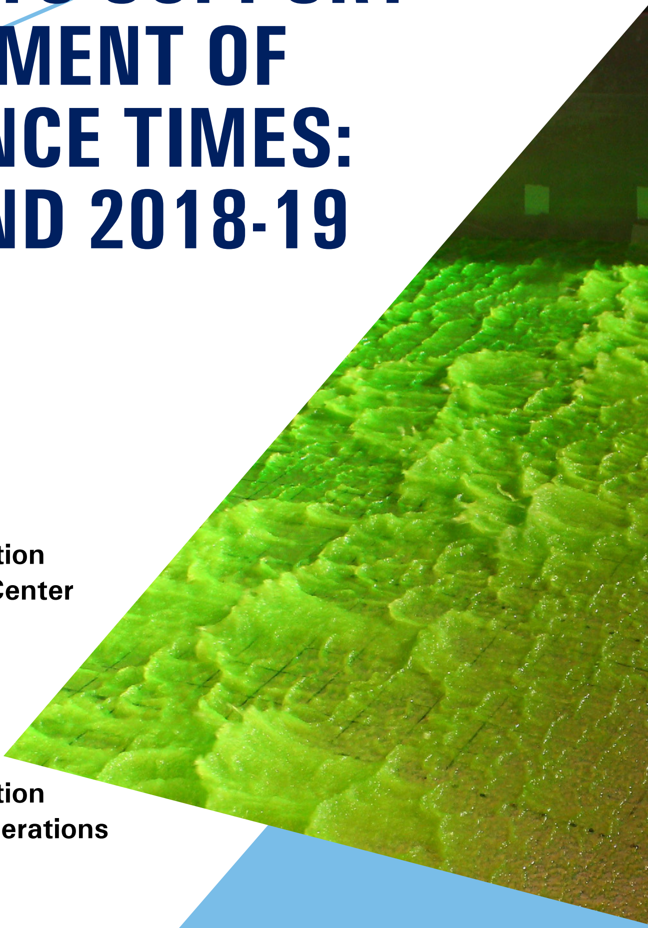
TP 15428E

WIND TUNNEL TRIALS TO SUPPORT FURTHER DEVELOPMENT OF ICE PELLET ALLOWANCE TIMES: WINTERS 2017-18 AND 2018-19



Prepared for:

Transport Canada
Innovation Centre

In cooperation with:

Federal Aviation Administration
William J. Hughes Technical Center

Transport Canada
Civil Aviation

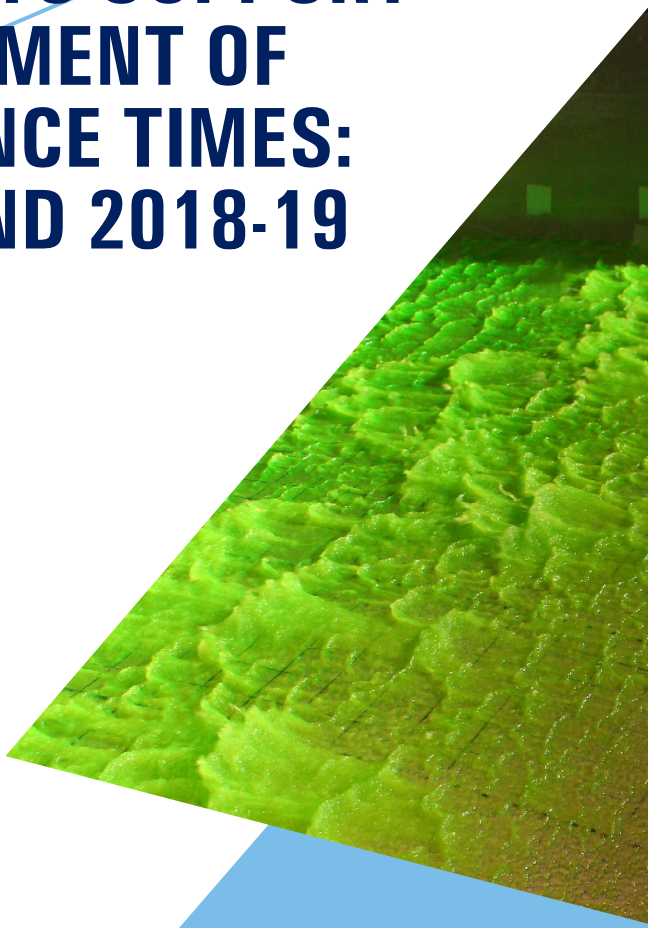
Federal Aviation Administration
Flight Standards – Air Carrier Operations

APS Aviation Inc.

FINAL VERSION 1.0
DECEMBER 2019

TP 15428E

WIND TUNNEL TRIALS TO SUPPORT FURTHER DEVELOPMENT OF ICE PELLET ALLOWANCE TIMES: WINTERS 2017-18 AND 2018-19



by:

Marco Ruggi

FINAL VERSION 1.0
DECEMBER 2019

The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transport Canada Innovation Centre or the co-sponsoring organizations.

Neither the Transport Canada Innovation Centre nor the co-sponsoring organizations endorse the 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:

Oct 23, 2020

Marco Ruggi, Eng., M.B.A. — Date
Senior Project Leader

Reviewed and Approved by:

Oct 23, 2020

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

Un sommaire français se trouve avant la table des matières.

This report was first provided to Transport Canada as Final Draft 1.0 in December 2019.
It has been published as Final Version 1.0 in October 2020.

PREFACE

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

- To develop holdover time data for all new de/anti-icing fluids;
- To evaluate fluid holdover times for snow at temperatures below -14°C;
- To evaluate and develop the use of artificial snow for holdover time development;
- To conduct wind tunnel testing to support the development of guidance material for operating in ice pellet conditions;
- To conduct additional testing and analysis for very cold snow to determine appropriate generic holdover times;
- To conduct preliminary research for the development of temperature-specific snow holdover time data;
- To conduct general and exploratory de/anti-icing research;
- To finalize the publication of historical reports;
- To update the regression information report to reflect changes made to the holdover time guidelines; and
- To update the holdover time guidance materials for annual publication by Transport Canada and the Federal Aviation Administration.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2018-19 are documented in four reports. The titles of the reports are as follows:

- TP 15425E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2018-19 Winter;
- TP 15426E Regression Coefficients and Equations Used to Develop the Winter 2019-20 Aircraft Ground Deicing Holdover Time Tables;
- TP 15427E Aircraft Ground Icing General Research Activities During the 2018-19 Winter; and
- TP 15428E Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winters 2017-18 and 2018-19.

In addition, the following interim report is being prepared:

- *Artificial Snow Research Activities for the 2018-19 Winter.*

This report, TP 15428E, has the following objective:

- To conduct research in the 3 m x 6 m Open-Circuit Icing Wind Tunnel with a thin high-performance wing section and an LS-0417 wing section to further support and develop the anti-icing fluid Ice Pellet Allowance Times.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Transport Canada Innovation Centre, with support from the Federal Aviation Administration William J. Hughes Technical Center, Transport Canada Civil Aviation, and Federal Aviation Administration Flight Standards – Air Carrier Operations. This program could not have been accomplished without the participation of many organizations. APS Aviation Inc. would therefore like to thank Transport Canada, the Federal Aviation Administration, National Research Council Canada, and supporting members of the SAE International G-12 Aircraft Ground Deicing Committees.

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data, completion of data analysis, and preparation of reports. This includes the following people: Brandon Auclair, David Beals, Steven Baker, Stephanie Bendickson, Benjamin Bernier, Chloë Bernier, Chris D'Avirro, John D'Avirro, Jaycee Ewald, Shaney Herrmann, Peter Kitchener, Shahdad Movaffagh, Annaelle Reuveni, Marco Ruggi, Javad Safari, Saba Tariq, Jodi Wilson, David Youssef, and Nondas Zoitakis.

Special thanks are extended to Antoine Lacroix, Yvan Chabot, Deborah deGrasse, Warren Underwood, and Charles J. Enders, who on behalf of Transport Canada and the Federal Aviation Administration, have participated, contributed, and provided guidance in the preparation of these documents.

PROJECT ACKNOWLEDGEMENTS

APS Aviation Inc. would like to acknowledge the team at National Research Council Canada who operate the icing wind tunnel, especially Catherine Clark and Marc MacMaster for engineering support and aerodynamic expertise. APS Aviation Inc. would like to acknowledge Andy Broeren of National Aeronautics and Space Administration who's engineering support and aerodynamic expertise have been crucial to the development of wind tunnel testing protocols used today. APS Aviation Inc. would also like to acknowledge the fluid manufacturers who have provided samples over the years to support the wind tunnel testing.

