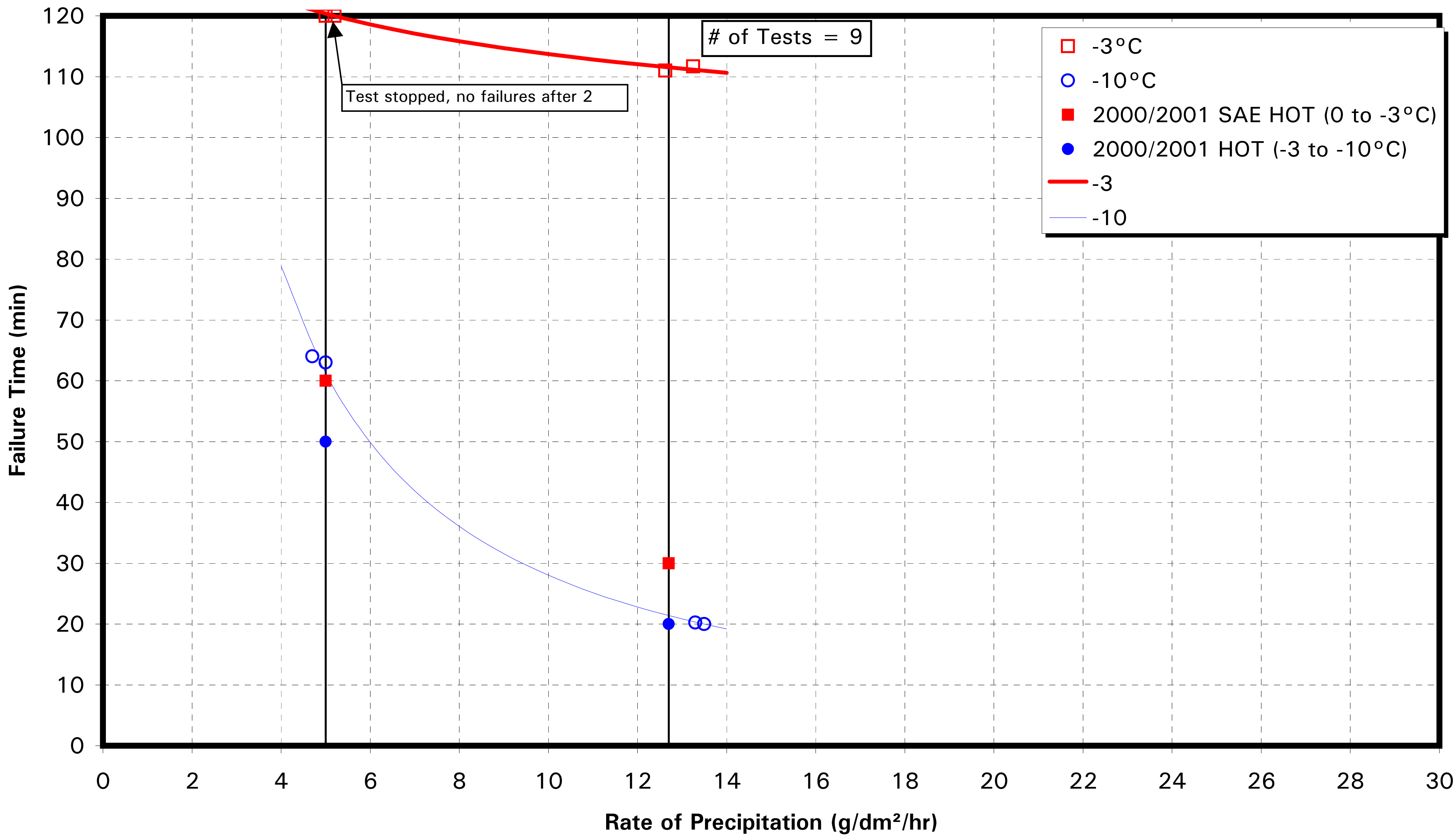


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZD
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (75/25)

FREEZING DRIZZLE

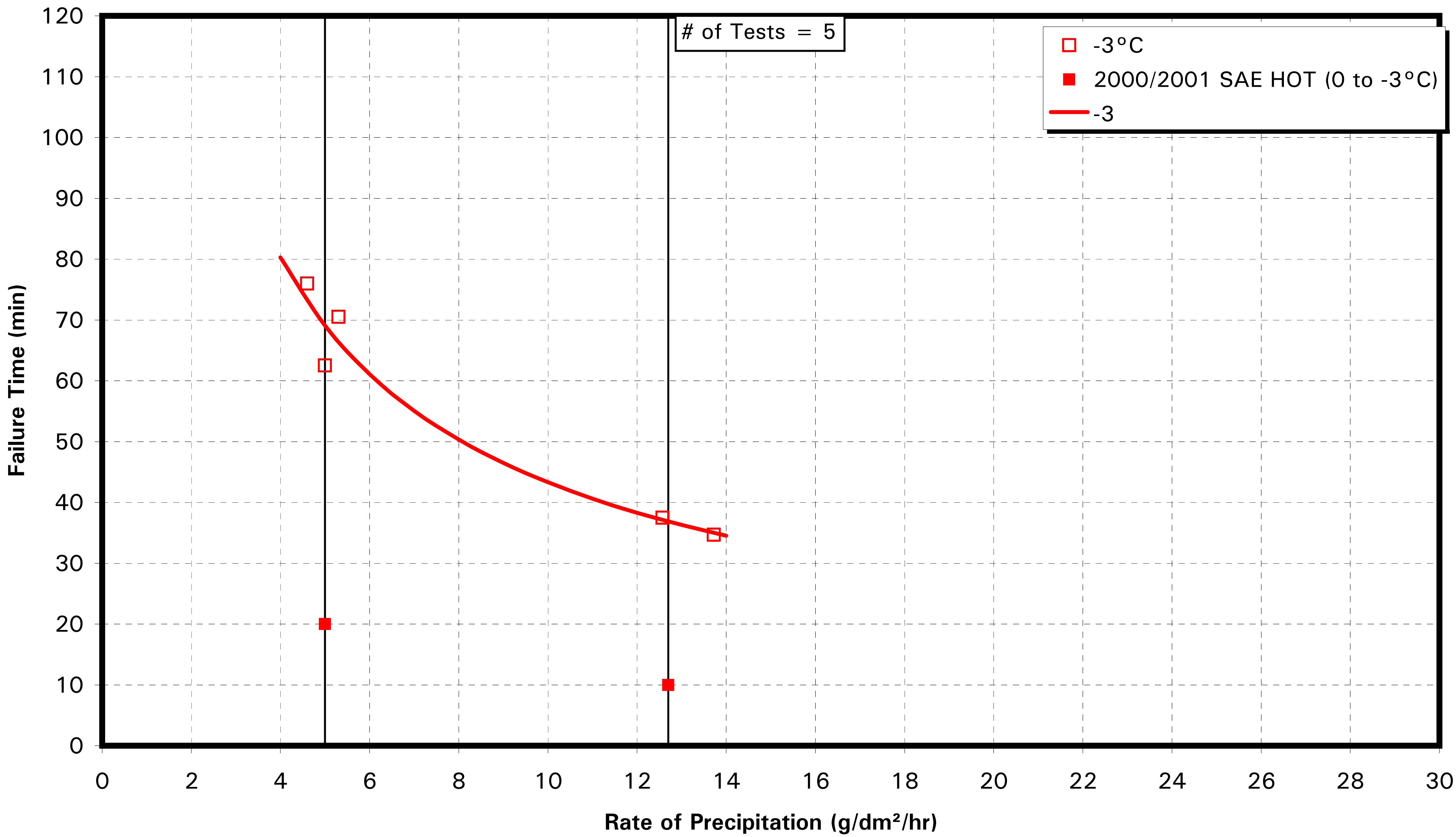


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZD
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (50/50)

FREEZING DRIZZLE

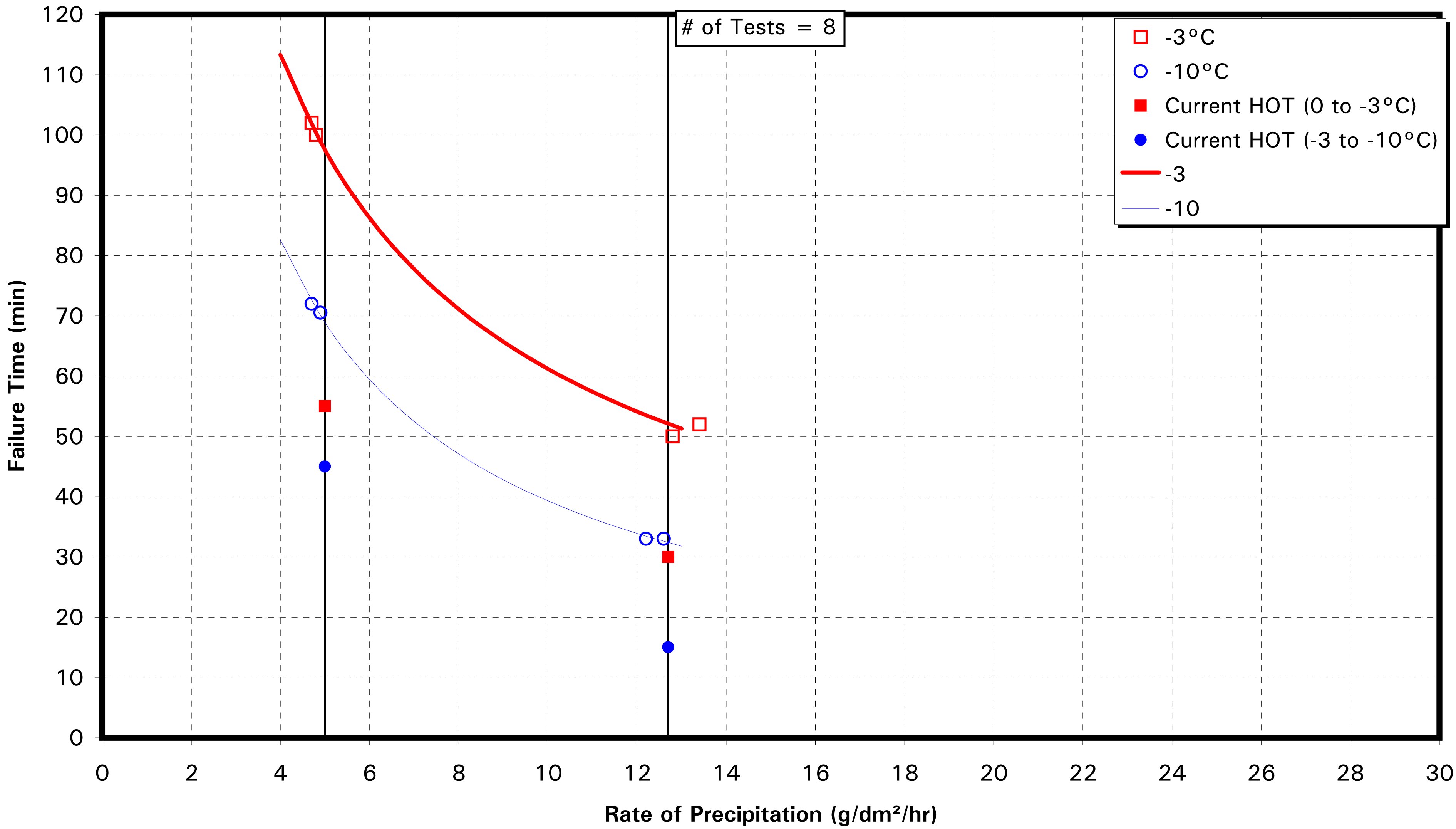


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZD
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (NEAT)

FREEZING DRIZZLE

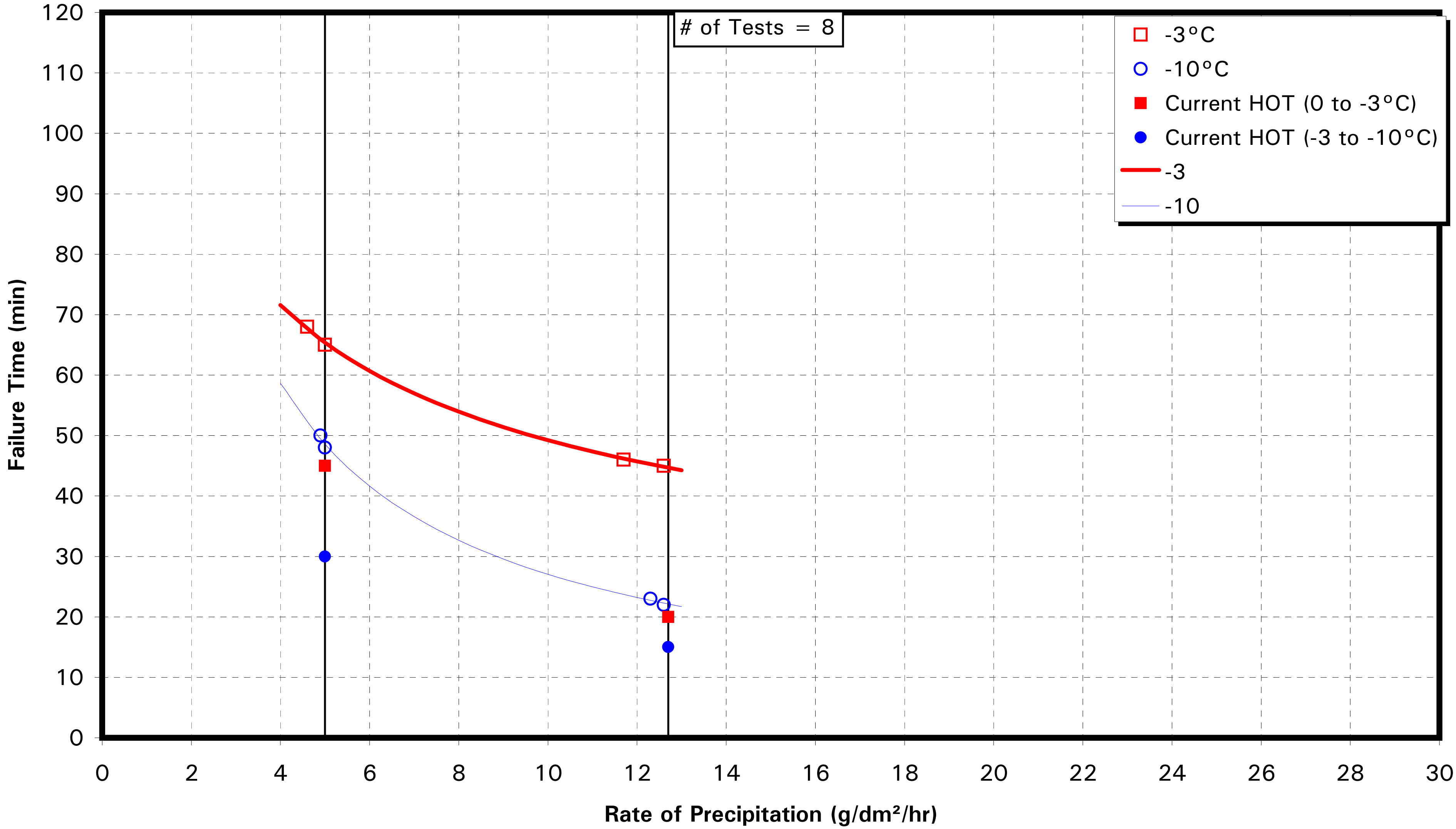


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - SPCA E26
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (75/25)

FREEZING DRIZZLE

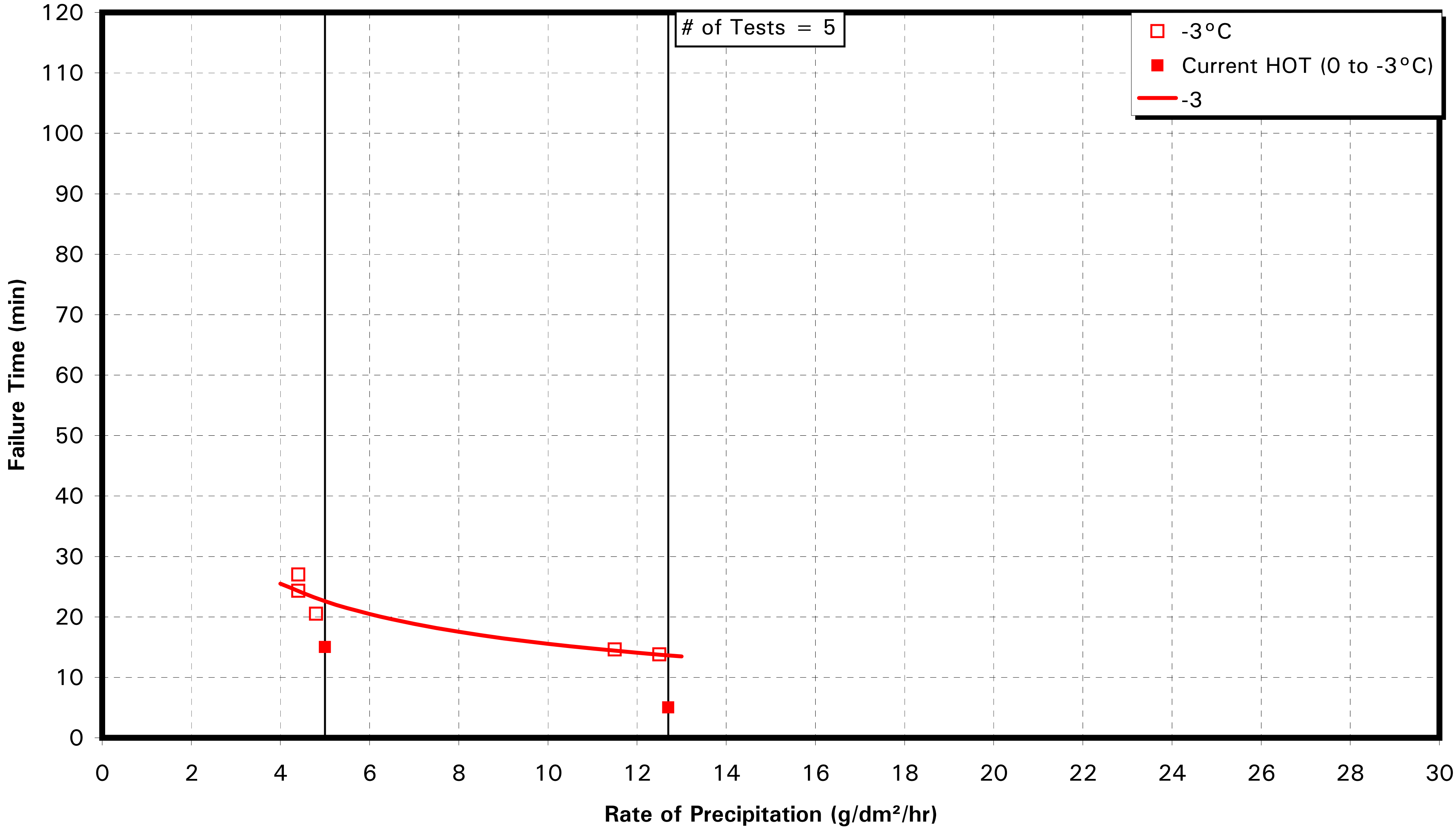


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZD - SPCA E26
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (50/50)

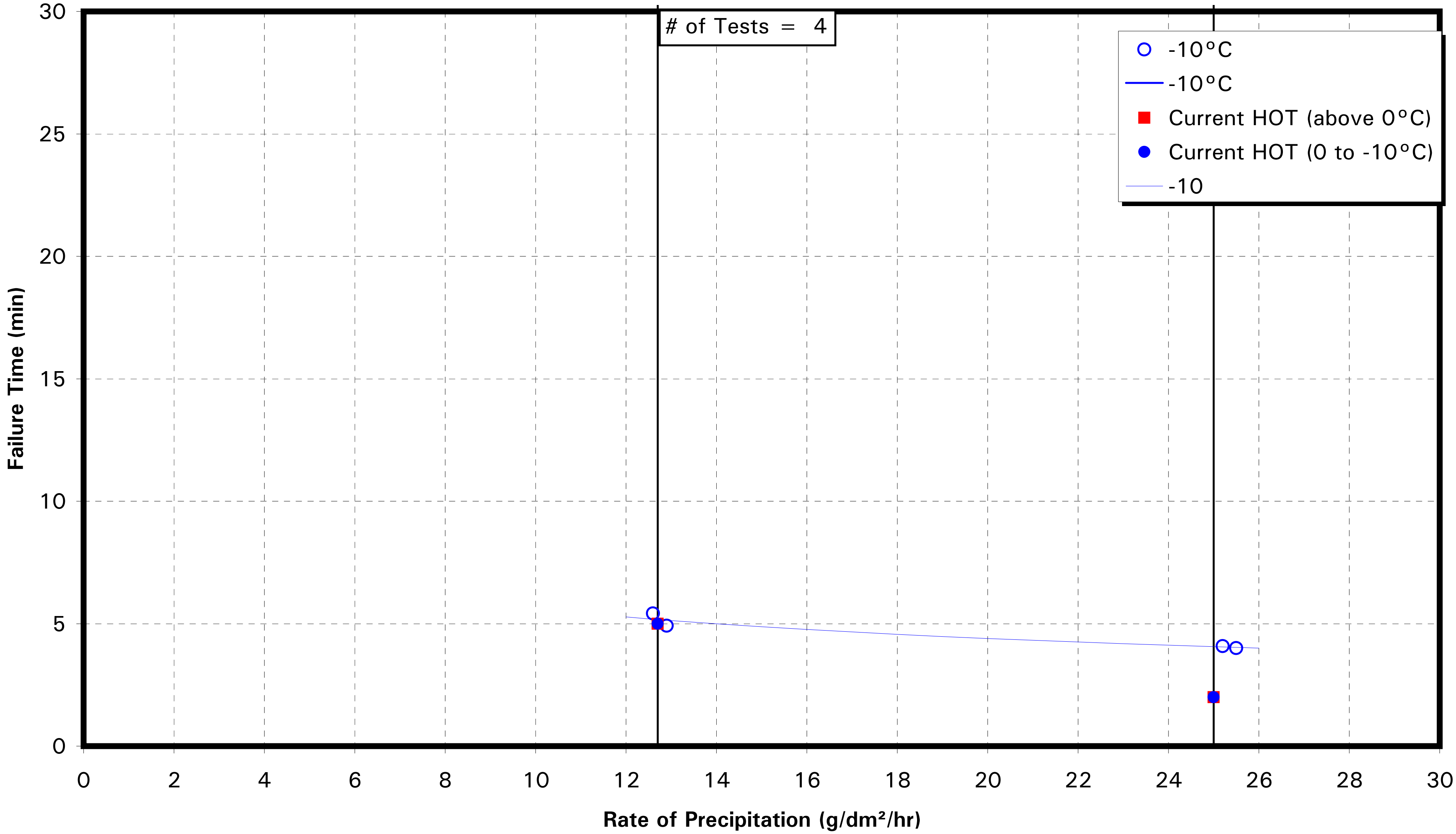
FREEZING DRIZZLE



EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

LYONDELL ARCO PLUS - ST (10°)

LIGHT FREEZING RAIN

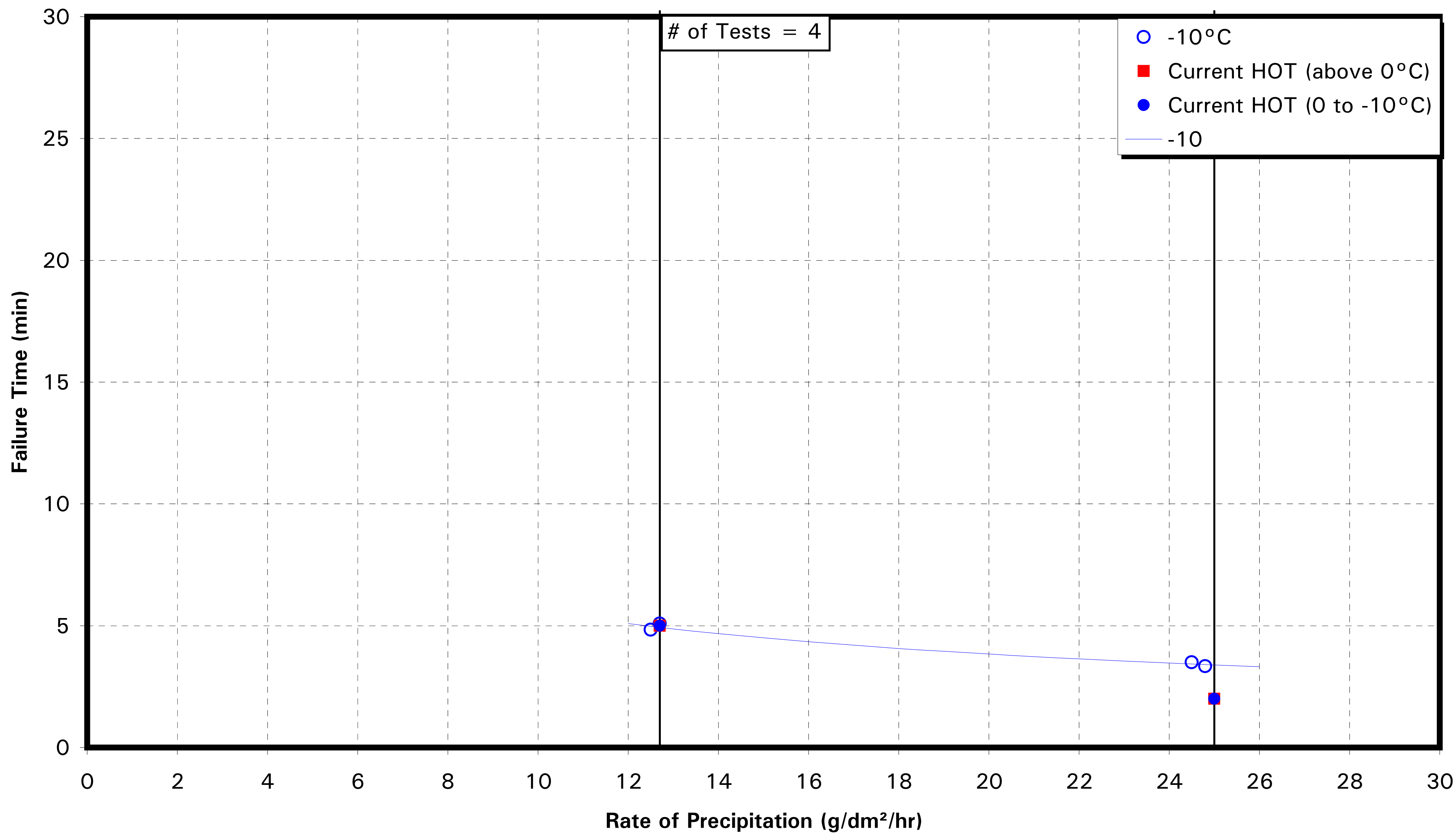


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - LYONDELL ARCO + AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

NEWAVE AEROCH. FCY-1A (10°)

LIGHT FREEZING RAIN

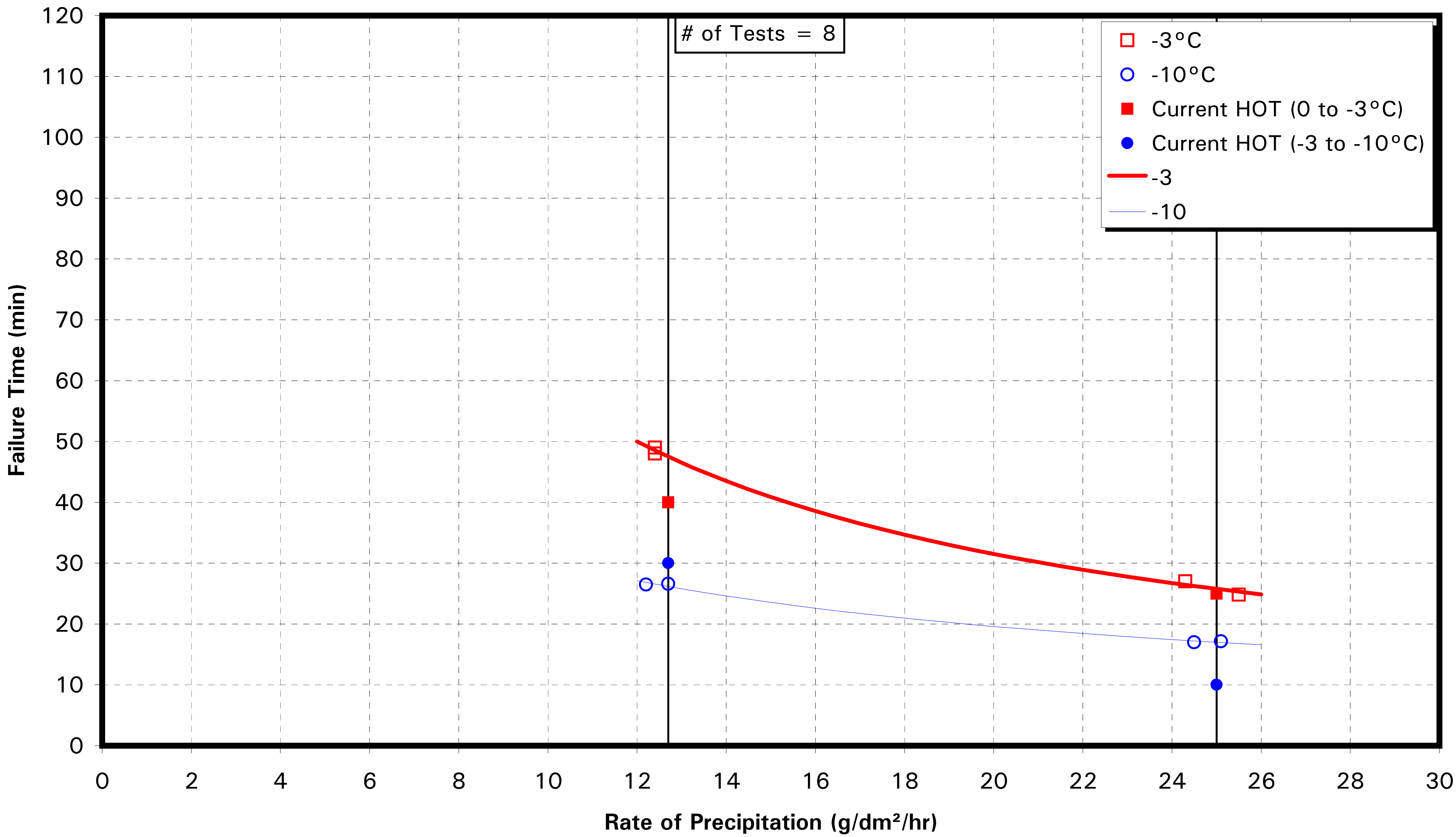


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - NEWAVE AEROCH FCY-1A
AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (NEAT)

LIGHT FREEZING RAIN

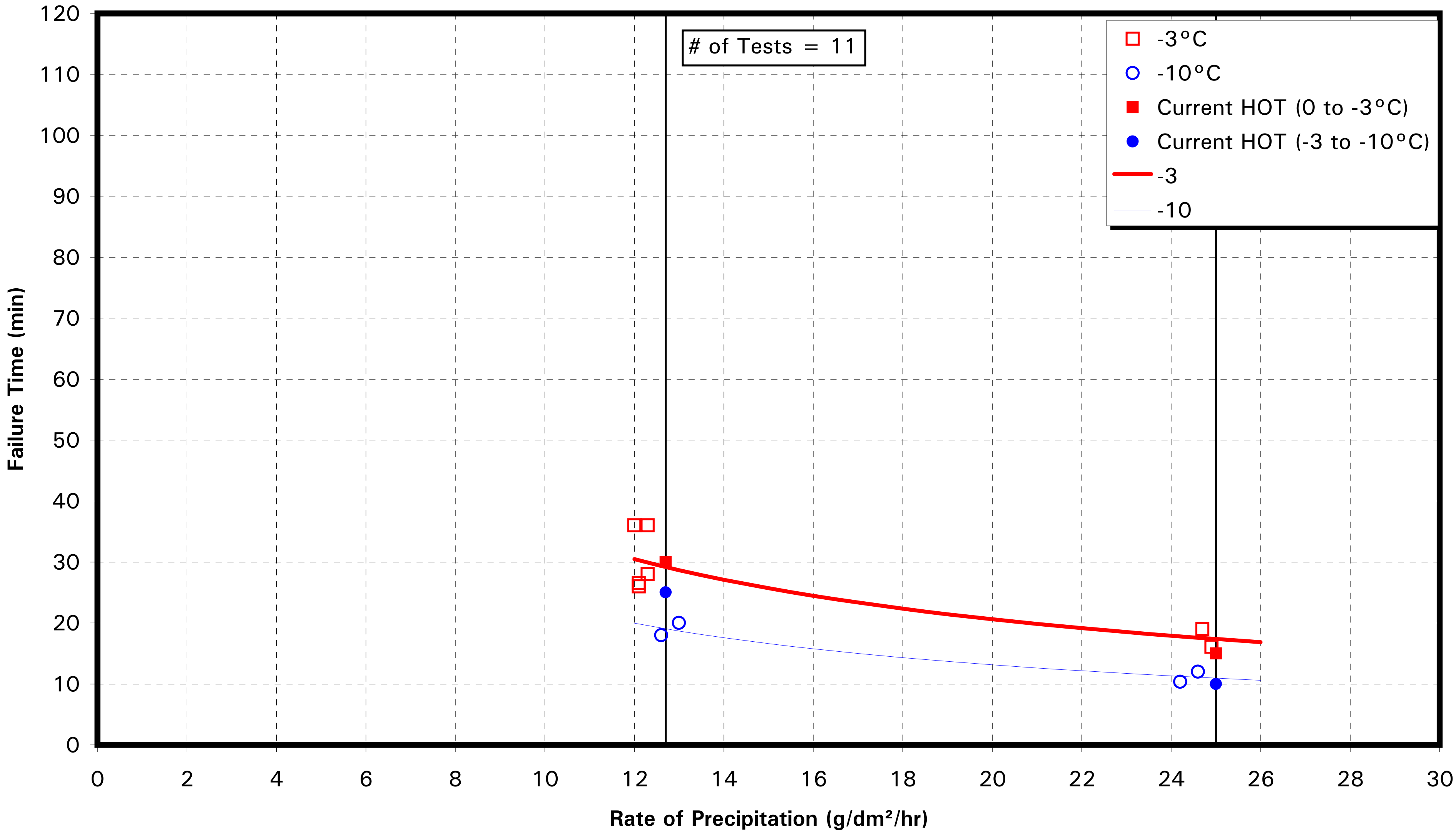


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - C2012
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (75/25)

LIGHT FREEZING RAIN

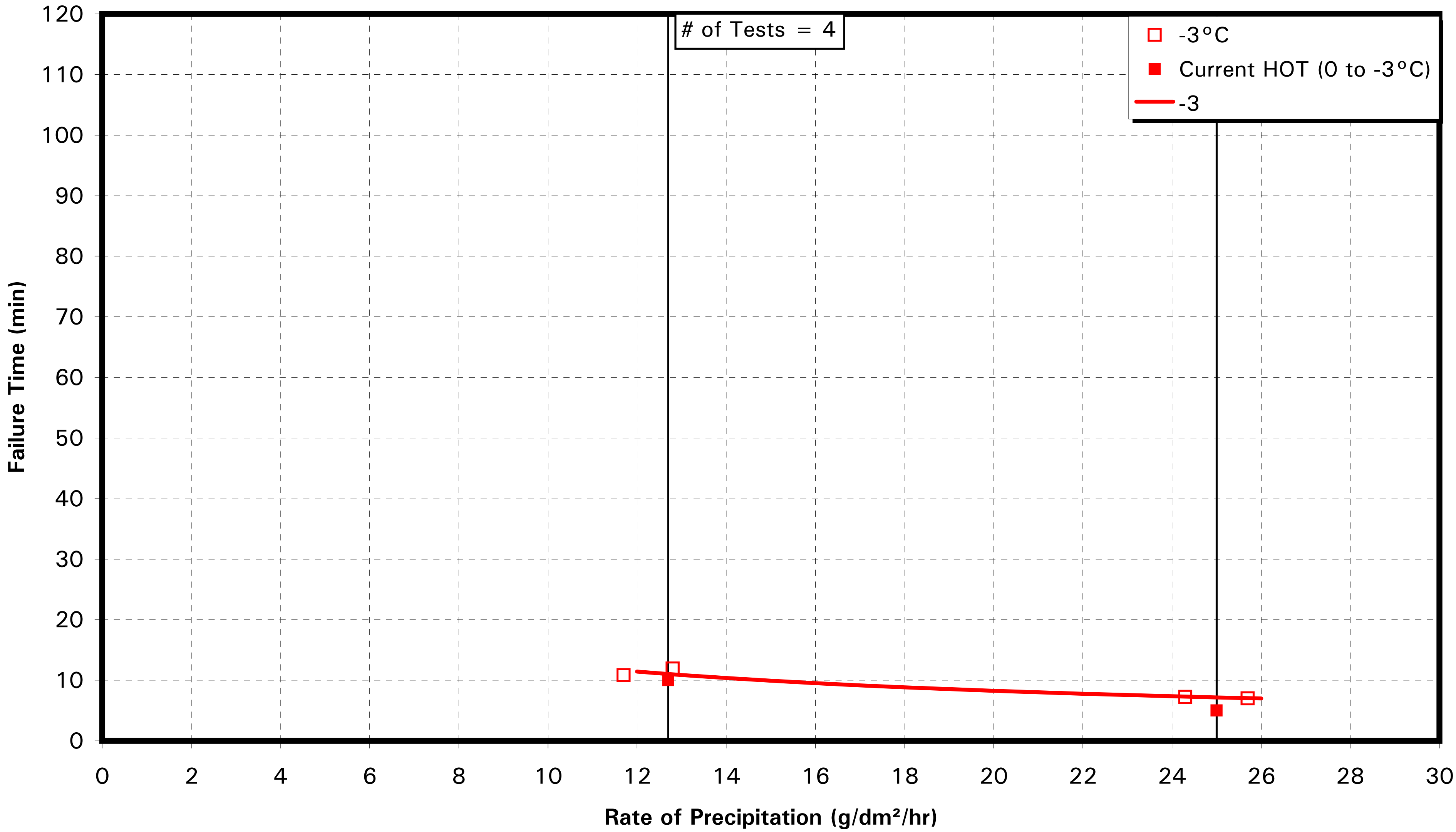


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - C2012
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (50/50)

LIGHT FREEZING RAIN

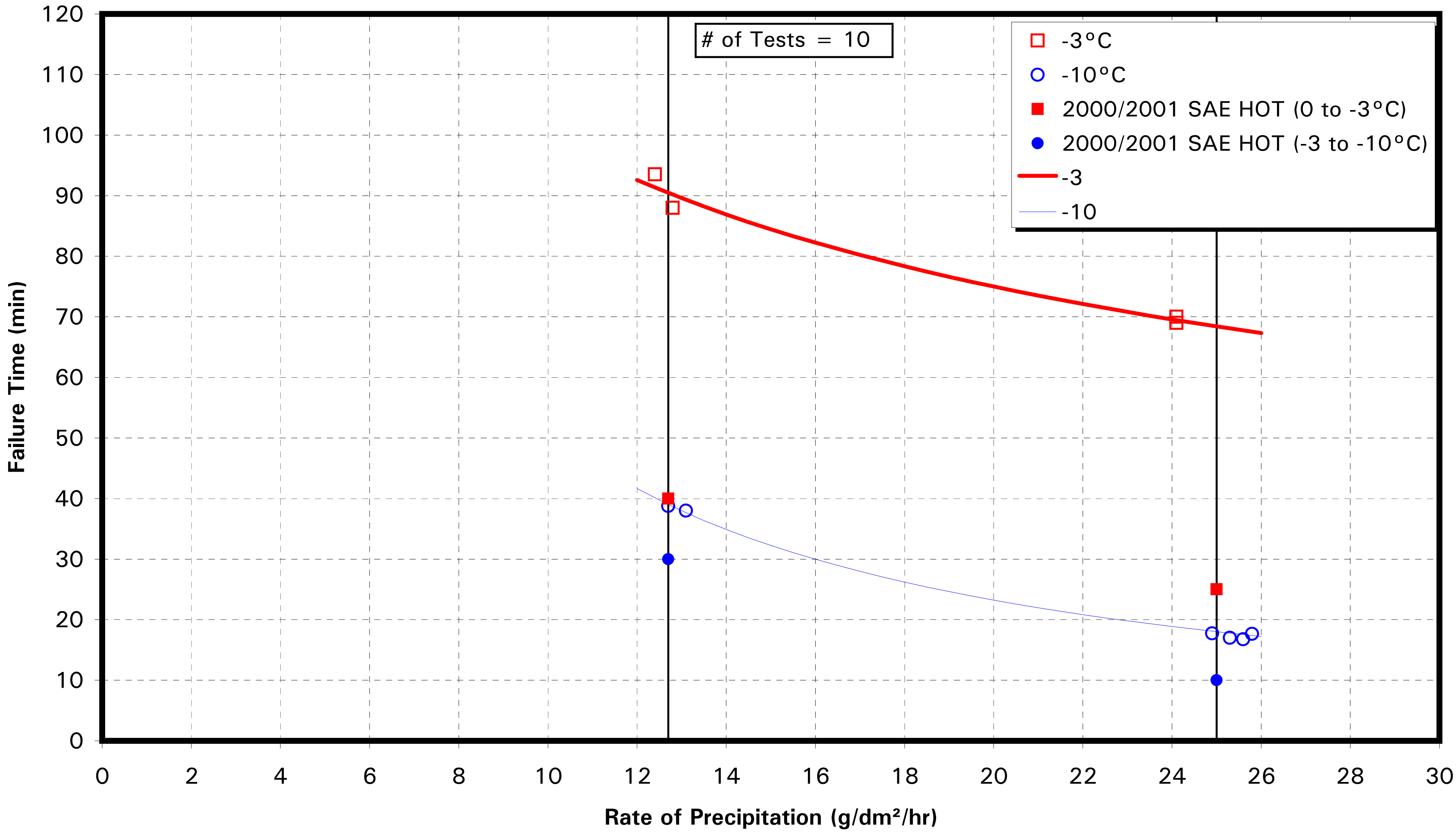


M\Groups\CM1680 (exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - C2012
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (NEAT)

LIGHT FREEZING RAIN

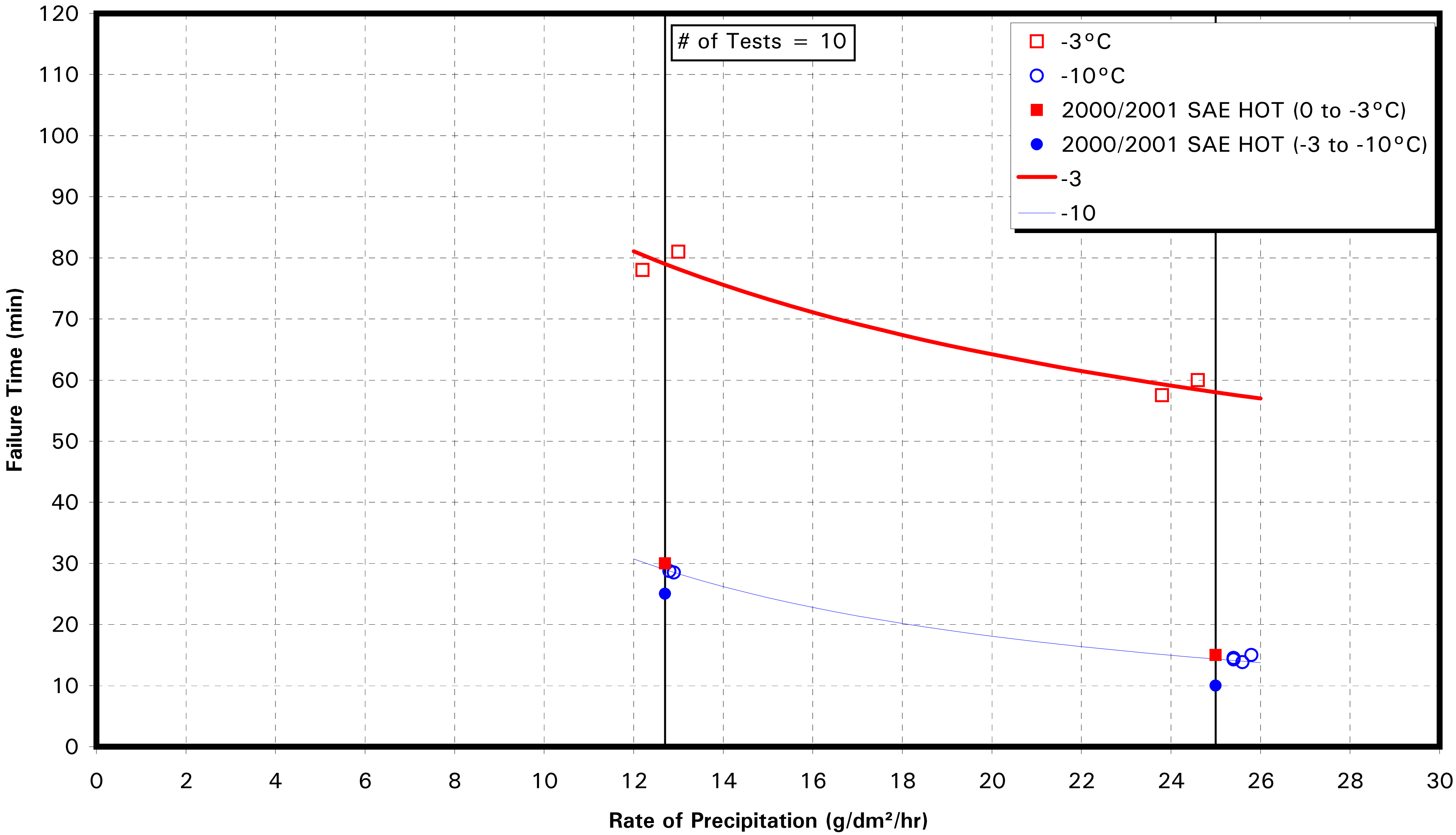


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZR AT:Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (75/25)

LIGHT FREEZING RAIN

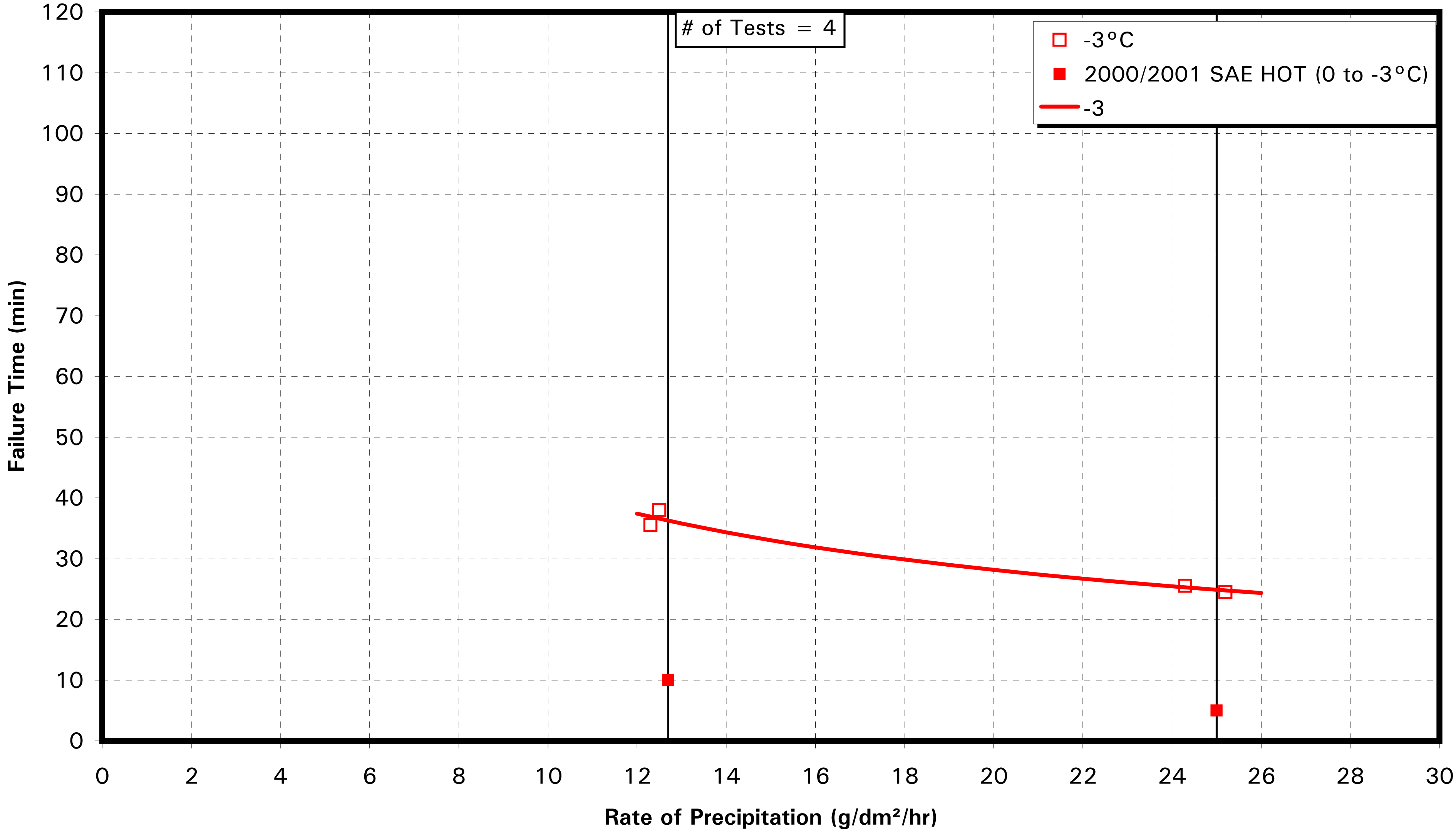


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZR
AT:75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (50/50)

LIGHT FREEZING RAIN

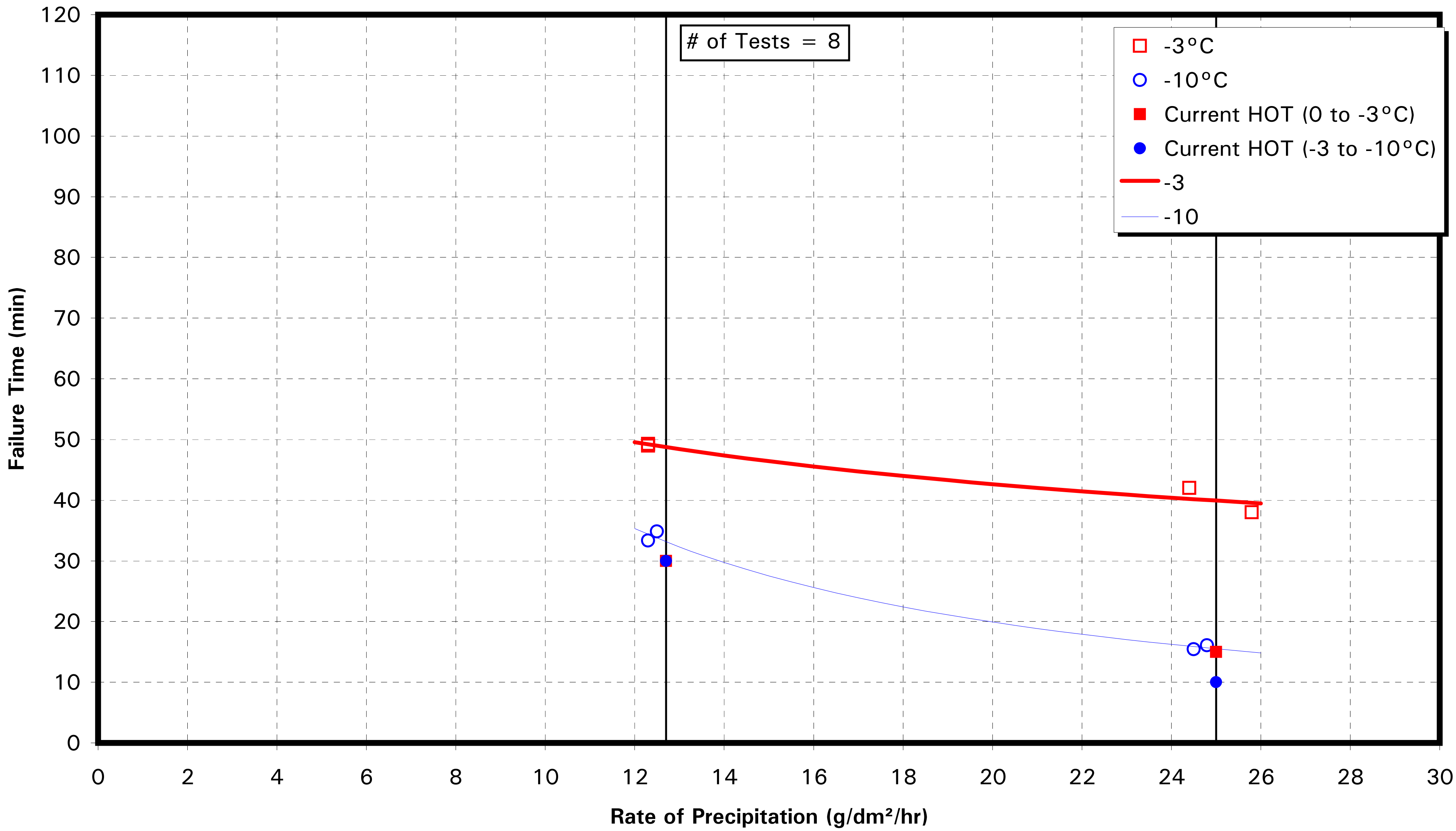


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZR
AT:50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (NEAT)

LIGHT FREEZING RAIN

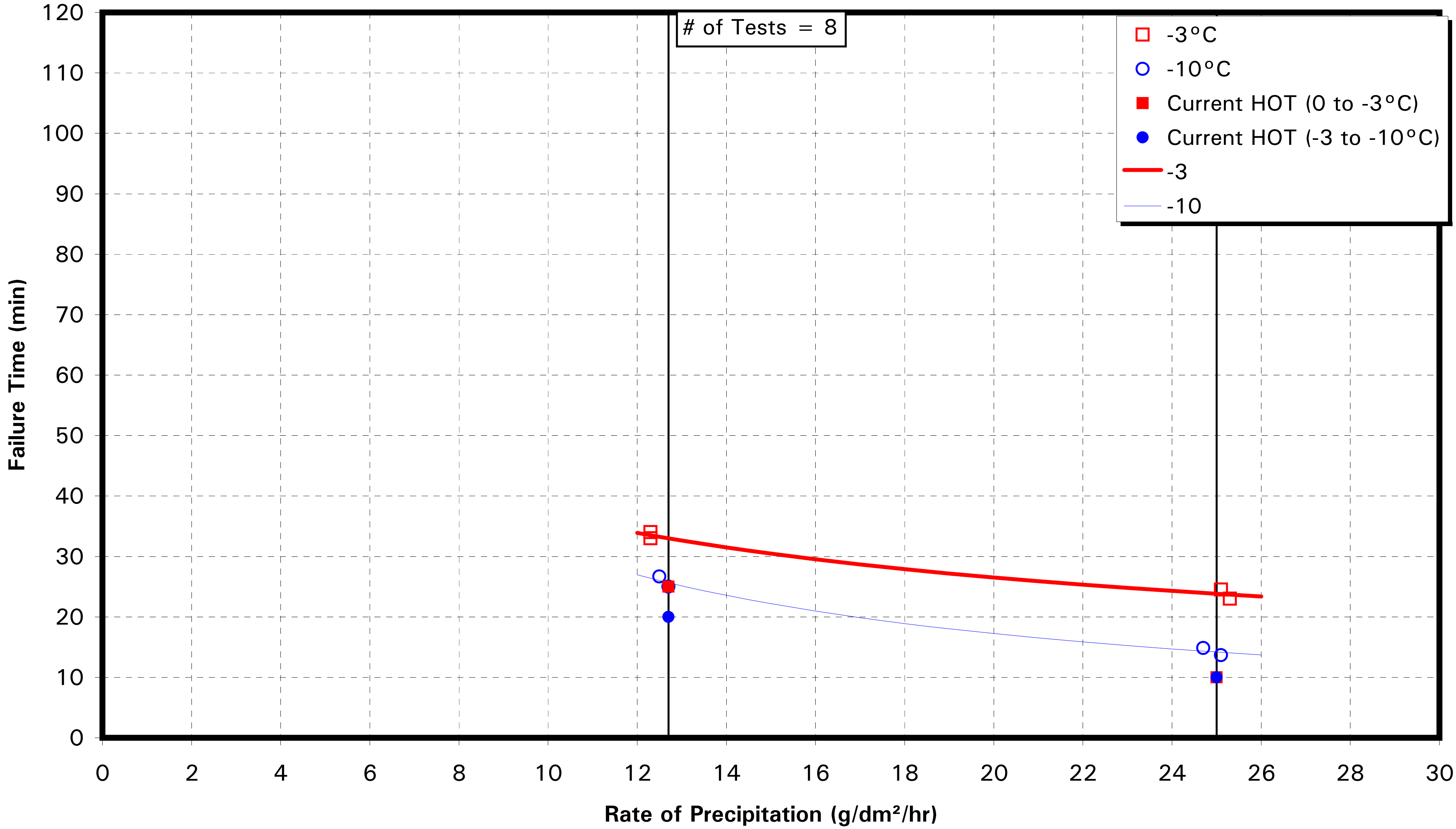


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - SPCA E26
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (75/25)

LIGHT FREEZING RAIN

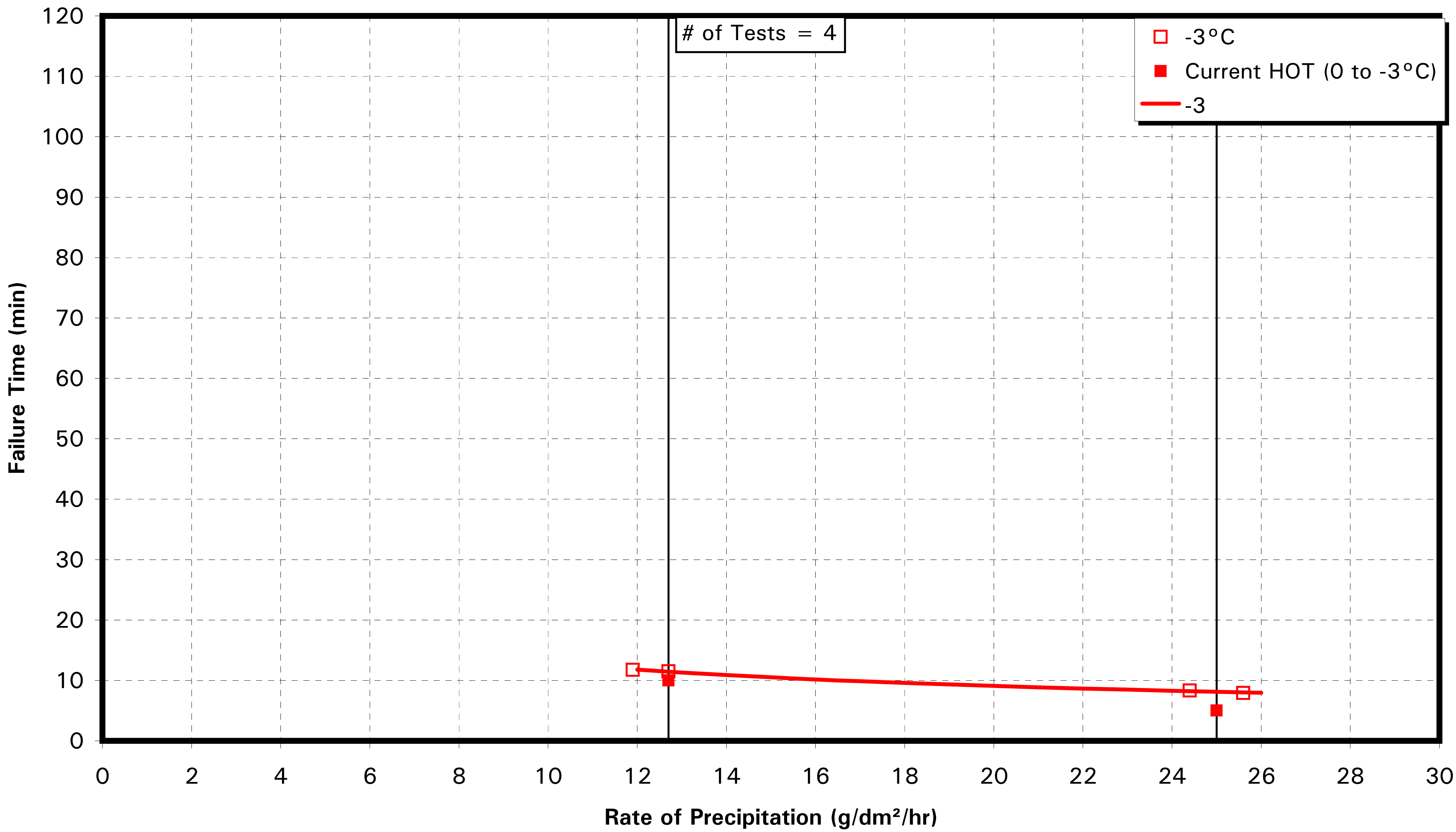


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - SPCA E26
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (50/50)

LIGHT FREEZING RAIN

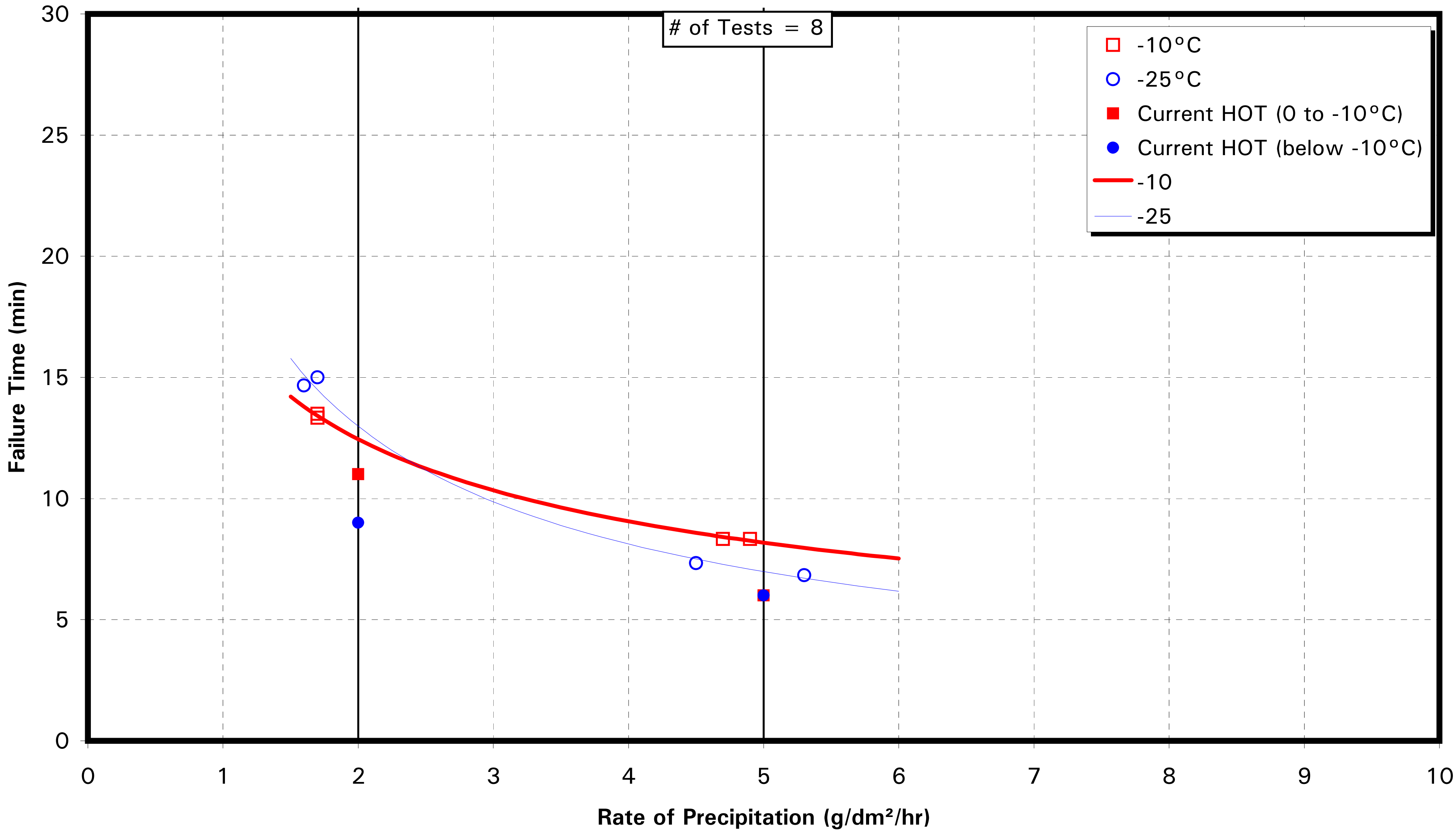


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZR - SPCA E26
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

LYONDELL ARCO PLUS - ST (10°)

FREEZING FOG

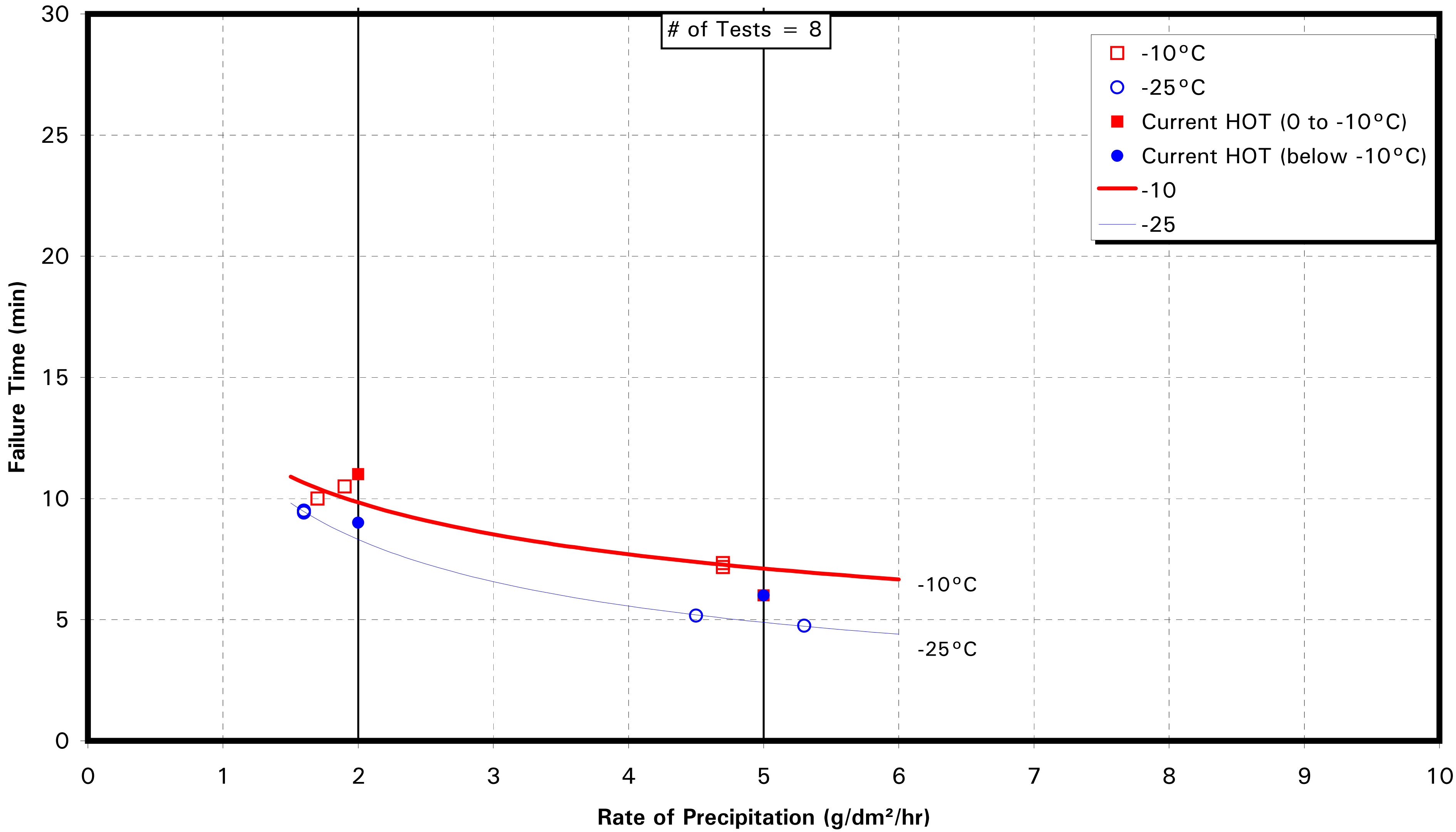


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - LYONDELL ARCO + AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

NEWAVE AEROCH. FCY-1A (10°)

FREEZING FOG

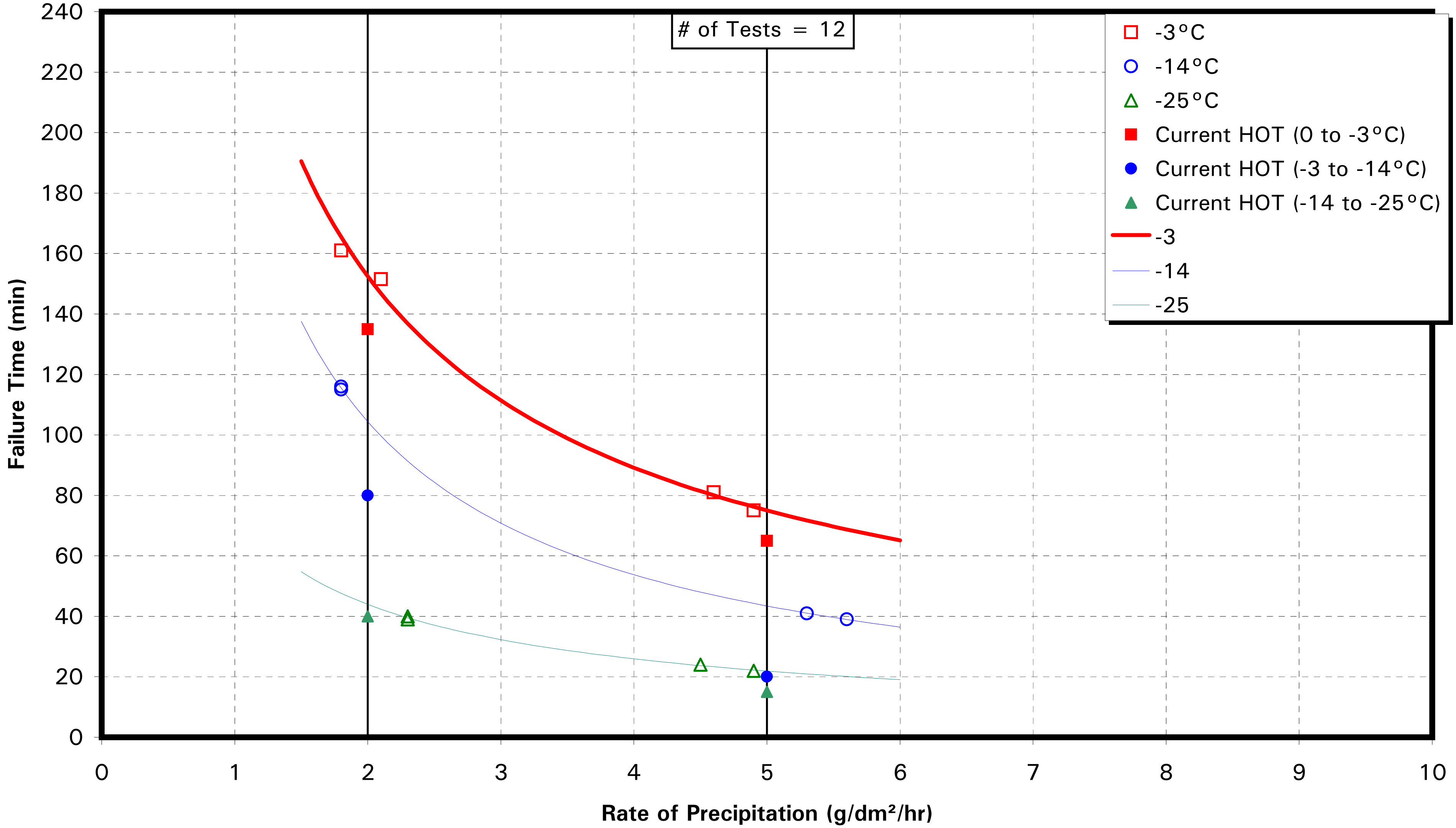


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - NEWAVE AEROCH. FCY-1A
AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (NEAT)

FREEZING FOG

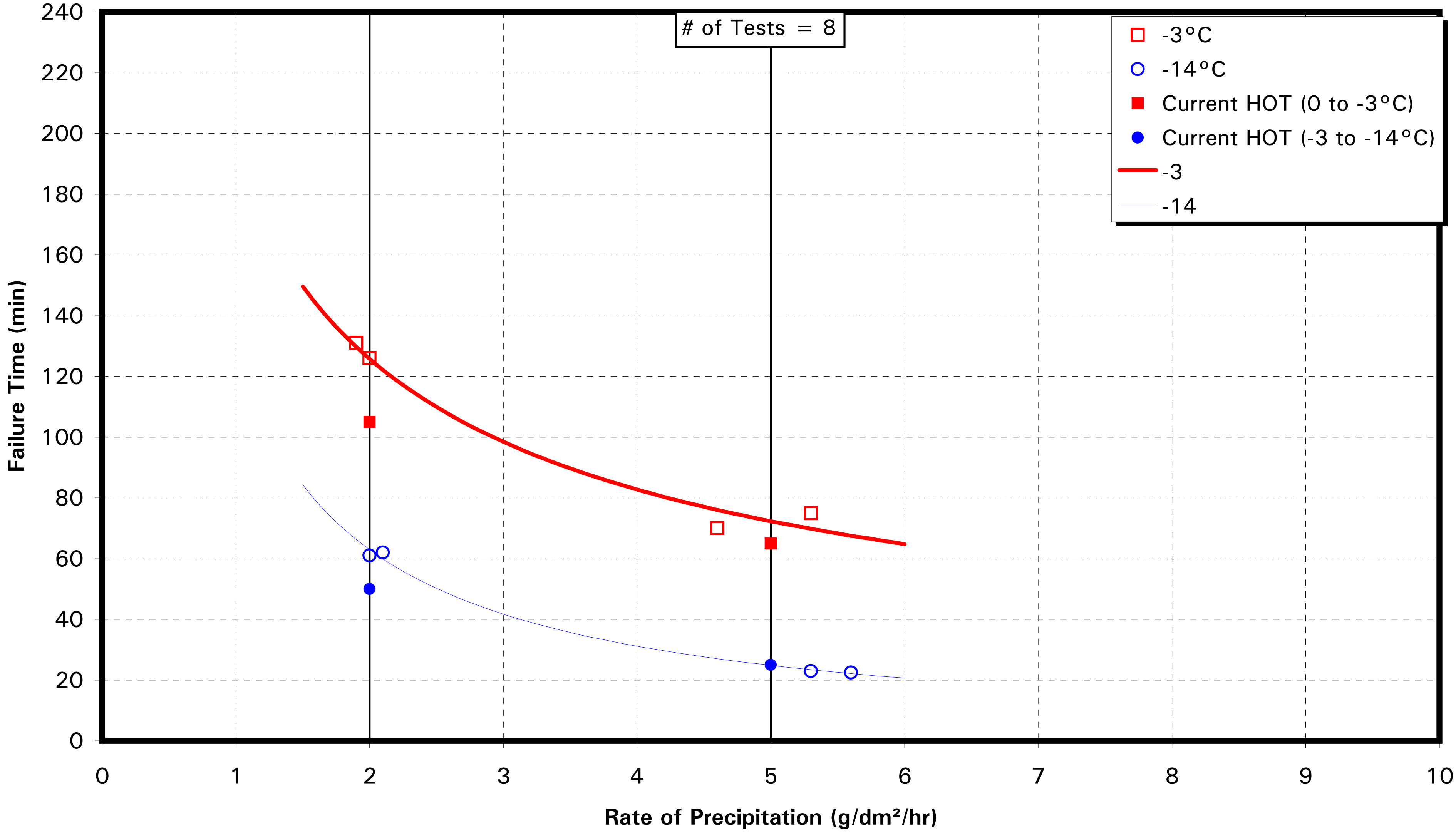


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - C2012
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (75/25)

FREEZING FOG

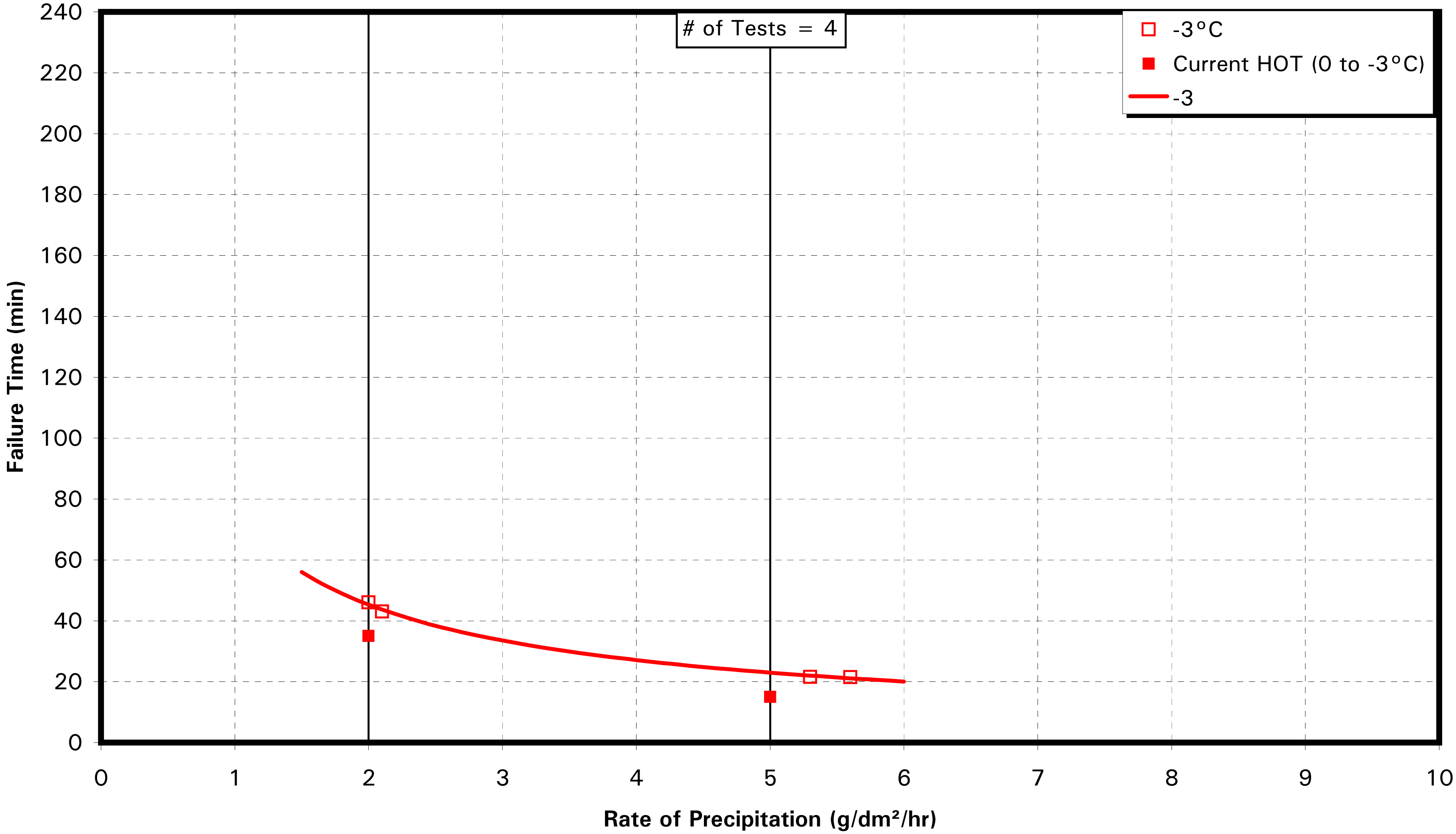


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - C2012
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (50/50)