Transport Canada | Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 15428E	2. Project No. B14W	3. Recipient's Catalogue No.
4. Title and Subtitle Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winters 2017-18 and 2018-19		5. Publication Date December 2019 6. Performing Organization Document No. 300293
7. Author(s) Marco Ruggi		8. Transport Canada File No. 2450-BP-14
9. Performing Organization Name and Address APS Aviation Inc. 6700 Cote-de-Liesse Rd., Suite 102 Montreal, Quebec, H4T 2B5		10. PWGSC File No. TOR-7-40103 11. PWGSC or Transport Canada Contract No. T8156-170044/001/TOR
12. Sponsoring Agency Name and Address Transport Canada Innovation Centre 330 Sparks St., 18th Floor Ottawa, Ontario, K1A 0N5		13. Type of Publication and Period Covered Final 14. Project Officer Antoine Lacroix

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

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

16. Abstract

As part of a larger research program examining de/anti-icing fluid flow-off during simulated aircraft takeoff, APS Aviation Inc. conducted a series of full-scale wing tests in National Research Council Canada 3 m x 6 m Icing Wind Tunnel to determine the flow-off characteristics of anti-icing fluid with and without mixed precipitation conditions with ice pellets.

A wind tunnel testing program was developed for the winters of 2017-18 and 2018-19 with the primary objectives of conducting aerodynamic testing to substantiate the current Type IV fluid Ice Pellet Allowance Times with new fluids, possibly extend the current Type IV fluid Ice Pellet Allowance Times for ethylene glycol (EG), and evaluate the current Type III fluid Ice Pellet Allowance Times at 80 knots.

Type IV testing conducted during the winters of 2017-18 and 2018-19 validated the current Type IV allowance times for use with the following fluids: CHEMCO Inc. ChemR EG IV, Clariant Produkte (Deutschland) GmbH Max Flight AVIA, Clariant Produkte (Deutschland) GmbH Max Flight SNEG, Oksayd Co. Ltd. Defrost ECO 4, and Oksayd Co. Ltd. Defrost EG 4. Planned testing could not be completed for two fluids, Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH and Inland Technologies ECO-SHIELD.

EG fluid testing and an analysis of historical data indicated a potential for longer allowance times for EG fluids exists in most of the allowance time cells.

Testing with the LS-0417 indicated a good potential to develop low speed allowance times for Type III fluids, and a potential to expand the allowance times to have longer times.

It is expected that industry discussions about snow allowance times and the way forward will continue as part of the Aerodynamics Working Group in the SAE International Fluids Committee.

The results of the validation, EG expansion, and low speed Type III testing did not require any changes to the current Ice Pellet Allowance Times or supporting guidance. As such, no changes were issued to the Ice Pellet Allowance Times published in the Holdover Time guidelines for the winter of 2018-19 and 2019-20.

17. Key Words Ice Pellet, Allowance Time, High Speed Rotation, Low Speed Rotation, Type II, Type III, Type IV, Fluid Adherence, Fluid Flow-Off, Wind Tunnel, Icing Wind Tunnel, Wing Aerodynamics.	18. Distribution Statement Available from the Transport Canada Innovation Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xvi, 62 apps	—

CDT/TDC 79-005
Rev. 96

Canada

Transport Canada | Transports Canada

PUBLICATION DATA FORM

1. No de la publication de Transports Canada TP 15428E	2. No de l'étude B14W	3. No de catalogue du destinataire
4. Titre et sous-titre Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winters 2017-18 and 2018-19		5. Date de la publication Décembre 2019
		6. No de document de l'organisme exécutant 300293
7. Auteur(s) Marco Ruggi		8. No de dossier - Transports Canada 2450-BP-14
9. Nom et adresse de l'organisme exécutant APS Aviation Inc. 6700, Chemin de la Côte-de-Liesse, Bureau 102 Montréal (Québec) H4T 2B5		10. No de dossier - TPSGC TOR-7-40103
		11. No de contrat - TPSGC ou Transports Canada T8156-170044/001/TOR
12. Nom et adresse de l'organisme parrain Transports Canada Centre d'innovation 330, rue Sparks, 18ième étage Ottawa (Ontario) K1A 0N5		13. Genre de publication et période visée Final
		14. Agent de projet Antoine Lacroix

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

Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). Ils sont disponibles auprès du Centre d'innovation de TC. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. Leur objet apparaît à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

Dans le cadre d'un plus vaste programme de recherche étudiant le ruissellement du liquide de dégivrage et d'antigivrage durant le décollage simulé d'un aéronef, APS Aviation Inc. a mené une série d'essais sur des ailes pleine grandeur dans la soufflerie de givrage de 3 m sur 6 m du Conseil national de recherches Canada afin de déterminer les caractéristiques de ruissellement du liquide d'antigivrage avec et sans conditions de précipitations mixtes comprenant des granules de glace.

Un programme d'essais en soufflerie a été élaboré pour les hivers 2017-2018 et 2018-2019 avec comme principaux objectifs de réaliser des tests aérodynamiques visant à corroborer les marges de tolérance actuelles pour les granules de glace avec de nouveaux liquides de type IV, à possiblement élargir les marges de tolérance actuelles dans des conditions de granules de glace pour les liquides de type IV à base d'éthylène glycol et à évaluer les marges de tolérance actuelles pour les liquides de type III dans des conditions de granules de glace à une vitesse de 80 nœuds.

Les essais menés durant les hivers 2017-2018 et 2018-2019 sur des liquides de type IV ont permis de valider les marges de tolérance actuelles à utiliser avec les liquides ChemR EG IV de CHEMCO inc., Max Flight AVIA et Max Flight SNEG de Clariant Produkte (Deutschland) GmbH et Defrost ECO 4 et Defrost EG 4 d'Oksayd Co. Ltd. Des essais prévus n'ont pas pu être réalisés pour deux liquides, soit Safewing EG IV NORTH de Clariant Produkte (Deutschland) GmbH et ECO-SHIELD d'Inland Technologies.

À la lumière des essais réalisés sur les liquides à base d'éthylène glycol et d'une analyse des données historiques, les marges de tolérance pour ces liquides pourraient être augmentées dans la plupart des cellules.

Des essais menés sur le profil d'aile LS-0417 ont démontré un bon potentiel de développement des marges de tolérance à basse vitesse pour les liquides de type III et la possibilité d'élargir les marges de tolérance de façon à inclure des durées plus longues.

Il est attendu que les discussions au sein du secteur se poursuivront quant aux marges de tolérance dans des conditions de neige et aux marches à suivre dans le cadre du groupe de travail de la SAE sur l'aérodynamisme du comité international sur les liquides de la SAE.

Aucun changement n'a dû être apporté aux marges de tolérance actuelles pour les granules de glace ou aux lignes directrices connexes en raison des résultats des essais de validation, d'élargissement des marges pour les liquides à base d'éthylène glycol et sur les liquides de type III à basse vitesse. Par conséquent, aucun changement n'a été apporté aux marges de tolérance pour les granules de glace publiées dans les lignes directrices sur les durées d'efficacité pour les hivers 2018-2019 et 2019-2020.

17. Mots clés Granule de glace, marge de tolérance, rotation à haute vitesse, rotation à basse vitesse, Type II, Type III, Type IV, adhérence de liquide, écoulement de liquide, soufflerie, soufflerie de givrage, aérodynamisme des ailes	18. Diffusion Disponible auprès du Centre d'innovation de Transports Canada

19. Classification de sécurité (de cette publication) Non classifiée	20. Classification de sécurité (de cette page) Non classifiée	21. Déclassification (date) —	22. Nombre de pages xvi, 62 ann.	23. Prix —

CDT/TDC 79-005
Rev. 96

Canada

EXECUTIVE SUMMARY

Under contract to Transport Canada (TC) with support from the Federal Aviation Administration (FAA), APS Aviation Inc. (APS) has undertaken a research program to advance aircraft ground de/anti-icing technology.

As part of a larger research program, APS conducted a series of full-scale wing tests in the National Research Council Canada (NRC) 3 m x 6 m Icing Wind Tunnel (IWT) to determine the flow-off characteristics of anti-icing fluid with and without mixed precipitation conditions with ice pellets.

Background and Objective

A wind tunnel testing program was developed for the winters of 2017-18 and 2018-19 with the primary objectives of conducting aerodynamic testing to:

- Substantiate the current Type IV fluid Ice Pellet Allowance Times with new fluids using the thin high-performance regional jet (RJ) airfoil, and weather permitting, at temperatures close to the fluid lowest operational use temperature (LOUT);
- Possibly extend the current Type IV fluid Ice Pellet Allowance Times for ethylene glycol (EG) fluids using the thin high-performance RJ airfoil; and
- Evaluate Type III fluid Ice Pellet Allowance Times at 80 knots using the LS-0417 low speed airfoil, which required additional calibration / characterization testing with the support of National Aeronautics and Space Administration (NASA).