FREEZING FOG

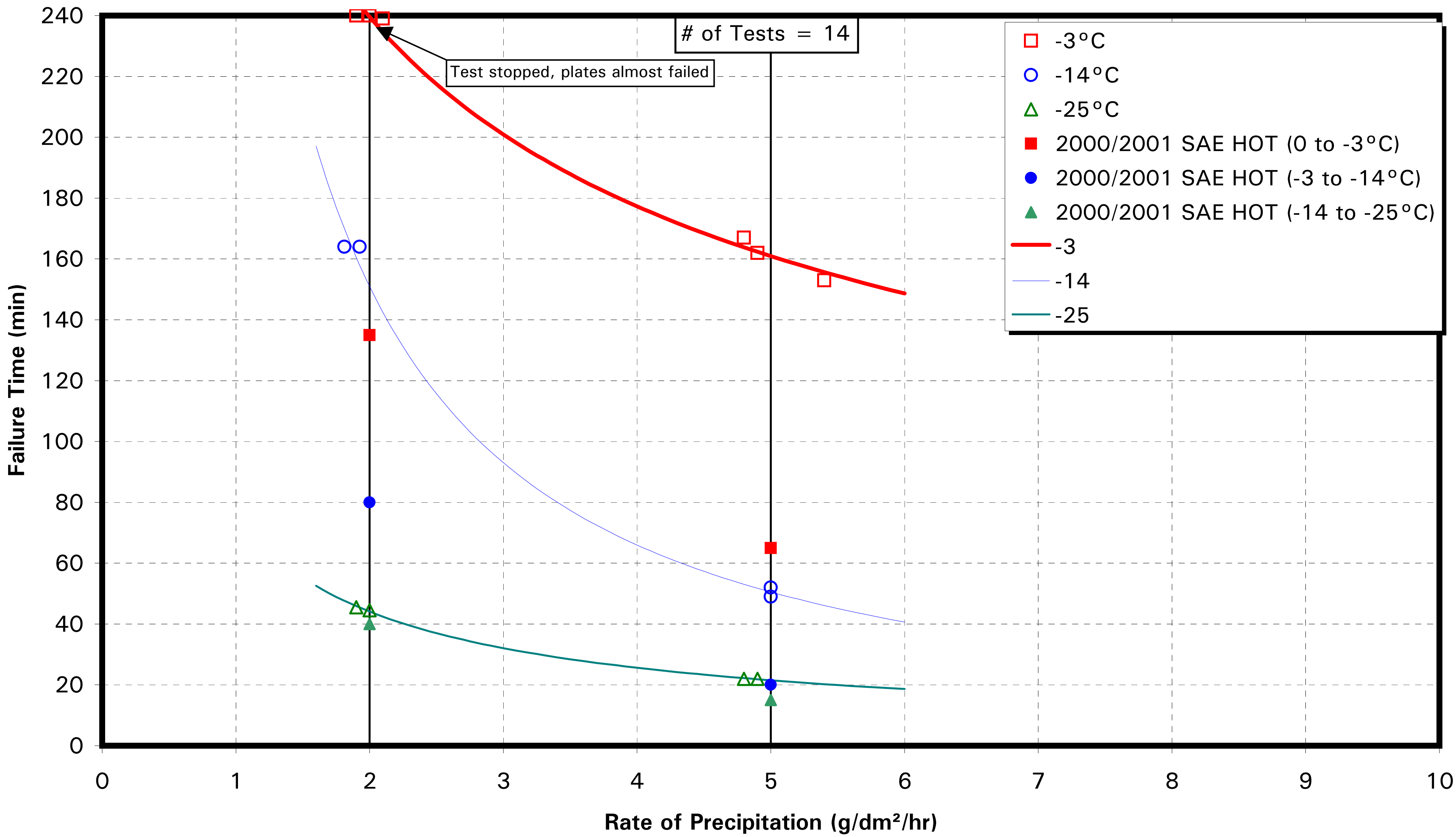


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - C2012
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (NEAT)

FREEZING FOG

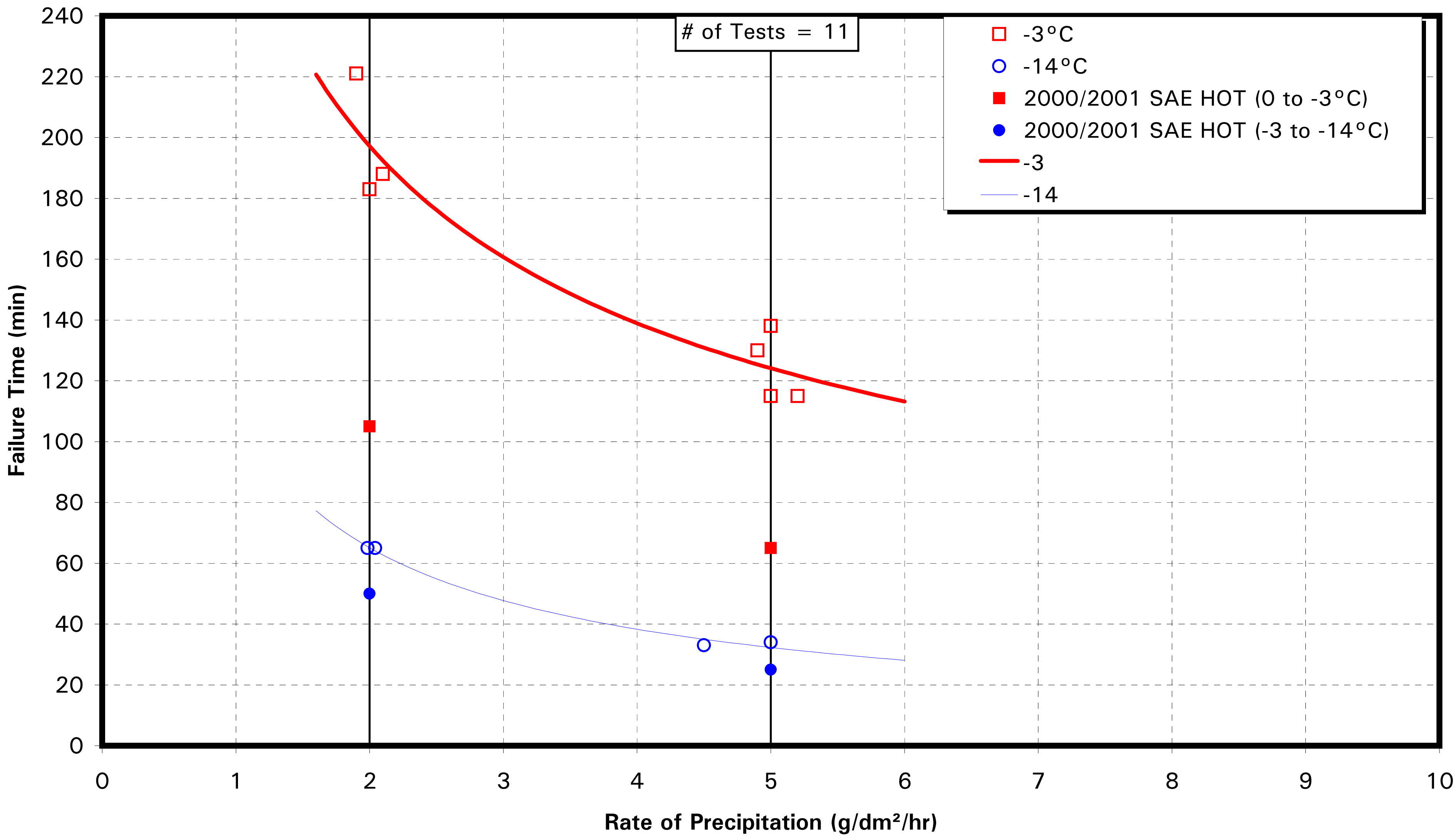


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZF
AT:Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (75/25)

FREEZING FOG

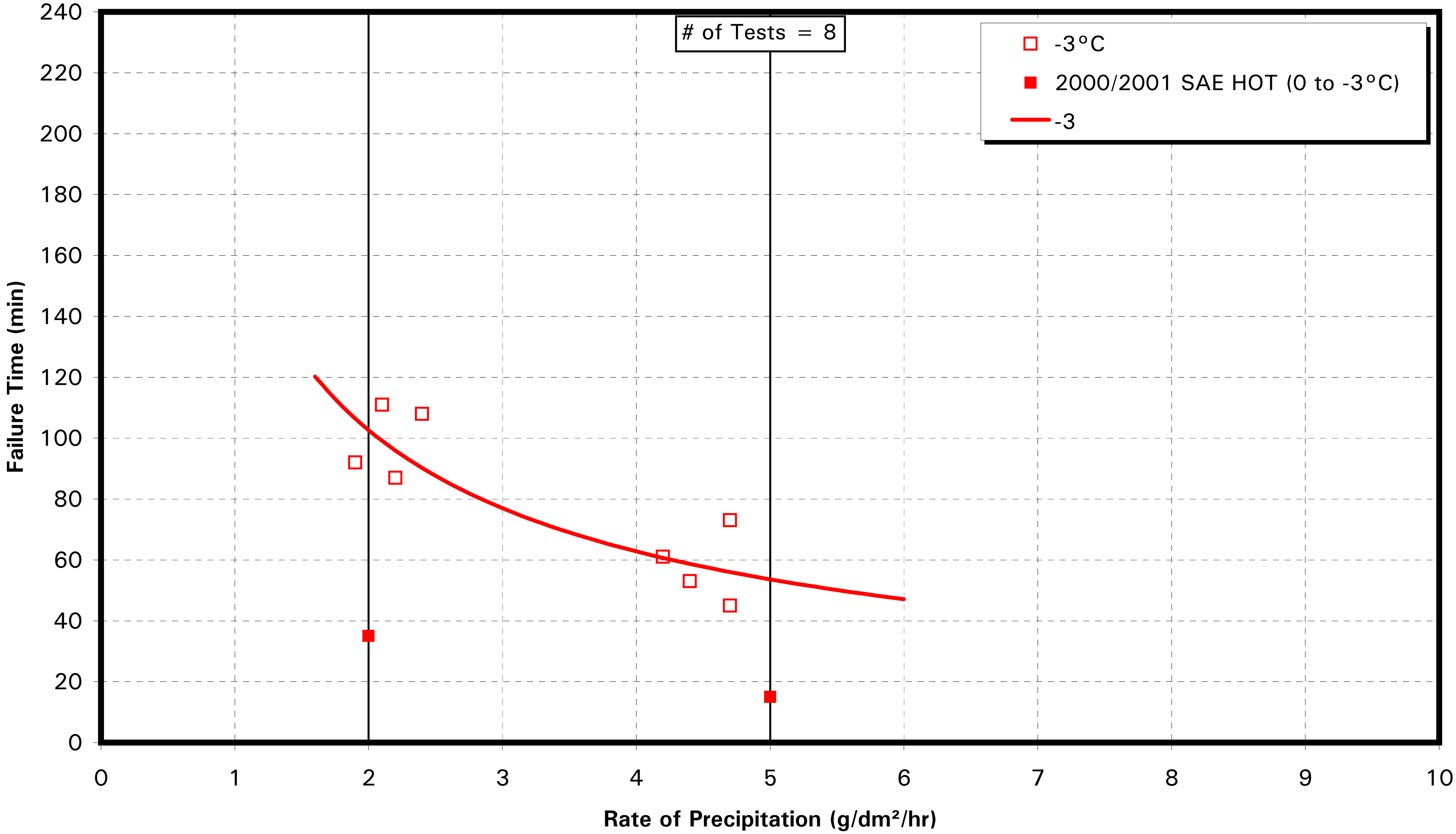


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZF
AT:75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (50/50)

FREEZING FOG

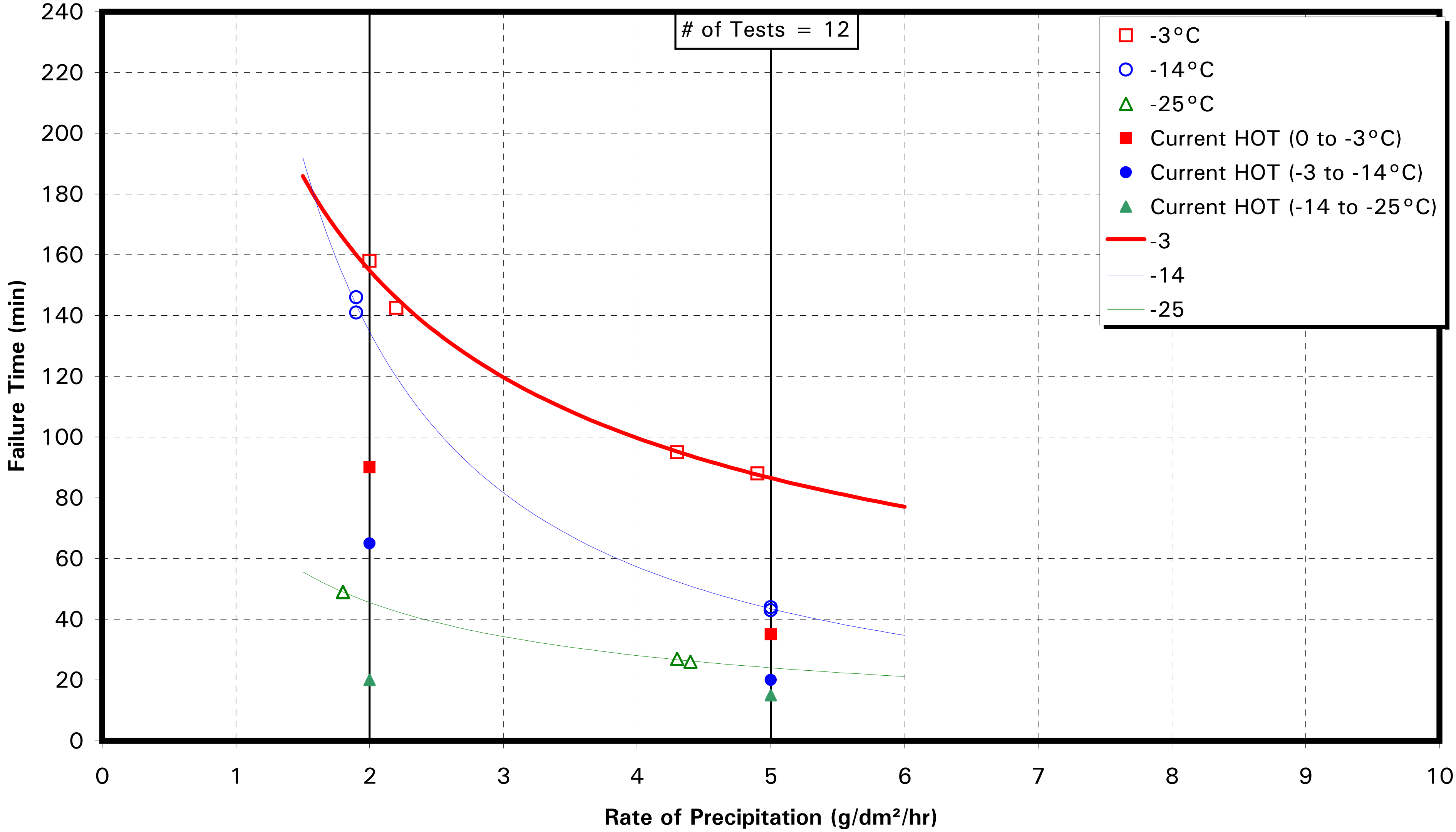


M\Groups\CM1680 (exBM3833)\Analysis\NRC 2001 JUNE\Charts\ZF
AT:50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (NEAT)

FREEZING FOG

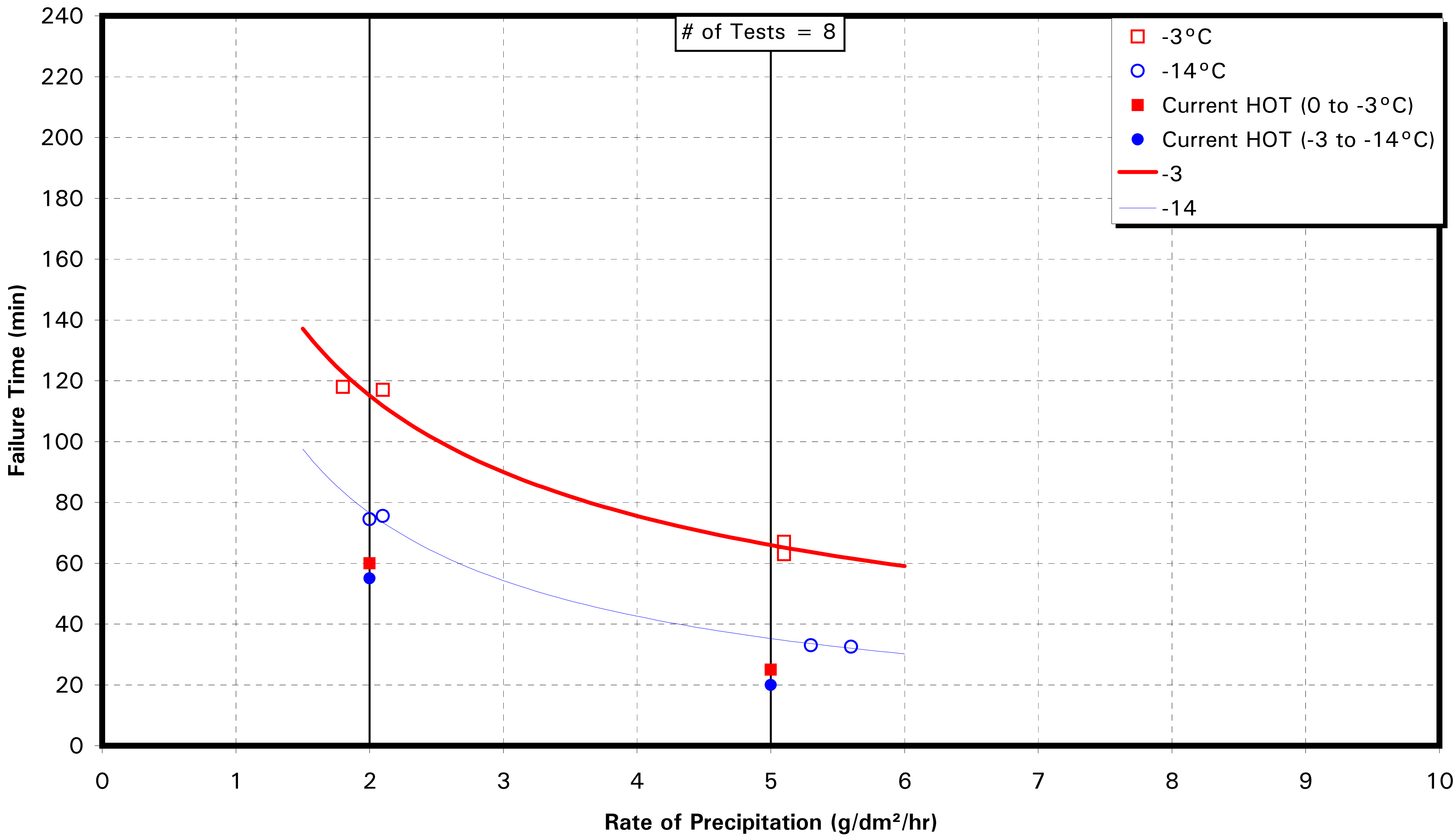


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - SPCA E26
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (75/25)

FREEZING FOG

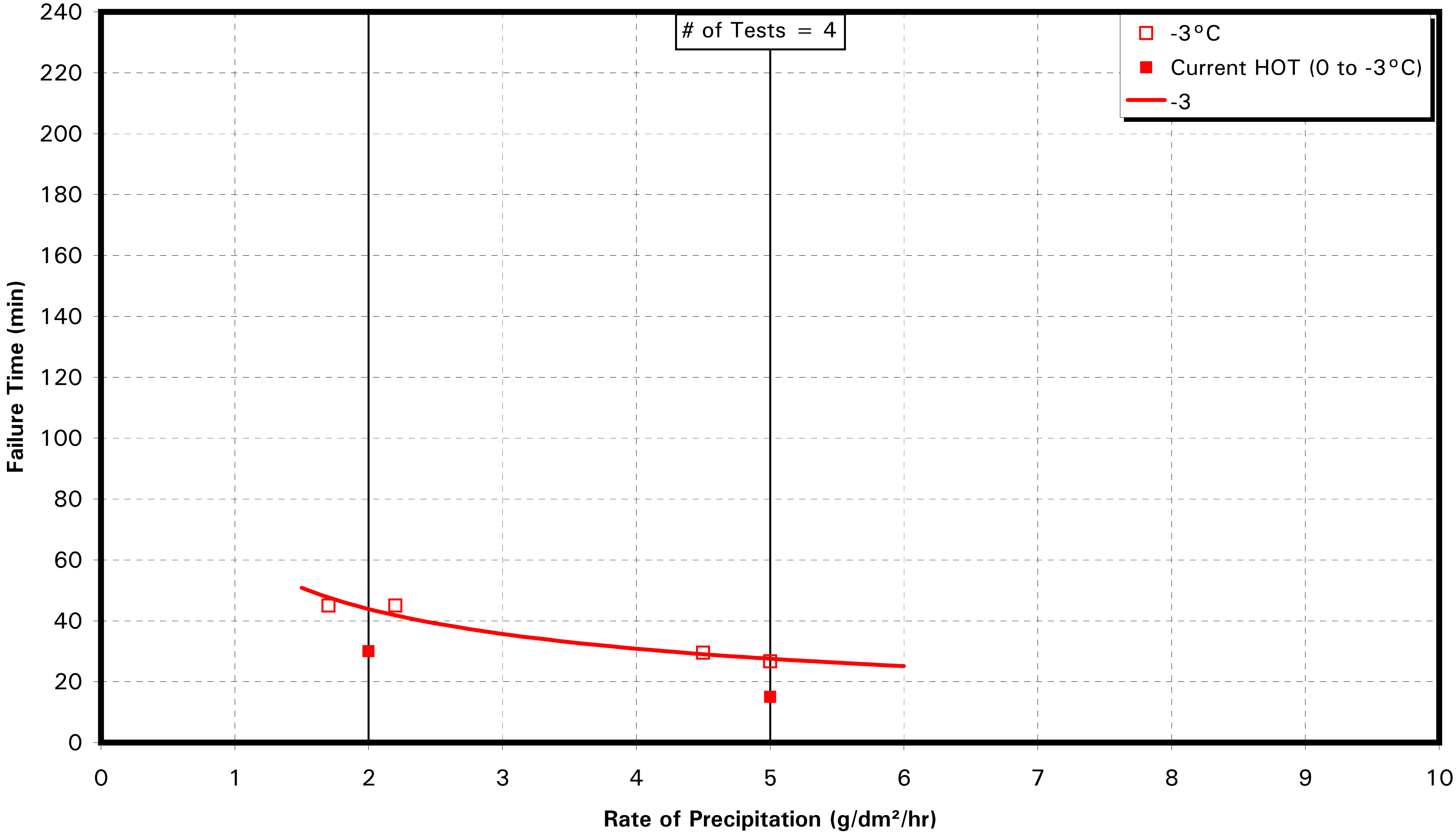


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - SPCA E26
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (50/50)

FREEZING FOG

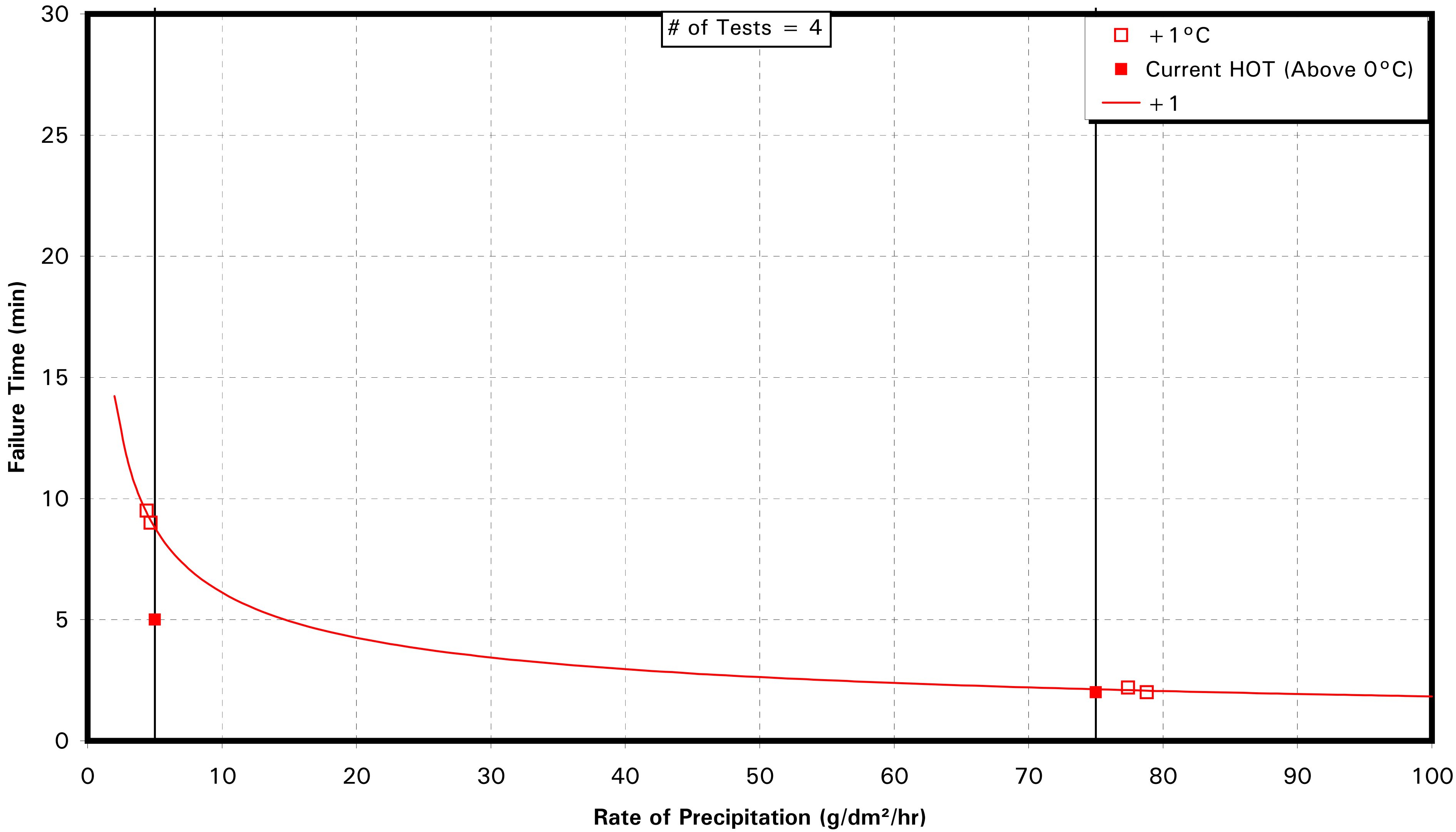


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\ZF - SPCA E26
AT: 50-50

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

LYONDELL ARCO PLUS - ST (10°)

RAIN ON COLD-SOAKED SURFACE

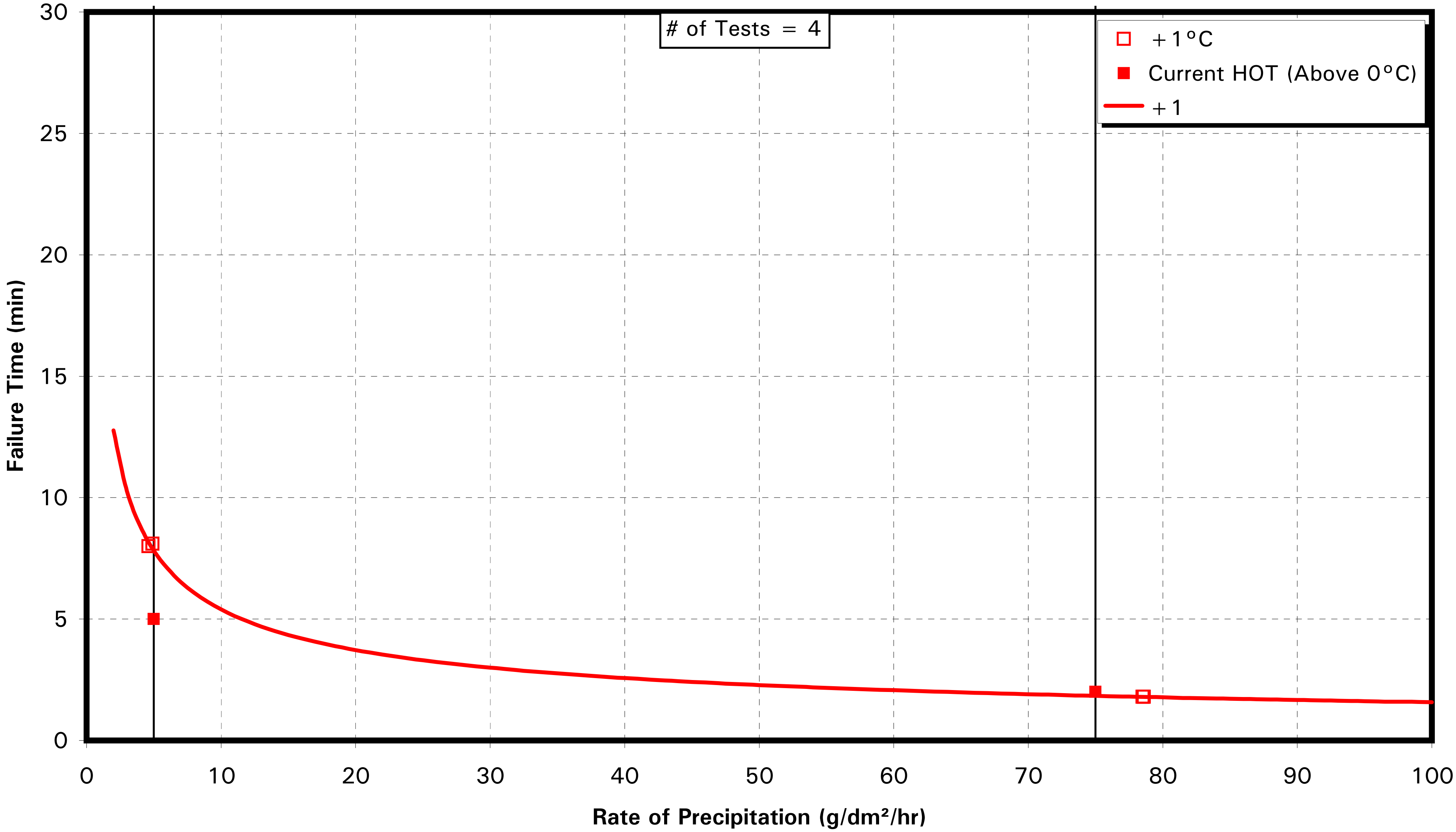


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\CS - LYONDELL ARCO+
AT: 10° (2)

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

NEWAVE AEROCH. FCY-1A (10°)

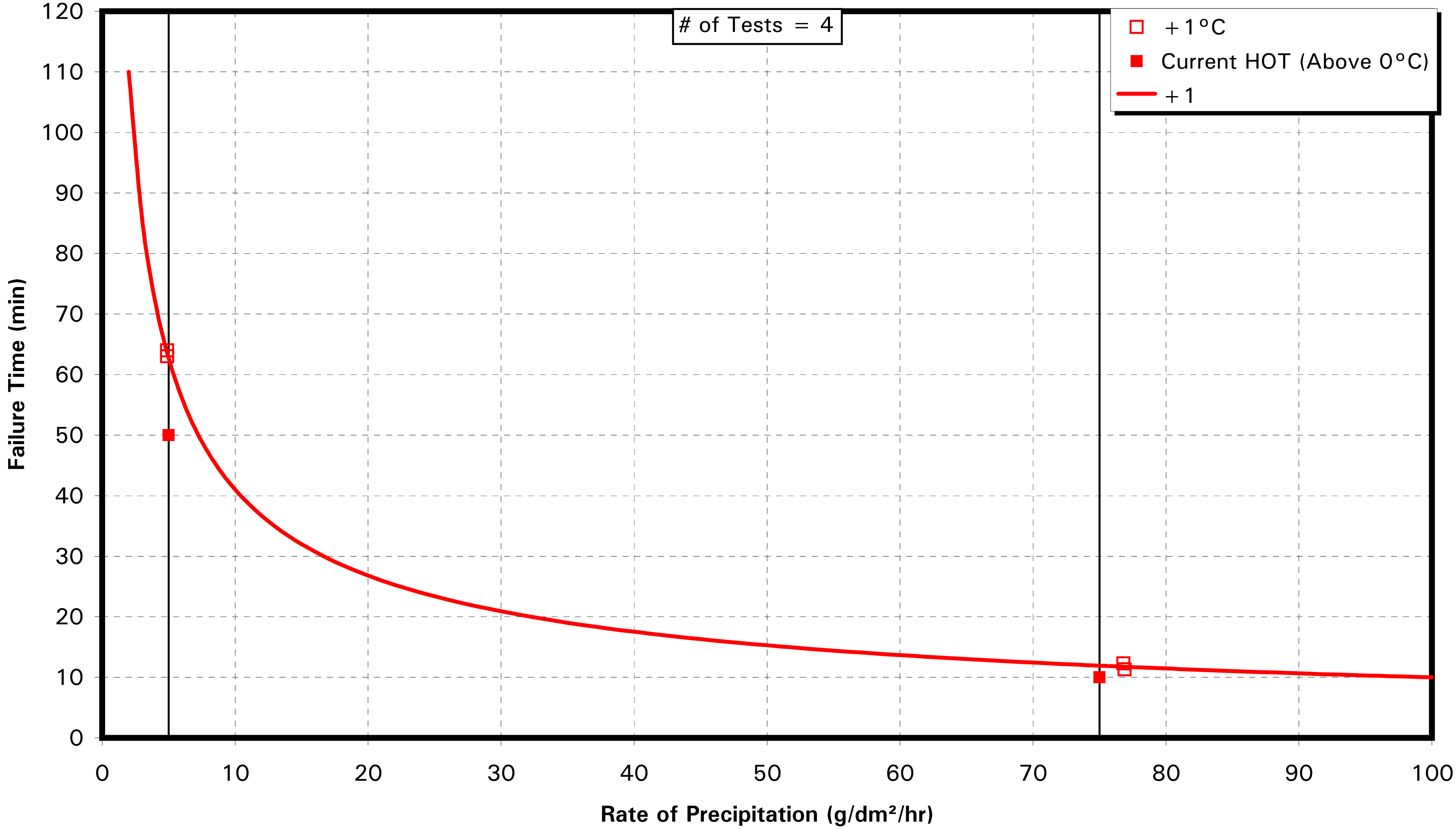
RAIN ON COLD-SOAKED SURFACE



EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (NEAT)

RAIN ON COLD-SOAKED SURFACE

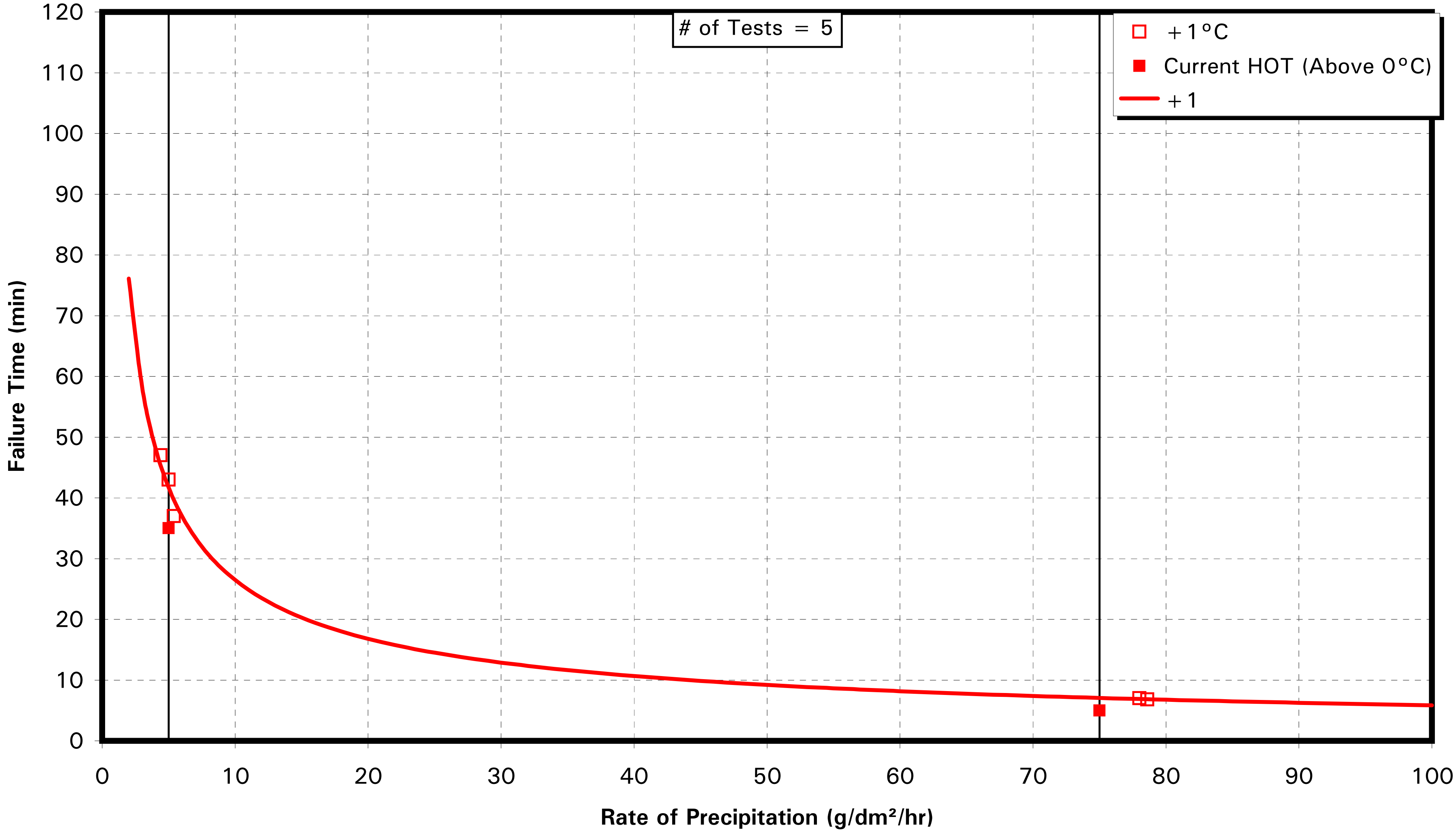


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\CS - C2012
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

CLARIANT 2012 (75/25)

RAIN ON COLD-SOAKED SURFACE

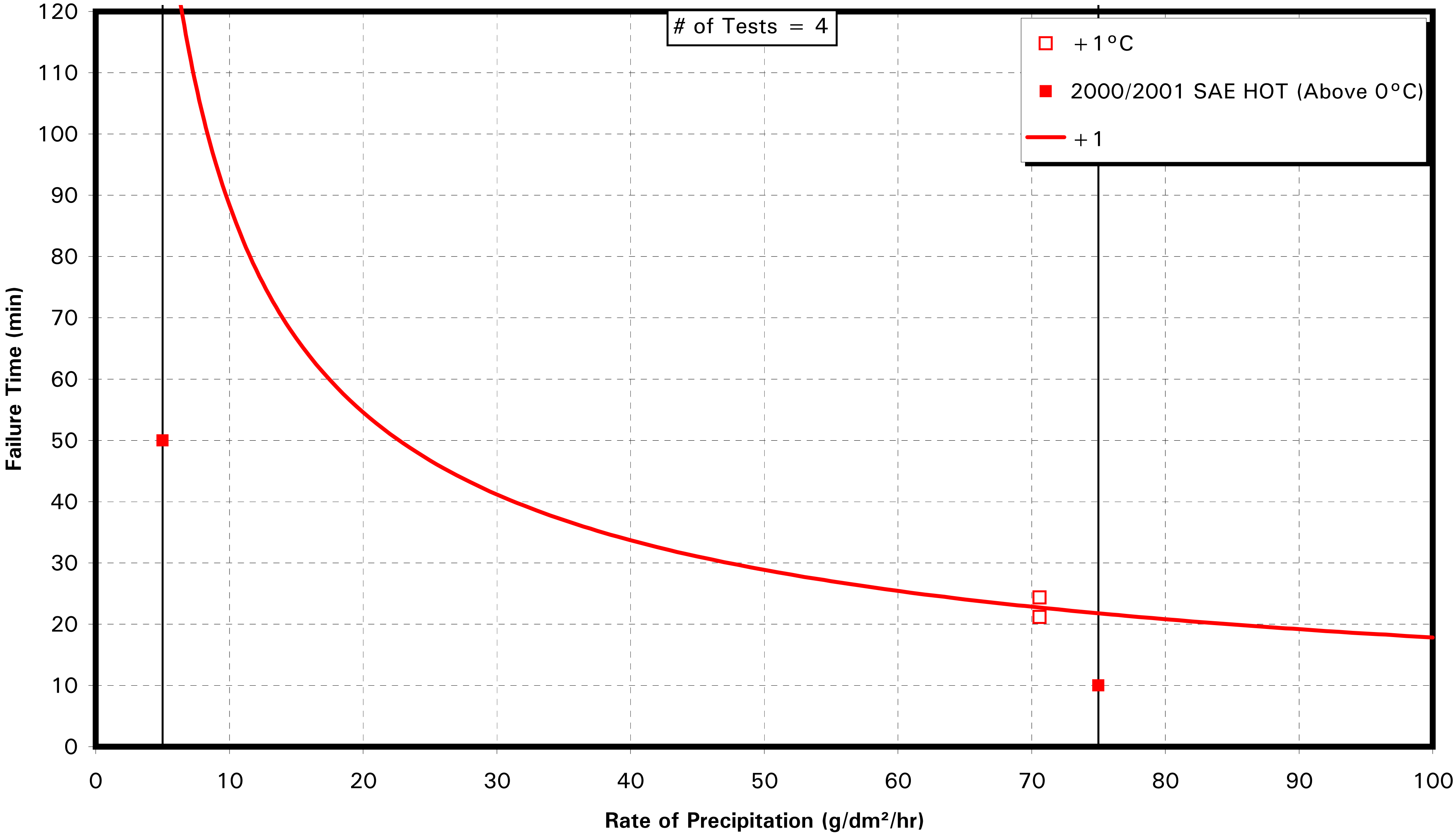


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\CS - C2012
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (NEAT)