In addition, baseline dry wing tests were conducted daily as well as following system changes to validate the repeatability of the wind tunnel. One heavy contamination test was also conducted.

Conclusions and Recommendations

Type IV testing conducted during the winters of 2017-18 and 2018-19 validated the current Type IV allowance times for use with the following fluids:

- CHEMCO Inc. ChemR EG IV;
- Clariant Produkte (Deutschland) GmbH Max Flight AVIA;
- Clariant Produkte (Deutschland) GmbH Max Flight SNEG;
- Oksayd Co. Ltd. Defrost ECO 4; and
- Oksayd Co. Ltd. Defrost EG 4.

Planned testing could not be completed for two fluids, Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH and Inland Technologies ECO-SHIELD, and, therefore, should be reconsidered during the next testing campaign.

EG fluid testing and an analysis of historical data indicated a potential for longer allowance times for EG fluids exists in most of the allowance time cells. Additional data and analysis is required to substantiate the results.

Testing with the LS-0417 indicated a good potential to develop low speed allowance times for Type III fluids. Discussions with the SAE International (SAE) G-12 Aerodynamics Working Group (AWG) are suggested in order to validate the methodologies proposed to move forward with developing guidance material.

It is expected that industry discussions related to snow allowance times will continue at the SAE G-12 AWG.

The results of the validation, EG expansion, and low speed Type III testing did not require any changes to the current Ice Pellet Allowance Times or supporting guidance. As such, no changes were issued to the Ice Pellet Allowance Times published in the holdover time (HOT) guidelines for the winter of 2018-19 and 2019-20.

SOMMAIRE

En vertu d'un contrat avec Transports Canada (TC), avec l'appui de la Federal Aviation Administration (FAA), APS Aviation Inc. (APS) a entrepris des activités de recherche visant à faire progresser les technologies associées au dégivrage et à l'antigivrage d'aéronefs au sol.

Dans le cadre d'un plus vaste programme de recherche, APS Aviation Inc. a mené une série d'essais sur des ailes pleine grandeur dans la soufflerie de givrage de 3 m sur 6 m du Conseil national de recherches Canada afin de déterminer les caractéristiques de ruissellement du liquide d'antigivrage avec et sans conditions de précipitations mixtes comprenant des granules de glace.

Contexte et objectif

Un programme d'essais en soufflerie a été élaboré pour les hivers 2017-2018 et 2018-2019 avec comme principaux objectifs de réaliser des tests aérodynamiques visant à :

- Corroborer les marges de tolérance actuelles pour les granules de glace avec de nouveaux liquides de type IV au moyen d'une surface portante haute performance à profil mince d'un avion de transport régional à réaction et, selon les conditions météorologiques, à des températures se rapprochant de la température minimale d'utilisation opérationnelle (LOUT) ;
- Possiblement élargir les marges de tolérance actuelles dans des conditions de granules de glace pour les liquides de type IV à base d'éthylène glycol au moyen d'une surface portante haute performance à profil mince d'un avion de transport régional à réaction ; et
- Évaluer les marges de tolérance pour les liquides de type III dans des conditions de granules de glace à une vitesse de 80 nœuds au moyen du profil d'aile LS-0417 à basse vitesse, lequel nécessitait des essais d'étalonnage et de caractérisation supplémentaires avec l'appui de la National Aeronautics and Space Administration (NASA).

En outre, des essais de référence sur aile sèche ont été réalisés quotidiennement et après chaque changement apporté aux systèmes afin de valider la répétabilité de la soufflerie. Un essai avec forte contamination a aussi été mené.

Conclusions and recommandations

Les essais menés durant les hivers 2017-2018 et 2018-2019 sur des liquides de type IV ont permis de valider les marges de tolérance actuelles à utiliser avec les liquides qui suivent :

- ChemR EG IV de CHEMCO inc. ;
- Max Flight AVIA de Clariant Produkte (Deutschland) GmbH ;
- Max Flight SNEG de Clariant Produkte (Deutschland) GmbH ;
- Defrost ECO 4 d'Oksayd Co. Ltd ; et
- Defrost EG 4 d'Oksayd Co. Ltd.

Des essais prévus n'ont pas pu être réalisés pour deux liquides, soit Safewing EG IV NORTH de Clariant Produkte (Deutschland) GmbH et ECO-SHIELD d'Inland Technologies. Ils devraient par conséquent être examinés de nouveau durant la prochaine campagne d'essais.

À la lumière des essais réalisés sur les liquides à base d'éthylène glycol et d'une analyse des données historiques, les marges de tolérance pour ces liquides pourraient être augmentées dans la plupart des cellules. Des données et analyses supplémentaires sont nécessaires pour corroborer les résultats.

Des essais menés sur le profil d'aile LS-0417 ont démontré un bon potentiel de développement des marges de tolérance à basse vitesse pour les liquides de type III. Il est recommandé de discuter avec le groupe de travail G-12 de la SAE sur l'aérodynamisme afin de valider les méthodologies proposées pour aller de l'avant dans l'élaboration des lignes directrices.

Il est attendu que les discussions au sein du secteur se poursuivront quant aux marges de tolérance dans des conditions de neige et aux marches à suivre dans le cadre du groupe de travail de la SAE sur l'aérodynamisme du comité international sur les liquides de la SAE.

Aucun changement n'a dû être apporté aux marges de tolérance actuelles pour les granules de glace ou aux lignes directrices connexes en raison des résultats des essais de validation, d'élargissement des marges pour les liquides à base d'éthylène glycol et sur les liquides de type III à basse vitesse. Par conséquent, aucun changement n'a été apporté aux marges de tolérance pour les granules de glace publiées dans les lignes directrices sur les durées d'efficacité pour les hivers 2018-2019 et 2019-2020.

CONTENTS

Page

LIST OF APPENDICES

LIST OF TABLES Page

LIST OF FIGURES Page

LIST OF PHOTOS Page

GLOSSARY

A4A	Airlines for America
APS	APS Aviation Inc.
AWG	G-12 Aerodynamics Working Group
EASA	European Aviation Safety Agency
EG	Ethylene Glycol
FAA	Federal Aviation Administration
HOT	Holdover Time
IWT	3 m x 6 m Icing Wind Tunnel
LOUT	Lowest Operational Use Temperature
NASA	National Aeronautics and Space Administration
NRC	National Research Council Canada
OAT	Outside Air Temperature
PG	Propylene Glycol
RJ	Regional Jet
RTD	Resistance Temperature Detector
SAE	SAE International
TC	Transport Canada

This page intentionally left blank.

1. INTRODUCTION

Under winter precipitation conditions, aircraft are cleaned prior to takeoff. This is typically done with aircraft ground deicing fluids, which are freezing point depressant fluids developed specifically for aircraft use. If required, aircraft are then protected against further accumulation of precipitation by the application of aircraft ground anti-icing fluids, which are also freezing point depressant fluids. Most anti-icing fluids contain thickeners to extend protection time.

Prior to the 1990s, aircraft ground de/anti-icing had not been extensively researched. However, following several ground icing related incidents in the late 1980s, an aircraft ground icing research program was initiated by Transport Canada (TC). The objective of the program is to improve knowledge, improve safety, and enhance operational capabilities of aircraft operating in winter precipitation conditions.

Since its inception in the early 1990s, the aircraft ground icing research program has been managed by TC, with the co-operation of the United States Federal Aviation Administration (FAA), the National Research Council Canada (NRC), several major airlines, and de/anti-icing fluid manufacturers.

There is still an incomplete understanding of some of the hazards related to aircraft ground icing. As a result, the aircraft ground icing research program continues, with the objective of further reducing the risks posed by the operation of aircraft in winter precipitation conditions.

Under contract to the TC Innovation Centre, with support from the FAA William J. Hughes Technical Center, TC Civil Aviation, and FAA Flight Standards – Air Carrier Operations, APS Aviation Inc. (APS) carried out research in the winter of 2018-19 in support of the aircraft ground icing research program. Each major project completed as part of the 2018-19 research is documented in a separate individual report. This report documents the wind tunnel Ice Pellet Allowance Time development project.

1.1 Background

In 2005-06, the inability for operators to release aircraft in ice pellet conditions led TC and the FAA to begin a research campaign to develop allowance times. Developing holdover times (HOTs) was not feasible due to the properties of the ice pellets; they remain embedded in the fluid and take long to dissolve compared to snow, which is immediately absorbed and dissolved. Research was initiated through live aircraft testing with the NRC Falcon 20 in Ottawa, Canada, and later evolved to a more controlled environment with the NRC 3 m x 6 m Icing Wind Tunnel (IWT), also in Ottawa.