RAIN ON COLD-SOAKED SURFACE

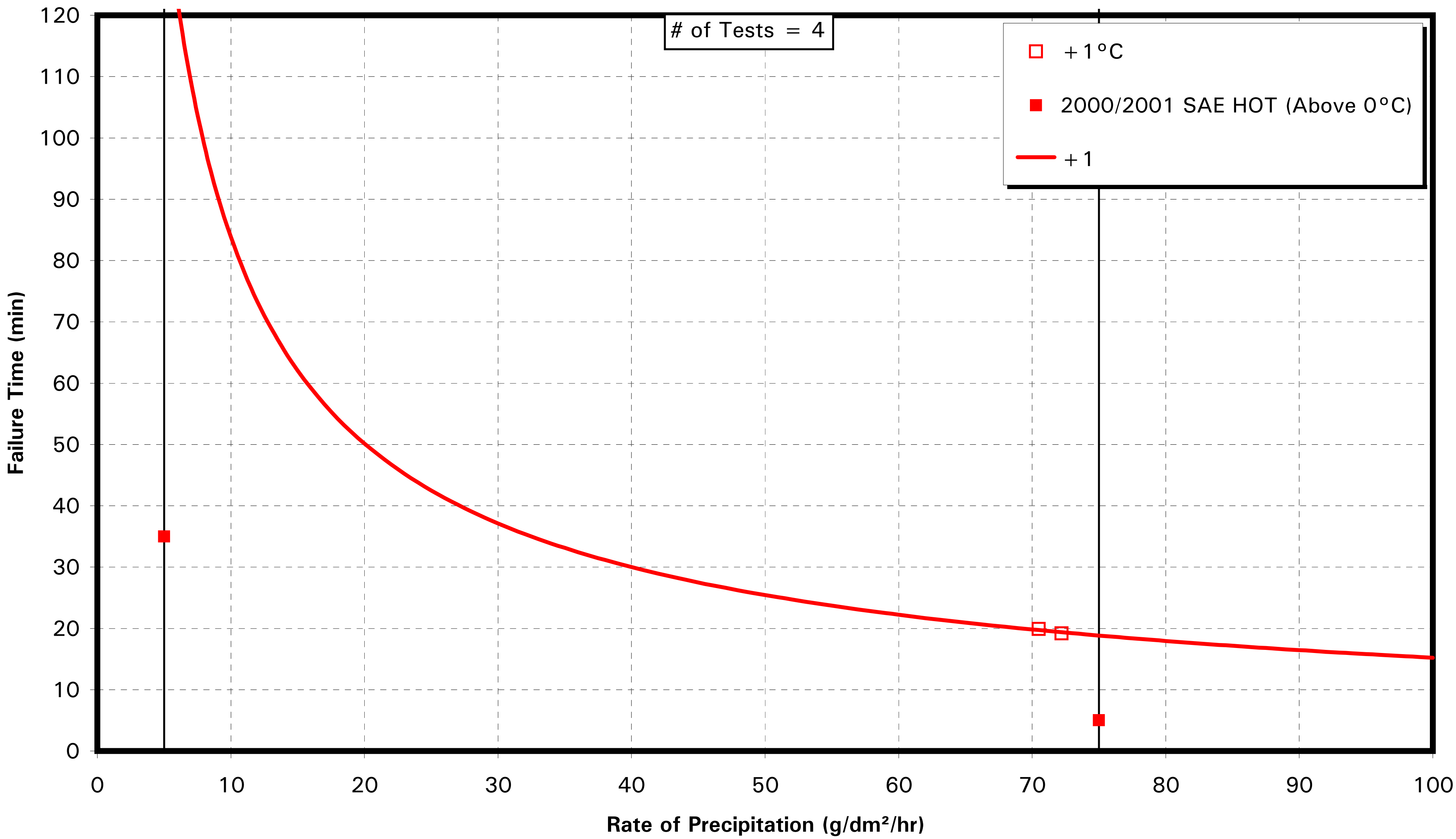


Groups\CM1680(exBM3833)\Analysis\NRC 2001 JUNE\Charts\CS
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

OCTAGON MAXFLIGHT (75/25)

RAIN ON COLD-SOAKED SURFACE

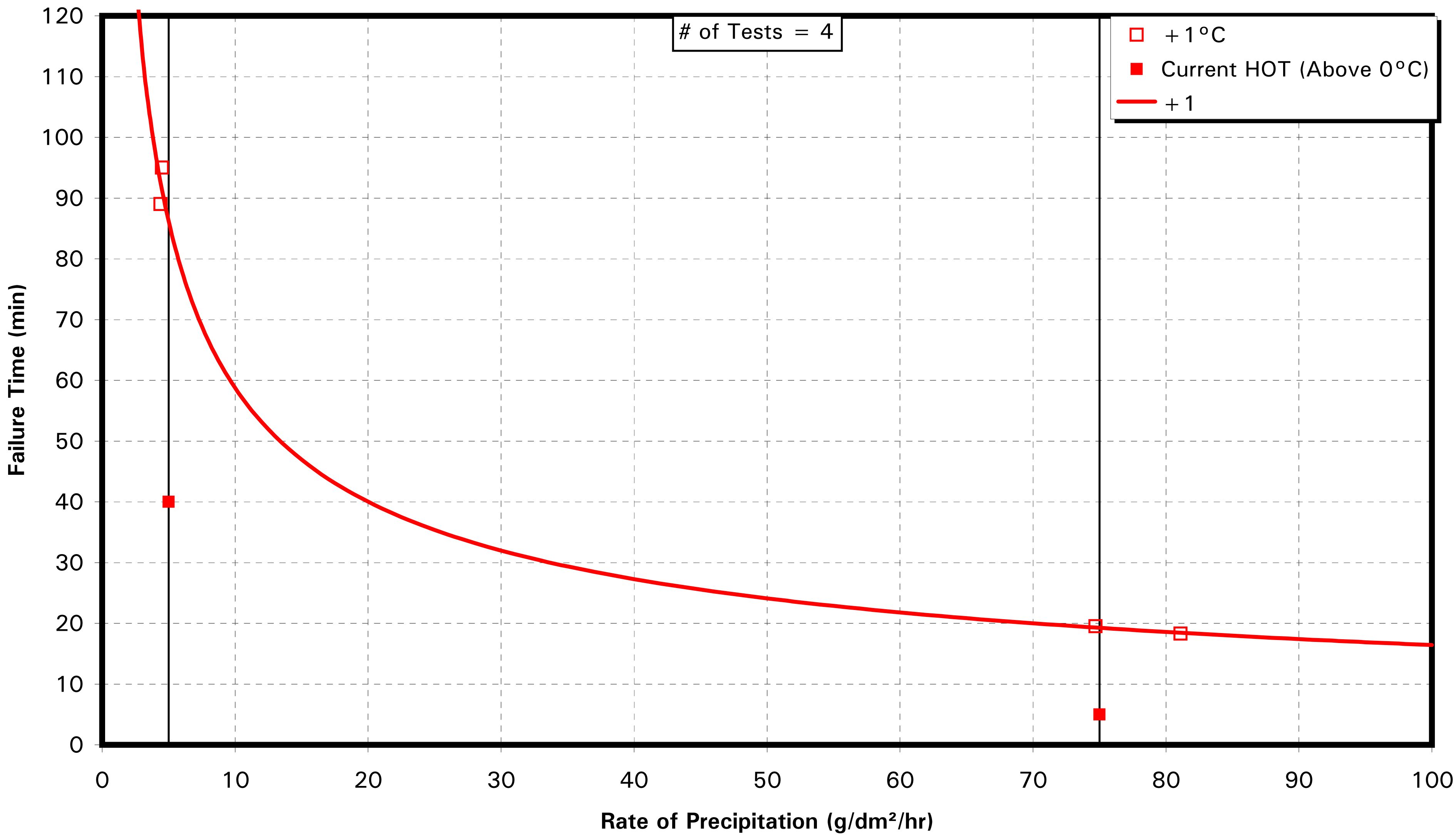


Groups\CM1680(exBM3833)\Analysis\NRC 2001 JUNE\Charts\CS
AT: 75-25

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (NEAT)

RAIN ON COLD-SOAKED SURFACE

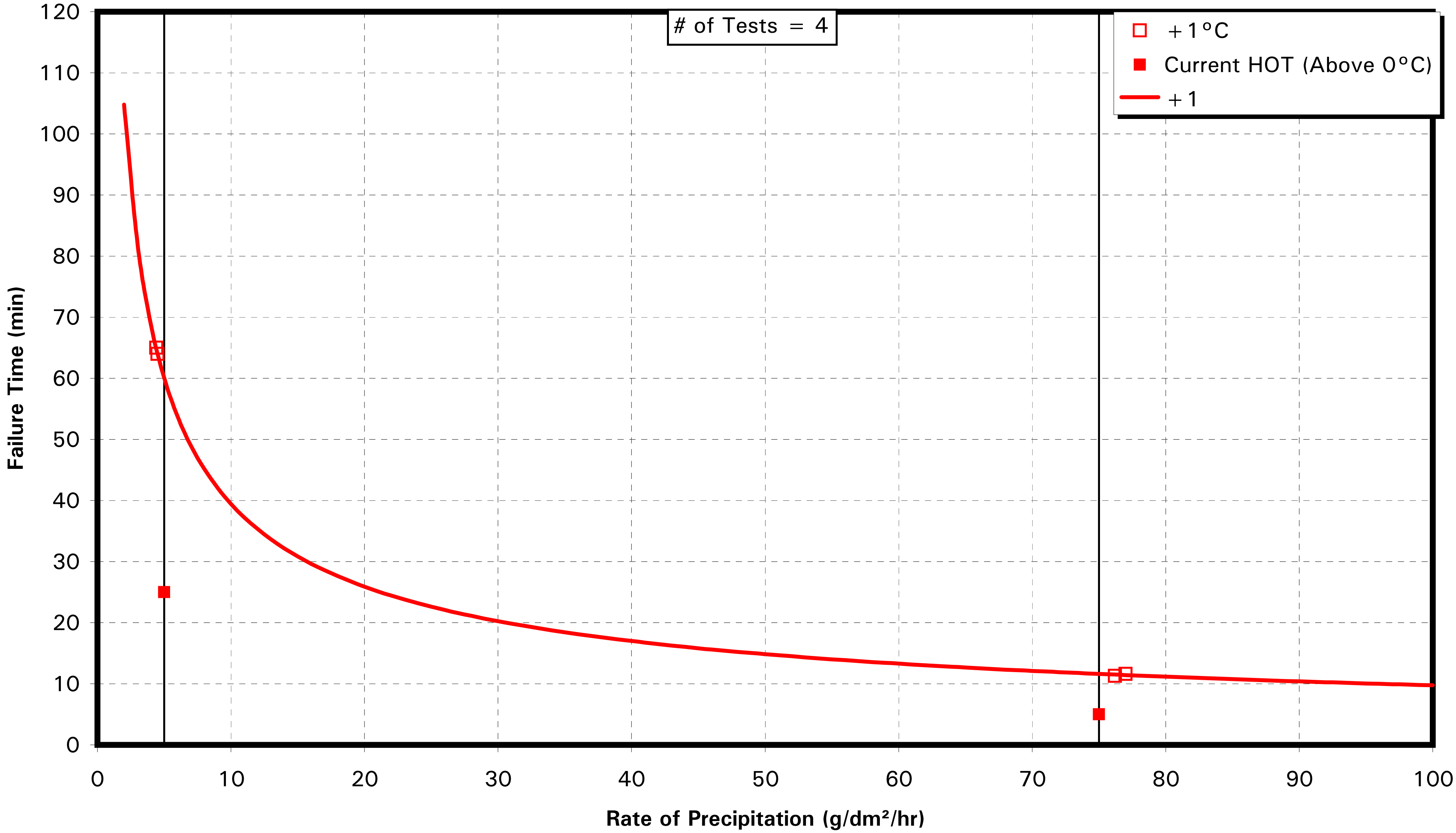


Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\CS - SPCA E26
AT: Neat

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON ENDURANCE TIME

SPCA Ecowing 26 (75/25)

RAIN ON COLD-SOAKED SURFACE



Groups\CM1680(exBM3833)\Analysis\HOT\CS,ZD,ZF,ZR\Charts for all conditions\CS - SPCA E26
AT: 75-25

APPENDIX H

RATE PROGRAM SPREADSHEET GUIDE

PRECIPITATION RATE PROGRAM SPREADSHEET GUIDE

The spreadsheet contains several macros. When run, these macros will create a summary page listing the tests run, the plate number, the four relevant rates, the average and standard deviation of the four rates as well as a calculation of the most extreme rate from the mean value. Space will be available for entering the fluid type and any comments but these will not be entered automatically.

The program is set up so that the main program is run in a normal version of Excel with macros added to perform certain repetitive tasks. As such, since page protection cannot be enabled when a macro is run, any portion of the program can be changed. This allows for new calculations and corrections to be made at any time. It also allows formatting to be changed that would affect the ability of the macro to run. It is important that aspects such as cell locations and page names be kept constant, particularly on the 'output' page.

In order to use the summary macros, a letter "t" (case insensitive) must be entered in the appropriate row in the column titled "RATE" on the individual forms. An individual rate would appear here. A sample location is marked with a comment on each form. The summary page can be updated at any time during the day or at the end, after all the results are in.

The macros copy the values from the summary sheets and copy them to an area of hidden cells at the top of the "output" page. They then search for occurrences of the letter "t" in this area. Due to limitations on the acceptable length of macros within Excel, each macro deals with only four forms with the first two forms (used for calibration) are omitted. When an instance of "t" is found, the plate number, as well as the two previous and two subsequent rates are pasted into the next row of the summary page. Formulas in the page then calculate the average, standard deviation, and most extreme value from the average rate. Links in the page update the date and chamber conditions provided those facts are changed on other pages. If new calculations are to be added, they should be inserted into additional columns of the output table.

Correcting errors

There are two possible types of errors:

1. The first involves a miscalculation or typing error that causes a single rate value to be in error. If this happens, the value should be changed

at the location of the error either immediately or later when the error is found. The next time the summary macros are run, the error will be corrected on the summary sheet. When the macros are run, they review all the values; if the macro for a certain form is run twice, some tests could be entered in duplicate. It is suggested that while the page can be updated throughout the day for use with other projects, at the end of the day, the page should be cleared using 'clear page' and then the values should be re-entered. This is estimated to take less more than a minute at the end of the day.

2. The second error concerns an abnormal number of rates being run between tests. If less than two previous and two following rates are performed, the macros will paste the value in the previous and following cells to the summary sheet. If the space is blank or contains another test, the statistics will ignore them in the calculations. If more than 4 rates are completed, the macros will only account for the closest four. An area has been provided at the bottom of the "output" page for values to be entered manually. If an account is to taken for more than four rates, the values should be entered here.

Instructions for use have been included as a comment in cell B1 on the "output" page.

Also included is an average and standard deviation calculation to the summary pages and each form that will be printed each time a set of tests is run.

APPENDIX I

OFFICIAL TRANSPORT CANADA HOLDOVER TIME TABLES

TABLE 1-S1C

SAE TYPE I[5] FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002

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

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[3]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[4]
above 0	above 32	0:45	0:12-0:30	0:06-0:15[1] *0:07-0:12*	0:05-0:08	0:02-0:05	0:02-0:05	
0 to -10	32 to 14	0:45	0:06-0:15[1] *0:06-0:11*	0:06-0:15[1] *0:03-0:16*	0:05-0:08	0:02-0:05	CAUTION:	
below -10	below 14	0:45	0:06-0:15[1] *0:06-0:09*	0:06-0:15[1] *0:02-0:04*	No holdover time guidelines exist			

° C = Degrees Celsius
° F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

NOTES

1. To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 litre/m² (2 gals/100ft²) must be applied to deiced surfaces, OTHERWISE THE ITALICISED TIMES MUST BE USED.
2. During conditions that apply to aircraft protection for ACTIVE FROST.
3. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain and hail.
5. Type I Fluid / Water Mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA , JULY 2001

TABLE 2-SAE

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002[1]

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

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	12:00	0:35-1:30	0:20-0:55	0:30-0:55	0:15-0:30	0:05-0:40	
		75/25	6:00	0:25-1:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20-1:05	0:15-0:35	0:15-0:45[3]	0:10-0:25[3]		
		75/25	5:00	0:20-0:55	0:15-0:25	0:15-0:30[3]	0:10-0:20[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type II WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA , JULY 2001

TABLE 2C

CLARIANT TYPE II FLUID HOLDOVER TABLE
SAFEWING MPII 1951 (8,700 mPa.s viscosity) (8,700 mPa.s viscosity)[1]

Guideline for Holdover Times Anticipated for Type II Fluid Concentrations as a Function of Weather Conditions and OAT

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

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	MODERATE SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	12:00	0:55-1:40	0:30-0:55	0:35-0:55	0:20-0:30	0:10-0:50	
		75/25	6:00	0:45-1:15	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:40	
		50/50	4:00	0:20-0:30	0:05-0:20	0:05-0:15	0:05-0:10	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	8:00	0:55-1:40	0:25-0:45	0:35-0:55	0:20-0:30		
		75/25	5:00	0:45-1:15	0:15-0:35	0:25-0:45	0:15-0:25		
		50/50	3:00	0:20-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45-1:25	0:20-0:40	0:25-0:50[3]	0:15-0:30[3]		
		75/25	5:00	0:35-1:00	0:15-0:25	0:20-0:35[3]	0:15-0:20[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:20-0:40	0:20-0:35				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C, 0.3rpm, for 15 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA , JULY 2001

TABLE 2K

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
ABC-II PLUS (3,600 mPa.s viscosity)[1]

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

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15	**CAUTION: No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	0:15-0:45[3]	0:10-0:30[3]		
		75/25	5:00	0:20-0:55	0:15-0:35	0:15-0:30[3]	0:10-0:20[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle LV2 with guard leg, 150ml of neat fluid, at 20°C, 0.3rpm, 10 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 2S-26

SPCA TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
ECOWING 26 (4,900 mPa.s viscosity)[1]

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

OAT		Type II Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	12:00	1:25-2:35	0:40-1:05	0:50-1:35	0:40-0:50	0:20-1:20	
		75/25	6:00	1:05-1:55	0:30-0:50	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	4:00	0:30-0:45	0:10-0:20	0:15-0:20	0:05-0:10	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	12:00	1:25-2:35	0:40-1:00	0:50-1:35	0:40-0:50		
		75/25	5:00	1:05-1:55	0:25-0:35	0:45-1:05	0:25-0:35		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45-2:15	0:35-0:55	0:30-1:10[3]	0:15-0:35[3]		
		75/25	5:00	0:35-1:15	0:25-0:40	0:20-0:50[3]	0:15-0:25[3]		
below -14 to -25	below 7 to -13	100/0	8:00	0:25-0:45	0:30-0:50				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type II fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C, 0.3rpm, for 30 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4-SAE

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:25-0:45	0:10-0:50	
		75/25	6:00	1:05-1:45	0:30-1:05	0:35-0:50	0:15-0:30	0:05-0:35	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10	CAUTION: No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:25-0:45		
		75/25	5:00	1:05-1:45	0:25-0:50	0:35-0:50	0:15-0:30		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:20-0:40	0:20-0:45[3]	0:10-0:25[3]		
		75/25	5:00	0:25-0:50	0:15-0:25	0:15-0:30[3]	0:10-0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius
° F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type IV WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4C-a

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
SAFEWING MPIV 1957 (16,200 mPa.s viscosity) (16,200 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION: No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40		
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:30	0:30-0:50	0:35-0:55[3]	0:20-0:35[3]		
		75/25	5:00	0:25-1:10	0:20-0:40	0:25-0:55[3]	0:15-0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1. Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C, 0.3rpm, for 15 minutes 0 seconds.
2. During conditions that apply to aircraft protection for ACTIVE FROST.
3. The lowest use temperature is limited to -10°C (14°F).
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4C-b

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
SAFEWING MPIV 2001 (18,000 mPa.s viscosity) (18,000 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	18:00	1:20-3:20	1:55-2:00	0:55-1:55	0:40-1:00	0:15-2:00	
		75/25	6:00	1:20-2:00	0:50-1:25	0:35-1:10	0:25-0:35	0:10-1:25	
		50/50	4:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15	CAUTION: No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	1:20-3:20	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:20-2:00	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:35	0:30-0:50	0:55-1:35[3]	0:30-0:45[3]		
		75/25	5:00	0:30-1:00	0:20-0:35	0:40-1:10[3]	0:20-0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:35				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius
° F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1. Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, 10ml fluid, at 20°C, 0.3rpm, for 15 minutes 0 seconds.
2. During conditions that apply to aircraft protection for ACTIVE FROST.
3. The lowest use temperature is limited to -10°C (14°F).
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4C-c

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
SAFEWING FOUR (6,400 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	18:00	1:50-2:45	0:45-1:45	1:05-1:45	0:50-1:05	0:10-1:20	
		75/25	6:00	1:45-2:25	0:40-1:25	0:50-1:30	0:30-0:45	0:15-1:25	
		50/50	4:00	0:30-0:45	0:15-0:25	0:15-0:25	0:10-0:15	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	12:00	1:50-2:45	0:35-1:20	1:05-1:45	0:50-1:05		
		75/25	5:00	1:45-2:25	0:30-1:05	0:50-1:30	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:30-1:30	0:25-0:55	0:25-1:05[3]	0:15-0:30[3]		
		75/25	5:00	0:30-1:05	0:20-0:45	0:20-0:50[3]	0:15-0:25[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:45				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, 10ml fluid, at 20°C, 0.3rpm, for 15 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4C-d

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
SAFEWING MP IV 2012 PROTECT (7,800 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		FROST[2]	FREEZING FOG	SNOW	FREEZING DRIZZLE[4]	LIGHT FREEZING RAIN	RAIN ON COLD SOAKED WING	OTHER[5]
above 0°	above 32°	100/0	18:00	1:15-2:30	1:10-2:00	0:40-1:10	0:25-0:45	0:10-1:05	
		75/25	6:00	1:10-2:05	0:35-1:10	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	4:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	12:00	1:15-2:30	0:40-1:15	0:40-1:10	0:25-0:45		
		75/25	5:00	1:10-2:05	0:25-0:55	0:35-0:50	0:15-0:30		
		50/50	3:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:35	0:20-0:40	0:25-0:45[3]	0:15-0:25[3]		
		75/25	5:00	0:25-1:05	0:20-0:40	0:15-0:30[3]	0:10-0:20[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:15-0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, 10ml fluid, at 20°C, 0.3rpm, for 15 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4K

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
ABC-S (17,000 mPa.s viscosity) (17,000 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10	**CAUTION:** **No holdover time guidelines exist**	
0 to -3	32 to 27	100/0	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25		
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-2:05	0:45-1:20	0:20-1:00[3]	0:10-0:30[3]		
		75/25	5:00	0:25-1:00	0:25-0:50	0:20-1:10[3]	0:10-0:35[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius
° F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

NOTES

1. Lowest on-wing viscosity - Brookfield Spindle LV2 with guard leg, 150ml of neat fluid, at 20°C, 0.3rpm, for 10 minutes 0 seconds.
2. During conditions that apply to aircraft protection for ACTIVE FROST.
3. The lowest use temperature is limited to -10°C (14°F).
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4S

SPCA TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
AD-480 (15,200 mPa.s viscosity) (15,200 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	2:00-3:30	0:55-1:50	0:50-1:30	0:35-0:55	0:15-1:35	
		75/25	6:00	1:30-2:45	0:40-1:20	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	4:00	0:30-0:45	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION: No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55		
		75/25	5:00	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:30-0:55	0:25-1:20[3]	0:15-0:30[3]		
		75/25	5:00	0:25-0:50	0:20-0:45	0:25-1:05[3]	0:15-0:30[3]		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:25-0:40				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-34/13R, small sample adapter, at 20°C, 0.3rpm, for 30 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 4U

UNION CARBIDE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2001-2002
ULTRA+ (36,000 mPa.s viscosity)[1]

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

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F		Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
above 0°	above 32°	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	
		75/25							
		50/50						CAUTION: No holdover time guidelines exist	
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	0:45-1:25[3]	0:30-0:45[3]		
		75/25							
below -14 to -25	below 7 to -13	100/0	12:00	0:40-2:10	0:20-0:45				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when Type IV fluid cannot be used.						

° C = Degrees Celsius **OAT = Outside Air Temperature**
° F = Degrees Fahrenheit **VOL = Volume**

NOTES

1 Lowest on-wing viscosity - Brookfield Spindle SC4-31/13R, small sample adapter, at 0°C, 0.3rpm, for 10 minutes 0 seconds.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain 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 also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

TRANSPORT CANADA, JULY 2001

TABLE 5

CURRENTLY QUALIFIED FLUIDS

Table 5-1: Qualified Type I De-icing Fluids**

#	COMPANY NAME	FLUID NAME	EXPIRY
1-1	Beijing Wangye Aviation Chemical Product Co. Ltd.	KLA-1	03-03-02
1-2	Clariant GmbH	Safewing DG I 1937	01-10-27
1-3	Clariant GmbH	Safewing MP I 1938	02-06-13
1-4	Clariant GmbH	Safewing MP I 1938 TF	02-08-23
1-5	Clariant GmbH	Safewing MP I 1938 PR-MIX	02-09-11
1-6	Clariant GmbH	Safewing EG I 1996	02-09-05
1-7	Cryotech Deicing Technology	DF Plus	02-07-07
1-8	Cryotech Deicing Technology	DF Plus (88)	03-07-03
1-9	Delta Rocky Mountain Petroleum Inc.	Ice Away	01-12-27
1-10	Dow Chemical Company	UCAR® ADF Concentrate	02-09-22
1-11	Dow Chemical Company	UCAR® DEGree ADF	02-09-13
1-12	Home Oil	SafeTemp	02-08-21
1-13	Inland Technologies Inc.	Duragly-P	02-12-15
1-14	Inland Technologies Inc.	Duragly-E	01-02-01
1-15	Jarchem Industries Inc.	JarKleer 1000TF	02-10-02
1-16	Kilfrost Limited	Kilfrost DF	01-10-22
1-17	Kilfrost Limited	Kilfrost DF PLUS	01-07-06
1-18	Kilfrost Limited	Kilfrost DF PLUS (80)	03-03-15
1-19	Lyondell Chemical Co.	ARCOPlus	02-06-26
1-20	Lyondell Chemical Co.	ARCOPlus-ST	03-03-15
1-21	Metss Corporation	ADF	02-12-04
1-22	Newave Aerochemical Co. Ltd.	FCY-1A	03-03-08
1-23	Octagon Process	Octaflo™ EF	03-05-18
1-24	Octagon Process	Octaflo™	01-09-28
1-25	Octagon Process	Octaflo™ (R) Dilute	01-07-06
1-26	Octagon Process	Octaflo™ EG	03-06-12
1-27	Oslo Airport	Oslo Airport Fluid	01-10-29
1-28	Sanshin Kagaku Kogyo Co.	San-Ai ADF Type 1-A	03-01-23
1-29	SPCA	SPCA DE-910	02-07-07

Table 5-2: Qualified Type II De-icing Fluids**

#	COMPANY NAME	FLUID NAME	EXPIRY
2-1	Clariant GmbH	Safewing MP II 1951	03-xx-xx*
2-2	Kilfrost Limited	Kilfrost ABC II PLUS	03-xx-xx*
2-3	Kilfrost Limited	Kilfrost ABC-3	02-02-18
2-4	Octagon Process	Forty Below	03-xx-xx*
2-5	SPCA	SPCA AD-104/N	*
2-6	SPCA	Ecowing 26	03-05-04

Table 5-3: Qualified Type III De-icing Fluids**

#	COMPANY NAME	FLUID NAME	EXPIRY

Table 5-4: Qualified Type IV De-icing Fluids**

#	COMPANY NAME	FLUID NAME	EXPIRY
4-1	Clariant GmbH	Safewing MP IV 1957	01-05-25
4-2	Clariant GmbH	Safewing MP IV 2001	02-02-16
4-3	Clariant GmbH	Safewing Four	02-06-13
4-4	Clariant GmbH	Safewing MP IV 2012 Protect	03-02-19
4-5	Cryotech Deicing Technology	ABC-S	02-07-11
4-6	Dow Chemical Company	UCAR® ADF/AAF ULTRA+	02-04-10
4-7	Ely Chemical Company	Max-Flight	02-10-17
4-8	Kilfrost Limited	ABC-S	02-10-17
4-9	Octagon Process	Max-Flight™	03-06-18
4-10	SPCA	SPCA AD-480	03-06-12

** Qualified solely with respect to anti-icing performance and aerodynamic acceptance by the Anti-icing Materials International Laboratory, Université du Quebec à Chicoutimi, **Web site: http://www.uqac.uquebec.ca/amil/**

For other specification requirements for Type I fluids, see SAE AMS 1424 (latest version). For other specification requirements for Type II, III or IV fluids, see SAE AMS 1428 (latest version).

* Qualification in progress.

TRANSPORT CANADA , SEPTEMBER 2001

TABLE 6

SAE TYPE I DE-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)	**One-step Procedure De-icing/Anti-icing**	**Two-step Procedure**	
		First step: De-icing	**Second step: Anti-icing[1]**
-3°C (27°F) and above	FP of heated fluid mixture shall be at least 10°C (18°F) below OAT	Water heated to 60°C (140° F) minimum at the nozzle or a heated mix of fluid and water	FP of fluid mixture shall be at least 10°C (18°F) below OAT
Below -3°C (27° F)		FP of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

Note: For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.
Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

Caution: Wing skin temperatures may differ and in some cases may be lower than OAT; a stronger mix may be needed under these conditions.

1 To be applied before first step fluid freezes, typically within 3 minutes.

TRANSPORT CANADA , JULY 2001

TABLE 7

SAE TYPE II and TYPE IV ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type II and IV fluid mixtures (minimum concentrations in % by volume) as a Function of Outside Air Temperature (OAT)

Outside Air Temperature (OAT)	One-step Procedure De-icing/Anti-icing	Two-step Procedure	
		First step: De-icing	**Second step: Anti-icing[1]**
-3°C (27°F) and above	50/50 Heated[2] Type II/IV	Heated water or a heated mix of Type I, II or IV with water	50/50 Type II/IV
Below -3°C (27°F) to -14°C (7°F)	75/25 Heated[2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3°C (5°F) above actual OAT	75/25 Type II/IV
Below -14°C (7°F) to -25°C (-13°F)	100/0 Heated[2] Type II/IV	Heated suitable mix of Type I, Type II/IV and water with FP not more than 3°C (5°F) above actual OAT	100/0 Type II/IV
Below -25°C (-13°F)	SAE Type II/IV fluid may be used below -25°C (-13°F) provided that the freezing point of the fluid is at least a 7°C (13°F) below OAT and that aerodynamic acceptance criteria are met. Consider the use of SAE Type I when Type II/IV fluid cannot be used (see Table 6).		

Note: For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.
Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

Caution: Wing skin temperatures may differ and in some cases may be lower than OAT; a stronger mix 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 or IV should not be used for the anti-icing step because fluid freezing may occur.

An insufficient amount of anti-icing 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.

1 To be applied before first step fluid freezes, typically within 3 minutes.
2 Clean aircraft may be anti-iced with unheated fluid.

TRANSPORT CANADA , JULY 2001

TABLE 8

SNOW VISIBILITY VS SNOWFALL INTENSITY CHART[1]

Lighting	Temperature Range		Visibility in statute miles		
	°C	°F	Heavy[2]	Moderate[2]	Light[2]
Daylight	Above -1	Above 30	<1	1 - 2	>2
	-1 to -7	30 to 19	<½	½ - 1¼	>1¼
	Below -7	Below 19	<3/8	3/8 - 5/8	>5/8
Darkness	Above -1	Above 30	<2	2 - 4	>4
	-1 to -7	30 to 19	<1	1 - 2½	>2½
	Below -7	Below 19	<¾	¾ - 1¼	>1¼

1 Rasmussen et al., "The Estimation of Snowfall Rate Using Visibility", Journal of Applied Meteorology, Vol 38, No 10, October 1999.

2 Heavy snowfall intensity is defined as greater than **2.5 mm/hr equivalent liquid water precipitation**, moderate snow as **1 mm/hr to 2.5 mm/hr**, and light snow as than **1 mm/hr**.

TRANSPORT CANADA , JULY 2001

APPENDIX J

OFFICIAL FEDERAL AVIATION ADMINISTRATION HOLDOVER TIME TABLES

TABLE OF CONTENTS FOR HOT GUIDELINES

TABLE OF CONTENTS FOR HOT GUIDELINES
(Cont.)

TABLE 1 - Guideline for Holdover Times Anticipated for SAE Type I Fluid Mixture as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	*Frost	Freezing Fog	Snow◆	**Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0°	above 32°	0:45	0:12 - 0:30	0:06 - 0:15◆◆	0:05 - 0:08	0:02 - 0:05	0:02 - 0:05	CAUTION : No holdover time guidelines exist
0 to -10	32 to 14	0:45	0:06 - 0:15◆◆	0:06 - 0:15◆◆	0:05 - 0:08	0:02 - 0:05	CAUTION: Clear ice may require touch for confirmation	
below -10	below 14	0:45	0:06 - 0:15◆◆	0:06 - 0:15◆◆				

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains
◆◆ **TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M^2 (≈ 2 GALS/100FT^2) MUST BE APPLIED TO DEICED SURFACES**

SAE Type I fluid/water mixture is selected so that the FP of the mixture is at least 10 ° C (18 ° F) below OAT.

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST 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.

CAUTION: SAE TYPE I FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 1A - Guidelines for the Application of SAE Type I Fluid Mixtures.
Minimum Concentrations as a Function of Outside Air Temperature (OAT).
Concentrations in % V/V

<table>
<tr><th rowspan="2">Outside Air Temperature OAT</th><th rowspan="2">One-step Procedure Deicing/anti-icing</th><th colspan="2">Two-step Procedure</th></tr>
<tr><th>First step: Deicing</th><th>Second step Anti-icing [1]</th></tr>
<tr><td>-3 °C (27°F) and above</td><td rowspan="2">FP of heated fluid mixture shall be at least 10 °C (18 °F) below OAT</td><td>Water heated to 60 °C (140 °F) minimum at the nozzle or a heated mix of fluid and water</td><td rowspan="2">FP of fluid mixture shall be at least 10 °C (18 °F) below actual OAT</td></tr>
<tr><td>Below -3 °C (27 °F)</td><td>FP of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT</td></tr>
<tr><td colspan="4">Note: For heated fluids, a fluid temperature not less than 60 °C (140 °F) at the nozzle is desirable.
Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

Caution: Wing skin temperatures may differ and in some cases may be lower than OAT.
A stronger mix (more glycol) can be used under the latter conditions.</td></tr>
<tr><td colspan="4">1) To be applied before first step fluid freezes, typically within 3 minutes.</td></tr>
</table>

Effective: October 1, 2001

TABLE 2 - Guideline for Holdover Times Anticipated for SAE Type II Fluid Mixtures as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	12:00	0:35-1:30	0:20-0:55	0:30-0:55	0:15-0:30	0:05-0:40	CAUTION: No holdover time guidelines exist
		75/25	6:00	0:25-1:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	4:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30		
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
		50/50	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20-1:05	0:15-0:35	**0:15-0:45	**0:10-0:25		
		75/25	5:00	0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE Type II fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

°C = Degrees Celsius   OAT = Outside Air Temperature
°F = Degrees Fahrenheit   VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAE TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October1, 2001

TABLE 2A - Guideline for Holdover Times Anticipated for KILFROST ABC-II PLUS Type II Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 3,600cP, 20 °C, 0.3 RPM, Spindle LV2, 250ml beaker, 150ml fluid, 10 min. grd. leg.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	12:00	1:10-2:25	0:35-1:20	0:35-1:10	0:30-0:40	0:05-1:00	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10-2:25	0:35-1:10	0:30-1:00	0:20-0:40	0:05-0:50	
		50/50	4:00	0:15-0:45	0:20-0:40	0:05-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	1:10-2:25	0:25-0:55	0:35-1:10	0:30-0:40		
		75/25	5:00	1:10-2:25	0:25-0:50	0:30-1:00	0:20-0:40		
		50/50	3:00	0:15-0:45	0:15-0:35	0:05-0:25	0:05-0:15		
below -3 to -14	Below 27 to 7	100/0	8:00	0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:35	**0:15-0:30	**0:10-0:20		
below -14 to -25	Below 7 to –13	100/0	8:00	0:15-0:20	0:15-0:30				
below -25	below –13	100/0	**Kilfrost ABC-II PLUS** Type II fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **Kilfrost ABC-II PLUS** Type II fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **Kilfrost ABC-II PLUS** TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 2B - Guideline for Holdover Times Anticipated for Clariant Safewing MPII 1951 Type II Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 8,700cP, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 15 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type II Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	12:00	0:55-1:40	0:30-0:55	0:35-0:55	0:20-0:30	0:10-0:50	CAUTION: No holdover time guidelines exist
		75/25	6:00	0:45-1:15	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:40	
		50/50	4:00	0:20-0:30	0:05-0:20	0:05-0:15	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	0:55-1:40	0:25-0:45	0:35-0:55	0:20-0:30		
		75/25	5:00	0:45-1:15	0:15-0:35	0:25-0:45	0:15-0:25		
		50/50	3:00	0:20-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45-1:25	0:20-0:40	**0:25-0:50	**0:15-0:30		
		75/25	5:00	0:35-1:00	0:15-0:25	**0:20-0:35	**0:15-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:20-0:40	0:20-0:35				
below -25	below -13	100/0	**Clariant Safewing MP II 1951** Type II fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **Clariant Safewing MP II 1951** Type II fluid cannot be used.						

°C = Degrees Celsius   OAT = Outside Air Temperature
°F = Degrees Fahrenheit   VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **Clariant Safewing MP II 1951** TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 2C – Guideline for Holdover Times Anticipated for SPCA ECOWING 26 Type II Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% fluid Tested 4,900cp, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 30 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT °C	OAT °F	SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
			Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
above 0	above 32	100/0	12:00	1:25-2:35	0:40-1:05	0:50-1:35	0:40-0:50	0:20-1:25	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:55	0:30-0:50	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	4:00	0:30-0:45	0:10-0:20	0:15-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	8:00	1:25-2:35	0:40-1:00	0:50-1:35	0:40-0:50		
		75/25	5:00	1:05-1:55	0:25-0:45	0:45-1:05	0:25-0:35		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:45-2:15	0:35-0:55	**0:30-1:10	**0:15-0:35		
		75/25	5:00	0:35-1:15	0:25-0:40	**0:20-0:50	**0:15-0:25		
below -14 to -25	below 7 to -13	100/0	8:00	0:25-0:45	0:30-0:50				
below -25	below -13	100/0	**SPCA ECOWING 26** Type II fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SPCA ECOWING 26** Type II fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SPCA ECOWING 26 TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

TABLE 4 - Guideline for Holdover Times Anticipated for SAE Type IV Fluid Mixtures as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:25-0:40	0:10-0:50	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:30-1:05	0:35-0:50	0:15-0:30	0:05-0:35	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:25-0:40		
		75/25	5:00	1:05-1:45	0:25-0:50	0:35-0:50	0:15-0:30		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:20-0:40	**0:20-0:45	**0:10-0:25		
		75/25	5:00	0:25-0:50	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:15-0:30				
below -25	below -13	100/0	SAE Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C(13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: SAE TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October1, 2001

TABLE 4A - Guideline for Holdover Times Anticipated for UCAR ULTRA+ Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 36,000cP, 0 °C, 0.3 RPM, Spindle SC4-31/13R, 10ml fluid, 10 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:35-3:35	0:40-1:25	0:45-1:35	0:25-0:40	0:10-1:20	CAUTION: No holdover time guidelines exist
		75/25							
		50/50						CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:35-3:35	0:35-1:15	0:45-1:35	0:25-0:40		
		75/25							
		50/50							
below -3 to -14	below 27 to 7	100/0	12:00	1:25-3:00	0:25-0:55	**0:45-1:25	**0:30-0:45		
		75/25							
below -14 to -24	below 7 to -12	100/0	12:00	0:40-2:10	0:20-0:45				
below -24	below -12	100/0	**UCAR ULTRA+** Type IV fluid may be used below –24 °C (-12 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **UCAR ULTRA+** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **UCAR ULTRA+** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4B - Guideline for Holdover Times Anticipated for OCTAGON MAX-FLIGHT Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 5,540cP, 20 °C, 0.3 RPM, Spindle LV1, 600ml beaker, 500ml fluid, 33 min 20 sec, grd. leg.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	2:40-4:00	1:15-2:00	0:55-2:00	0:35-1:00	0:15-1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	2:05-3:15	1:20-2:00	1:15-2:00	0:35-1:10	0:10-0:40	
		50/50	4:00	0:55-1:45	0:40-1:20	0:35-1:00	0:15-0:30	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	2:40-4:00	0:50-1:35	0:55-2:00	0:35-1:00		
		75/25	5:00	2:05-3:15	0:45-1:45	1:15-2:00	0:35-1:10		
		50/50	3:00	0:55-1:45	0:25-1:15	0:35-1:00	0:15-0:30		
below -3 to -14	below 27 to 7	100/0	12:00	0:50-2:30	0:25-0:50	**0:25-1:10	**0:20-0:40		
		75/25	5:00	0:30-1:05	0:20-0:50	**0:20-1:00	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:40				
below -25	below -13	100/0	**OCTAGON MAX-FLIGHT** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **OCTAGON MAX-FLIGHT** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **OCTAGON MAX-FLIGHT** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4C - Guideline for Holdover Times Anticipated for KILFROST ABC-S Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested17,000cP, 20 °C, 0.3 RPM, Spindle LV2,250ml beaker,150ml fluid,10 min. grd. leg.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	2:35-4:00	1:10-2:00	1:20-1:50	1:00-1:25	0:20-1:15	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:05-1:45	0:30-1:05	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	4:00	0:20-0:35	0:05-0:20	0:15-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25		
		75/25	5:00	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50		
		50/50	3:00	0:20-0:35	0:05-0:15	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-2:05	0:45-1:20	**0:20-1:00	**0:10-0:30		
		75/25	5:00	0:25-1:00	0:25-0:50	**0:20-1:10	**0:10-0:35		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:40	0:40-1:10				
below -25	below -13	100/0	**KILFROST ABC-S** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **KILFROST ABC-S** Type IV fluid cannot be used.						