The early testing in 2005-06 with the Falcon 20 primarily used visual observations to evaluate fluid flow-off. During the Falcon 20 work, the wing was anti-iced and exposed to contamination, and aborted takeoff runs allowed researchers onboard to observe and evaluate the fluid flow-off. Testing in 2006-07 began in the IWT, allowing aerodynamic data to be used for evaluating fluid flow-off performance. The IWT also allowed for a more controlled environment less susceptible to the elements.

The work continued each year, and the test methods and equipment improved, allowing for real-time data analysis, better repeatability, and overall greater confidence in the results. The work conducted by TC/FAA was presented by APS to the SAE International (SAE) G-12 Aerodynamics Working Group (AWG) and the HOT Committee yearly since 2006. Additional presentations were also given at the AWG in May 2012 and May 2013 by National Aeronautics and Space Administration (NASA) and the NRC that focused on the extensive calibration and characterization work performed with a generic thin high-performance airfoil. This work also helped increase confidence in how the data was used to help support the development of TC/FAA guidance material. A detailed account of the more recent work conducted is included in the TC report, TP 15232E*, Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winters 2009-10 to 2012-13* (1).

The Ice Pellet Allowance Time research has helped further develop and improve the IWT facility. As a result, a new medium is now available for aerodynamic testing of aircraft ground icing fluids with or without contamination in a full-scale format. Several other ground deicing projects have been ongoing as a result of industry requests and are expected to continue. The IWT has evolved into a multidisciplinary facility; however, it continues to be the primary source for the development and further refinement of the ground deicing Ice Pellet Allowance Time guidance material.

Testing was once again focused on the development of Ice Pellet Allowance Times for the winter of 2013-14 with intentions of conducting yearly or bi-yearly testing campaigns. During the winter of 2014-15, the Ice Pellet Allowance Time testing was suspended to allow for a European Aviation Safety Agency (EASA)–led project looking at thickened fluid effects on unpowered elevators; TC and APS were also involved in this research. Ice Pellet Allowance Time testing resumed for the winter of 2015-16; however, funding was limited for the following winter and, therefore, no testing was conducted during the winter of 2016-17.

For the winters of 2017-18 and 2018-19, research resumed. This report contains the findings from these two years of research. Note that an abbreviated test report of the 2017-18 research was included as a section of the TC report, TP 15398E, *Aircraft Ground Icing General Research Activities During the 2017-18 Winter* (2) as an interim documentation of results in anticipation of this report; this report now replaces that section.

1.2 Program Objectives

A wind tunnel testing program was developed for the winters of 2017-18 and 2018-19 with the primary objectives of conducting aerodynamic testing to:

- Substantiate the current Type IV fluid Ice Pellet Allowance Times with new fluids using the thin high-performance regional jet (RJ) airfoil and, weather permitting, at temperatures close to the fluid lowest operational use temperature (LOUT);
- Possibly extend the current Type IV fluid Ice Pellet Allowance Times for ethylene glycol (EG) fluids using the thin high-performance RJ airfoil; and
- Evaluate Type III fluid Ice Pellet Allowance Times at 80 knots using the LS-0417 low-speed airfoil, which required additional calibration and characterization testing with the support of NASA.

In addition, baseline dry wing tests were conducted daily as well as following system changes to validate the repeatability of the wind tunnel. One heavy contamination test was also conducted.

The statement of work for these tests is provided in Appendix A.

Table 1.1 and Table 1.2 demonstrates the groupings for the global set of tests conducted at the wind tunnel during the winters of 2017-18 and 2018-19 on the RJ wing and LS-0417 wing models. Objective #10 has not been reported on, as this was primarily exploratory.

Table 1.1: Summary of 2017-18 and 2018-19 RJ Wing Tests by Objective

Objective #	Objective	# of Runs
1	Baseline (Dry wing)	27
2	Type IV IP AT Validation (New Fluids)	57
3	EG Expansion	5
4	Type III (Support Tests for LS-0417 Airfoil)	2
	Total	***91***

Table 1.2: Summary of 2017-18 LS-0417 Wing Tests by Objective

Objective #	Objective	# of Runs
5	Baseline (Dry Wing)	4
6	Clean Wing Sweeps (Calibration and Characterization)	10
7	Roughness (Calibration and Characterization)	20
8	Boundary Layer Rake (Calibration and Characterization)	12
9	Type III IP AT Validation at 80 Knots	17
10	R&D (Heavy Contamination)	1
	Total	***64***

1.3 Previous Ice Pellet Allowance Time Tables

The Type IV allowance time tables have been available since the winter of 2007-08. Each year the Type IV testing has built upon the latest version of the allowance time table published in the TC and FAA HOT Guidelines.

In the case of Type III fluid, a preliminary table was developed during the winter of 2008-09; however, high rotation speed allowance time tables have only been available and published since the winter of 2014-15 following some more extensive testing. Future testing will build upon the latest version of the allowance time table published in the TC and FAA HOT Guidelines and look to expand the table to include low-speed rotations.

1.4 Report Format

The wind tunnel work has been conducted since the winter of 2006-07 and has been documented in yearly reports. TP 15232E (1) contains more thorough details regarding the testing methodologies as well as links to previous historical reports. The current report has been prepared in a more abbreviated format. The following list provides short descriptions of subsequent sections of this report:

a) Section 2 describes the methodology used in testing, as well as equipment and personnel requirements necessary to carry out testing;
b) Section 3 describes data collected during the full-scale testing conducted;

c) Section 4 describes the results from the validation testing for new-to-market Type IV fluids;

d) Section 5 describes the results from the research aimed at extending the allowance times for EG fluids;

e) Section 6 describes the results from the LS-0417 airfoil testing for developing low-speed Type III allowance times;

f) Section 7 provides a summary of the TC/FAA supported participation in the Airlines for America (A4A)-led project to investigate snow allowance times; and

g) Section 8 provides a summary of the conclusions and recommendations.

This page intentionally left blank.

2. METHODOLOGY

This section provides a brief description of the test methodology and equipment specific to the full-scale aerodynamic tests conducted at the NRC IWT.

NOTE: TP 15232E (1) contains more thorough details regarding the testing methodologies.

2.1 Test Schedule

For the first year, ten days of testing were conducted over a period of two weeks starting January 29, 2018, and ending February 9, 2018. The following year, six days of testing were conducted over a period of two weeks starting January 21, 2019, and ending January 30, 2019.

Setup and teardown time was kept to a minimum and was done during the first two hours on the first day of testing and during the last two hours on the last day of testing. Testing days were selected based on weather. Table 2.1 and Table 2.2 present the calendar of wind tunnel tests performed. It should be noted that the tests listed comprise all the tests conducted, which also includes the tests pertaining to other objectives not discussed in this report. At the beginning of each test day, a plan was developed that included the list of tests (taken from the global test plan) to be completed based on the weather conditions and testing priorities. This daily plan was discussed, approved, and modified (if necessary) by TC, the FAA, and APS.

Table 2.1: 2017-18 Calendar of Tests

Date (Start date of overnight)	**# of Tests Run**
January 29, 2018	7
January 30, 2018	10
January 31, 2018	14
February 1, 2018	10
February 2, 2018	2
February 5, 2018	16
February 6, 2018	12
February 7, 2018	14
February 8, 2018	12
February 9, 2018	10
Total	107

Table 2.2: 2018-19 Calendar of Tests

Date (Start date of overnight)	# of Tests Run
January 21, 2019	14
January 22, 2019	10
January 23, 2019	8
January 24, 2019	5
January 29, 2019	6
January 30, 2019	5
Total	48

2.1.1 Wind Tunnel Procedure

To satisfy the fluid testing objective, simulated takeoff and climb-out tests were performed with the thin high-performance wing section. Different parameters including fluid thickness, wing temperature, and fluid freezing point were recorded at designated times during the tests. The thin high-performance wing section was constructed by the NRC in 2009 specifically to conduct these tests following extensive consultations with an airframe manufacturer to ensure a representative thin high-performance design.

The typical procedure for each fluid test was as follows:

- The wing section was treated with anti-icing fluid, poured in a one-step operation (no Type I fluid was used during the tests);
- When applicable, contamination, in the form of simulated ice pellets, freezing rain, and/or snow, was applied to the wing section. Test parameters were measured at the beginning and end of the exposure to contamination;
- At the end of the contamination period, the tunnel was cleared of all equipment and scaffolding;
- The wind tunnel was subsequently operated through a simulated takeoff and climb-out test; and
- The behaviour of the fluid during takeoff and climb-out was recorded with digital high-speed still cameras. In addition, windows overlooking the wing section allowed observers to document the fluid elimination performance in real-time.