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **KILFROST ABC-S** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4D - Guideline for Holdover Times Anticipated for SAFEWING MP IV 1957 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 16,200cP, 20°, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 15 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:10	0:30-0:45	0:15-1:10	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10-2:10	0:35-1:05	0:35-1:05	0:25-0:40	0:10-1:00	
		50/50	4:00	0:25-0:50	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:10	0:30-0:45		
		75/25	5:00	1:10-2:10	0:30-0:50	0:35-1:05	0:25-0:40		
		50/50	3:00	0:25-0:50	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:30	0:30-0:50	**0:35-0:55	**0:20-0:35		
		75/25	5:00	0:25-1:10	0:20-0:40	**0:25-0:55	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:25-0:40	0:25-0:45				
below -25	below -13	100/0	**SAFEWING® MP IV 1957** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING® MP IV 1957** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **SAFEWING MP IV 1957** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4E - Guideline for Holdover Times Anticipated for SAFEWING MP IV 2001 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 18,000cP, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 15 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F		Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:20-3:20	1:55-2:00	0:55-1:55	0:40-1:00	0:15-2:00	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:20-2:00	0:50-1:25	0:35-1:10	0:25-0:35	0:10-1:25	
		50/50	4:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:20-3:20	1:00-1:55	0:55-1:55	0:40-1:00		
		75/25	5:00	1:20-2:00	0:35-1:00	0:35-1:10	0:25-0:35		
		50/50	3:00	0:15-0:40	0:10-0:20	0:10-0:20	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:35	0:30-0:50	**0:55-1:35	**0:30-0:45		
		75/25	5:00	0:30-1:00	0:20-0:35	**0:40-1:10	**0:20-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:35				
below -25	below -13	100/0	**SAFEWING® MP IV 2001** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING® MP IV 2001** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **SAFEWING MP IV 2001** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4F – Guideline for Holdover Times Anticipated for CLARIANT SAFEWING MP IV 2012 PROTECT Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – *Viscosity of Neat 100% fluid Tested 7,800cp, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 15 min.*

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT		SAE Type IV Fluid Concentration	Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
°C	°F	Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:15-2:30	1:10-2:00	0:40-1:10	0:25-0:45	0:10-1:05	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:10-2:05	0:35-1:10	0:35-0:50	0:15-0:30	0:05-0:40	
		50/50	4:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:15-2:30	0:40-1:15	0:40-1:10	0:25-0:45		
		75/25	5:00	1:10-2:05	0:25-0:55	0:35-0:50	0:15-0:30		
		50/50	3:00	0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:45-1:45	0:20-0:40	**0:25-0:45	**0:15-0:25		
		75/25	5:00	0:25-1:05	0:20-0:40	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:15-0:30				
below -25	below -13	100/0	**CLARIANT SAFEWING MP IV 2012 PROTECT** TYPE IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING MP IV 2012 PROTECT** TYPE IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **SAFEWING MP IV** FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4G - Guideline for Holdover Times Anticipated for SAFEWING FOUR Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – *Viscosity of Neat 100% Fluid Tested 6,400cP, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 15 min.*

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT °C	OAT °F	SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
above 0	above 32	100/0	18:00	1:50-2:45	0:45-1:45	1:05-1:45	0:50-1:05	0:10-1:20	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:45-2:25	0:40-1:25	0:50-1:30	0:30-0:45	0:15-1:25	
		50/50	4:00	0:30-0:45	0:15-0:25	0:15-0:25	0:10-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	1:50-2:45	0:35-1:20	1:05-1:45	0:50-1:05		
		75/25	5:00	1:45-2:25	0:30-1:05	0:50-1:30	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:30-1:30	0:25-0:55	**0:25-1:05	**0:15-0:30		
		75/25	5:00	0:30-1:05	0:20-0:45	**0:20-0:50	**0:15-0:25		
below -14 to -25	below 7 to -13	100/0	12:00	0:20-0:45	0:20-0:45				
below -25	below -13	100/0	**SAFEWING® FOUR** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SAFEWING® FOUR** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **SAFEWING® FOUR** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 4H - Guideline for Holdover Times Anticipated for SPCA AD-480 Type IV Fluid Mixtures as a Function of Weather Conditions and OAT – ***Viscosity of Neat 100% Fluid Tested 15,200cP, 20 °C, 0.3 RPM, Spindle SC4-34/13R, 10ml fluid, 30 min.***

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY, AND IT SHOULD BE USED IN CONJUNCTION WITH PRE-TAKEOFF CHECK PROCEDURES.

OAT °C	OAT °F	SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol. %/Vol. %)	Frost*	Freezing Fog	Snow◆	Freezing Drizzle***	Light Freezing Rain	Rain on Cold Soaked Wing	Other‡
			Approximate Holdover Times under Various Weather Conditions (hours: minutes)						
above 0	above 32	100/0	18:00	2:00-3:30	0:55-1:50	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	6:00	1:30-2:45	0:40-1:20	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	4:00	0:30-0:45	0:15-0:30	0:15-0:25	0:05-0:15	CAUTION: Clear ice may require touch for confirmation	
0 to -3	32 to 27	100/0	12:00	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55		
		75/25	5:00	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45		
		50/50	3:00	0:30-0:45	0:10-0:20	0:15-0:25	0:05-0:15		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:30-0:55	**0:25-1:20	**0:15-0:30		
		75/25	5:00	0:25-0:50	0:20-0:45	**0:25-1:05	**0:15-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:25-0:40				
below -25	below -13	100/0	**SPCA AD-480** Type IV fluid may be used below –25 °C (-13 °F) provided the freezing point of the fluid is at least 7 °C (13 °F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when **SPCA AD-480** Type IV fluid cannot be used.						

°C = Degrees Celsius OAT = Outside Air Temperature
°F = Degrees Fahrenheit VOL = Volume

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

* During conditions that apply to aircraft protection for ACTIVE FROST
** No holdover time guidelines exist for this condition below -10 °C (14 °F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
‡ Snow pellets, ice pellets, heavy snow, moderate and heavy freezing rain, hail
◆ Snow includes snow grains

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS. HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT, HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT.

CAUTION: **SPCA AD-480** TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

Effective: October 1, 2001

TABLE 5 - Guidelines for the Application of SAE Type II and Type IV Fluid Mixtures.
Minimum Concentrations as a Function of Outside Air Temperature (OAT).
Concentrations in % V/V

Outside Air Temperature OAT	One-step Procedure Deicing/anti-icing	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing[1]
-3 °C (27 °F) and above	50/50 Heated [2] Type II/IV	Water heated or a heated mix of Type I, II, or IV with water	50/50 Type II/IV
Below –3 °C (27 °F) to –14 °C (7 °F)	75/25 Heated [2] Type II/IV	Heated suitable mix of Type I, Type II/IV, and water with FP not more than 3 °C (5 °F) above actual OAT	75/25 Type II/IV
Below –14 °C (7 °F) to –25 °C (-13 °F)	100/0 Heated [2] Type II/IV	Heated suitable mix of Type I, Type II/IV, and water with FP not more than 3 °C (5 °F) above actual OAT	100/0 Type II/IV
Below –25 °C (-13 °F)	SAE Type II/IV fluid may be used below –25 °C (-13 °F) provided that the freezing point of the fluid is at least a 7 °C (13 °F) below OAT and that aerodynamic acceptance criteria are met. Consider the use of SAE Type I when Type II/IV fluid cannot be used (see table 1).		

NOTE: For heated fluids, a fluid temperature not less than 60 °C (140 °F) at the nozzle is desirable.
Upper temperature limit shall not exceed fluid and aircraft manufacturers recommendations.

CAUTION: Wing skin temperatures may differ and in some cases may be lower than OAT.
A stronger mix can be used under the latter conditions.

CAUTION: As fluid freezing may occur, 50/50 Type II 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.

1) To be applied before first step fluid freezes, typically within 3 minutes.
2) Clean aircraft may be anti-iced with unheated fluid.

CAUTION: 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).

Effective: October 1, 2001

Table 6. List of Qualified [1] Deicing/Anti-Icing Fluids – Winter 2001-2002

Qualified Type I Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing DGI 1937
Clariant	Safewing MPI 1938
Clariant	Safewing MP I 1938 TF
Clariant	Safewing EG I 1996
Delta Petroleum	Ice Away
Home Oil Inc.	SAFETEMP I PG 100
Inland	Duragly – P
Inland	Duragly – E
Jarchem	JarKleer 1000
Kilfrost	Kilfrost® DF
Kilfrost	Kilfrost® DF PLUS
Kilfrost	Kilfrost® DF PLUS (80)
Lyondell Chemical Worldwide, Inc	ARCOPlus Concentrate
Lyondell Chemical Worldwide, Inc	ARCOPlus Dilute
Lyondell Chemical Worldwide, Inc	ARCOPlus Canadian Dilute
Metss Corporation	ADF
Newwave Aerochemical Co. Ltd.	FCY-1A
Octagon Process, Inc	OCTAFLO
Octagon Process, Inc	OCTAFLO EG
Octagon Process, Inc	OCTAFLO EF
SPCA	SPCA DE-910
Union Carbide	UCAR® ADF Concentrate
Union Carbide	UCAR® ADF 50/50
Union Carbide	UCAR® XL 54
Union Carbide	UCAR®DEGree™

Table 6 – Continued.

Qualified Type II Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing MP II 1951
Kilfrost	Kilfrost® ABC-II PLUS
Kilfrost	Kilfrost® ABC-3
Octagon Process, Inc	Forty Below
SPCA	SPCA AD-104/N(MPG)
SPCA	SPCA Ecowing 26

Qualified Type IV Deicing/Anti-Icing Fluids

Company Name	Fluid Name
Clariant	Safewing MP IV 1957
Clariant	Safewing MP IV 2001
Clariant	Safewing FOUR
Clariant	Safewing MP IV 2012 PROTECT
Kilfrost	Kilfrost ABC-S
Octagon Process, Inc.	Max Flight
SPCA	SPCA AD-480
Union Carbide	UCAR® ADF/AAF ULTRA+

(1) Qualified implies that the fluid has met the requirements of the applicable SAE AMS performance specifications as conducted by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, in effect at the time of certification; and has completed holdover time testing. Fluids that successfully qualify after the issuance of this list will appear in a later update.

APPENDIX K

LOG OF ENDURANCE TIME TESTS 2000-01

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
1	1	Dec-11-00	1	1	22:47:45	22:52:45	dil.	Clariant EG I 1996	1a	-14	19.25	16	U	5.0	12.4	11%	7.0	-4.8	29	44	0.6	-5.0	S	44	
8	3	Dec-11-00	3	1	23:08:25	23:14:15	dil.	Clariant EG I 1996	1a	-14	19	16	U	5.8	9.1	4%	8.4	-5.2	31	52	0.7	-6.0	S	52	
12	4	Dec-11-00	4	1	23:26:00	23:31:10	dil.	Clariant EG I 1996	1a	-14	19.25	16	V	5.2	12.9	5%	11.5	-5.4	34	49	0.8	-6.0	S	49	
15	5	Dec-11-00	5	1	23:58:13	0:02:10	dil.	Clariant EG I 1996	1a	-16	19.75	17	V	4.0	29.9	11%	19.0	-5.7	38	49	0.4	-6.0	S	49	
18	6	Dec-12-00	6	1	0:29:55	0:34:55	dil.	Clariant EG I 1996	1a	-16	20.25	16	V	5.0	14.8	5%	23.1	-5.8	37	46	0.4	-6.4	S	46	
21	7	Dec-12-00	7	1	0:47:15	0:51:20	dil.	Clariant EG I 1996	1a	-16	20.25	18	V	4.1	18.4	9%	12.0	-5.8	37	42	0.5	-6.0	S	42	
27	9	Dec-14-00	2	2	5:59:20	6:03:10	dil.	Clariant EG I 1996	1a	-22	24	23	U	3.8	17.4	13%	53.3	-11.8	24	41	0.3	-12.0	S	41	
32	11	Dec-14-00	4	1	7:56:33	8:02:10	dil.	Clariant EG I 1996	1a	-22	23.75	23	U	5.6	10.9	20%	12.4	-11.3	23	40	0.6	-12.0	S	40	
36	12	Dec-30-00	1	1	19:45:01	19:50:59	dil.	Clariant EG I 1996	1a		19.5	20	V	6.0	11.0	10%	4.7	-4.3	28	29	0.8	-5.0	S	29	
39	13	Dec-30-00	2	1	20:19:07	20:24:31	dil.	Clariant EG I 1996	1a		19.5	19	V	5.4	14.0	16%	15.0	-4.0	29	37	0.7	-5.0	S	37	
42	14	Dec-30-00	3	1	20:51:14	20:55:15	dil.	Clariant EG I 1996	1a		19.25	19	V	4.0	19.0	9%	15.8	-4.1	26	27	0.5	-5.0	S	27	
45	15	Dec-30-00	4	1	21:22:53	21:28:30	dil.	Clariant EG I 1996	1a		19	22	V	5.6	13.1	10%	10.3	-4.3	36	30	0.5	-5.0	S	30	
79	21	Jan-31-01	2	1	12:41:50	12:53:10	dil.	Clariant EG I 1996	1a	-18	21.0	17	2	11.3	5.3	13%	0.4	-7.6	35	36	0.7	-8.6	S	0	
91	23	Jan-31-01	4	1	16:18:00	16:24:40	dil.	Clariant EG I 1996	1a			21	2	6.7	5.1	31%	4.2	-8.5	20	20	0.7	-9.0	S	0	
179	37	Feb-19-01	4	1	16:01:50	16:05:30	dil.	Clariant EG I 1996	1a	-12	17	19	4	3.7	26.4	26%		-2.2	28.9	175	0.3	-3.0	S	0	
284	46	Mar-05-01	3C	2	23:23:55	23:35:10	dil.	Clariant EG I 1996	1a	-13			10	11.3	6.9	0%		-1.9	34.2	42	1.2	-2.5	S		
287	46	Mar-05-01	3D	2	23:58:15	0:11:00	dil.	Clariant EG I 1996	1a	-13			10	12.8	6.1	2%		-1.7	32.0	37	1.6	-2.5	S		
388	52	Mar-13-01	1D	1	5:41:00	5:44:30	dil.	Clariant EG I 1996	1a	-16			U	3.5	20.0	5%		-6.2	29.2	47	0.4	-6.5	S		
2	1	Dec-11-00	1	1	22:48:35	22:54:00	dil.	Clariant MP I 1938	1a	-14	23.25	17	V	5.4	12.4	11%	7.0	-4.8	28	43	0.6	-5.0	S	43	
9	3	Dec-11-00	3	1	23:09:00	23:15:15	dil.	Clariant MP I 1938	1a	-14	23.25	16	V	6.3	9.1	4%	8.1	-5.2	32	52	0.7	-6.0	S	52	
11	4	Dec-11-00	4	1	23:25:15	23:30:30	dil.	Clariant MP I 1938	1a	-14	23.25	18	U	5.3	12.9	5%	11.5	-5.4	34	48	0.8	-6.0	S	48	
14	5	Dec-11-00	5	1	23:57:29	0:01:40	dil.	Clariant MP I 1938	1a	-16	24.75	18	U	4.2	29.9	11%	14.3	-5.7	36	48	0.4	-6.0	S	48	
17	6	Dec-12-00	6	1	0:29:10	0:34:30	dil.	Clariant MP I 1938	1a	-16	24.75	20	U	5.3	14.8	5%	23.1	-5.8	37	46	0.4	-6.4	S	46	
22	7	Dec-12-00	7	1	0:48:00	0:52:05	dil.	Clariant MP I 1938	1a	-16	24.75	18	W	4.1	18.4	9%	12.0	-5.8	37	43	0.5	-6.0	S	43	
28	9	Dec-14-00	2	2	6:00:05	6:04:20	dil.	Clariant MP I 1938	1a	-22	28.5	25	V	4.3	17.4	13%	40.0	-11.8	24	41	0.3	-12.0	S	41	
33	11	Dec-14-00	4	1	7:57:27	8:03:07	dil.	Clariant MP I 1938	1a	-22	28.5	23	V	5.7	10.9	20%	12.4	-11.3	24	40	0.6	-12.0	S	40	
37	12	Dec-30-00	1	1	19:45:40	19:51:40	dil.	Clariant MP I 1938	1a		24.5	18	W	6.0	11.0	10%	4.7	-4.3	29	30	0.8	-5.0	S	30	
40	13	Dec-30-00	2	1	20:19:53	20:25:00	dil.	Clariant MP I 1938	1a		24.25	18	W	5.1	14.0	16%	18.0	-4.0	29	38	0.7	-5.0	S	38	
43	14	Dec-30-00	3	1	20:52:09	20:56:16	dil.	Clariant MP I 1938	1a		24.5	18	W	4.1	19.0	9%	16.7	-4.1	25	27	0.5	-5.0	S	27	
46	15	Dec-30-00	4	1	21:23:39	21:29:20	dil.	Clariant MP I 1938	1a		24.5	21	W	5.7	13.1	10%	10.3	-4.3	37	30	0.5	-5.0	S	30	
80	21	Jan-31-01	2	1	12:42:40	12:54:30	dil.	Clariant MP I 1938	1a	-18	26.0	18	3	11.8	5.3	13%	0.4	-7.6	36	36	0.7	-8.6	S	0	
92	23	Jan-31-01	4	1	16:18:45	16:25:30	dil.	Clariant MP I 1938	1a			20	3	6.8	5.1	31%	4.9	-8.5	20	21	0.8	-9.0	S	0	
283	46	Mar-05-01	3C	2	23:23:05	23:36:15	dil.	Clariant MP I 1938	1a	-13			5	13.2	6.9	1%		-1.9	34.1	42	1.2	-2.5	S		
286	46	Mar-05-01	3D	2	23:57:30	0:12:30	dil.	Clariant MP I 1938	1a	-13			5	15.0	6.0	2%		-1.7	32.1	37	1.6	-2.5	S		
307	48	Mar-09-01	1B	2	2:37:10	2:54:40	dil.	Clariant MP I 1938	1a	-12	28.75	19	U	17.5	3.4	2%		-1.3	3.5	105	0.9	-1.3	S		
52	17	Jan-15-01	1	2	20:39:30	22:46:00	Neat	Clariant Safewing Protect 2012	4				V	126.5	4.9	6%	4.4	-8.0	21	30	2.4	-8.6	S	30	
55	17	Jan-15-01	1	2	20:42:00	22:46:00	Neat	Clariant Safewing Protect 2012	4				Y	124.0	4.9	6%	4.3	-8.0	21	30	2.4	-8.6	S	30	
57	17.1	Jan-15-01	2	2	23:35:31	0:02:00	Neat	Clariant Safewing Protect 2012	4				V	26.5	19.8	2%	16.2	-7.7	17	27	0.5	-8.3	S	27	
63	18	Jan-30-01	1	2	17:46:00	18:16:00	Neat	Clariant Safewing Protect 2012	4				Y	30.0	21.2	2%	7.2	-3.7	37	38	0.7	-4.5	S	0	
68	19	Jan-30-01	2	2	20:05:00	22:00:00	Neat	Clariant Safewing Protect 2012	4				Y	115.0	5.7	10%	3.6	-2.9	29	23	1.3	-3.5	S	0	
70	20	Jan-31-01	1	2	11:30:00	13:11:00	Neat	Clariant Safewing Protect 2012	4				U	101.0	5.6	2%	0.4	-7.4	32	38	1.0	-8.0	S	0	
76	20	Jan-31-01	1A	2	13:12:00	14:32:00	Neat	Clariant Safewing Protect 2012	4				U	80.0	9.8	7%	4.3	-7.8	29	32	0.7	-9.0	S	0	
82	22	Jan-31-01	3	2	14:42:00	15:37:00	Neat	Clariant Safewing Protect 2012	4				U	55.0	11.5	6%	8.1	-8.4	26	31	0.5	-9.2	S	0	
88	22	Jan-31-01	3A	2	15:50:00	17:59:00	Neat	Clariant Safewing Protect 2012	4				U	129.0	3.7	13%	3.3	-8.7	23	22	1.7	-9.8	S	0	
101	27	Feb-05-01	1	2	9:29:00	10:38:00	Neat	Clariant Safewing Protect 2012	4				U	69.0	8.1	9%	10.6	-7.9	16	28	0.7	-9.0	S	0	
107	28	Feb-05-01	2	2	11:40:00	13:16:00	Neat	Clariant Safewing Protect 2012	4				U	96.0	6.5	3%	6.4	-6.2	17	41	0.8	-8.0	S	0	
110	29	Feb-05-01	3	2	16:28:00	17:46:00	Neat	Clariant Safewing Protect 2012	4				U	78.0	8.4	8%	5.2	-4.8	20	27	0.7	-6.0	S	0	
118	30	Feb-14-01	1	2	10:30:00	11:36:00	Neat	Clariant Safewing Protect 2012	4				W	66.0	11.9	3%		-6.8	14.9	28	0.6	-7.5	S	0	
120	30	Feb-14-01	1	2	10:30:00	11:38:00	Neat	Clariant Safewing Protect 2012	4				Y	68.0	11.9	3%		-6.8	15.0	28	0.6	-7.5	S	0	
125	31	Feb-14-01	2	2	13:29:30	14:14:00	Neat	Clariant Safewing Protect 2012	4				W	44.5	16.1	0%		-6.1	5.0	171	0.4	-7.0	S	0	
127	31	Feb-14-01	2	2	13:30:00	14:14:00	Neat	Clariant Safewing Protect 2012	4				Y	44.0	16.1	0%		-6.1	5.0	175	0.4	-7.0	S	0	

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
131	32	Feb-14-01	3	2	15:26:00	18:35:00	Neat	Clariant Safewing Protect 2012	4				W	189.0	3.2	2%		-4.5			0.6	-5.0	S	0	
133	32	Feb-14-01	3	2	15:26:00	18:42:00	Neat	Clariant Safewing Protect 2012	4				Y	196.0	3.2	2%		-4.5			0.6	-5.0	S	0	
135	33	Feb-14-01	4	2	20:52:00	22:07:00	Neat	Clariant Safewing Protect 2012	4				V	75.0	7.8	5%		-3.9	4	252	0.4	-3.0	S	0	
136	33	Feb-14-01	4	2	20:52:00	22:06:00	Neat	Clariant Safewing Protect 2012	4				W	74.0	7.8	5%		-3.9	4	255	0.4	-3.0	S	0	
168	36	Feb-19-01	3	2	15:08:00	15:51:00	Neat	Clariant Safewing Protect 2012	4				X	43.0	22.2	7%		-2.4	26.1	187	0.3	-2.8	S	0	
184	38	Feb-22-01	1	2	22:16:00	23:31:00	Neat	Clariant Safewing Protect 2012	4				W	75.0	2.6	4%		-15.1	20.7	39	2.3	-15.0	S	0	
187	38	Feb-22-01	1	2	22:16:00	23:30:00	Neat	Clariant Safewing Protect 2012	4				Z	74.0	2.6	5%		-15.1	20.7	39	2.3	-15.0	S	0	Rate increased at 23:20
191	38	Feb-22-01	1	2	22:33:00	0:06:00	Neat	Clariant Safewing Protect 2012	4				10	93.0	2.8	6%		-15.2	19.5	36	1.9	-15.0	S	0	Rate increased at 23:20
193	38	Feb-22-01	1A	2	23:49:00	0:57:00	Neat	Clariant Safewing Protect 2012	4				5	68.0	4.0	10%		-15.8			1.0	-15.0	S	0	
194	38	Feb-22-01	1A	2	23:34:00	0:26:00	Neat	Clariant Safewing Protect 2012	4				6	52.0	4.0	8%		-15.4			1.0	-15.0	S	0	
198	39	Feb-23-01	2	1	22:41:00	23:50:00	Neat	Clariant Safewing Protect 2012	4				4	69.0	2.5	2%		-15.2	19.2	34	2.1	-15.0	S	0	
200	39	Feb-23-01	2	1	22:42:00	23:53:00	Neat	Clariant Safewing Protect 2012	4				6	71.0	2.4	3%		-15.2	19.2	35	2.0	-15.0	S	0	
203	40	Feb-23-01	3	2	1:27:00	2:25:00	Neat	Clariant Safewing Protect 2012	4				W	58.0	4.3	1%		-16.4	18.3	22	1.1	-15.0	S	0	
206	40	Feb-23-01	3	2	1:27:00	2:27:00	Neat	Clariant Safewing Protect 2012	4				Z	60.0	4.2	2%		-16.4	18.3	22	1.1	-15.0	S	0	
209	41	Feb-23-01	4	2	3:27:00	4:41:00	Neat	Clariant Safewing Protect 2012	4				W	74.0	2.6	11%		-16.4	18.5	28	1.3	-17.0	S	0	
211	41	Feb-23-01	4	2	3:27:00	4:41:00	Neat	Clariant Safewing Protect 2012	4				Z	74.0	2.6	11%		-16.4	18.5	28	1.3	-17.0	S	0	
222	42	Feb-25-01	1	2	6:15:30	7:18:00	Neat	Clariant Safewing Protect 2012	4				Y	62.5	10.0	9%		-9.3	21	52	1.4	-11.3	S	0	
235	43	Feb-25-01	2	2	8:13:00	8:34:00	Neat	Clariant Safewing Protect 2012	4				Y	21.0	32.3	13%		-9.8	21	46	0.4	-10.7	S	0	
273	46	Mar-05-01	3	2	21:28:45	22:53:00	Neat	Clariant Safewing Protect 2012	4				Y	84.3	10.2	12%		-2.0	34.5	50	0.9	-2.5	S		
296	47	Mar-06-01	4	2	1:06:00	2:47:00	Neat	Clariant Safewing Protect 2012	4				Y	101.0	8.3	4%		-1.7	34.8	42	1.0	-2.6	S		
362	51	Mar-11-01	2	2	12:21:00	13:18:00	Neat	Clariant Safewing Protect 2012	4				1	57.0	12.4	2%		-0.7	14.2	172	0.8	-0.5	S		Plate temperatures are above 0 °C
384	52	Mar-13-01	1C	1	5:18:30	5:43:30	Neat	Clariant Safewing Protect 2012	4				W	25.0	27.0	1%		-6.1	26.1	51	0.4	-6.5	S		
435	55	Mar-13-01	4	1	21:55:00	22:36:00	Neat	Clariant Safewing Protect 2012	4				2	41.0	18.7	3%		-1.6	5	229	0.4	-2.0	S		
95	24	Feb-02-01	1	2	11:40:30	12:13:30	50%	Clariant Safewing Protect 2012	4a				W	33.0	6.0	6%		-2.4	14	130	0.9	-2.1	S	0	
97	24	Feb-02-01	1	2	11:41:00	12:14:40	50%	Clariant Safewing Protect 2012	4a				Z	33.7	6.1	6%		-2.4	14	130	0.9	-2.1	S	0	
98	26	Feb-02-01	3	2	16:44:50	17:19:15	50%	Clariant Safewing Protect 2012	4a				U	34.4	5.7	3%		-0.9	15	147	1.1	-1.1	S	0	
100	26	Feb-02-01	3	2	16:45:25	17:19:30	50%	Clariant Safewing Protect 2012	4a				X	34.1	5.7	3%		-0.9	15	148	1.1	-1.1	S	0	
139	33	Feb-14-01	4A	2	21:48:10	22:07:40	50%	Clariant Safewing Protect 2012	4a				Y	19.5	6.3	2%		-3.8	1	77	0.4	-3.0	S	0	
142	33	Feb-14-01	4	2	22:17:00	22:37:40	50%	Clariant Safewing Protect 2012	4a				W	20.7	11.1	3%		-3.6	7	310	0.4	-3.0	S	0	
148	34	Feb-19-01	1	2	13:21:00	13:38:50	50%	Clariant Safewing Protect 2012	4a				Z	17.8	8.3	2%		-2.5	25.6	210	0.7	-2.4	S	0	
151	34	Feb-19-01	1A	2	13:45:15	14:00:45	50%	Clariant Safewing Protect 2012	4a				Z	15.5	13.2	1%		-2.6	22.9	198	0.7	-2.4	S	0	
158	34	Feb-19-01	1C	2	14:22:45	14:36:00	50%	Clariant Safewing Protect 2012	4a				Y	13.3	23.8	8%		-2.4	24.2	190	0.4	-2.4	S	0	
249	44	Mar-05-01	1	2	18:27:45	19:02:15	50%	Clariant Safewing Protect 2012	4a				3	34.5	6.2	3%		-2.3				-2.7	S		
255	44	Mar-05-01	1A	2	19:31:00	20:01:15	50%	Clariant Safewing Protect 2012	4a				X	30.3	7.4	5%		-2.0				-2.7	S		
261	44	Mar-05-01	1B	2	20:17:00	20:49:15	50%	Clariant Safewing Protect 2012	4a				Y	32.3	6.7	0%		-1.8	34.6	48	1.1	-2.7	S		
263	45	Mar-05-01	2	1	21:06:15	21:32:00	50%	Clariant Safewing Protect 2012	4a				U	25.8	9.2	15%		-2.0	35.1	49	1.0	-2.5	S		
264	45	Mar-05-01	2	1	21:06:30	21:32:30	50%	Clariant Safewing Protect 2012	4a				V	26.0	9.3	15%		-2.0	35.1	49	1.0	-2.5	S		
278	46	Mar-05-01	3B	2	22:51:00	23:16:00	50%	Clariant Safewing Protect 2012	4a				V	25.0	11.0	6%		-2.0	33.0	45	0.9	-2.5	S		
288	46	Mar-06-01	3E	2	0:21:40	0:46:30	50%	Clariant Safewing Protect 2012	4a				U	24.8	11.8	5%		-1.9	34.0	38	0.9	-2.5	S		Sub Run
305	48	Mar-09-01	1	2	1:52:40	2:48:00	50%	Clariant Safewing Protect 2012	4a				Z	55.3	3.0	2%		-1.3	4.5	122	1.2	-1.3	S		
310	48	Mar-09-01	1C	2	2:44:00	3:14:00	50%	Clariant Safewing Protect 2012	4a				10	30.0	3.8	2%		-1.3	4.7	108	0.9	-1.3	S		
312	49	Mar-09-01	2	1	2:15:48	3:04:00	50%	Clariant Safewing Protect 2012	4a				U	48.2	3.4	3%		-1.3	4.0	111	1.0	-1.5	S		
316	49	Mar-09-01	2A	1	3:11:10	3:42:30	50%	Clariant Safewing Protect 2012	4a				U	31.3	6.2	2%		-1.2	3.6	94	0.8	-1.5	S		Sub Run
345	50	Mar-11-01	1D	2	10:44:10	11:03:00	50%	Clariant Safewing Protect 2012	4a				W	18.8	12.9	2%		-1.3	14.6	155	1.1	-1.2	S		
439	55	Mar-13-01	4A	1	22:37:00	23:01:40	50%	Clariant Safewing Protect 2012	4a				2	24.7	12.4	1%		-1.6	7	315	0.5	-2.0	S		
451	57	Mar-23-01	2	1	16:05:15	16:19:00	50%	Clariant Safewing Protect 2012	4a				W	13.8	25.4	6%		0.3	12	324	0.9	0.1	S		
460	57	Mar-23-01	2B	1	17:15:45	17:31:30	50%	Clariant Safewing Protect 2012	4a				U	15.8	14.4	3%		0.2	10	351	0.7	0.1	S		
53	17	Jan-15-01	1	2	20:40:10	22:28:00	75%	Clariant Safewing Protect 2012	4b				W	107.8	4.7	6%	4.6	-8.0	22	31	2.3	-8.6	S	31	
56	17	Jan-15-01	1	2	20:42:50	22:34:00	75%	Clariant Safewing Protect 2012	4b				Z	111.2	4.7	6%	4.5	-8.0	22	31	2.4	-8.6	S	31	
58	17.1	Jan-15-01	2	2	23:36:15	23:57:00	75%	Clariant Safewing Protect 2012	4b				W	20.8	20.0	2%	16.1	-7.7	17	27	0.5	-8.3	S	27	
64	18	Jan-30-01	1	2	17:45:00	18:07:00	75%	Clariant Safewing Protect 2012	4b				Z	22.0	17.9	1%	6.2	-3.7	36	39	0.9	-4.5	S	0	

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
69	19	Jan-30-01	2	2	20:06:00	21:38:00	75%	Clariant Safewing Protect 2012	4b				Z	92.0	5.1	11%	3.5	-2.9	29	24	1.4	-3.5	S	0	
71	20	Jan-31-01	1	2	11:31:00	12:39:00	75%	Clariant Safewing Protect 2012	4b				V	68.0	5.6	1%	0.4	-7.3	30	39	1.1	-8.0	S	0	
77	20	Jan-31-01	1A	2	12:48:00	13:49:00	75%	Clariant Safewing Protect 2012	4b				V	61.0	6.9	7%	0.4	-7.7	33	35	0.8	-9.0	S	0	
83	22	Jan-31-01	3	2	14:43:00	15:22:00	75%	Clariant Safewing Protect 2012	4b				V	39.0	12.0	5%	7.3	-8.3	26	33	0.5	-9.2	S	0	
89	22	Jan-31-01	3A	2	15:50:00	17:10:00	75%	Clariant Safewing Protect 2012	4b				V	80.0	4.8	13%	3.8	-8.6	23	23	1.1	-9.8	S	0	
104	27	Feb-05-01	1	2	9:31:00	10:23:00	75%	Clariant Safewing Protect 2012	4b				X	52.0	7.9	8%	11.7	-8.0	17	28	0.8	-9.0	S	0	
108	28	Feb-05-01	2	2	11:42:00	12:45:00	75%	Clariant Safewing Protect 2012	4b				X	63.0	7.1	3%	5.5	-6.3	16	39	0.8	-8.0	S	0	
113	29	Feb-05-01	3	2	16:27:00	17:38:00	75%	Clariant Safewing Protect 2012	4b				X	71.0	8.6	8%	5.3	-4.8	19	27	0.7	-6.0	S	0	
121	30	Feb-14-01	1	2	10:31:00	11:13:00	75%	Clariant Safewing Protect 2012	4b				Z	42.0	9.5	1%		-6.8	15.5	31	0.6	-7.5	S	0	
122	30	Feb-14-01	1A	2	11:20:00	12:16:00	75%	Clariant Safewing Protect 2012	4b				Z	56.0	9.8	3%		-6.7	12.2	70	0.6	-7.5	S	0	
128	31	Feb-14-01	2	2	13:31:00	14:10:00	75%	Clariant Safewing Protect 2012	4b				Z	39.0	16.6	0%		-6.1	5.0	153	0.4	-7.0	S	0	
134	32	Feb-14-01	3	2	15:27:00	17:57:00	75%	Clariant Safewing Protect 2012	4b				Z	150.0	3.1	1%		-4.6		129	0.7	-5.0	S	0	
137	33	Feb-14-01	4	2	20:48:00	21:43:00	75%	Clariant Safewing Protect 2012	4b				Y	55.0	8.4	6%		-3.9	5	315	0.4	-3.0	S	0	
138	33	Feb-14-01	4	2	20:48:00	21:42:00	75%	Clariant Safewing Protect 2012	4b				Z	54.0	8.5	6%		-3.9	5	315	0.4	-3.0	S	0	
170	36	Feb-19-01	3A	2	15:44:00	16:09:00	75%	Clariant Safewing Protect 2012	4b				U	25.0	27.8	11%		-2.3	27.6	177	0.3	-2.8	S	0	
172	36	Feb-19-01	3A	2	15:52:00	16:23:00	75%	Clariant Safewing Protect 2012	4b				X	31.0	27.6	7%		-2.4	29.1	171	0.3	-2.8	S	0	
189	38	Feb-22-01	1	2	22:49:00	23:37:00	75%	Clariant Safewing Protect 2012	4b				5	48.0	2.7	7%		-15.1	19.0	33	2.5	-15.0	S	0	
223	42	Feb-25-01	1	2	6:16:15	7:10:00	75%	Clariant Safewing Protect 2012	4b				Z	53.8	9.1	11%		-9.4	22	51	1.5	-11.3	S	0	
236	43	Feb-25-01	2	2	8:13:30	8:29:00	75%	Clariant Safewing Protect 2012	4b				Z	15.5	32.1	14%		-9.9	22	46	0.4	-10.7	S	0	
274	46	Mar-05-01	3	2	21:29:25	22:33:00	75%	Clariant Safewing Protect 2012	4b				Z	63.6	10.7	12%		-2.0	35.5	50	0.9	-2.5	S		
297	47	Mar-06-01	4	2	1:07:00	2:16:00	75%	Clariant Safewing Protect 2012	4b				Z	69.0	8.6	4%		-1.7	33.8	43	1.0	-2.6	S		
319	49	Mar-09-01	2A	1	2:18:00	3:52:00	75%	Clariant Safewing Protect 2012	4b				X	94.0	4.9	2%		-1.2	4.0	104	0.9	-1.5	S		
354	50	Mar-11-01	1F	2	11:26:00	11:56:00	75%	Clariant Safewing Protect 2012	4b				V	30.0	16.5	1%		-1.5	15.8	156	0.7	-1.2	S		
3	1	Dec-11-00	1	1	22:49:05	22:54:25	dil.	Lyondell Arco Plus.	1a	-13	21.25	17	W	5.3	12.4	11%	7.0	-4.8	28	43	0.6	-5.0	S	43	
10	3	Dec-11-00	3	1	23:09:40	23:15:40	dil.	Lyondell Arco Plus.	1a	-14	22.75	17	W	6.0	9.1	4%	7.0	-5.2	33	51	0.7	-6.0	S	51	
13	4	Dec-11-00	4	1	23:26:50	23:31:55	dil.	Lyondell Arco Plus.	1a	-12	22.75	17	W	5.1	12.9	5%	11.5	-5.4	34	49	0.8	-6.0	S	49	
16	5	Dec-11-00	5	1	23:59:01	0:02:45	dil.	Lyondell Arco Plus.	1a	-16	24.75	17	W	3.7	29.9	11%	14.3	-5.7	39	49	0.4	-6.0	S	49	
19	6	Dec-12-00	6	1	0:30:40	0:35:35	dil.	Lyondell Arco Plus.	1a	-10	24.75	17	W	4.9	14.8	5%	26.1	-5.8	38	47	0.4	-6.4	S	47	
20	7	Dec-12-00	7	1	0:46:30	0:50:50	dil.	Lyondell Arco Plus.	1a	-16	24.75	17	U	4.3	18.4	9%	12.0	-5.8	37	42	0.5	-6.0	S	42	
29	9	Dec-14-00	2	2	6:00:50	6:04:50	dil.	Lyondell Arco Plus.	1a	-22	28	25	W	4.0	17.4	13%	40.0	-11.8	24	41	0.3	-12.0	S	41	
34	11	Dec-14-00	4	1	7:58:17	8:03:42	dil.	Lyondell Arco Plus.	1a	-22	28	25	W	5.4	10.9	20%	10.3	-11.3	24	40	0.6	-12.0	S	40	
35	12	Dec-30-00	1	1	19:44:18	19:50:30	dil.	Lyondell Arco Plus.	1a		24.5	19	U	6.2	11.0	10%	4.7	-4.3	28	29	0.8	-5.0	S	29	
38	13	Dec-30-00	2	1	20:18:22	20:24:20	dil.	Lyondell Arco Plus.	1a		24	19	U	6.0	14.0	16%	18.0	-4.0	29	37	0.7	-5.0	S	37	
41	14	Dec-30-00	3	1	20:49:44	20:54:24	dil.	Lyondell Arco Plus.	1a		24.5	19	U	4.7	19.0	9%	18.1	-4.1	29	27	0.5	-5.0	S	27	
44	15	Dec-30-00	4	1	21:22:09	21:28:15	dil.	Lyondell Arco Plus.	1a		24.25	21	U	6.1	13.1	10%	8.6	-4.3	36	30	0.5	-5.0	S	30	
81	21	Jan-31-01	2	1	12:43:15	12:55:50	dil.	Lyondell Arco Plus.	1a	-18	26.0	22	4	12.6	5.3	13%	0.4	-7.6	36	36	0.7	-8.6	S	0	
93	23	Jan-31-01	4	1	16:19:25	16:26:30	dil.	Lyondell Arco Plus.	1a			20	4	7.1	5.1	31%	4.2	-8.5	20	21	0.8	-9.0	S	0	
162	35	Feb-19-01	2	1	13:43:40	13:50:20	dil.	Lyondell Arco Plus.	1a	-12	22	19	4	6.7	13.1	1%		-2.6	27.1	198	0.7	-3.0	S	0	
323	49	Mar-09-01	2B	1	3:41:20	3:52:20	dil.	Lyondell Arco Plus.	1a	-12			Y	11.0	8.1	2%		-1.1	2.8	86	0.6	-1.5	S		
359	50	Mar-11-01	1G	2	11:49:55	12:00:00	dil.	Lyondell Arco Plus.	1a	-12	28.50	21	7	10.1	17.3	2%		-1.4	15.3	154	0.7	-1.2	S		Sub Run
160	35	Feb-19-01	2	1	13:42:15	13:49:30	dil.	Lyondell Arco Plus-ST	1a	-12	23	26	2	7.3	13.1	1%		-2.6	27.8	197	0.7	-3.0	S	0	
163	35	Feb-19-01	2	1	13:44:15	13:50:40	dil.	Lyondell Arco Plus-ST	1a	-12	23	26	5	6.4	13.1	1%		-2.5	26.7	198	0.7	-3.0	S	0	
177	37	Feb-19-01	4	1	16:00:45	16:05:15	dil.	Lyondell Arco Plus-ST	1a	-12	23	19	2	4.5	26.4	26%		-2.2	28.7	175	0.3	-3.0	S	0	
180	37	Feb-19-01	4	1	16:02:20	16:06:00	dil.	Lyondell Arco Plus-ST	1a	-12	23	19	5	3.7	26.4	26%		-2.2	28.9	175	0.3	-3.0	S	0	
214	41	Feb-23-01	4A	2	4:58:30	5:22:15	dil.	Lyondell Arco Plus-ST	1a	-27			Y	23.8	0.8	19%		-16.1	15.3	30	2.9	-17.0	S	0	
215	41	Feb-23-01	4A	2	4:59:06	5:23:00	dil.	Lyondell Arco Plus-ST	1a	-27			Z	23.9	0.8	19%		-16.1	15.3	29	2.9	-17.0	S	0	
217	41	Feb-23-01	4B	2	5:46:30	6:02:20	dil.	Lyondell Arco Plus-ST	1a	-27			X	15.8	1.1	11%		-16.0	14.5	26	1.5	-17.0	S	0	
228	42	Feb-25-01	1B	2	7:25:00	7:29:30	dil.	Lyondell Arco Plus-ST	1a	-20	28	23	Z	4.5	17.9	3%		-7.6	15	63	0.6	-11.3	S	0	
230	42	Feb-25-01	1C	2	7:42:25	7:49:25	dil.	Lyondell Arco Plus-ST	1a	-20	28	22	Z	7.0	9.9	7%		-8.3	25	51	0.6	-11.3	S	0	
239	43	Feb-25-01	2B	2	8:33:15	8:36:15	dil.	Lyondell Arco Plus-ST	1a	-20	28	19	2	3.0	31.4	9%		-9.1	21	46	0.4	-10.0	S	0	
275	46	Mar-05-01	3A	2	21:57:10	22:10:00	dil.	Lyondell Arco Plus-ST	1a	-13			3	12.8	7.8	18%		-2.0	35.5	51	1.0	-2.5	S		Sub Run Brix 3.5 = 23