The procedures for the 2017-18 and 2018-19 wind tunnel trials are included in Appendix B and Appendix C, respectively. The procedures include details regarding the test objectives, test plan, procedure and methodology, and pertinent information and documentation.

2.1.2 Test Sequence

The length of each test (from start of setup to end of last measurement) varied largely due to the length of exposure to precipitation (if applicable). Time required for setup and teardown as well as preparing and configuring the wing section was relatively the same from test to test. Figure 2.1 demonstrates a sample timeline for a typical wind tunnel trial. It should be noted that a precipitation exposure time of 30 minutes was used for illustration purposes; this time varied for each test depending on the objective.

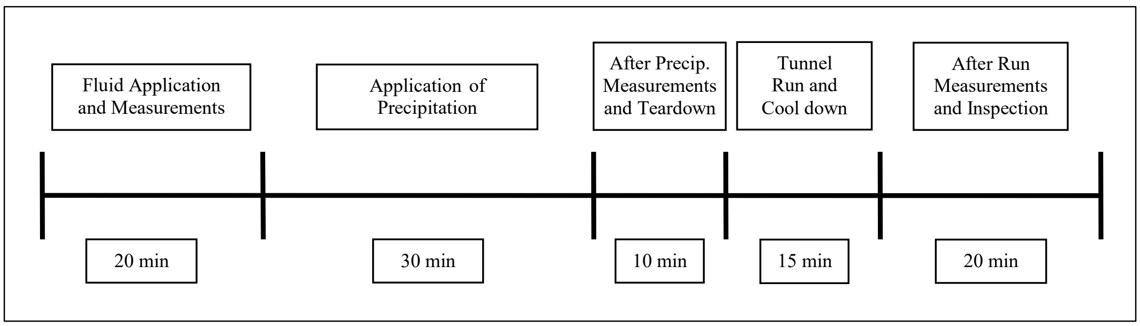


Figure 2.1: Typical Wind Tunnel Test Timeline

2.2 Methodology for Developing or Expanding New Allowance Times

Initial testing to first develop the allowance times is done with representative "grandfather" fluids (fluids with a long history of data). Testing is conducted at different temperatures and rates, and the allowance times are based on the limits where tests fail the acceptance criteria (based on visual ratings and aerodynamic performance). Much "trial and error" is needed to determine where the limits of the allowance times are (i.e., it may require running tests with a grandfather fluid at 15, 20, and 25 minutes to determine that the allowance time should be limited to 20 minutes). Once the target allowance times are determined, they are validated with other fluids; this is done using limited spot checks with multiple fluids. This also applies to expanding allowance times for specific fluid types, like EG fluids.

2.3 Methodology for Validating New Fluids for Use with Allowance Times

Over the years, all new commercially available fluids have been tested. This is typically done within 1-2 years of the fluid being available on the market. At a minimum, testing is conducted in a subset of the conditions; the allowance times are generic, so this process is satisfactory and provides a “first alert” in the event that a fluid may be underperforming, in which case further action would be required.

2.4 Methodology for Low-Speed Testing

Low-speed testing at 80 knots or lower is primarily done using the LS-0417 airfoil. Some limited preliminary testing has been conducted at lower speeds using the RJ type airfoil; however, the lower speeds at rotation are not representative of what that wing would typically encounter. Therefore, whenever possible, the LS-0417 sections should be used for lower speed testing. The general testing methodologies, including fluid application and calibration, remain the same for both airfoils.

2.5 Wind Tunnel and Airfoil Model Technical Overview

The following sections describe the wind tunnel and major components.

2.5.1 Wind Tunnel Test Site

IWT tests are performed at the NRC Aerospace Facilities, Building M-46, at the NRC Montreal Road campus, located in Ottawa, Canada. Figure 2.2 provides a schematic of the NRC Montreal Road campus showing the location of the NRC IWT. Photo 2.1 shows an outside view of the wind tunnel trial facility. Photo 2.2 shows an inside view of the wind tunnel test section. The open-circuit layout, with a fan at entry, permits contaminants associated with the test articles (such as heat or de/anti-icing fluid) to discharge directly, without recirculating or contacting the fan. The test section is 3 m (10 ft.) wide by 6 m (20 ft.) high by 12 m (40 ft.) long, with a maximum wind speed of 78 knots when using the electrical turbine drive and with a maximum wind speed of just over 115 knots when using the gas turbine drive. The fan is normally driven electrically, but high-speed operation can be accommodated by a gas turbine drive system. Due to the requirements of both high-speed and low-speed operations during the testing, the gas turbine was selected to allow for greater flexibility; the gas turbine drive can perform both low- and high-speed operations, whereas the electric drive is limited to low-speed operations. Scaffolding was constructed to allow access to the wing section, which facilitated the application of fluids and the subsequent inspection and cleaning of the airfoil.

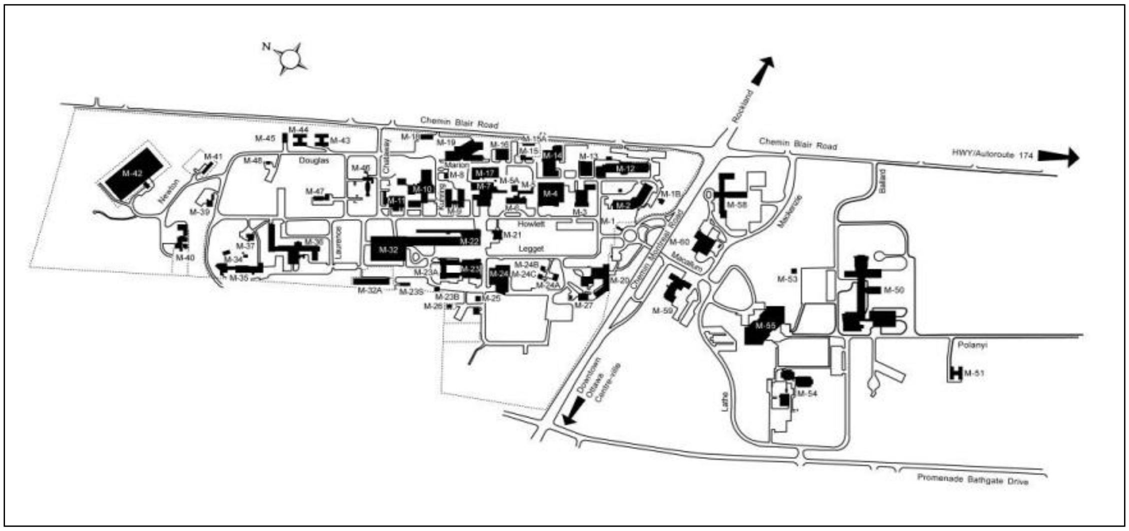


Figure 2.2: Schematic of NRC Montreal Road Campus

2.5.2 Generic Thin High-Performance "RJ" Type Commuter Airfoil

The wing section used for testing was a generic high-performance commuter airfoil, also referred to as a "thin high-performance" or "RJ" type. This wing section was constructed by the NRC in 2009 specifically to conduct these tests following extensive consultations with an airframe manufacturer to ensure a representative thin high-performance design. The original wing design was representative of an outboard section and did not include a flap; the flap was later added at the request of TC, the FAA, and APS. A computational fluid dynamics analysis of the modified wing section was conducted by the airframe manufacturer, and it was confirmed that the wing section provided a good representation of a flapped section of an operational thin high-performance wing. Photo 2.3 shows the wing section used for testing.

A cross sectional view of the thin high-performance wing section used for testing has been included in Figure 2.3; the dimensions indicated are in meters. Some of the pertinent dimensions of the wing section are:

- Chord length not including flap: 1.4 m (4.6 ft.); and
- Width: 2.4 m (8 ft.).