M\Groups\CM1680 (exBM3833)\Analysis\HOT\Snow\Table
AT: Dorval Log

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
276	46	Mar-05-01	3A	2	21:58:10	22:12:15	dil.	Lyondell Arco Plus-ST	1a	-13			5	14.1	8.2	18%		-2.0	35.2	51	1.0	-2.5	S		brix 10= 17
282	46	Mar-05-01	3C	2	23:22:05	23:34:00	dil.	Lyondell Arco Plus-ST	1a	-13			3	11.9	6.8	1%		-1.9	34.3	42	1.2	-2.5	S		-3C OUT
285	46	Mar-05-01	3D	2	23:56:30	0:10:30	dil.	Lyondell Arco Plus-ST	1a	-13			3	14.0	5.8	2%		-1.7	31.9	37	1.6	-2.5	S		
308	48	Mar-09-01	1B	2	2:38:00	2:56:40	dil.	Lyondell Arco Plus-ST	1a	-12	25	19	Y	18.7	3.4	2%		-1.3	3.5	104	0.9	-1.3	S		
324	49	Mar-09-01	2B	1	3:42:15	3:54:20	dil.	Lyondell Arco Plus-ST	1a	-12			Z	12.1	8.1	2%		-1.1	3.1	96	0.5	-1.5	S		
360	50	Mar-11-01	1G	2	11:50:40	12:02:50	dil.	Lyondell Arco Plus-ST	1a	-12	28	21	10	12.2	16.9	1%		-1.3	14.8	154	0.7	-1.2	S		
389	52	Mar-13-01	1D	1	5:41:50	5:46:00	dil.	Lyondell Arco Plus-ST	1a	-16			V	4.2	20.0	5%		-6.3	28.7	48	0.4	-6.5	S		
429	54	Mar-13-01	3D	1	21:37:40	21:42:40	dil.	Lyondell Arco Plus-ST	1a	-12	28.5	19	U	5.0	18.8	2%		-1.3	8	173	0.4	-1.0	S		Sub Run
161	35	Feb-19-01	2	1	13:43:00	13:49:45	dil.	Newave Aerochemical FCY-1A	1a	-12	16	25	3	6.8	13.1	1%		-2.6	27.5	197	0.7	-3.0	S	0	
164	35	Feb-19-01	2	1	13:44:35	13:50:45	dil.	Newave Aerochemical FCY-1A	1a	-12	16	25	6	6.2	13.1	1%		-2.5	26.7	198	0.7	-3.0	S	0	
178	37	Feb-19-01	4	1	16:01:25	16:05:15	dil.	Newave Aerochemical FCY-1A	1a	-12	16	19	3	3.8	26.4	26%		-2.2	28.9	175	0.3	-3.0	S	0	
181	37	Feb-19-01	4	1	16:02:50	16:06:15	dil.	Newave Aerochemical FCY-1A	1a	-12	16	19	6	3.4	26.4	26%		-2.2	28.9	175	0.3	-3.0	S	0	
212	41	Feb-23-01	4A	2	4:56:55	5:07:30	dil.	Newave Aerochemical FCY-1A	1a	-27			V	10.6	0.7	27%		-16.0	16.5	34	2.6	-17.0	S	0	
213	41	Feb-23-01	4A	2	4:57:45	5:08:00	dil.	Newave Aerochemical FCY-1A	1a	-27			W	10.3	0.7	28%		-16.0	16.5	34	2.7	-17.0	S	0	
216	41	Feb-23-01	4B	2	5:45:50	5:57:20	dil.	Newave Aerochemical FCY-1A	1a	-27	21	18	U	11.5	1.0	9%		-16.0	14.4	24	1.3	-17.0	S	0	
227	42	Feb-25-01	1B	2	7:24:15	7:28:50	dil.	Newave Aerochemical FCY-1A	1a	-20	23	21	Y	4.6	17.9	3%		-7.5	15	66	0.6	-11.3	S	0	
229	42	Feb-25-01	1C	2	7:41:50	7:48:20	dil.	Newave Aerochemical FCY-1A	1a	-20	24	20	Y	6.5	10.5	7%		-8.2	25	51	0.6	-11.3	S	0	
240	43	Feb-25-01	2B	2	8:34:30	8:37:30	dil.	Newave Aerochemical FCY-1A	1a	-20	24	18	6	3.0	30.4	8%		-8.9	21	46	0.4	-10.0	S	0	
277	46	Mar-05-01	3A	2	21:59:15	22:10:00	dil.	Newave Aerochemical FCY-1A	1a	-13			10	10.8	8.1	18%		-2.0	35.5	51	1.0	-2.5	S		20 C +/- 5 fluid -3 C OUT
322	49	Mar-09-01	2B	1	3:40:15	3:49:15	dil.	Newave Aerochemical FCY-1A	1a	-12			W	9.0	8.1	2%		-1.1	2.2	71	0.6	-1.5	S		
361	50	Mar-11-01	1G	2	11:51:30	11:59:30	dil.	Newave Aerochemical FCY-1A	1a	-12	25	20.5	11	8.0	17.3	2%		-1.4	15.4	154	0.7	-1.2	S		
390	52	Mar-13-01	1D	1	5:42:45	5:46:15	dil.	Newave Aerochemical FCY-1A	1a	-16			W	3.5	20.0	5%		-6.3	28.5	48	0.4	-6.5	S		
430	54	Mar-13-01	3D	1	21:38:00	21:41:45	dil.	Newave Aerochemical FCY-1A	1a	-12				3.8	18.8	2%		-1.3	7	172	0.4	-1.0	S		
4	2	Dec-11-00	2	2	22:33:00	23:56:40	Neat	OCTAGON MAXFLIGHT	4				U	83.7	14.8	8%	9.6	-5.1	31	48	0.7	-5.0	S	48	
6	2	Dec-11-00	2	2	22:35:00	0:03:30	Neat	OCTAGON MAXFLIGHT	4				W	88.5	15.2	8%	10.1	-5.2	32	48	0.7	-5.0	S	48	
23	8	Dec-14-00	1	2	4:50:00	5:40:00	Neat	OCTAGON MAXFLIGHT	4				U	50.0	15.0	5%	11.0	-12.1	27	48	0.7	-12.5	S	48	
25	8	Dec-14-00	1	2	4:52:00	5:45:00	Neat	OCTAGON MAXFLIGHT	4				W	53.0	17.1	7%	11.5	-12.1	27	48	0.7	-12.5	S	48	
30	10	Dec-14-00	3	2	6:21:00	7:01:00	Neat	OCTAGON MAXFLIGHT	4				U	40.0	23.8	3%	16.7	-11.2	21	39	0.4	-12.0	S	39	
48	16	Dec-30-00	5	1	22:50:51	23:56:09	Neat	OCTAGON MAXFLIGHT	4				W	65.3	18.8	5%	6.8	-4.5	44	27	0.4	-5.0	S	27	
50	16	Dec-30-00	5	1	23:47:40	0:53:17	Neat	OCTAGON MAXFLIGHT	4				Z	65.6	21.2	4%	8.3	-4.7	42	27	0.3	-5.0	S	27	
51	17	Jan-15-01	1	2	20:38:37	23:16:10	Neat	OCTAGON MAXFLIGHT	4				U	157.6	7.2	3%	5.4	-7.9	21	30	2.2	-8.6	S	30	
61	18	Jan-30-01	1	2	17:44:00	19:54:00	Neat	OCTAGON MAXFLIGHT	4				W	130.0	11.0	3%	3.4	-3.7	37	36	0.6	-4.5	S	0	
74	20	Jan-31-01	1	2	11:33:00	14:28:00	Neat	OCTAGON MAXFLIGHT	4				Y	175.0	7.4	5%	2.1	-7.6	31	35	0.8	-8.0	S	0	
86	22	Jan-31-01	3	2	14:45:00	18:13:00	Neat	OCTAGON MAXFLIGHT	4				Y	208.0	5.9	9%	4.7	-8.6	24	24	1.3	-9.2	S	0	
103	27	Feb-05-01	1	2	9:30:30	11:28:00	Neat	OCTAGON MAXFLIGHT	4				W	117.5	14.7	4%	9.0	-7.5	16	32	0.7	-9.0	S	0	
112	29	Feb-05-01	3	2	16:28:00	19:30:00	Neat	OCTAGON MAXFLIGHT	4				W	182.0	6.5	8%	3.5	-4.9	20	27	0.9	-6.0	S	0	
116	30	Feb-14-01	1	2	10:28:00	13:13:00	Neat	OCTAGON MAXFLIGHT	4				U	165.0	9.1	2%		-6.6	12.0	79	0.6	-7.5	S	0	
129	32	Feb-14-01	3	2	15:23:00	20:25:00	Neat	OCTAGON MAXFLIGHT	4				U	302.0	3.1	3%		-4.5			0.6	-5.0	S	0	
173	36	Feb-19-01	3A	2	15:09:00	16:20:00	Neat	OCTAGON MAXFLIGHT	4				Y	71.0	24.1	8%		-2.4	27.2	181	0.3	-2.8	S	0	
182	38	Feb-22-01	1	2	22:18:00	0:25:00	Neat	OCTAGON MAXFLIGHT	4				U	127.0	3.2	6%		-15.3			1.8	-15.0	S	0	
185	38	Feb-22-01	1	2	22:18:00	0:28:00	Neat	OCTAGON MAXFLIGHT	4				X	130.0	3.2	6%		-15.3			1.7	-15.0	S	0	
197	39	Feb-23-01	2	1	22:44:00	0:56:00	Neat	OCTAGON MAXFLIGHT	4				3	132.0	2.9	6%		-15.5			1.5	-15.0	S	0	
202	40	Feb-23-01	3	2	1:25:00	3:09:00	Neat	OCTAGON MAXFLIGHT	4				V	104.0	3.9	8%		-16.5	19.0	23	1.1	-15.0	S	0	
205	40	Feb-23-01	3	2	1:26:00	3:09:00	Neat	OCTAGON MAXFLIGHT	4				Y	103.0	3.9	8%		-16.5	19.1	23	1.1	-15.0	S	0	
208	41	Feb-23-01	4	2	3:26:00	8:28:00	Neat	OCTAGON MAXFLIGHT	4				V	302.0	1.6	5%		-15.7	14.7	29	2.0	-17.0	S	0	
221	42	Feb-25-01	1	2	6:14:30	8:00:00	Neat	OCTAGON MAXFLIGHT	4				X	105.5	12.1	7%		-8.8	21	53	1.1	-11.3	S	0	
292	47	Mar-06-01	4	2	1:00:00	4:06:00	Neat	OCTAGON MAXFLIGHT	4				U	186.0	6.6	4%		-1.5	37.7	41	1.2	-2.6	S		
348	50	Mar-11-01	1E	2	9:47:00	11:57:00	Neat	OCTAGON MAXFLIGHT	4				3	130.0	11.4	1%		-1.4	14.5	153	0.9	-1.2	S		sub run
413	54	Mar-13-01	3A	1	20:20:00	21:48:00	Neat	OCTAGON MAXFLIGHT	4				2	88.0	19.5	1%		-0.9	8	212	0.5	-1.0	S		
147	34	Feb-19-01	1	2	13:20:30	14:17:00	50%	OCTAGON MAXFLIGHT	4a				Y	56.5	12.7	1%		-2.5	23.0	200	0.6	-2.4	S	0	
251	44	Mar-05-01	1	2	18:49:00	21:06:00	50%	OCTAGON MAXFLIGHT	4a				10	137.0	7.0	3%		-2.1				-2.7	S		

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
252	44	Mar-05-01	1	2	19:06:00	21:13:00	50%	OCTAGON MAXFLIGHT	4a				3	127.0	7.0	4%		-2.1				-2.7	S		
254	44	Mar-05-01	1A	2	18:21:00	20:43:00	50%	OCTAGON MAXFLIGHT	4a				W	142.0	6.8	1%		-2.1				-2.7	S		
280	46	Mar-05-01	3B	2	22:38:45	0:34:00	50%	OCTAGON MAXFLIGHT	4a				X	115.3	7.9	1%		-1.9	33.2	41	1.1	-2.5	S		
300	47	Mar-06-01	4A	2	1:06:30	3:22:00	50%	OCTAGON MAXFLIGHT	4a				10	135.5	7.3	4%		-1.6	35.8	41	1.1	-2.6	S		
332	50	Mar-11-01	1A	2	9:56:00	11:21:00	50%	OCTAGON MAXFLIGHT	4a				8	85.0	10.0	2%		-1.3	14.4	151	1.0	-1.2	S		
333	50	Mar-11-01	1A	2	9:41:00	11:21:00	50%	OCTAGON MAXFLIGHT	4a				10	100.0	9.6	1%		-1.3	13.9	153	1.0	-1.2	S		
405	54	Mar-13-01	3	1	20:06:40	20:48:00	50%	OCTAGON MAXFLIGHT	4a				5	41.3	23.7	3%		-0.9	10	80	0.5	-1.0	S		
412	54	Mar-13-01	3A	1	20:37:00	21:16:30	50%	OCTAGON MAXFLIGHT	4a				1	39.5	17.0	1%		-0.8	8	266	0.5	-1.0	S		
418	54	Mar-13-01	3A	1	20:16:00	21:09:15	50%	OCTAGON MAXFLIGHT	4a				2	53.3	20.1	1%		-0.8	9	167	0.5	-1.0	S		Sub Run
5	2	Dec-11-00	2	2	22:34:00	0:12:00	75%	OCTAGON MAXFLIGHT	4b				V	98.0	16.4	7%	10.6	-5.2	32	48	0.6	-5.0	S	48	
7	2	Dec-11-00	2	2	22:36:00	0:07:50	75%	OCTAGON MAXFLIGHT	4b				X	91.8	16.1	7%	10.4	-5.2	32	48	0.6	-5.0	S	48	
24	8	Dec-14-00	1	2	4:51:00	5:44:00	75%	OCTAGON MAXFLIGHT	4b				V	53.0	16.7	7%	11.4	-12.1	27	48	0.7	-12.5	S	48	
26	8	Dec-14-00	1	2	4:53:00	5:40:00	75%	OCTAGON MAXFLIGHT	4b				X	47.0	14.9	5%	10.3	-12.1	28	47	0.7	-12.5	S	47	
31	10	Dec-14-00	3	2	6:22:00	7:00:00	75%	OCTAGON MAXFLIGHT	4b				V	38.0	23.6	3%	17.1	-11.2	21	39	0.5	-12.0	S	39	
47	16	Dec-30-00	5	1	22:49:59	23:53:07	75%	OCTAGON MAXFLIGHT	4b				U	63.1	19.1	4%	6.8	-4.5	44	27	0.4	-5.0	S	27	
49	16	Dec-30-00	5	1	23:46:33	0:45:00	75%	OCTAGON MAXFLIGHT	4b				Y	58.5	20.8	4%	8.3	-4.6	43	28	0.3	-5.0	S	28	
54	17	Jan-15-01	1	2	20:41:05	23:05:00	75%	OCTAGON MAXFLIGHT	4b				X	143.9	6.4	3%	4.7	-7.9	21	30	2.3	-8.6	S	30	
62	18	Jan-30-01	1	2	17:47:00	19:53:00	75%	OCTAGON MAXFLIGHT	4b				X	126.0	11.1	3%	3.3	-3.6	37	36	0.6	-4.5	S	0	
67	19	Jan-30-01	2	2	20:05:00	23:13:00	75%	OCTAGON MAXFLIGHT	4b				X	188.0	6.7	5%	4.3	-2.8	26	26	1.0	-3.5	S	0	
75	20	Jan-31-01	1	2	11:34:00	14:04:00	75%	OCTAGON MAXFLIGHT	4b				Z	150.0	6.6	4%	1.1	-7.5	32	36	0.9	-8.0	S	0	
87	22	Jan-31-01	3	2	14:46:00	17:08:00	75%	OCTAGON MAXFLIGHT	4b				Z	142.0	7.6	9%	5.7	-8.5	25	26	0.8	-9.2	S	0	
106	27	Feb-05-01	1	2	9:33:00	11:09:00	75%	OCTAGON MAXFLIGHT	4b				Z	96.0	15.2	4%	9.9	-7.6	16	29	0.7	-9.0	S	0	
115	29	Feb-05-01	3	2	16:29:00	19:15:00	75%	OCTAGON MAXFLIGHT	4b				Z	166.0	6.2	8%	4.2	-4.9	20	27	0.9	-6.0	S	0	
119	30	Feb-14-01	1	2	10:29:00	12:35:00	75%	OCTAGON MAXFLIGHT	4b				X	126.0	10.5	3%		-6.7	12.9	46	0.6	-7.5	S	0	
126	31	Feb-14-01	2	2	13:27:30	14:39:00	75%	OCTAGON MAXFLIGHT	4b				X	71.5	16.5	0%		-6.0	4.8	204	0.4	-7.0	S	0	
132	32	Feb-14-01	3	2	15:24:00	20:05:00	75%	OCTAGON MAXFLIGHT	4b				X	281.0	2.7	1%		-4.5			0.6	-5.0	S	0	
167	36	Feb-19-01	3	2	15:07:00	16:14:00	75%	OCTAGON MAXFLIGHT	4b				W	67.0	23.7	8%		-2.3	26.8	183	0.3	-2.8	S	0	
220	42	Feb-25-01	1	2	6:14:00	7:56:00	75%	OCTAGON MAXFLIGHT	4b				W	102.0	11.8	7%		-8.8	21	53	1.1	-11.3	S	0	
293	47	Mar-06-01	4	2	1:01:30	4:06:00	75%	OCTAGON MAXFLIGHT	4b				V	184.5	6.6	4%		-1.5	37.7	41	1.2	-2.6	S		
385	52	Mar-13-01	1C	1	5:19:45	6:17:00	75%	OCTAGON MAXFLIGHT	4b				X	57.3	22.8	2%		-6.1		48	0.4	-6.5	S		
144	34	Feb-19-01	1	2	13:20:00	14:09:00	Neat	SPCA Ecowing 26	2				V	49.0	11.4	0%		-2.5	23.6	202	0.7	-2.4	S	0	
152	34	Feb-19-01	1B	2	14:05:00	14:39:00	Neat	SPCA Ecowing 26	2				U	34.0	22.3	6%		-2.5	21.6	190	0.4	-2.4	S	0	
153	34	Feb-19-01	1B	2	14:14:00	14:48:30	Neat	SPCA Ecowing 26	2				V	34.5	22.3	6%		-2.4	23.2	189	0.3	-2.4	S	0	
165	36	Feb-19-01	3	2	15:05:00	15:41:00	Neat	SPCA Ecowing 26	2				U	36.0	20.7	6%		-2.4	25.8	188	0.3	-2.8	S	0	
169	36	Feb-19-01	3	2	15:09:30	15:47:00	Neat	SPCA Ecowing 26	2				Z	37.5	21.3	7%		-2.4	26.0	188	0.3	-2.8	S	0	
174	36	Feb-19-01	3A	2	15:49:00	16:19:00	Neat	SPCA Ecowing 26	2				Z	30.0	26.7	9%		-2.4	28.5	173	0.3	-2.8	S	0	
183	38	Feb-22-01	1	2	22:17:00	0:03:00	Neat	SPCA Ecowing 26	2				V	106.0	2.8	4%		-15.2	20.0	37	1.9	-15.0	S	0	
186	38	Feb-22-01	1	2	22:17:00	0:02:00	Neat	SPCA Ecowing 26	2				Y	105.0	2.8	4%		-15.2	20.1	38	1.9	-15.0	S	0	
190	38	Feb-22-01	1	2	22:32:00	0:08:00	Neat	SPCA Ecowing 26	2				8	96.0	2.9	5%		-15.2	19.5	35	1.9	-15.0	S	0	
192	38	Feb-22-01	1A	2	23:50:00	1:00:00	Neat	SPCA Ecowing 26	2				3	70.0	3.2	10%		-15.8			1.0	-15.0	S	0	
195	38	Feb-22-01	1A	2	23:33:00	0:58:00	Neat	SPCA Ecowing 26	2				11	85.0	3.9	9%		-15.7			1.0	-15.0	S	0	
196	39	Feb-23-01	2	1	22:43:00	0:10:00	Neat	SPCA Ecowing 26	2				2	87.0	2.7	4%		-15.2	19.0	34	1.9	-15.0	S	0	
199	39	Feb-23-01	2	1	22:43:00	0:12:00	Neat	SPCA Ecowing 26	2				5	89.0	2.8	4%		-15.2			1.9	-15.0	S	0	
201	40	Feb-23-01	3	2	1:24:00	2:36:00	Neat	SPCA Ecowing 26	2				U	72.0	4.1	6%		-16.4	18.5	22	1.1	-15.0	S	0	
204	40	Feb-23-01	3	2	1:24:00	2:38:00	Neat	SPCA Ecowing 26	2				X	74.0	4.1	6%		-16.4	18.5	22	1.1	-15.0	S	0	
207	41	Feb-23-01	4	2	3:25:00	5:42:00	Neat	SPCA Ecowing 26	2				U	137.0	2.0	10%		-16.3	17.4	29	1.9	-17.0	S	0	
210	41	Feb-23-01	4	2	3:25:00	5:45:00	Neat	SPCA Ecowing 26	2				X	140.0	2.0	9%		-16.3	17.4	29	1.9	-17.0	S	0	
218	42	Feb-25-01	1	2	6:13:00	7:29:00	Neat	SPCA Ecowing 26	2				U	76.0	11.1	8%		-9.0	20	54	1.3	-11.3	S	0	
224	42	Feb-25-01	1A	2	7:03:00	7:58:00	Neat	SPCA Ecowing 26	2				3	55.0	15.8	4%		-8.1	20	56	0.7	-11.3	S	0	
231	43	Feb-25-01	2	2	8:10:00	8:41:00	Neat	SPCA Ecowing 26	2				U	31.0	31.9	12%		-9.6	22	46	0.4	-10.7	S	0	
244	44	Mar-05-01	1	2	17:41:00	19:31:00	Neat	SPCA Ecowing 26	2				X	110.0	5.9	1%		-2.2				-2.7	S		

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	visibility (mi)	APS OBS temp [°C]	Snow Type	D angle (°)	comments
271	46	Mar-05-01	3	2	21:27:10	22:47:00	Neat	SPCA Ecowing 26	2				W	79.8	10.2	12%		-2.0	34.8	50	0.9	-2.5	S		
298	47	Mar-06-01	4A	2	1:03:30	2:32:00	Neat	SPCA Ecowing 26	2				3	88.5	8.8	4%		-1.7	34.3	42	1.0	-2.6	S		Additional Pplates
331	50	Mar-11-01	1A	2	9:48:00	10:58:30	Neat	SPCA Ecowing 26	2				5	70.5	8.9	3%		-1.3	13.5	152	1.2	-1.2	S		Sub Run
363	51	Mar-11-01	2	2	12:26:00	13:18:00	Neat	SPCA Ecowing 26	2				9	52.0	12.4	2%		-0.7	14.5	173	0.9	-0.5	S		Rate increased 13:15
372	52	Mar-13-01	1	1	3:12:30	3:57:00	Neat	SPCA Ecowing 26	2				Y	44.5	21.1	7%		-6.4	21.0	47	0.5	-6.5	S		
386	52	Mar-13-01	1C	1	5:20:30	5:58:00	Neat	SPCA Ecowing 26	2				Y	37.5	24.0	2%		-6.1	26.9	51	0.4	-6.5	S		
393	52	Mar-13-01	1E	1	5:51:30	6:36:00	Neat	SPCA Ecowing 26	2				W	44.5	19.2	5%		-6.0		47	0.4	-6.5	S		
406	54	Mar-13-01	3	1	20:09:00	20:46:00	Neat	SPCA Ecowing 26	2				6	37.0	24.1	3%		-0.9	10	67	0.5	-1.0	S		
438	55	Mar-13-01	4	1	22:01:00	22:52:00	Neat	SPCA Ecowing 26	2				6	51.0	16.1	2%		-1.6	5	242	0.4	-2.0	S		
143	34	Feb-19-01	1	2	13:19:00	13:38:30	50%	SPCA Ecowing 26	2a				U	19.5	8.2	2%		-2.5	25.9	210	0.8	-2.4	S	0	
146	34	Feb-19-01	1	2	13:19:15	13:37:50	50%	SPCA Ecowing 26	2a				X	18.6	8.1	2%		-2.5	25.9	210	0.8	-2.4	S	0	
149	34	Feb-19-01	1A	2	13:46:10	14:01:45	50%	SPCA Ecowing 26	2a				U	15.6	13.3	1%		-2.6	22.5	199	0.7	-2.4	S	0	
150	34	Feb-19-01	1A	2	13:46:30	14:02:00	50%	SPCA Ecowing 26	2a				X	15.5	13.3	1%		-2.6	22.1	199	0.6	-2.4	S	0	
157	34	Feb-19-01	1C	2	14:23:30	14:37:20	50%	SPCA Ecowing 26	2a				X	13.8	23.3	8%		-2.4	24.8	189	0.4	-2.4	S	0	
176	36	Feb-19-01	3B	2	16:15:30	16:23:10	50%	SPCA Ecowing 26	2a				W	7.7	32.4	4%		-2.8	31.3	163	0.3	-2.8	S	0	
246	44	Mar-05-01	1	2	17:42:30	18:30:00	50%	SPCA Ecowing 26	2a				Z	47.5	4.4	2%		-2.3				-2.7	S		
248	44	Mar-05-01	1	2	18:05:10	18:48:00	50%	SPCA Ecowing 26	2a				10	42.8	5.3	2%		-2.3				-2.7	S		
253	44	Mar-05-01	1A	2	19:22:00	19:56:00	50%	SPCA Ecowing 26	2a				V	34.0	8.0	3%		-2.0				-2.7	S		Sub Run
260	44	Mar-05-01	1B	2	20:16:15	20:50:00	50%	SPCA Ecowing 26	2a				X	33.8	6.7	0%		-1.9	34.6	48	1.1	-2.7	S		
262	44	Mar-05-01	1B	2	20:31:30	21:08:45	50%	SPCA Ecowing 26	2a				Z	37.3	6.7	3%		-1.9	35.0	49	1.0	-2.7	S		
265	45	Mar-05-01	2	1	21:07:15	21:32:30	50%	SPCA Ecowing 26	2a				W	25.3	9.3	15%		-2.0	35.1	50	1.0	-2.5	S		
266	45	Mar-05-01	2	1	21:07:30	21:33:00	50%	SPCA Ecowing 26	2a				X	25.5	9.3	15%		-2.0	35.1	50	1.0	-2.5	S		
279	46	Mar-05-01	3B	2	22:51:30	23:19:00	50%	SPCA Ecowing 26	2a				W	27.5	10.4	6%		-2.0	32.8	44	0.8	-2.5	S		
289	46	Mar-06-01	3E	2	0:22:15	0:52:00	50%	SPCA Ecowing 26	2a				V	29.8	12.0	6%		-1.9	33.8	38	0.9	-2.5	S		
302	48	Mar-09-01	1	2	1:51:30	2:37:00	50%	SPCA Ecowing 26	2a				W	45.5	3.0	2%		-1.3	4.8	126	1.4	-1.3	S		
306	48	Mar-09-01	1A	2	1:52:00	2:32:30	50%	SPCA Ecowing 26	2a	-12	29	19	10	40.5	2.9	2%		-1.3	4.9	127	1.4	-1.3	S		Sub Run
313	49	Mar-09-01	2	1	2:16:39	3:01:00	50%	SPCA Ecowing 26	2a				V	44.4	3.3	2%		-1.3	3.9	110	1.0	-1.5	S		
315	49	Mar-09-01	2	1	2:19:36	2:59:25	50%	SPCA Ecowing 26	2a				Z	39.8	3.3	2%		-1.3	3.8	110	1.0	-1.5	S		
317	49	Mar-09-01	2A	1	3:11:40	3:40:30	50%	SPCA Ecowing 26	2a				W	28.8	6.1	2%		-1.2	3.8	101	0.8	-1.5	S		
344	50	Mar-11-01	1D	2	10:43:30	10:58:15	50%	SPCA Ecowing 26	2a				4	14.8	12.6	3%		-1.3	14.6	155	1.2	-1.2	S		
355	50	Mar-11-01	1F	2	11:25:00	11:39:20	50%	SPCA Ecowing 26	2a				W	14.3	16.1	1%		-1.5	15.2	156	0.7	-1.2	S		
408	54	Mar-13-01	3	1	20:08:00	20:19:00	50%	SPCA Ecowing 26	2a				V	11.0	22.3	7%		-0.9	10	38	0.7	-1.0	S		
426	54	Mar-13-01	3B	1	21:13:30	21:27:10	50%	SPCA Ecowing 26	2a				3	13.7	19.0	0%		-0.9	7	236	0.4	-1.0	S		
434	55	Mar-13-01	4	1	22:05:45	22:18:15	50%	SPCA Ecowing 26	2a				4	12.5	19.9	2%		-1.6	5	34	0.4	-2.0	S		
452	57	Mar-23-01	2	1	16:05:45	16:19:00	50%	SPCA Ecowing 26	2a				X	13.3	25.4	6%		0.3	12	324	0.9	0.1	S		
456	57	Mar-23-01	2A	1	16:51:00	17:10:00	50%	SPCA Ecowing 26	2a				V	19.0	12.5	0%		0.2	9	97	0.8	0.1	S		
145	34	Feb-19-01	1	2	13:20:00	13:56:00	75%	SPCA Ecowing 26	2b				W	36.0	10.1	1%		-2.5	25.6	204	0.7	-2.4	S	0	
154	34	Feb-19-01	1B	2	13:58:00	14:23:00	75%	SPCA Ecowing 26	2b				W	25.0	19.2	4%		-2.5	18.8	193	0.4	-2.4	S	0	
166	36	Feb-19-01	3	2	15:06:20	15:34:00	75%	SPCA Ecowing 26	2b				V	27.7	20.2	6%		-2.4	25.5	189	0.3	-2.8	S	0	
171	36	Feb-19-01	3A	2	15:37:15	16:03:00	75%	SPCA Ecowing 26	2b				V	25.8	26.5	10%		-2.3	27.0	180	0.3	-2.8	S	0	
175	36	Feb-19-01	3B	2	16:11:00	16:41:00	75%	SPCA Ecowing 26	2b				U	30.0	23.7	2%		-2.7	30.2	166	0.3	-2.8	S	0	
188	38	Feb-22-01	1	2	22:49:00	23:41:00	75%	SPCA Ecowing 26	2b				3	52.0	2.8	6%		-15.1	18.9	33	2.4	-15.0	S	0	
219	42	Feb-25-01	1	2	6:13:30	7:10:00	75%	SPCA Ecowing 26	2b				V	56.5	8.9	12%		-9.5	22	51	1.6	-11.3	S	0	
225	42	Feb-25-01	1A	2	7:03:00	7:41:00	75%	SPCA Ecowing 26	2b				5	38.0	17.2	3%		-7.9	19	57	0.6	-11.3	S	0	
226	42	Feb-25-01	1A	2	7:10:00	7:51:00	75%	SPCA Ecowing 26	2b				4	41.0	15.7	3%		-7.9	20	56	0.6	-11.3	S	0	
232	43	Feb-25-01	2	2	8:10:00	8:28:00	75%	SPCA Ecowing 26	2b				V	18.0	32.0	14%		-9.9	21	46	0.4	-10.7	S	0	
238	43	Feb-25-01	2A	2	8:23:00	8:45:00	75%	SPCA Ecowing 26	2b				5	22.0	31.6	9%		-9.2	22	48	0.4	-10.7	S	0	8:50 wind shift
245	44	Mar-05-01	1	2	17:42:00	19:15:00	75%	SPCA Ecowing 26	2b				Y	93.0	5.4	2%		-2.2				-2.7	S		
257	44	Mar-05-01	1A	2	18:31:00	19:47:00	75%	SPCA Ecowing 26	2b				Z	76.0	7.1	0%		-2.0				-2.7	S		
272	46	Mar-05-01	3	2	21:28:00	22:33:00	75%	SPCA Ecowing 26	2b				X	65.0	10.7	12%		-2.0	35.6	50	0.9	-2.5	S		
299	47	Mar-06-01	4A	2	1:04:00	2:16:00	75%	SPCA Ecowing 26	2b				5	72.0	8.6	4%		-1.7	33.9	43	1.0	-2.6	S		

NATURAL SNOW TESTS AT DORVAL 2000-01

Test no.	Form no.	Date	Run no.	Stand no.	Start Time (Local)	Fail Time (Local)	Fluid dilution	Fluid Name	Fluid Type	FFP (°C)	Fluid Brix	Fluid Temp. (°C)	Plate Locat'n	Fail Time [min.]	AVG PAN [g/dm²/h]	Pan diff %	READAC Data rate [g/dm²/h]	temp [°C]	Wind Sp [km/h]	wind dir	APS OBS visibility (mi)	temp [°C]	Snow Type	D angle (°)	comments
309	48	Mar-09-01	1C	2	3:03:00	3:58:00	75%	SPCA Ecowing 26	2b				9	55.0	6.1	0%		-1.2	3.9	100	0.7	-1.3	S		
318	49	Mar-09-01	2A	1	2:17:25	3:38:00	75%	SPCA Ecowing 26	2b				W	80.6	4.3	3%		-1.3	4.2	109	0.9	-1.5	S		
350	50	Mar-11-01	1E	2	11:22:00	11:55:00	75%	SPCA Ecowing 26	2b				8	33.0	16.2	1%		-1.5	15.9	156	0.7	-1.2	S		
353	50	Mar-11-01	1F	2	11:22:00	11:55:00	75%	SPCA Ecowing 26	2b				U	33.0	16.2	1%		-1.5	15.9	156	0.7	-1.2	S		
379	52	Mar-13-01	1B	1	4:48:00	5:12:00	75%	SPCA Ecowing 26	2b				W	24.0	23.7	2%		-6.1	25.3	52	0.4	-6.5	S		
407	54	Mar-13-01	3	1	20:10:00	20:36:00	75%	SPCA Ecowing 26	2b				U	26.0	25.0	4%		-0.9	10	34	0.5	-1.0	S		
433	55	Mar-13-01	4	1	22:05:00	22:38:00	75%	SPCA Ecowing 26	2b				3	33.0	17.3	2%		-1.6	5	209	0.4	-2.0	S		
441	55	Mar-13-01	4A	1	22:17:00	23:00:00	75%	SPCA Ecowing 26	2b				4	43.0	13.9	2%		-1.6	6	309	0.5	-2.0	S		

SIMULATED FREEZING PRECIPITATION AT CEF-NRC (OTTAWA) FOR 2000-01 SEASON

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution	Fluid Type	Fail Time (min)	Actual Rate of Precip (g/dm²/h)	Ambient Temp (°C)	Precipitation (Type)	comments
137	3	27-Mar-01	16:55:00	17:10:30	CLAR SF PRO 2012 (TIV)	50	4a	15.5	12.1	-3	Freezing Drizzle	
138	3	27-Mar-01	16:57:15	17:10:50	CLAR SF PRO 2012 (TIV)	50	4a	13.6	11.8	-3	Freezing Drizzle	
113	1	28-Mar-01	11:03:15	11:23:30	CLAR SF PRO 2012 (TIV)	50	4a	20.3	4.8	-3	Freezing Drizzle	
114	2	28-Mar-01	12:38:10	12:59:20	CLAR SF PRO 2012 (TIV)	50	4a	21.2	4.9	-3	Freezing Drizzle	
31	1	4-Apr-01	9:43:45	9:51:00	CLAR SF PRO 2012 (TIV)	50	4a	7.3	24.3	-3	Light Freezing Rain	
32	1	4-Apr-01	9:48:45	9:55:45	CLAR SF PRO 2012 (TIV)	50	4a	7.0	25.7	-3	Light Freezing Rain	
5	3	4-Apr-01	14:08:20	14:20:15	CLAR SF PRO 2012 (TIV)	50	4a	11.9	12.8	-3	Light Freezing Rain	
6	4	4-Apr-01	15:23:40	15:34:30	CLAR SF PRO 2012 (TIV)	50	4a	10.8	11.7	-3	Light Freezing Rain	
217	1	5-Apr-01	11:51:00	12:37:00	CLAR SF PRO 2012 (TIV)	50	4a	46.0	2.0	-3	Freezing Fog	
218	2	5-Apr-01	13:06:00	13:49:00	CLAR SF PRO 2012 (TIV)	50	4a	43.0	2.1	-3	Freezing Fog	
241	1	10-Apr-01	11:10:15	11:31:50	CLAR SF PRO 2012 (TIV)	50	4a	21.6	5.3	-3	Freezing Fog	
242	2	10-Apr-01	13:17:30	13:39:00	CLAR SF PRO 2012 (TIV)	50	4a	21.5	5.6	-3	Freezing Fog	
135	2	27-Mar-01	15:42:00	16:18:00	CLAR SF PRO 2012 (TIV)	75	4b	36.0	12.3	-3	Freezing Drizzle	
136	2	27-Mar-01	16:28:00	17:02:00	CLAR SF PRO 2012 (TIV)	75	4b	34.0	13.3	-3	Freezing Drizzle	
112	3	28-Mar-01	13:56:00	14:49:00	CLAR SF PRO 2012 (TIV)	75	4b	53.0	5.0	-3	Freezing Drizzle	
367	4	28-Mar-01	14:59:00	15:48:00	CLAR SF PRO 2012 (TIV)	75	4b	49.0	5.5	-3	Freezing Drizzle	
327	1	29-Mar-01	11:44:00	12:21:00	CLAR SF PRO 2012 (TIV)	75	4b	37.0	5.4	1	Cold Soak Box	
371	2	29-Mar-01	13:48:00	14:35:00	CLAR SF PRO 2012 (TIV)	75	4b	47.0	4.4	1	Cold Soak Box	
328	2	29-Mar-01	12:56:00	13:39:00	CLAR SF PRO 2012 (TIV)	75	4b	43.0	5.0	1	Cold Soak Box	
347	1	30-Mar-01	9:49:45	9:56:30	CLAR SF PRO 2012 (TIV)	75	4b	6.8	78.6	1	Cold Soak Box	
348	2	30-Mar-01	10:21:30	10:28:30	CLAR SF PRO 2012 (TIV)	75	4b	7.0	78.0	1	Cold Soak Box	
195	1	2-Apr-01	11:56:00	12:10:00	CLAR SF PRO 2012 (TIV)	75	4b	14.0	12.2	-10	Freezing Drizzle	
196	2	2-Apr-01	12:38:00	12:54:00	CLAR SF PRO 2012 (TIV)	75	4b	16.0	12.1	-10	Freezing Drizzle	
173	3	2-Apr-01	15:51:00	16:21:00	CLAR SF PRO 2012 (TIV)	75	4b	30.0	4.8	-10	Freezing Drizzle	
174	3	2-Apr-01	15:51:45	16:24:00	CLAR SF PRO 2012 (TIV)	75	4b	32.3	5.0	-10	Freezing Drizzle	
81	1	3-Apr-01	11:12:40	11:23:00	CLAR SF PRO 2012 (TIV)	75	4b	10.3	24.2	-10	Light Freezing Rain	
82	1	3-Apr-01	11:19:40	11:31:40	CLAR SF PRO 2012 (TIV)	75	4b	12.0	24.6	-10	Light Freezing Rain	
55	4	3-Apr-01	15:21:00	15:39:00	CLAR SF PRO 2012 (TIV)	75	4b	18.0	12.6	-10	Light Freezing Rain	
56	4	3-Apr-01	15:27:00	15:47:00	CLAR SF PRO 2012 (TIV)	75	4b	20.0	13.0	-10	Light Freezing Rain	
29	1	4-Apr-01	9:43:00	10:02:00	CLAR SF PRO 2012 (TIV)	75	4b	19.0	24.7	-3	Light Freezing Rain	
30	1	4-Apr-01	9:47:55	10:04:00	CLAR SF PRO 2012 (TIV)	75	4b	16.1	24.9	-3	Light Freezing Rain	
3	3	4-Apr-01	14:07:00	14:43:00	CLAR SF PRO 2012 (TIV)	75	4b	36.0	12.3	-3	Light Freezing Rain	