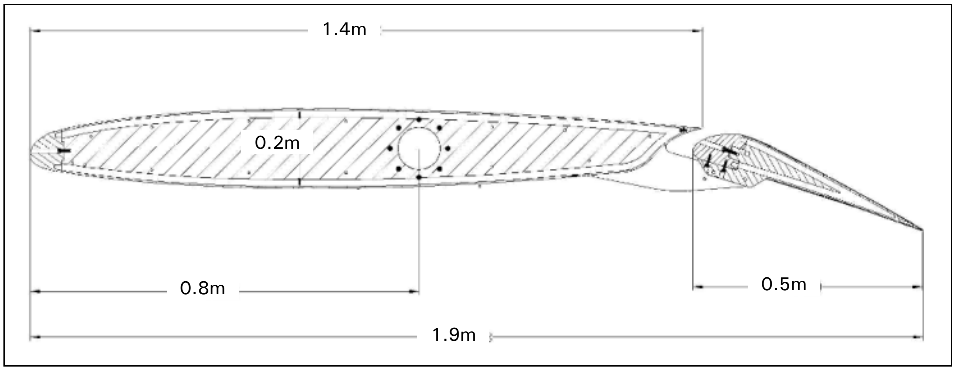


Figure 2.3: Generic "Thin High-Performance" Wing Section

An analysis of the wing section model was conducted by the airframe manufacturer to determine the typical rest position of this type of wing section. It was determined that on a typical commuter aircraft, this section of wing would typically be pitched forward by 2º when sitting on the ground. As a result, the NRC ensured the rest position of the wing model was set to -2º for each test.

The wing section was fitted with a hinged flap. The flap position was fixed at 20º and was not intended to be changed during testing. The top surface of the flap wing section had a steeper angle; a flap setting of 20º created close to a 26º slope on the top surface of the flap (with the wing pitched forward by 2º). As testing progressed, the ability to change the flap setting from 0º to 20º was necessary; contrary to a nested flap, which is typically protected during precipitation, a hinged flap is always exposed, and results indicated earlier failures were due to the shallower angle of the hinged flap. Modifications were made by the NRC to allow the flap setting to alternate between 0º and 20º for the fluid application and contamination periods; however, all takeoff simulations were conducted with the flap set to 20º. No moveable devices were available on the wing section. Detailed coordinates for this airfoil are available.

End plates were installed on the wing section to eliminate the "wall effects" from the wind tunnel walls and to provide a better aerodynamic flow-off above the test area. Figure 2.4 demonstrates the end plates installed on the thin high-performance wing section (note: the wing section is depicted without the top wing skin).

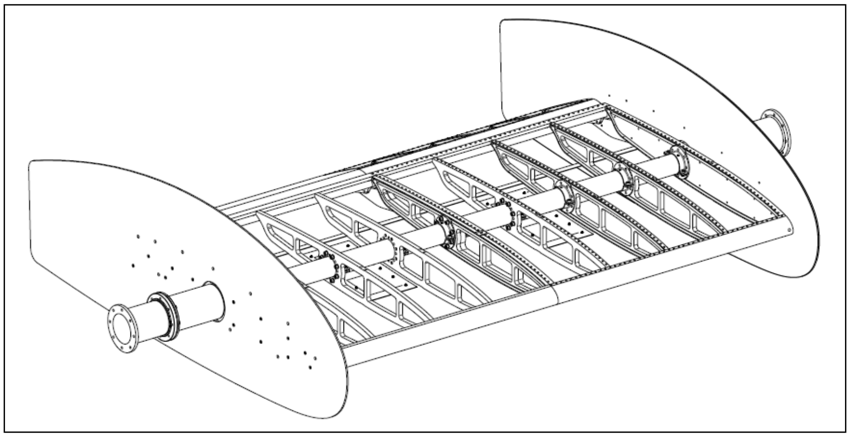


Figure 2.4: End Plates Installed on Thin High-Performance Wing Section

2.5.3 NASA LS(1)-0417 Design Characteristics

A cross sectional view of the NASA LS(1)-0417 wing section used for low-speed testing has been included in Figure 2.5. Some of the pertinent dimensions of the wing section are:

- Chord length not including flap: 1.8 m (6 ft.); and
- Width: 2.4 m (8 ft.).

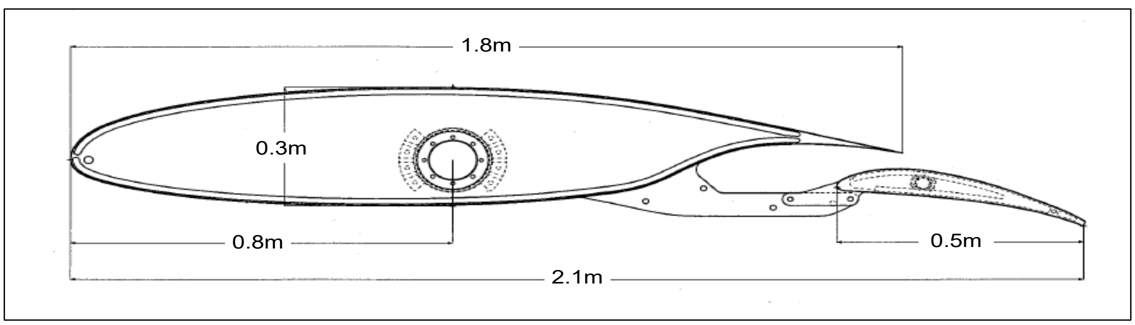


Figure 2.5: NASA LS(1)-0417 Wing Section

The wing section was fitted with a Fowler flap; however, the flap position was fixed at 15º and was not changed during testing. No moveable devices were available on the wing section.

End plates were installed on the wing section to eliminate the “wall effects” from the wind tunnel walls (aerodynamic interference caused by the walls on an airfoil spanning the wind tunnel) and to provide a better aerodynamic flow-off above the test area. Figure 2.6 demonstrates the end plates installed on the NASA LS(1)-0417 wing section.

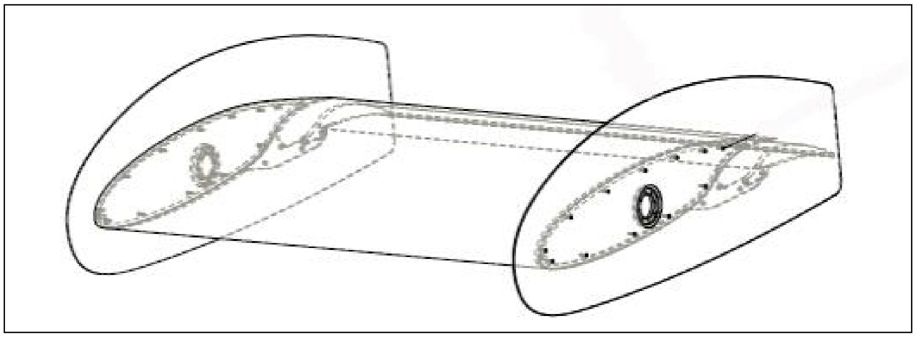


Figure 2.6: End Plates Installed on NASA LS(1)-0417 Wing Section

2.5.4 Test Area Grid

APS personnel used markers to draw a grid on the wing upper surface (excluding the flap). Each grid cell measured 5.1 cm x 5.1 cm (2 in. x 2 in.) with the cell axis positioned perpendicular and parallel to the leading edge (see Photo 2.4). The grid section was 2.4 m (8 ft.), which covered the entire wing section. The grid markings began aft of the leading edge stagnation point and continued along the length of the main chord; grid markings were not drawn on the flap section. The grid was used to facilitate observations of the fluid shearing off the wing and the movement of ice pellets during takeoff.

2.5.5 Wind Tunnel Measurement Capabilities

The wing section was supported on either side by 2-axis weigh scales capable of measuring drag and lift forces generated on the wing section. The wing section was attached to servo-systems capable of pitching the wing section to a static angle or generating dynamic movements. The servo-system was programmed to simulate pitch angles during takeoff and climb-out based on operational aircraft flight profiles.

The wing section was also equipped with eight resistance temperature detectors (RTDs); these were installed by NRC personnel) recording the skin temperature on the leading edge (LE), mid-chord (MID), trailing edge (TE), and under-wing (UND). RTDs were placed along a chord 0.5 m (1.5 ft.) in pairs to the left and to the right of the wing centreline. The following are the locations of the RTDs for the RJ wing:

- RTD LE located approximately 25 cm from the leading edge (as measured along wing skin curvature);
- RTD MID located approximately 70 cm from the leading edge (as measured along wing skin curvature);

- RTD TE located approximately 30 cm from the trailing edge (as measured along wing skin curvature); and
- RTD UND located approximately 45 cm from the leading edge.

Figure 2.7 demonstrates the general location of the RTDs. These RTDs were primarily used to monitor the skin temperature in real-time through the NRC data display system and were recorded by APS personnel.

The wind tunnel was also equipped with sensors recording the following parameters:

1. Air temperature inside the tunnel;
2. Outside air temperature (OAT);
3. Air pressure;
4. Wind speed; and
5. Relative humidity.