SIMULATED FREEZING PRECIPITATION AT CEF-NRC (OTTAWA) FOR 2000-01 SEASON

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution	Fluid Type	Fail Time (min)	Actual Rate of Precip (g/dm²/h)	Ambient Temp (°C)	Precipitation (Type)	comments
9	3	4-Apr-01	14:10:00	14:46:00	CLAR SF PRO 2012 (TIV)	75	4b	36.0	12.0	-3	Light Freezing Rain	
4	3	4-Apr-01	14:46:00	15:12:00	CLAR SF PRO 2012 (TIV)	75	4b	26.0	12.1	-3	Light Freezing Rain	
403	4	4-Apr-01	15:36:30	16:03:00	CLAR SF PRO 2012 (TIV)	75	4b	26.5	12.1	-3	Light Freezing Rain	
402	4	4-Apr-01	15:27:00	15:55:00	CLAR SF PRO 2012 (TIV)	75	4b	28.0	12.3	-3	Light Freezing Rain	
216	2	5-Apr-01	14:07:00	16:13:00	CLAR SF PRO 2012 (TIV)	75	4b	126.0	2.0	-3	Freezing Fog	
215	2	5-Apr-01	12:59:00	15:10:00	CLAR SF PRO 2012 (TIV)	75	4b	131.0	1.9	-3	Freezing Fog	
271	1	9-Apr-01	11:19:00	12:21:00	CLAR SF PRO 2012 (TIV)	75	4b	62.0	2.1	-14	Freezing Fog	
272	1	9-Apr-01	11:21:00	12:22:00	CLAR SF PRO 2012 (TIV)	75	4b	61.0	2.0	-14	Freezing Fog	
287	4	9-Apr-01	16:48:00	17:11:00	CLAR SF PRO 2012 (TIV)	75	4b	23.0	5.3	-14	Freezing Fog	
288	4	9-Apr-01	16:48:30	17:11:00	CLAR SF PRO 2012 (TIV)	75	4b	22.5	5.6	-14	Freezing Fog	
239	2	10-Apr-01	12:01:00	13:11:00	CLAR SF PRO 2012 (TIV)	75	4b	70.0	4.6	-3	Freezing Fog	
240	2	10-Apr-01	12:44:00	13:59:00	CLAR SF PRO 2012 (TIV)	75	4b	75.0	5.3	-3	Freezing Fog	
134	1	27-Mar-01	14:16:00	14:58:00	CLAR SF PRO 2012 (TIV)	100	4	42.0	12.3	-3	Freezing Drizzle	
133	1	27-Mar-01	14:20:00	14:55:00	CLAR SF PRO 2012 (TIV)	100	4	35.0	13.1	-3	Freezing Drizzle	
365	2	27-Mar-01	15:41:00	16:23:00	CLAR SF PRO 2012 (TIV)	100	4	42.0	12.3	-3	Freezing Drizzle	
109	1	28-Mar-01	11:04:00	12:11:00	CLAR SF PRO 2012 (TIV)	100	4	67.0	4.8	-3	Freezing Drizzle	
110	2	28-Mar-01	11:51:00	13:05:00	CLAR SF PRO 2012 (TIV)	100	4	74.0	4.8	-3	Freezing Drizzle	
325	1	29-Mar-01	11:31:00	12:35:00	CLAR SF PRO 2012 (TIV)	100	4	64.0	4.9	1	Cold Soak Box	
326	2	29-Mar-01	13:04:00	14:07:00	CLAR SF PRO 2012 (TIV)	100	4	63.0	4.9	1	Cold Soak Box	
345	1	30-Mar-01	9:48:45	10:00:00	CLAR SF PRO 2012 (TIV)	100	4	11.3	76.9	1	Cold Soak Box	
346	2	30-Mar-01	10:28:15	10:40:30	CLAR SF PRO 2012 (TIV)	100	4	12.3	76.8	1	Cold Soak Box	
193	1	2-Apr-01	11:52:00	12:20:00	CLAR SF PRO 2012 (TIV)	100	4	28.0	12.8	-10	Freezing Drizzle	
194	1	2-Apr-01	12:24:00	12:51:00	CLAR SF PRO 2012 (TIV)	100	4	27.0	12.2	-10	Freezing Drizzle	
171	3	2-Apr-01	15:43:00	16:31:00	CLAR SF PRO 2012 (TIV)	100	4	48.0	4.6	-10	Freezing Drizzle	
172	3	2-Apr-01	15:46:00	16:34:00	CLAR SF PRO 2012 (TIV)	100	4	48.0	4.7	-10	Freezing Drizzle	
79	1	3-Apr-01	11:11:45	11:28:45	CLAR SF PRO 2012 (TIV)	100	4	17.0	24.5	-10	Light Freezing Rain	
80	1	3-Apr-01	11:18:50	11:36:00	CLAR SF PRO 2012 (TIV)	100	4	17.2	25.1	-10	Light Freezing Rain	
51	4	3-Apr-01	15:20:00	15:46:30	CLAR SF PRO 2012 (TIV)	100	4	26.5	12.2	-10	Light Freezing Rain	
52	4	3-Apr-01	15:26:10	15:52:45	CLAR SF PRO 2012 (TIV)	100	4	26.6	12.7	-10	Light Freezing Rain	
27	1	4-Apr-01	9:42:00	10:09:00	CLAR SF PRO 2012 (TIV)	100	4	27.0	24.3	-3	Light Freezing Rain	
28	1	4-Apr-01	9:47:10	10:12:00	CLAR SF PRO 2012 (TIV)	100	4	24.8	25.5	-3	Light Freezing Rain	
1	3	4-Apr-01	14:06:00	14:55:00	CLAR SF PRO 2012 (TIV)	100	4	49.0	12.4	-3	Light Freezing Rain	

SIMULATED FREEZING PRECIPITATION AT CEF-NRC (OTTAWA) FOR 2000-01 SEASON

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution	Fluid Type	Fail Time (min)	Actual Rate of Precip (g/dm²/h)	Ambient Temp (°C)	Precipitation (Type)	comments
2	4	4-Apr-01	15:09:00	15:57:00	CLAR SF PRO 2012 (TIV)	100	4	48.0	12.4	-3	Light Freezing Rain	
213	1	5-Apr-01	11:46:30	14:18:00	CLAR SF PRO 2012 (TIV)	100	4	151.5	2.1	-3	Freezing Fog	
214	1	5-Apr-01	11:49:00	14:30:00	CLAR SF PRO 2012 (TIV)	100	4	161.0	1.8	-3	Freezing Fog	
313	1	6-Apr-01	11:17:00	11:39:00	CLAR SF PRO 2012 (TIV)	100	4	22.0	4.9	-25	Freezing Fog	
314	1	6-Apr-01	11:23:00	11:47:00	CLAR SF PRO 2012 (TIV)	100	4	24.0	4.5	-25	Freezing Fog	
301	4	6-Apr-01	15:03:00	15:42:00	CLAR SF PRO 2012 (TIV)	100	4	39.0	2.3	-25	Freezing Fog	
302	4	6-Apr-01	15:04:00	15:44:00	CLAR SF PRO 2012 (TIV)	100	4	40.0	2.3	-25	Freezing Fog	
269	1	9-Apr-01	11:14:00	13:10:00	CLAR SF PRO 2012 (TIV)	100	4	116.0	1.8	-14	Freezing Fog	
270	1	9-Apr-01	11:15:00	13:10:00	CLAR SF PRO 2012 (TIV)	100	4	115.0	1.8	-14	Freezing Fog	
285	3	9-Apr-01	16:03:00	16:44:00	CLAR SF PRO 2012 (TIV)	100	4	41.0	5.3	-14	Freezing Fog	
286	3	9-Apr-01	16:05:00	16:44:00	CLAR SF PRO 2012 (TIV)	100	4	39.0	5.6	-14	Freezing Fog	
237	1	10-Apr-01	11:03:00	12:24:00	CLAR SF PRO 2012 (TIV)	100	4	81.0	4.6	-3	Freezing Fog	
238	1	10-Apr-01	11:09:00	12:24:00	CLAR SF PRO 2012 (TIV)	100	4	75.0	4.9	-3	Freezing Fog	
341	3	29-Mar-01	14:46:30	14:55:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	9.0	4.7	1	Cold Soak Box	
342	3	29-Mar-01	14:38:30	14:48:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	9.5	4.4	1	Cold Soak Box	
361	2	30-Mar-01	10:43:50	10:46:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	2.2	77.4	1	Cold Soak Box	
362	3	30-Mar-01	10:51:15	10:53:15	LYON. ARCO PLUS-ST. (TI)	10°	1a	2.0	78.8	1	Cold Soak Box	
209	2	2-Apr-01	12:50:20	12:55:55	LYON. ARCO PLUS-ST. (TI)	10°	1a	5.6	12.8	-10	Freezing Drizzle	
210	2	2-Apr-01	12:58:40	13:04:15	LYON. ARCO PLUS-ST. (TI)	10°	1a	5.6	12.0	-10	Freezing Drizzle	
188	4	2-Apr-01	16:58:45	17:06:40	LYON. ARCO PLUS-ST. (TI)	10°	1a	7.9	4.7	-10	Freezing Drizzle	
187	4	2-Apr-01	16:52:49	17:00:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	7.2	4.9	-10	Freezing Drizzle	
105	3	3-Apr-01	12:34:40	12:38:40	LYON. ARCO PLUS-ST. (TI)	10°	1a	4.0	25.5	-10	Light Freezing Rain	
106	3	3-Apr-01	12:35:30	12:39:35	LYON. ARCO PLUS-ST. (TI)	10°	1a	4.1	25.2	-10	Light Freezing Rain	
75	5	3-Apr-01	16:27:05	16:32:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	5.4	12.6	-10	Light Freezing Rain	
76	5	3-Apr-01	16:28:35	16:33:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	4.9	12.9	-10	Light Freezing Rain	
321	3	6-Apr-01	12:11:10	12:18:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	6.8	5.3	-25	Freezing Fog	
322	3	6-Apr-01	12:14:10	12:21:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	7.3	4.5	-25	Freezing Fog	
309	4	6-Apr-01	15:01:30	15:16:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	15.0	1.7	-25	Freezing Fog	
310	4	6-Apr-01	15:02:20	15:17:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	14.7	1.6	-25	Freezing Fog	
265	5	9-Apr-01	17:48:00	17:56:20	LYON. ARCO PLUS-ST. (TI)	10°	1a	8.3	4.7	-10	Freezing Fog	
266	5	9-Apr-01	17:48:40	17:57:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	8.3	4.9	-10	Freezing Fog	
261	6	9-Apr-01	18:48:30	19:02:00	LYON. ARCO PLUS-ST. (TI)	10°	1a	13.5	1.7	-10	Freezing Fog	

SIMULATED FREEZING PRECIPITATION AT CEF-NRC (OTTAWA) FOR 2000-01 SEASON

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution	Fluid Type	Fail Time (min)	Actual Rate of Precip (g/dm²/h)	Ambient Temp (°C)	Precipitation (Type)	comments
262	6	9-Apr-01	18:49:10	19:02:30	LYON. ARCO PLUS-ST. (TI)	10°	1a	13.3	1.7	-10	Freezing Fog	
343	3	29-Mar-01	14:33:00	14:41:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	8.0	4.6	1	Cold Soak Box	
344	3	29-Mar-01	14:54:25	15:02:30	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	8.1	4.9	1	Cold Soak Box	
363	2	30-Mar-01	10:46:10	10:48:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	1.8	78.6	1	Cold Soak Box	
364	3	30-Mar-01	11:07:00	11:08:45	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	1.8	78.5	1	Cold Soak Box	
212	2	2-Apr-01	13:13:30	13:18:15	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	4.8	12.2	-10	Freezing Drizzle	
211	2	2-Apr-01	12:59:30	13:04:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	4.5	12.4	-10	Freezing Drizzle	
192	4	2-Apr-01	16:57:45	17:04:45	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	7.0	4.6	-10	Freezing Drizzle	
191	4	2-Apr-01	16:51:50	16:58:25	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	6.6	4.8	-10	Freezing Drizzle	
108	3	3-Apr-01	12:33:50	12:37:20	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	3.5	24.5	-10	Light Freezing Rain	
107	3	3-Apr-01	12:30:40	12:34:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	3.3	24.8	-10	Light Freezing Rain	
77	5	3-Apr-01	16:20:15	16:25:05	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	4.8	12.5	-10	Light Freezing Rain	
78	5	3-Apr-01	16:20:50	16:25:55	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	5.1	12.7	-10	Light Freezing Rain	
323	2	6-Apr-01	12:05:00	12:09:45	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	4.8	5.3	-25	Freezing Fog	
324	2	6-Apr-01	12:07:40	12:12:50	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	5.2	4.5	-25	Freezing Fog	
311	4	6-Apr-01	14:59:30	15:09:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	9.5	1.6	-25	Freezing Fog	
312	4	6-Apr-01	15:00:35	15:10:00	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	9.4	1.6	-25	Freezing Fog	
267	5	9-Apr-01	17:46:20	17:53:30	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	7.2	4.7	-10	Freezing Fog	
268	5	9-Apr-01	17:47:10	17:54:30	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	7.3	4.7	-10	Freezing Fog	
263	6	9-Apr-01	18:47:30	18:57:30	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	10.0	1.7	-10	Freezing Fog	
264	6	9-Apr-01	18:48:00	18:58:30	NEWAVE AEROCH. FCY-1A (TI)	10°	1a	10.5	1.9	-10	Freezing Fog	
27	3	4-Jun-01	20:40:20	21:15:00	Otagon MAXFLIGHT	50	4a	34.7	13.7	-3	Freezing Drizzle	
28	3	4-Jun-01	20:42:00	21:19:30	Otagon MAXFLIGHT	50	4a	37.5	12.6	-3	Freezing Drizzle	
21	4	4-Jun-01	17:24:00	18:40:00	Otagon MAXFLIGHT	50	4a	76.0	4.6	-3	Freezing Drizzle	
22	4	4-Jun-01	17:24:30	18:27:00	Otagon MAXFLIGHT	50	4a	62.5	5.0	-3	Freezing Drizzle	
79	4	4-Jun-01	17:25:30	18:36:00	Otagon MAXFLIGHT	50	4a	70.5	5.3	-3	Freezing Drizzle	
71	11	6-Jun-01	15:59:00	17:00:00	Otagon MAXFLIGHT	50	4a	61.0	4.2	-3	Freezing Fog	
72	11	6-Jun-01	16:05:00	16:50:00	Otagon MAXFLIGHT	50	4a	45.0	4.7	-3	Freezing Fog	
91	11	6-Jun-01	16:21:00	17:34:00	Otagon MAXFLIGHT	50	4a	73.0	4.7	-3	Freezing Fog	
92	11	6-Jun-01	17:35:00	18:28:00	Otagon MAXFLIGHT	50	4a	53.0	4.4	-3	Freezing Fog	
65	12	6-Jun-01	10:39:00	12:30:00	Otagon MAXFLIGHT	50	4a	111.0	2.1	-3	Freezing Fog	
66	12	6-Jun-01	10:38:00	12:26:00	Otagon MAXFLIGHT	50	4a	108.0	2.4	-3	Freezing Fog	

SIMULATED FREEZING PRECIPITATION AT CEF-NRC (OTTAWA) FOR 2000-01 SEASON

Test #	Form #	Date	Start Time (hh:mm:ss)	End Time (hh:mm:ss)	Fluid Name	Fluid Dilution	Fluid Type	Fail Time (min)	Actual Rate of Precip (g/dm²/h)	Ambient Temp (°C)	Precipitation (Type)	comments
86	12	6-Jun-01	10:37:00	12:04:00	Otagon MAXFLIGHT	50	4a	87.0	2.2	-3	Freezing Fog	
87	12	6-Jun-01	12:04:00	13:36:00	Otagon MAXFLIGHT	50	4a	92.0	1.9	-3	Freezing Fog	
48	9	5-Jun-01	20:31:30	20:57:00	Otagon MAXFLIGHT	50	4a	25.5	24.3	-3	Freezing Rain	
47	9	5-Jun-01	20:30:30	20:55:00	Otagon MAXFLIGHT	50	4a	24.5	25.2	-3	Freezing Rain	
41	10	5-Jun-01	18:24:30	19:00:00	Otagon MAXFLIGHT	50	4a	35.5	12.3	-3	Freezing Rain	
42	10	5-Jun-01	18:27:00	19:05:00	Otagon MAXFLIGHT	50	4a	38.0	12.5	-3	Freezing Rain	
7	1	4-Jun-01	11:27:50	11:47:00	Otagon MAXFLIGHT	75	4b	19.2	72.2	1	Cold Soak Box	
8	1	4-Jun-01	11:28:50	11:48:45	Otagon MAXFLIGHT	75	4b	19.9	70.5	1	Cold Soak Box	
3	2	4-Jun-01	13:51:20	16:08:00	Otagon MAXFLIGHT	75	4b	136.7	5.2	1	Cold Soak Box	no failure after 2 hours
4	2	4-Jun-01	13:52:00	16:08:00	Otagon MAXFLIGHT	75	4b	136.0	5.2	1	Cold Soak Box	no failure after 2 hours
26	3	4-Jun-01	20:24:00	22:15:00	Otagon MAXFLIGHT	75	4b	111.0	12.6	-3	Freezing Drizzle	
25	3	4-Jun-01	20:24:30	22:16:10	Otagon MAXFLIGHT	75	4b	111.7	13.3	-3	Freezing Drizzle	
19	4	4-Jun-01	17:23:00	19:23:00	Otagon MAXFLIGHT	75	4b	120.0	5.0	-3	Freezing Drizzle	no failure after 2 hours
20	4	4-Jun-01	17:12:30	19:13:00	Otagon MAXFLIGHT	75	4b	120.5	5.1	-3	Freezing Drizzle	no failure after 2 hours
81	4	4-Jun-01	17:13:00	19:13:00	Otagon MAXFLIGHT	75	4b	120.0	5.2	-3	Freezing Drizzle	no failure after 2 hours
69	11	6-Jun-01	16:03:00	18:21:00	Otagon MAXFLIGHT	75	4b	138.0	5.0	-3	Freezing Fog	
70	11	6-Jun-01	16:04:00	17:59:00	Otagon MAXFLIGHT	75	4b	115.0	5.2	-3	Freezing Fog	
89	11	6-Jun-01	15:57:00	17:52:00	Otagon MAXFLIGHT	75	4b	115.0	5.0	-3	Freezing Fog	
90	11	6-Jun-01	15:58:00	18:08:00	Otagon MAXFLIGHT	75	4b	130.0	4.9	-3	Freezing Fog	
63	12	6-Jun-01	10:31:00	14:12:00	Otagon MAXFLIGHT	75	4b	221.0	1.9	-3	Freezing Fog	
64	12	6-Jun-01	10:32:00	13:35:00	Otagon MAXFLIGHT	75	4b	183.0	2.0	-3	Freezing Fog	
85	12	6-Jun-01	10:33:00	13:41:00	Otagon MAXFLIGHT	75	4b	188.0	2.1	-3	Freezing Fog	
59	13	7-Jun-01	14:18:00	14:52:00	Otagon MAXFLIGHT	75	4b	34.0	5.0	-14	Freezing Fog	
60	13	7-Jun-01	14:19:00	14:52:00	Otagon MAXFLIGHT	75	4b	33.0	4.5	-14	Freezing Fog	
55	14	7-Jun-01	16:39:00	17:44:00	Otagon MAXFLIGHT	75	4b	65.0	2.0	-14	Freezing Fog	

APPENDIX L

PRELIMINARY REPORT
METHODOLOGY TO RE-CATEGORIZE
FLUID HOLDOVER TIME TABLES

1. INTRODUCTION

Two sets of guidelines currently exist in the aviation industry for anti-icing purposes, the Fluid-Specific Fluid Holdover Time Guidelines and the Generic Fluid Holdover Time Guidelines. Fluid-Specific Fluid Holdover Time Guidelines are tables that provide holdover time guidance to aircraft operators as to the duration of time available after an aircraft is de/anti-iced with a specific fluid prior to takeoff. There exist fluid-specific tables for several fluids in the industry. Generic Fluid Holdover Time Guidelines are tables that encompass the entire range of fluids available in the market. These tables provide the lowest/most conservative time duration available for an aircraft operator.

Three types of de/anti-icing fluids currently exist in the industry. Type I fluids are used as deicing agents that remove the contaminant of the aircraft's surface. Type II and Type IV fluids are anti-icing fluids that protect the aircraft's surface from precipitation. This report will focus on Type II and Type IV fluids only.

As new products are constantly being introduced into the market, the number of fluid-specific tables continues to increase. This has caused some concern in the industry. In addition, the Generic Fluid Holdover Time Guidelines are annually changed to encompass the new fluids that are introduced into the market. This report will provide a method that would reduce the number of Holdover Time Guidelines that exist in the industry.

1.1 Types of Fluid Guidelines

The Generic HOT Guidelines provide guidance in cases where the pilot is not aware of the fluid being used. There are two generic tables for the two anti-icing fluid types that exist:

- Generic Type II Fluid Holdover Time Guidelines
- Generic Type IV Fluid Holdover Time Guidelines

The Generic HOT guidelines have been used in the industry for many years. The values that are represented in the Generic HOT Guidelines are based on the lowest value obtained when HOT tests are conducted on the various fluids that are being used in the market. Introduction of new fluids to the market could have an effect on the values represented in the Generic HOT guidelines.

Seasoned pilots and operators use Fluid-Specific Fluid Holdover Time Guidelines. If a pilot is aware of the fluid that is being used on the aircraft, utilizing the fluid-specific tables will extend the window of time available for takeoff since the fluid specific tables portray the true capability of a specific product rather than the minimum, most conservative estimate of a fluid's holdover time at a particular temperature under a specific condition. Major airlines view the fluid-specific tables as a cost-efficient tool. Nine Fluid-Specific Holdover Time Guidelines exist:

Type II Fluids

- Kilfrost ABC-II Plus
- Clariant Safewing MPII 1951

Type IV Fluids

- Clariant Safewing MPIV 1957
- Clariant Safewing MPIV 2001
- Clariant Safewing Four
- Kilfrost ABC-S
- Octagon Maxflight
- SPCA AD-480
- UCAR Ultra +

Two more fluid-specific tables have been developed this year (for use in winter 2001-2002) for the following fluids:

- Type II - SPCA Ecowing 26
- Type IV - Clariant Safewing MPIV Protect 2012

1.2 Issues with the Current Situation

Every year, typically two or three new products are introduced to the market. Every new product that is introduced undergoes a series of holdover time tests. This process produces a fluid-specific table that is added to the HOT tables used in the industry. In addition, if the product fails to generate values that are superior to those reported in the Generic HOT Guidelines, the times in the generic guidelines are reduced to include the new product. This practice has the effect of constantly reducing the values represented in the Generic HOT Guidelines.

The constant changes to the Generic HOT Guidelines have prompted a discussion within the aviation industry that suggested freezing the Generic HOT Guidelines. Freezing the Generic HOT Guidelines will lock the minimum HOT values and therefore create a situation in which any new fluid introduced to the market will not be represented in the generic tables if it fails to generate holdover times that are superior to all the generic values.

The current generic tables are almost identical (Type II and Type IV). Some fluids are bad performers that are making the Type IV almost identical to

Type II. This is the reason the fluid-specific tables exist. Seasoned pilots will not use the Generic HOT Guidelines because they are not cost efficient since they penalize the high performers.

To summarize:

- Too many tables exist and the number of tables that exist will continue to grow.
- Levels of performance should be determined in which the high and the low performing fluids are identified and distinguished.

1.3 OBJECTIVES

This report will attempt to address the issues outlined in Section 1.2 and suggest one comprehensive method that will:

- Reduce the number of HOT tables; and
- Identify/segregate the high performers and the low performers.

The product of this report will be a set of three tables that will address these two points.

2. METHODOLOGY AND DATA REVIEW

2.1 Data Identification

The format of the holdover timetables divides the weather conditions in which anti-icing operations are carried out into six distinct categories occurring in five temperature zones. This combination creates 19 precipitation conditions. Within each temperature zone fluid dilutions are further subdivided to provide a matrix comprising 45 cells. Within each cell, two numbers are indicated, an upper limit holdover time value and a lower limit holdover time value.

For the purpose of this report, the upper limit holdover time values and the lower limit holdover time values will be called a table's *attributes*. The basic idea behind this analysis is to plot a line graph of all the *attributes* in one fluid-specific table and then compare this line graph with the 12 other line graphs created from the other 10 fluid-specific tables and the two generic tables (there are 11 fluid-specific tables in total).

Only 36 of the 45 cells will be analysed. Nine cells will not be analysed because the values within those cells of each table are identical. These nine cells belong to the frost condition. Since each cell contains two values, an upper limit holdover time value and a lower limit holdover time value, 72 attributes could be analysed in each table.

Analysis of the 72 attributes of 11 fluids can be complex, and various methods can be used to reduce the number of attributes per table to simplify the clustering process.

2.2 Data Extraction

The main objective of this analysis is the creation of a small set of tables that will encompass all the tables that currently exist in the market while separating the high performers from the low performers.

Data was extracted from the following tables:

1. Generic Type II Fluid Holdover Time Guidelines;
2. Generic Type IV Fluid Holdover Time Guidelines;
3. Kilfrost ABC-II Plus;
4. Clariant Safewing MPII 1951;
5. SPCA Ecowing 26;
6. Clariant Safewing MPIV 1957;
7. Clariant Safewing MPIV 2001;
8. Clariant Safewing Four;
9. Clariant Safewing MP IV Protect 2012;
10. Kilfrost ABC-S;
11. Octagon Maxflight;
12. SPCA AD-480; and
13. UCAR Ultra +

The values displayed in the tables were extracted in the form of HH:MM and converted to minutes in a log that was developed. The log contains the 72 attributes of each of the 11 fluid-specific tables and the two generic tables.

2.3 Selection of Important Attributes

The important attributes were identified based on a survey of airlines, which analyses the distribution of deicing operations, i.e. how many times in a year does a *precipitation condition* re-occur that requires deicing operations. This is calculated as a percentage of the total number of operations and is displayed in each of the 19 *precipitation conditions* in the holdover time format. The responses from the survey provided a total of 17,517 anti-icing operations for 7 major hub locations (Table L-1).

The data reveals that the analysis should be focused on two cells: SNOW 0°C to -3°C and SNOW below -3°C to -14°C (Neat Fluid), which comprise about 50% of all operations. The frost condition (about 33% of all operations) is not part of the analysis because the values in the frost condition on all the fluid-specific tables and generic tables are identical. These two groups of precipitation conditions represent 76% of all operations that are relevant to this analysis.

Previously, an analysis was conducted using all five cells including dilutions contained in the two snow precipitation conditions identified. The grouping of fluids using all five cells was identical to the grouping that is recommended in this report. Therefore, this report will concentrate on the two cells that are of interest to North American airports, and these are the ones that utilize fluids in their NEAT form. These cells each contain two values:

- Snow 0º to -3º 100/0 U (upper limit)
- Snow 0º to -3º 100/0 L (lower limit)
- Snow below -3º to -14º 100/0 U (upper limit)
- Snow below -3º to -14º 100/0 L (lower limit)

This will reduce the number of attributes chosen to represent each holdover timetable to four essential attributes.

2.4 Data Selection

The four essential attributes identified were extracted from each holdover time table and plotted in a line graph. Once the graph was plotted, clusters where then identified and separated. A cluster is a group of holdover time tables that reveal, once plotted in line graphs, that they are closely related.

Once a cluster was identified, the minimum value of each of the 72 attributes in the cluster of tables was used as the defining value (holdover time) of the table that would be used to identify and describe the cluster.

TABLE L-1 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S)

SUMMARY OF ALL AIRPORTS

Total # of Deicing Operations: *17517* **Type I included** NO **All values are estimates:**

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Weather Conditions: FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER RIME ICE	Total
above 0º	above 32º	100/0 75/25 50/50	5.5%	0.0%	6.0%	0.3%	0.2%	0.5%	0.0%	12.6%
0 to -3	32 to 27	100/0 75/25 50/50	22.1%	1.1%	26.6%	1.0%	1.8%		0.2%	52.9%
below -3 to -14	below 27 to 7	100/0 75/25	4.8%	0.6%	24.9%	2.0%	1.0%		0.0%	33.3%
below -14 to -25	below 7 to -13	100/0	0.1%	0.0%	1.1%				0.0%	1.2%
below -25	below -13	100/0	0.0%	0.0%	0.0%				0.0%	0.0%
Total			32.6%	1.7%	58.5%	3.3%	3.1%	0.5%	0.3%	

100.0% **of Operations**

M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: Table L-1

3. ANALYSIS AND OBSERVATIONS

3.1 Phase 1 – Is There a Need to Conduct the Analysis?

As mentioned Section 1.2, the two generic fluid holdover time guidelines that currently exist are almost identical. This can be seen in Figure L-1, which plots the values of the four essential attributes that have been chosen for use in this analysis. As can be seen from the graph, the maximum duration difference that exists between the two line graphs is 10 minutes.

The need to conduct the analysis can be further justified when all Type II fluids, Type IV fluids and the generic fluid holdover guidelines are plotted in Figure L-2, which shows:

a) Type II fluids cannot be easily distinguished from Type IV fluids.

b) There is a significant spread between the fluids (minimum of 30 minutes and maximum of 70 minutes). Some of the fluids in the plot are better performers than other fluids of the same fluid type.

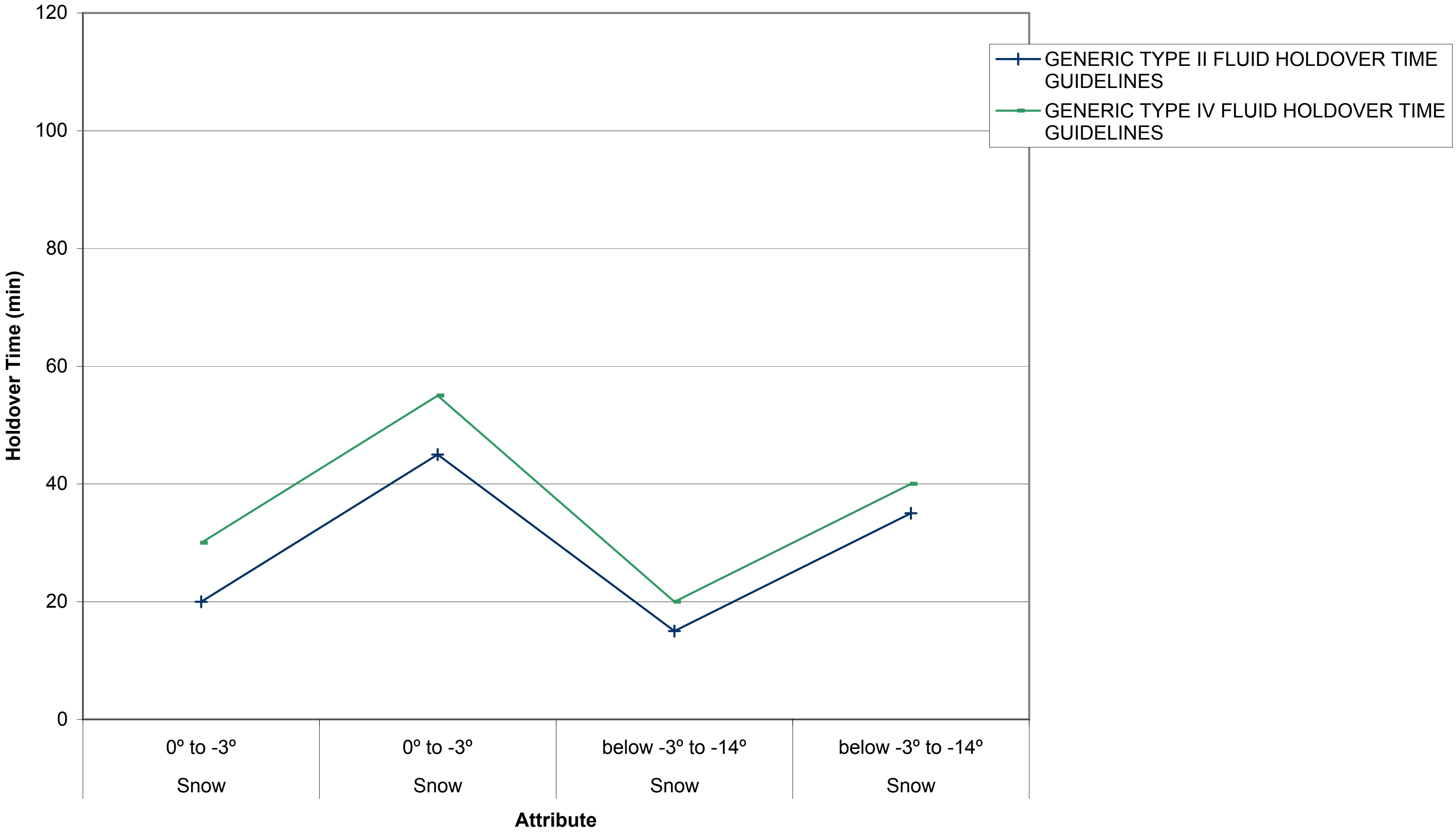
c) There is a significant difference in the performance of Kilfrost ABC-S when compared to the Generic Type IV Guidelines.

Figure L-3 is a plot of all Type II fluids and the generic Type II guideline. Figure L-4 is a plot of all Type IV fluids and the generic Type IV guideline. When comparing Figure L-3 to L-4, it can be seen that, while the Generic Type II Guideline may be an adequate representation of all Type II fluids under the four values being studied, there is a wide spread in the performance of the Type IV fluids.

3.2 Phase 2 – Identifying the Groups of Fluids

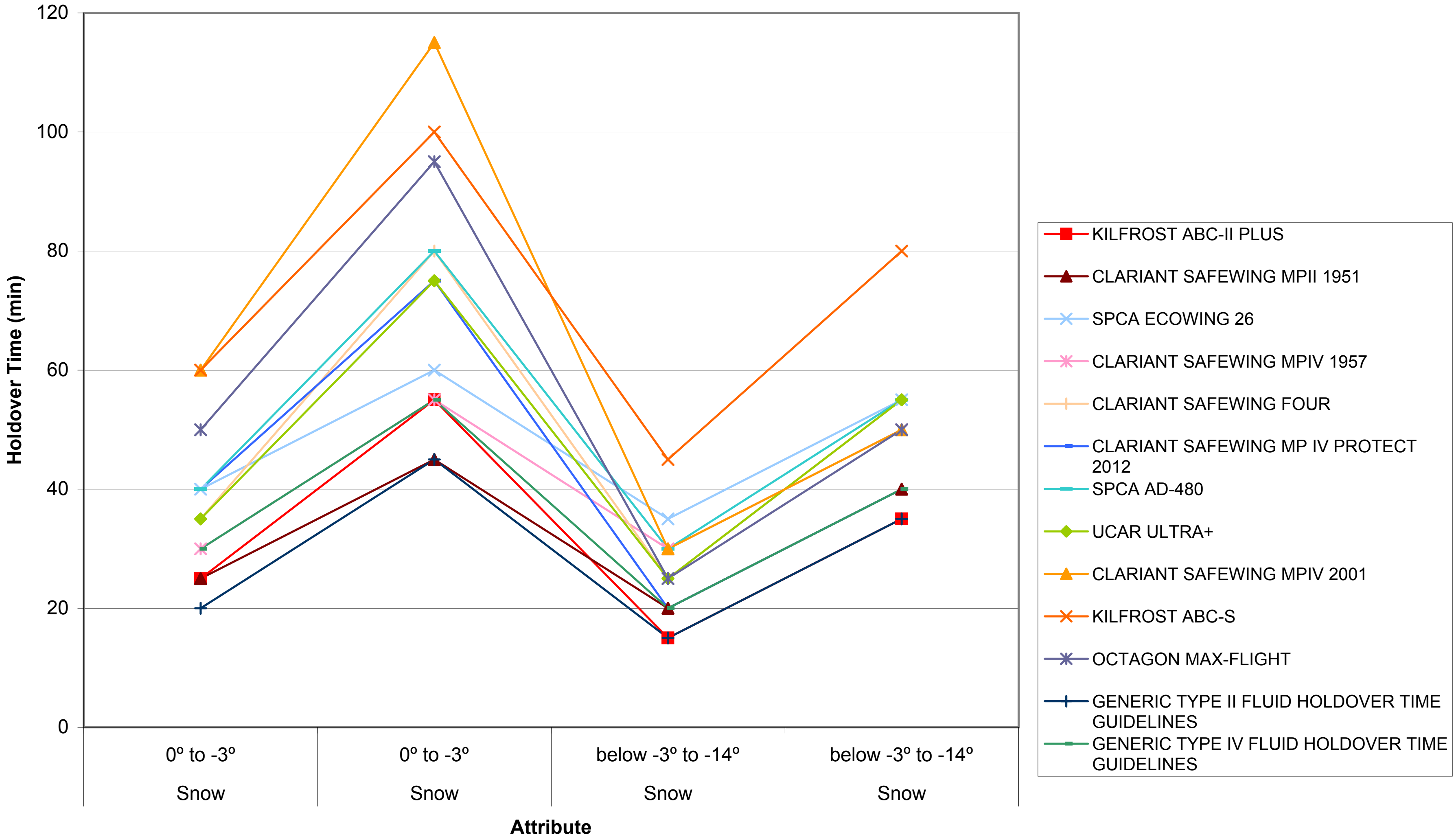
The analysis was then conducted while looking at all the fluids on one line graph and disregarding the type of fluid. Visually, the fluids where separated into three groups, low performers (Group A), medium performers (Group B) and high performers (Group C). Once the groups were formed, a line graph was generated to represent each group. This line graph was made up of the minimum value that exists under each essential attribute of the fluids that exist in the group (Figure L-5).