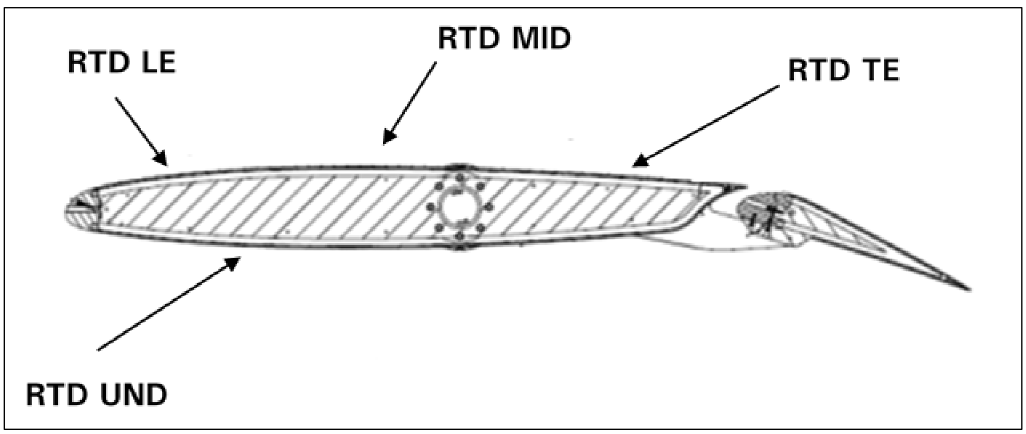


Figure 2.7: Location of RTDs Installed Inside Thin High-Performance Wing

It should be noted that the location of the RTDs in the LS-0417 wing section were positioned in similar locations.

2.6 Simulated Precipitation

The following types of precipitation have been simulated for aerodynamic research in the IWT:

1. Ice Pellets;
2. Snow;

3. Freezing Rain/Rain; and
4. Other conditions related to HOTs.

2.6.1 Ice Pellets

Simulated ice pellets were produced with diameters ranging from 1.4 mm to 4.0 mm to represent the most common ice pellet sizes observed during natural events. The ice pellets were manufactured inside a refrigerated truck (see Photo 2.5). Cubes of ice were crushed and passed through calibrated sieves (see Photo 2.6) to obtain the required ice pellet size range. Hand-held motorized dispensers (see Photo 2.7) were used to dispense the ice pellets. The ice pellets were applied to the leading and trailing edges of the wing at the same time.

2.6.2 Snow

Snow was produced using the same method for producing ice pellets. The snow used consisted of small ice crystals measuring less than 1.4 mm in diameter. Previous testing conducted by APS investigated the dissolving properties of the artificial snow versus natural snow. The artificial snow was selected as an appropriate substitute for natural snow.

The snow was manufactured inside a refrigerated truck. Cubes of ice were crushed and passed through calibrated sieves to obtain the required snow size range. Hand-held motorized dispensers were used to dispense the snow. The snow was applied to the leading and trailing edges of the wing at the same time.

2.6.3 Freezing Rain/Rain

The same sprayer head and scanner used for HOT testing at the NRC Climatic Engineering Facility was employed for testing. The sprayer system (see Photo 2.8) uses compressed air and distilled water to produce freezing rain. The temperature of the water is controlled and is kept just above freezing temperature in order to produce freezing rain. To produce rain, the temperature of the water is raised until the precipitation no longer freezes on the test surfaces.

2.6.4 Definition of Precipitation Rates

When simulating precipitation rates for full-scale and plate testing, the rate limits defined for standard HOT testing were referenced. Figure 2.8 demonstrates the HOT testing rate precipitation breakdown.

HOT testing protocol for ice pellets does not currently exist. As a result, ice pellet precipitation rate limits were based upon the freezing rain rate breakdown. The following precipitation rates were used for the full-scale and flat plate testing conducted during the winter of 2008-09:

1. Light Ice Pellets: 13-25 g/dm²/h;
2. Moderate Ice Pellets: 25-75 g/dm²/h;
3. Light Freezing Rain: 13-25 g/dm²/h;
4. Moderate Freezing Drizzle: 5-13 g/dm²/h;
5. Light Rain: 13-25 g/dm²/h;
6. Moderate Rain: 25-75 g/dm²/h;
7. Light Snow: 4-10 g/dm²/h; and
8. Moderate Snow: 10-25 g/dm²/h.

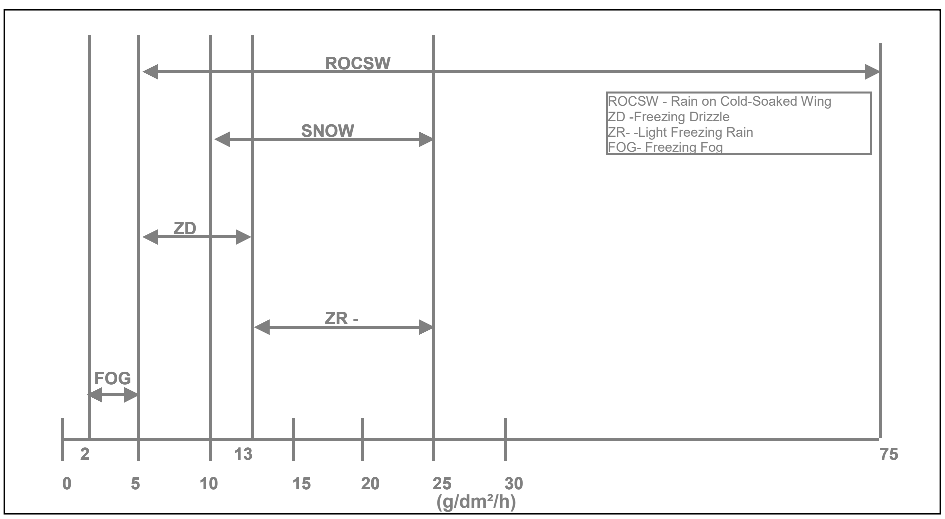


Figure 2.8: Precipitation Rate Breakdown

2.7 Test Equipment

A considerable amount of test equipment was used to perform these tests. Key items are described in the following subsections; a full list of equipment is provided in the test procedure, which is included in Appendix B.

2.7.1 Video and Photo Equipment

APS used the observation windows on the sides of the test section to install Canon EOS XTi DSLR cameras and Profoto Compact 600 flashes capable of second-by-second photography with an intervalometer. In addition, GoPro cameras were used for wide-angle filming of fluid flow-off during the test runs. Photo 2.9 and Photo 2.10 demonstrate the camera setup used for the testing period.

2.7.2 Refractometer/Brixometer

Fluid freezing points were measured using a hand-held Misco 10431VP refractometer with a Brix scale (shown in Figure 2.9). The freezing points of the various fluid samples were determined using the conversion curve or table provided to APS by the fluid manufacturer.

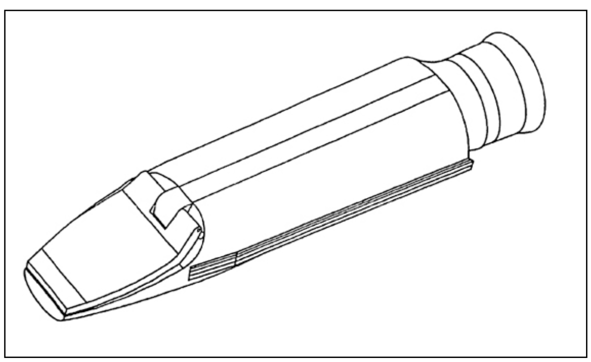


Figure 2.9: Hand-Held Refractometer/Brixometer

2.7.3 Wet Film Thickness Gauges

Wet film thickness gauges, shown in Figure 2.10, were used to measure fluid film thickness. These gauges were selected because they provide an adequate range of thicknesses (0.1 mm to 10.2 mm) for Type I/II/III/IV fluids. The rectangular gauge has a finer scale and was used in some cases when the fluid film was thinner (toward the end of a test). The observer recorded a thickness value (in mils), as read directly from the thickness gauge. The recorded value was the last wetted tooth of the thickness gauge; however, the true thickness lies between the last wetted tooth and the next un-wetted tooth; the measured thickness was corrected accordingly.

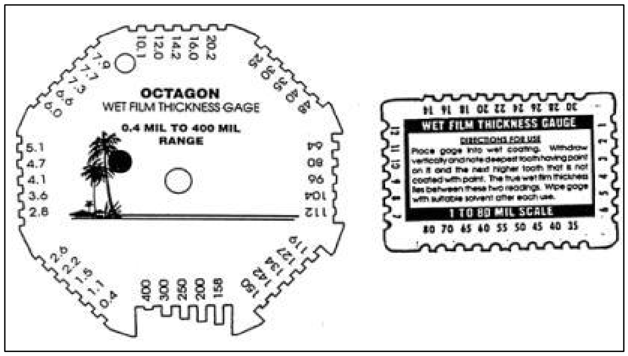


Figure 2.10: Wet Film Thickness Gauges

2.7.4 Temperature Sensor

When required, wing skin temperature and fluid temperature were measured using a Wahl digital heat-probe thermometer Model 392Vxc. A surface temperature probe was used for wing skin temperature measurements (however, generally the wing-mounted RTDs were used), and an immersion probe was used for measuring and monitoring fluid temperatures.