FIGURE L-1
GENERIC TYPE II AND TYPE IV FLUID HOLDOVER GUIDELINES



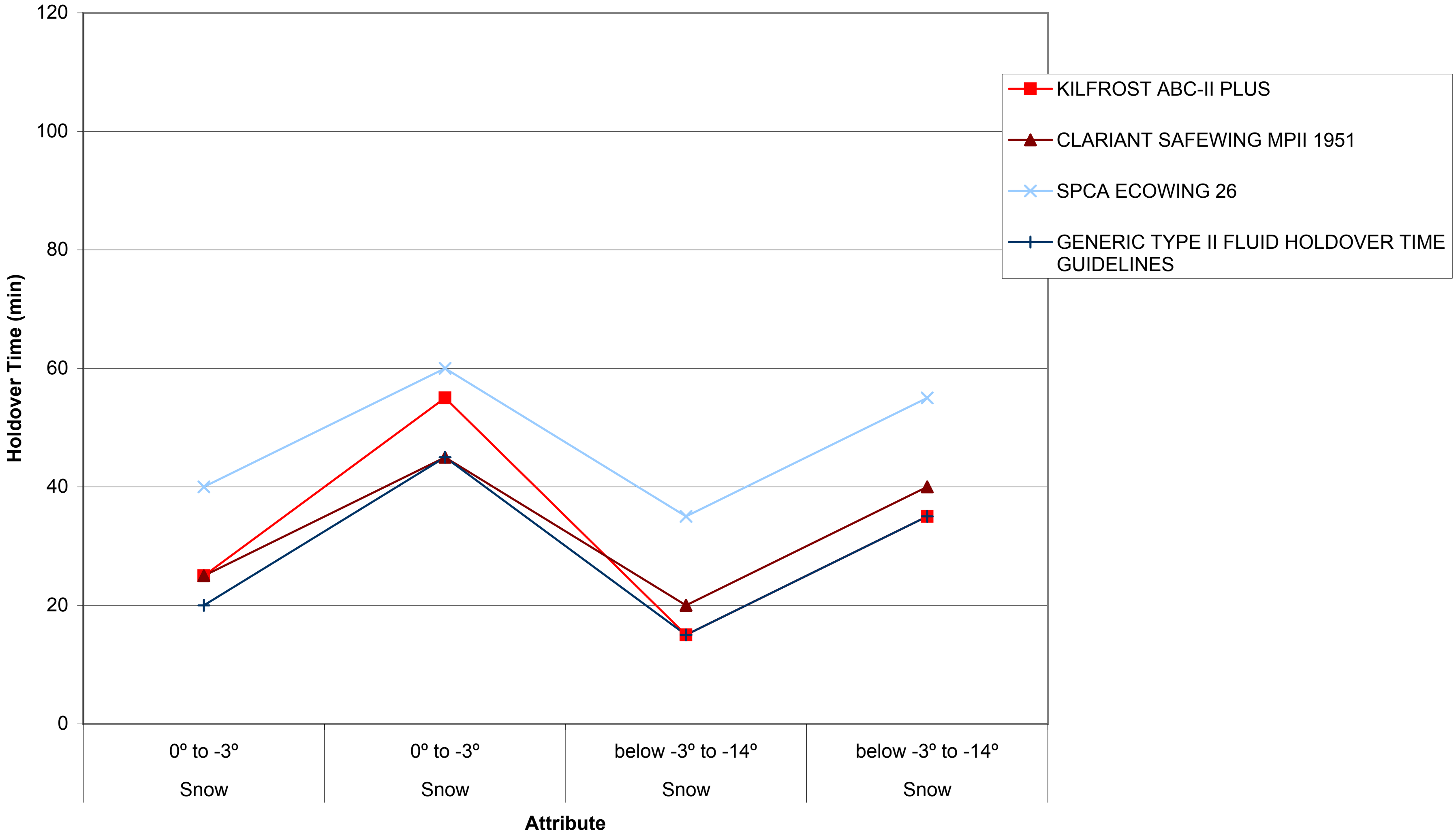
M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: 1 -GEN Type II & GEN Type IV

FIGURE L-2
ALL FLUIDS AND GENERIC TYPE II AND TYPE IV FLUID HOLDOVER GUIDELINES



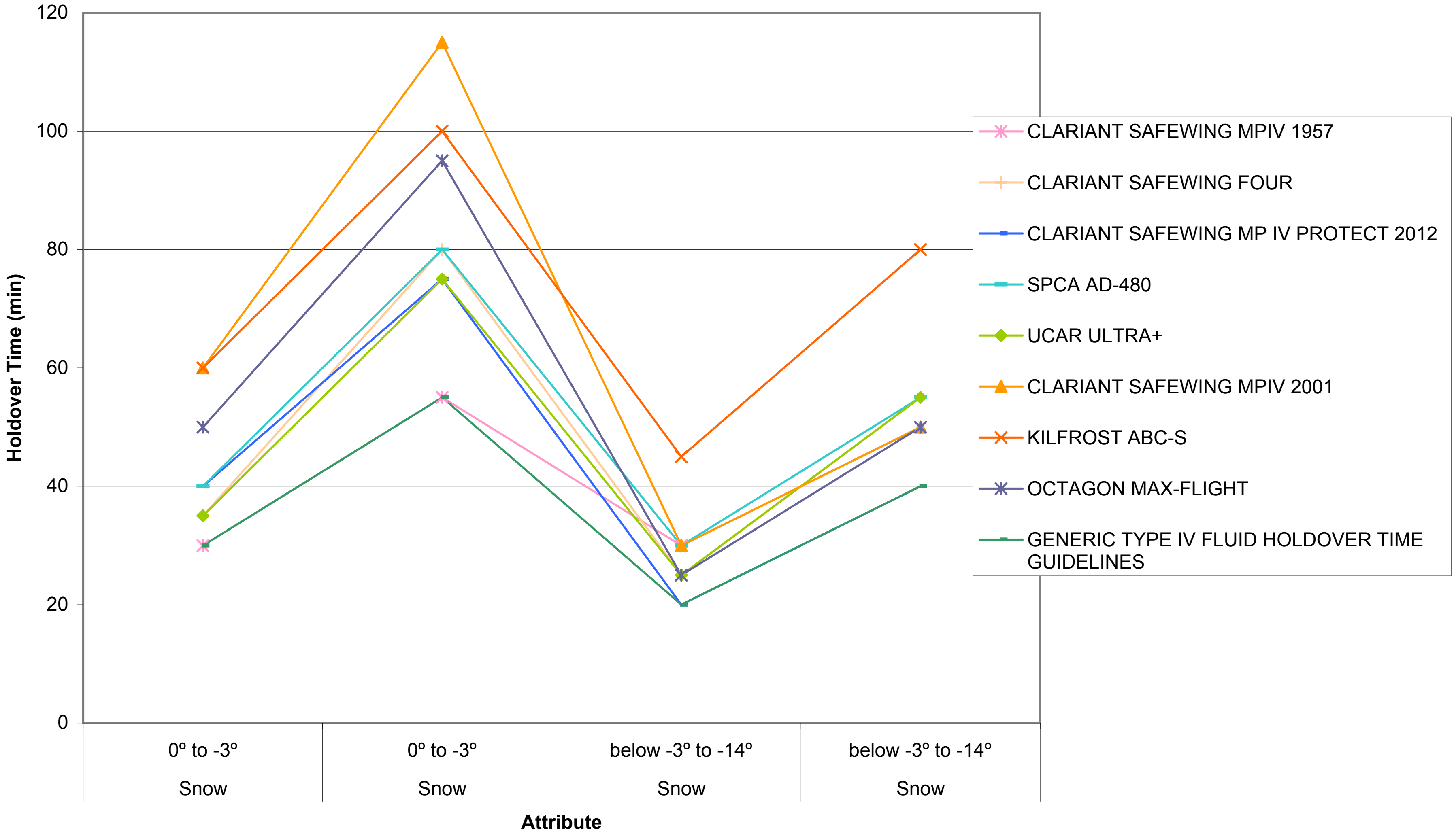
M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: 2a-All Fluids & GEN Type II &IV

FIGURE L-3
TYPE II FLUIDS COMPARED TO GENERIC TYPE II FLUID HOLDOVER GUIDELINE



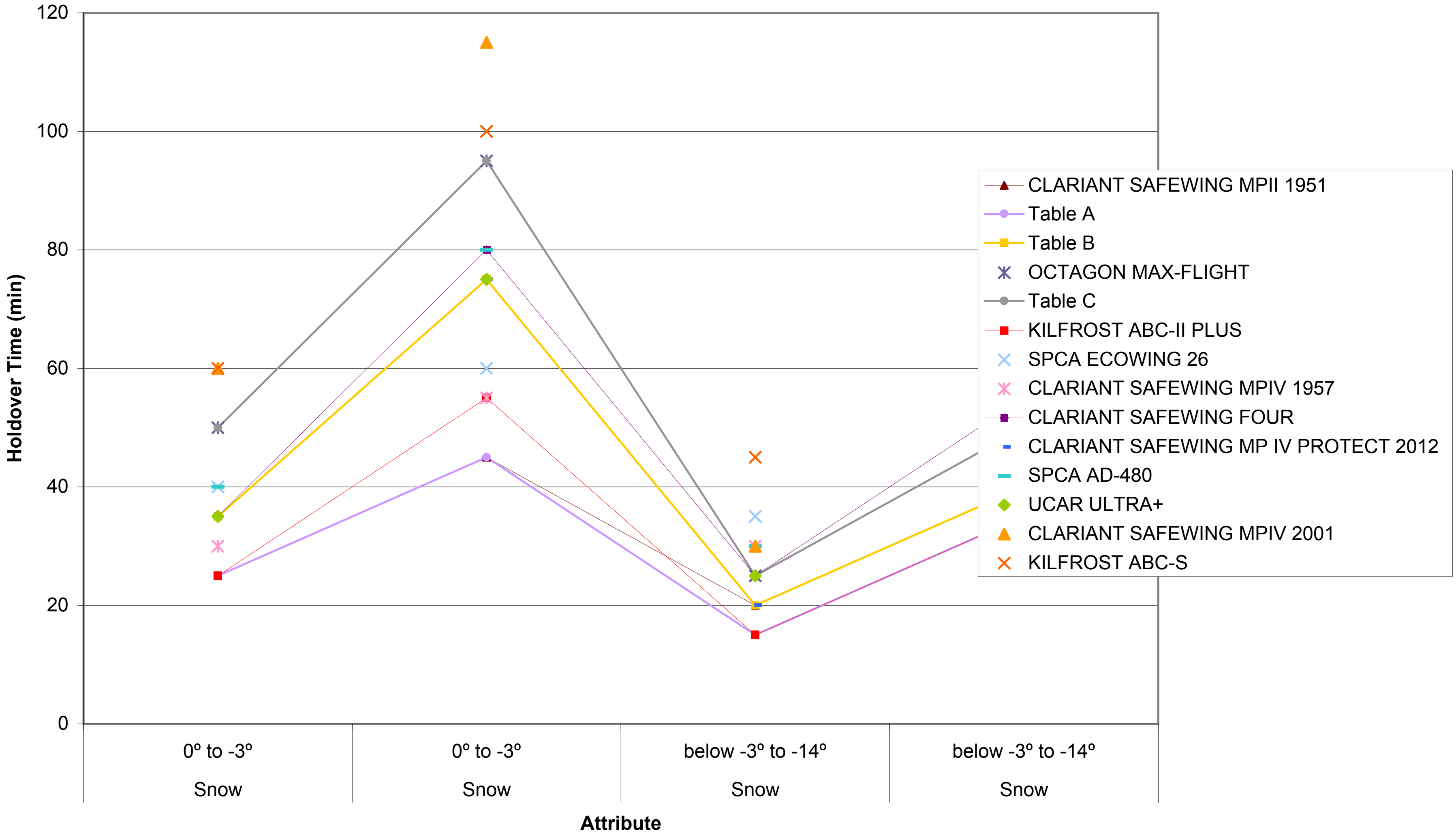
IM\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: 3 -Type II Fluids & GEN TYPE II

FIGURE L-4
TYPE IV FLUIDS COMPARED TO GENERIC TYPE IV FLUID GUIDELINE



M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: 4 -Type IV Fluids & GEN Type IV

FIGURE L-5
ALL FLUIDS AND TABLES A, B, AND C



IM\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT: 5 -All Fluids & Tables A, B &C

It was observed that the following fluids are closely related in performance under the essential attributes that were chosen for this analysis:
Low Performers:

- Kilfrost ABC-II Plus
- Clariant Safewing MPII 1951
- SPCA Ecowing 26
- Clariant Safewing MPIV 1957

Table A was created and plotted to encompass and represent this group of fluids (Figure L-6)

Medium Performers

- Clariant Safewing Four
- Clariant Safewing MP IV Protect 2012
- SPCA AD-480
- UCAR Ultra +

Table B was created and plotted to encompass and represent this group of fluids (Figure L-7)

High Performers

- Clariant Safewing MPIV 2001
- Kilfrost ABC-S
- Octagon Maxflight

Table C was created and plotted to encompass and represent this group of fluids (Figure L-8)

3.3 Phase 3 – How Valid are These Groups?

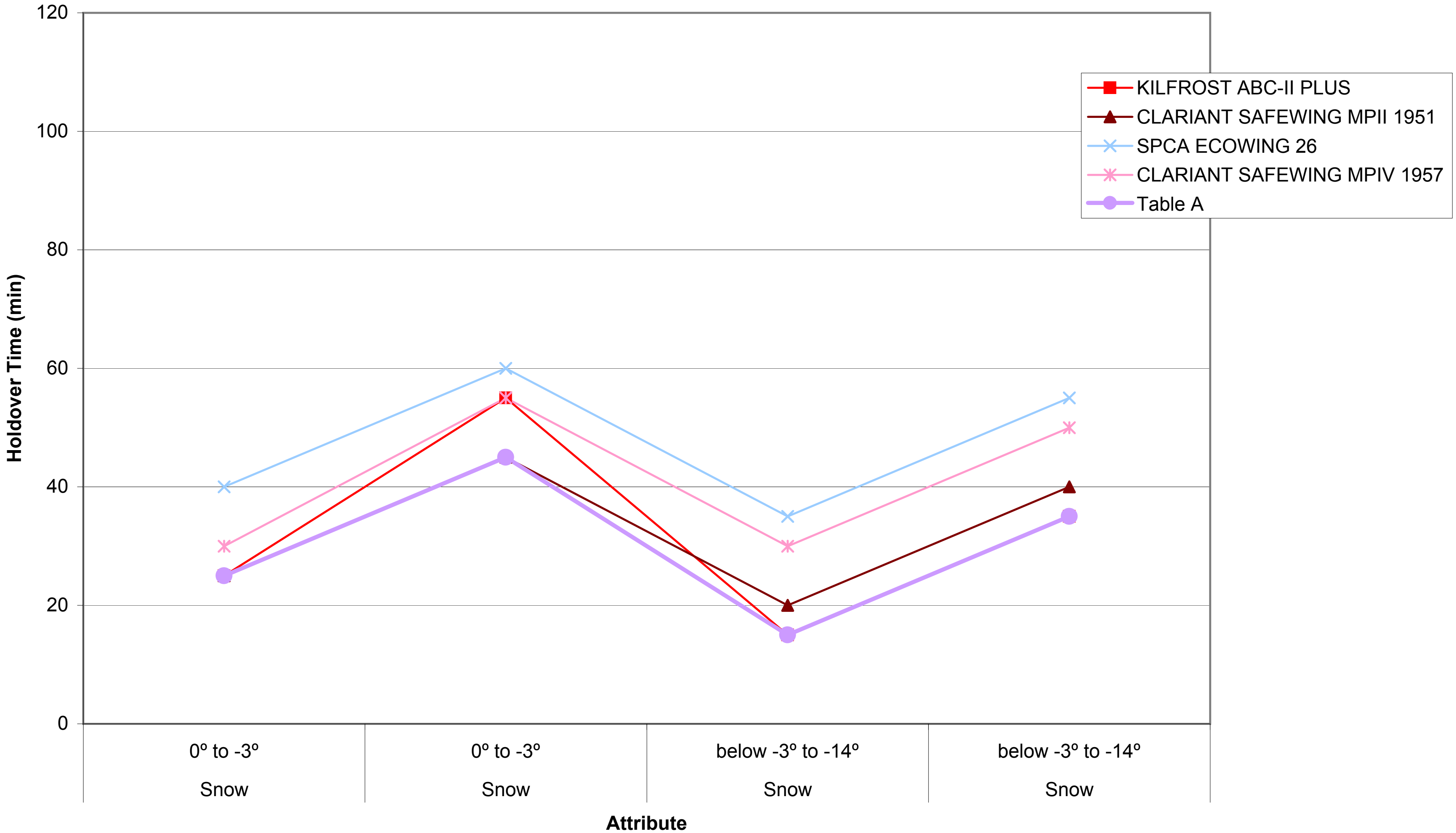
It can be seen that the three groupings that have been established are distinct from each other (Figure L-9). When the three groupings are compared to the two Generic Fluid Holdover Guidelines, a significant difference exists between the Generic Guidelines and the three grouping/tables (Figure L-10).

3.4 Phase 4 – Creation of the Tables

To create the new sets of tables that address the objectives of this report, attributes of a set of fluids in one specific group were compared to one another and the minimum value that exists within the set for a specific attribute was extracted and used to generate the table.

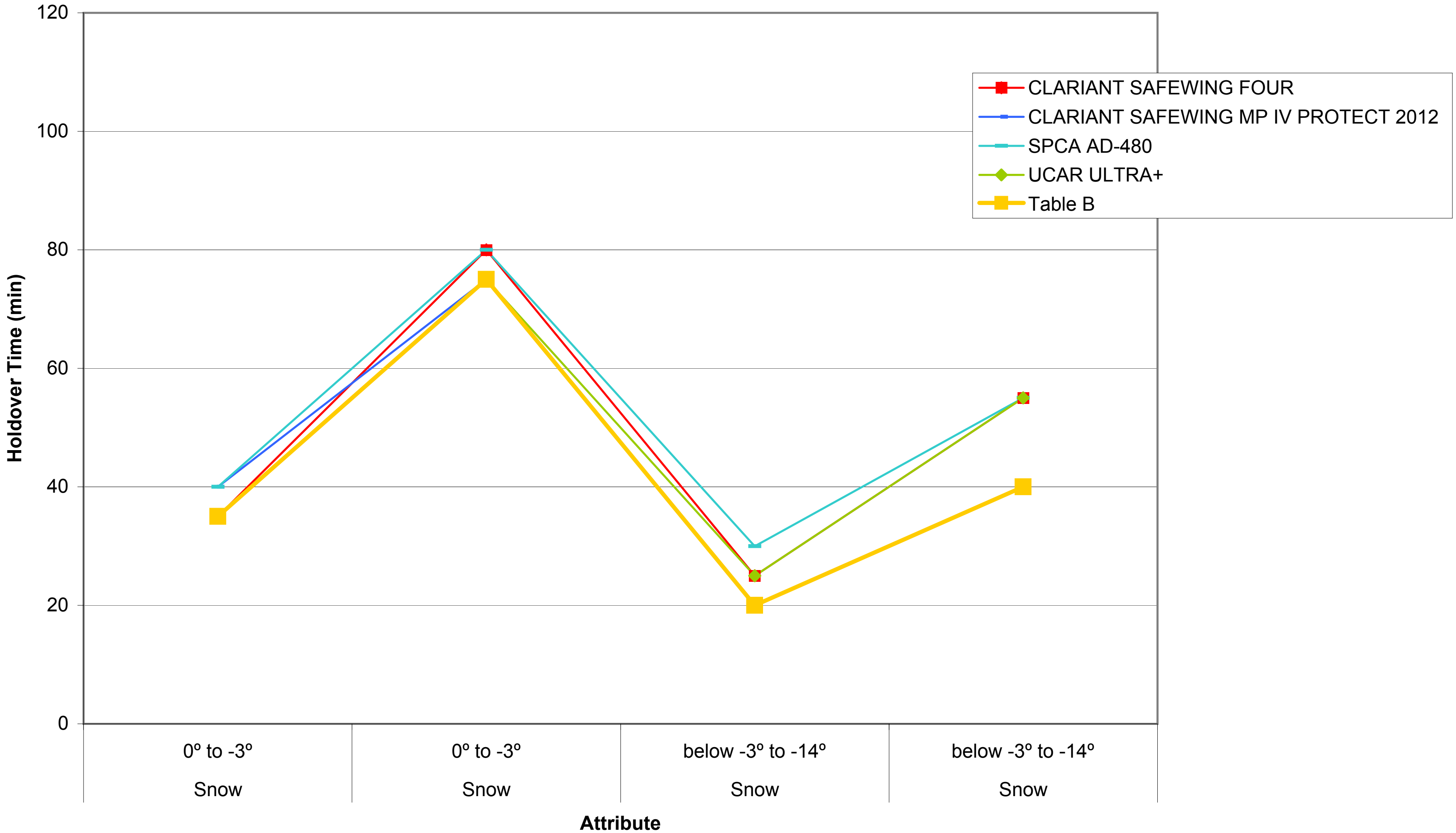
The three tables that were generated based on the lowest value of a set of fluids are represented in Section 3.5.

FIGURE L-6
FLUIDS AND TABLE A



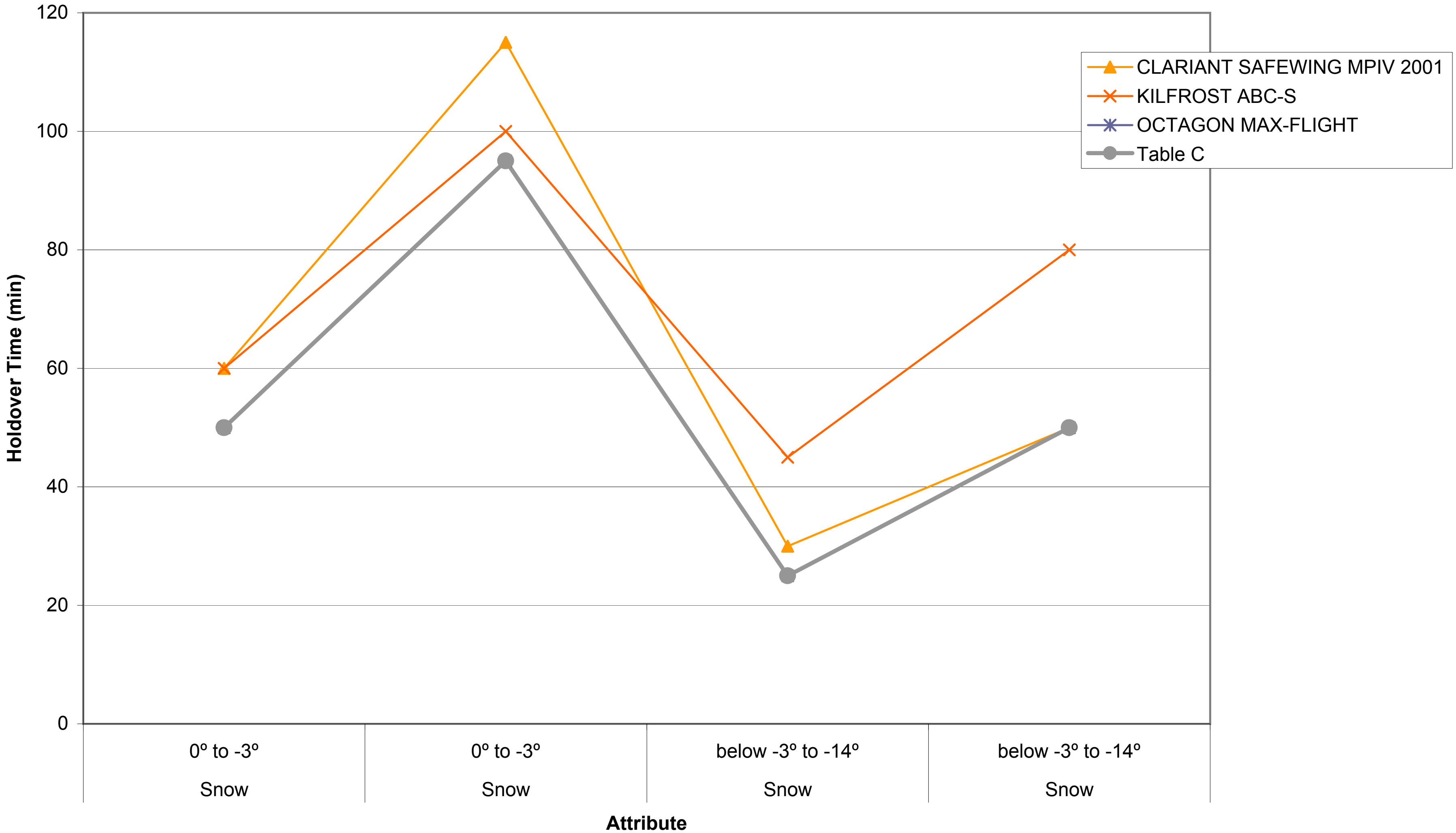
M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT:6 -Fluids & Table A

FIGURE L-7
FLUIDS AND TABLE B



M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT:7- Fluids & Table B

FIGURE L-8
FLUIDS AND TABLE C



M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT:8 -Fluids & Table C

FIGURE L-9
TABLE A, B AND C

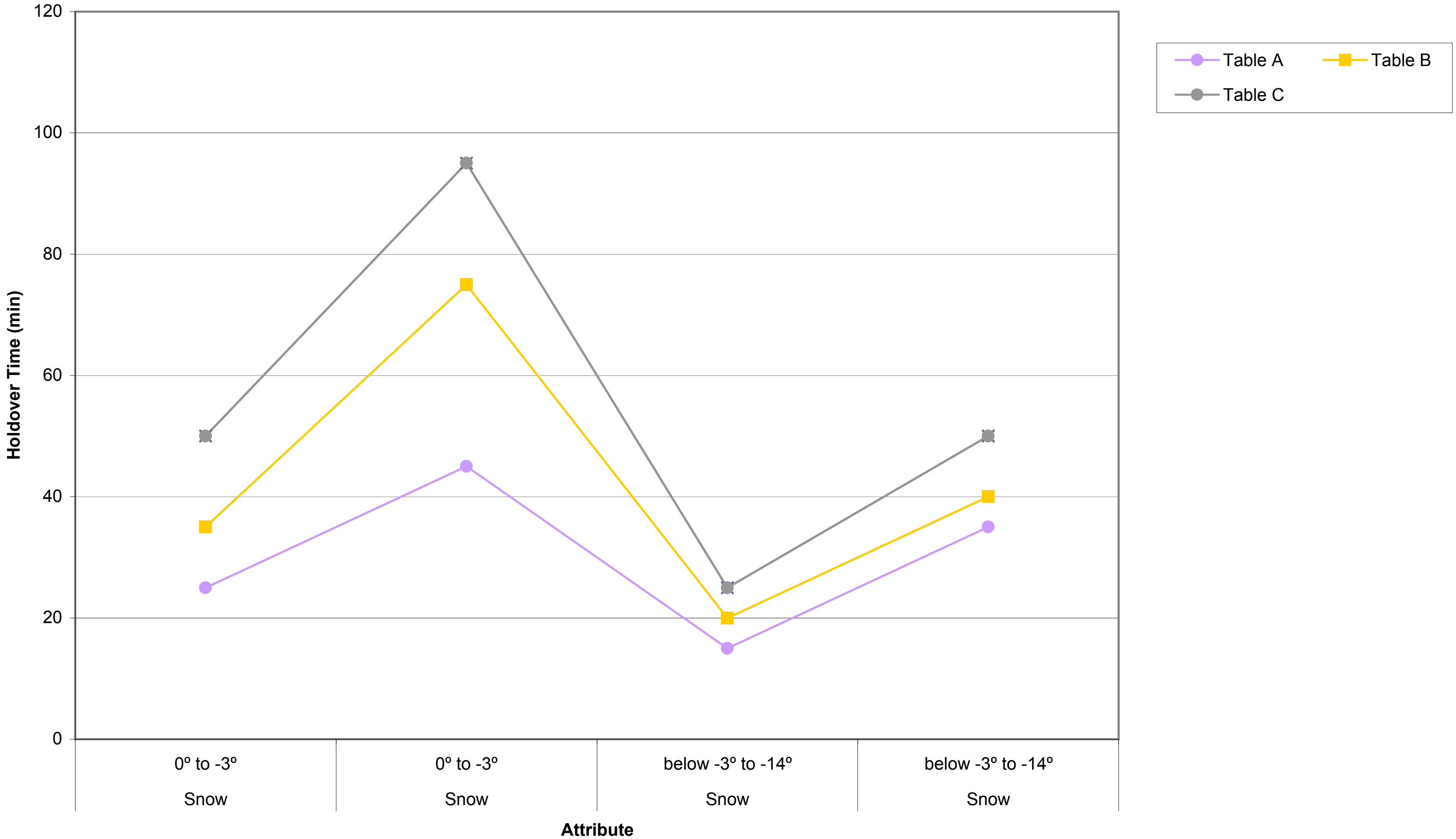
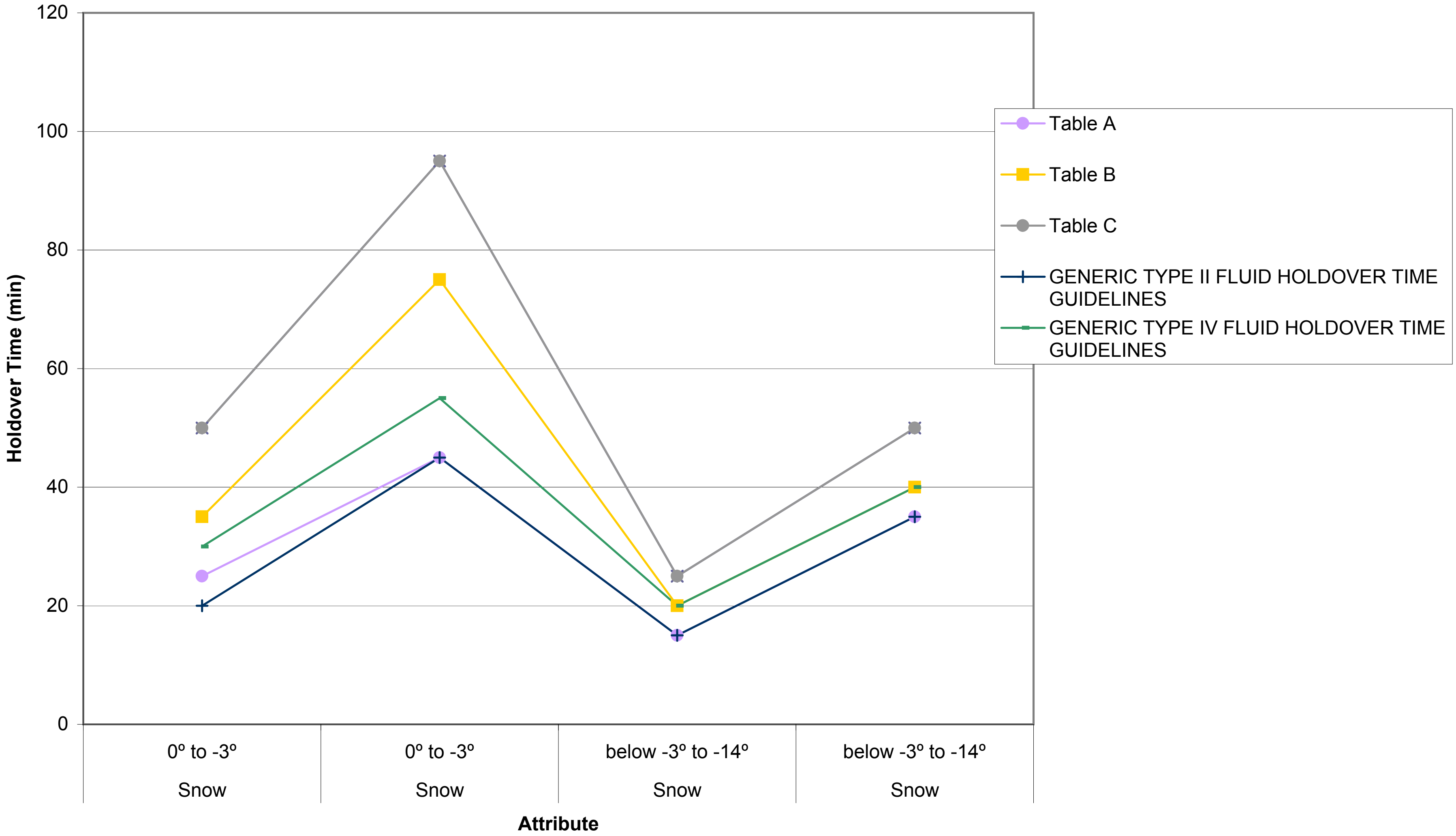


FIGURE L-10
TABLE A, B, C COMPARED TO TYPE II AND TYPE IV FLUID HOLDOVER TIME GUIDLINES



M\Groups\CM1680 (exBM3833)\Reports\HOT\Appendices\Analysis
AT:10 -Table A, B, C & GEN II & IV

3.5 Summary of the Analysis

The three tables that were generated based on the lowest value of a set of fluids are represented in Table L-2, L-3, L-4. The three tables are the product of one method of analysis. Should the industry decide to adopt these tables, then the method of analysis would need further discussion to reach a unified and scientific approach.

3.6 Changes to the Analysis

This analysis can be conducted using different methods that will allow for better definition of how well fluids perform. Following are two suggestions that may bring forward a deeper appreciation for a system of tables that adequately represent the fluids that belong to each group.

- The method used to identify the essential attributes may be changed. This analysis focused on identifying a small set of critical cells through the analysis of the distribution of deicing operations under the various precipitation conditions. The cells identified as critical may be changed if more useful criteria are identified.
- Groups of fluids may be identified through analysis of all cells in the fluid-specific tables instead of identifying only two critical cells. The analysis would use statistical methods of analysis.

3.7 Advantages and Disadvantages to the Stakeholders

Following is a list of advantages and disadvantages that may be experienced by the various stakeholders should the industry and the regulating bodies proceed with this new approach (i.e., to address the existence of a large number of fluid specific holdover time tables and the constant changes that are occurring to the generic fluid tables).

Although this report puts forward a method that may or may not be adopted by the industry, the debate is ongoing and will require solutions that use advanced scientific methods to perform the analysis and produce a new set of tables. The advantages and disadvantages listed below will be experienced regardless of the methods used to segregate the better fluid performers from the average and low performers.

TABLE L-2

TABLE A COMPARED TO GENERIC TYPE II FLUID HOLDOVER TIME GUIDELINE

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	12:00	0:35-1:30	0:20-0:55	0:30-0:55	0:15-0:30	0:05-0:40	
				0:55-1:40	0:30-0:55	0:35-0:55	0:20-0:30	0:05-0:50	
		75/25	6:00	0:25-1:00	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
				0:45-1:15	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:40	
		50/50	4:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
				0:15-0:30	0:05-0:20	0:05-0:15	0:05-0:10		
0 to -3	32 to 27	100/0	8:00	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30		CAUTION
				0:55-1:40	0:25-0:45	0:35-0:55	0:20-0:30		No holdover
		75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		time
				0:45-1:15	0:15-0:35	0:25-0:45	0:15-0:25		guidelines
		50/50	3:00	0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		exist
				0:15-0:30	0:05-0:15	0:05-0:15	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
				0:30-1:05	0:15-0:35	**0:15-0:45	**0:10-0:30		
		75/25	5:00	0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
				0:20-0:55	0:15-0:25	**0:15-0:30	**0:10-0:20		
below -14 to -25	below 7 to -13	100/0	8:00	0:15-0:20	0:15-0:30				
				0:15-0:20	0:15-0:30				
below -25	below -13	100/0	SAE TYPE II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.						

GENERIC TYPE II FLUID	0:15-0:30
Table A	0:15-0:30

Table A represents the following fluids:
KILFROST ABC-II PLUS
Viscosity of Neat 100% Fluid Tested 3,600 cP (20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, grd.leg)
CLARIANT SAFEWING MPII 1951
Viscosity of Neat 100% Fluid Tested 8,700 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min)
SPCA ECOWING 26
Viscosity of Neat 100% Fluid Tested 4,900 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min)
CLARIANT SAFEWING MPIV 1957
Viscosity of Neat 100% Fluid Tested 16,200 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min)

TABLE L-3

TABLE B COMPARED TO GENERIC TYPE IV FLUID HOLDOVER TIME GUIDELINE

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
above 0°	above 32°	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	
				1:15-2:30	0:40-1:25	0:40-1:10	0:25-0:40	0:10-1:05	
		75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
				1:10-2:05	0:35-1:10	0:35-0:50	0:15-0:30	0:15-0:40	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
				0:25-0:45	0:15-0:25	0:15-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40	CAUTION No holdover time guidelines exist	
				1:15-2:30	0:35-1:25	0:40-1:10	0:25-0:40		
		75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
				1:10-2:05	0:25-0:55	0:35-0:50	0:15-0:30		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
				0:25-0:45	0:10-0:20	0:15-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:20-0:40	**0:20-0:55	**0:10-0:30		
				0:20-1:20	0:20-0:40	0:25-0:45	0:15-0:25		
		75/25	5:00	0:25-0:50	0:15-0:25	**0:20-0:50	**0:10-0:25		
				0:25-0:50	0:20-0:45	0:15-0:30	0:10-0:20		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:15-0:30				
				0:15-0:40	0:15-0:30				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

GENERIC TYPE IV FLUID	0:15-0:30
Table B	0:15-0:30

Table B represents the following fluids:
CLARIANT SAFEWING FOUR
Viscosity of Neat 100% Fluid Tested 6,400 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min)
CLARIANT SAFEWING MP IV PROTECT 2012
Viscosity of Neat 100% Fluid Tested 7,800 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min)
SPCA AD-480
Viscosity of Neat 100% Fluid Tested 15,200 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 30 min)
UCAR ULTRA+
Viscosity of Neat 100% Fluid Tested 36,000 cP (0°C, 0.3 rpm, Spindle SC4-31/13R, 10 mL fluid, 10 min)

TABLE L-4

TABLE C COMPARED TO GENERIC TYPE IV FLUID HOLDOVER TIME GUIDELINE

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	*FROST	FREEZING FOG	SNOW ①	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER****
			Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)						
above 0º	above 32º	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	
				1:20-3:20	1:10-2:00	0:55-1:50	0:35-1:00	0:15-1:15	
		75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
				1:05-1:45	0:30-1:05	0:35-1:10	0:25-0:35	0:10-0:40	
		50/50	4:00	0:15-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
				0:30-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
0 to -3	32 to 27	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40		CAUTION No holdover time guidelines exist
				1:20-3:20	0:50-1:35	0:55-1:50	0:35-1:00		
		75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
				1:05-1:45	0:30-0:55	0:35-1:10	0:25-0:35		
		50/50	3:00	0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
				0:15-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20-1:20	0:20-0:40	**0:20-0:55	**0:10-0:30		
				0:45-1:35	0:25-0:50	0:20-1:00	0:10-0:30		
		75/25	5:00	0:25-0:50	0:15-0:25	**0:20-0:50	**0:10-0:25		
				0:25-1:00	0:20-0:35	0:20-1:00	0:10-0:30		
below -14 to -25	below 7 to -13	100/0	12:00	0:15-0:40	0:15-0:30				
				0:20-0:40	0:20-0:35				
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25ºC (-13ºF) provided the freezing point of the fluid is at least 7ºC (13ºF) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.						

GENERIC TYPE IV FLUID	0:15-0:30
Table C	0:15-0:30

Table C represents the following fluids:
CLARIANT SAFEWING MPIV 2001
Viscosity of Neat 100% Fluid Tested 18,000 cP (20°C, 0.3 rpm, Spindle SC4-34/13R, 10 mL fluid, 15 min)
KILFROST ABC-S
Viscosity of Neat 100% Fluid Tested 17,000 cP (20°C, 0.3 rpm, Spindle LV2, 250 mL beaker, 150 mL fluid, 10 min, grd.leg)

OCTAGON MAXFLIGHT
Viscosity of Neat 100% Fluid Tested 5,540 cP (20°C, 0.3 rpm, Spindle LV1, 600 mL beaker, 500 mL fluid, 33 min 20 sec, grd.leg)

Advantages to operators using generic tables:

- Reducing the number of fluid-specific tables reduces the confusion.
- No decision required as to the choice of table to use (fluid-specific or generic).
- If a small aircraft operator typically uses generic tables, the new set increases the window of time available. This is because the new set of tables provides more time for fluids that belong to the high performing category.

Disadvantages to operators using generic tables:

- When using generic tables, an operator is not required to know the fluid that is being sprayed. The only information required is the type of fluid being sprayed, whether it is Type II or Type IV. However, when using the new set of tables, the operator is required to know the fluid being sprayed to identify the table that must be used.

Advantages to operators using fluid-specific tables:

- Reducing the number of tables reduces the probability of error.
- Using the new set of tables introduces added safety (shorter times).
- The major loss experienced in holdover time when choosing generic fluid holdover timetables instead of fluid-specific tables is greatly diminished. For example, the holdover time of Clariant SAFEWING MPIV 2001, neat, in snow below 0° to -3° in the upper limit is 115 minutes. The holdover time stated in the Generic Holdover Time Guidelines for Type IV fluids is 55 minutes. This signifies a loss of 60 minutes. This fluid was categorized in this analysis under the third category of tables, Table C; therefore, the holdover time stated for this condition is 95 minutes, producing a loss of only 20 minutes. In fact, the maximum loss experienced by all 11 fluids under the four values analyzed when using the new set of table is 30 minutes.

Disadvantages to operators using fluid-specific tables:

- There will continue to be some loss in holdover time experienced when choosing to use the new set of tables instead of the fluid-specific tables.

Advantages to the fluid manufacturers:

- The new set of tables may remove the possibility of the regulating bodies imposing minimum performance levels, and will allow for fluids to be categorized in one of three categories. The good performers will be recognized and the bad performers will continue to be allowed to market their products.

Disadvantages to the fluid manufacturers:

- Some fluid manufacturers will lose a strong marketing tool.

Advantages to the regulating bodies:

- The concern over too many fluid specific tables will be removed.
- The concern over the lowering and ever-changing Generic Tables will be removed.
- If aircraft operators welcome the use of the new set of tables instead of the fluid-specific tables, an added safety buffer will be re-introduced.
- SAE may recognize the new tables and accept that they be published in APR 4737.

Disadvantages to the regulating bodies:

- The introduction of a new set of tables will require time, effort and a scientific approach that will be valid and sustainable in the long term.

4. CONCLUSIONS AND RECOMMENDATIONS

It has been proven in this report that there is a need to conduct further investigations into the nature of the fluids in the market, where they stand when compared to one another, and how the generic fluid holdover guidelines are irrelevant to the performance of many of these fluids.

Although the principles that were used to conduct this analysis are based on a basic, somewhat subjective method of visually separating eleven fluids into three groups after simplifying the analysis by choosing only four points to describe each fluid, even though the four points chosen are values that were deemed the most in use, the procedure employed nevertheless provides a good method and simplifies the HOT tables.

It is recommended that a scientific method of analysis be used to conduct this analysis. A statistician using sophisticated software is capable of running models that will encompass all of the fluids' attributes and produce clusters that are numerically closely related.

Once the clusters are identified, the same methodology used to generate the Generic Tables and Table A, Table B, and Table C may be used to generate the tables that adequately represent the fluids in the market. The number of tables generated does not have to be limited to three.