2.8 Personnel

During the fluid testing and exploratory research testing, four APS staff members were required to conduct the tests, and four additional persons from Ottawa were tasked to manufacture and dispense ice pellets as well as to help with general setup tasks. A professional photographer was retained to record digital images of the test setup and test runs. Representatives from NASA, TC, and the FAA provided direction in testing and participated as observers. Photo 2.12 and Photo 2.13 show a portion of the research team (due to scheduling, not all participants were available for the photos).

2.9 Data Forms

Several different forms were used to facilitate the documentation of the various data collected in the wind tunnel trials. These forms include:

1. General Form;
2. Wing Temperature, Fluid Thickness and Fluid Brix Form;
3. Ice Pellet and Snow Dispensing Forms;
4. Sprayer Calibration Form;
5. Visual Evaluation Rating Form;
6. Condition of Wing and Plate Form;
7. Fluid Receipt Form; and
8. Log of Fluid Sample Bottles.

Copies of these forms are provided in the test procedure, which is included in Appendix B and Appendix C. Completed wing temperature, fluid thickness, and fluid Brix data forms have been included in Appendix D, Appendix E, and Appendix F.

2.10 Data Collection

Fluid thickness, fluid Brix, and skin temperature measurements were collected by APS personnel. The measurements were collected before and after fluid application, after the application of contamination, and at the end of the test. The completed data forms have been scanned and included in Appendix D, Appendix E, and Appendix F for referencing purposes.

High-speed digital photographs of each test were taken. In addition, videos were also taken during a greater portion of the tests. Due to the large amount of data available, photos of the individual tests have not been included in this report, but rather the high-resolution photos available in electronic format have been provided to TC and can be made available upon request.

2.11 De/Anti-Icing Fluids

Eight new fluids were received for wind tunnel testing conducted during the winters of 2017-18 and 2018-19. Several other fluids remained in inventory from previous years' testing. The viscosity of the new fluids received was measured using the Stony Brook PDVdi-120 Falling Ball Viscometer and the Brookfield Digital Viscometer Model DV-1+ to ensure the fluid was within the fluid manufacturer production specifications and comparable to previous samples received. The pertinent characteristics of these fluids are given in Table 2.3.

Table 2.3: Wind Tunnel Fluid Viscosity Information for 2017-18 and 2018-19 Testing

						2013-14			2014-15			2015-16			2017-18			2018-19		
Sample Name	Dilution	Batch #	Year Rec'd	Receiving Qty (L)	Leftover Inventory Pre 2017-18 (L)	Measured Viscosity (cP)	Falling Ball Temp. (°C)	Falling Ball Time (mm:ss)	Measured Viscosity (cP)	Falling Ball Temp. (°C)	Falling Ball Time (mm:ss)	Measured Viscosity (cP)	Falling Ball Temp. (°C)	Falling Ball Time (mm:ss)	Measured Viscosity (cP)	Falling Ball Temp. (°C)	Falling Ball Time (mm:ss)	Measured Viscosity (cP)	Falling Ball Temp. (°C)	Falling Ball Time (mm:ss)
Clariant Safewing MP II FLIGHT	100/0	DEG 4145408 (EASA)	2014-15		150				13,600	22.4	0:26		22.9	0:26						
Dow UCAR™ FlightGuard AD 49	75/25	L14-290 (EASA)	2014-15		140				36,000	22.0	0:48		20.2	0:47						
Cryotech Polar Guard Advance	50/50	12964 (EASA)	2014-15		100				5320	22.4	0:03									
Kilfrost ABC-S Plus	100/0	WT 13-14 ABC-S+	2013-14		200	19,800	21.7	0:37				27,100	19.5	0:32	36,200	19.7	0:49			
Dow FlightGuard AD-49	100/0	WT 12-13 AD-49	2012-13		180	14,100	20.5	0:21				13,200	19.4	0:22	13,480	n/a	n/a			
Cryotech Polar Guard Advance	100/0	WT 13-14 PGA	2013-14		140	15,400	20.6	0:25				16040	19.5	0:24	15,980	n/a	n/a			
AllClear AeroClear MAX	100/0	TAB15-PB1112	2015-16		40							13,800	19.7	0:02						
AllClear AeroClear MAX	100/0	TAB17-1023	2017-18	400											16,500	19.0	0:02			
Inland ECO-SHIELD	100/0	n/a	2017-18	300											n/a	n/a	n/a			
CHEMCO ChemR EG IV	100/0	IV 35317-1	2017-18	400											46,000	19.6	0:13			
Clariant MaxFlight AVIA	100/0	41	2017-18	400											1,838	19.6	0:08	1,980	19.2	0:09
Clariant MaxFlight SNEG	100/0	8	2017-18	400											18700	19.6	0:39	19,100	19.5	0:41
Clariant Safewing EG IV NORTH	100/0	01819	2018-19	400														1,028	19.2	0:05
Oksayd Defrost EG 4	100/0	#1 (Lot #47)	2018-19	400														19,200	19.5	.:8
Oksayd Defrost ECO 4	100/0	#4 (Lot #48)	2018-19	300														13,300	19.9	0:34

Note: Viscosity measured using manufacturer method.

2.11.1 Viscometer

Historically, viscosity measurements have been carried out using a Brookfield viscometer (Model DV-1+, shown in Photo 2.14) fitted with a recirculating fluid bath and small sample adapter. In recent years, on-site measurements are also done with the Stony Brook PDVdi-120 Falling Ball Viscometer (Photo 2.15) to obtain a verification of the fluid integrity. The falling ball tests are much faster and more convenient to perform compared to tests with the Brookfield viscometer. The falling ball, however, does not provide the absolute value of viscosity, but rather a time interval that is compared to historical samples to identify changes in viscosity.

2.11.2 Type II/III/IV Fluid Application Equipment

The Type II/III/IV fluids were stored outside the wind tunnel and were kept at air temperature. The fluids were poured rather than sprayed so that application would not change the fluid viscosity. This methodology was appropriate given the relatively small test area of the wing section and the goal of minimizing the amount of fluid flowing off the wing.

Type II, III, and IV fluids are generally received in 20 L containers; however, some fluids are received in large 200 L barrels and larger 1000 L totes. The fluid is applied to the wing section by using smaller 2 L containers (Photo 2.11). Approximately 16 L to 20 L of fluid were applied to the wing section for each test; less fluid was required for the less viscous Type III fluid. Due to the flat top surface of the thin high-performance wing, the thickened fluid did not easily settle and flow on the top surface. Therefore, the wing was tilted forward (by approximately 10 degrees) for 1 minute following the end of fluid application to allow for the fluid to spread out evenly over the top surface of the wing.

2.11.3 Waste Fluid Collection

Using a relatively small test area and applying the fluids by pouring minimized the amount of fluid falling off the wing. APS personnel used a vacuum to collect the fluid that would drip onto the tunnel floor prior to each test. The NRC also fitted the wind tunnel with appropriate drainage tubes to collect spent fluid during the takeoff test runs. At the end of the testing period, the services of Lacombe Waste Services were employed to safely dispose of the waste glycol fluid.

2.12 Analysis Methodology

The following provides a brief description of the analysis methodology. More details on the analysis methodology can be found in TP 15232E (1).

Each ice pellet test was analysed in detail using the following objectives:

1. Test parameters;
2. Visual ratings at the start of the test;
3. Visual ratings at rotation;
4. 8° lift loss; and
5. Overall test status.

The evaluation grades for each criterion were "good," "review," or "bad." These grades were determined based on whether the criteria satisfied each test objective requirement. Figure 2.11 shows a summary of each test objective and criteria.

Several test parameters were evaluated, such as tunnel temperature before the start of the test, rate of precipitation, and exposure time of precipitation. These parameters were compared against the target parameters described in the test plan. The ramp-up time was also evaluated and compared to the target ramp-up time determined; this became less of an issue after 2011-12 with the use of the automated ramp-up system instead of the previous manual system.

2.12.1 Visual Ratings at the Start of the Test

During each of the tests conducted, visual contamination ratings were determined by three observers: one observer from the FAA and two observers from APS. The level of contamination present on the leading edge and trailing edge of the wing, as well as on the flap, was quantified using a scale of one-to-five with five being the worst case scenario; partial numbers were sometimes assigned when cases were marginally above or below a specific rating.

The visual contamination rating criteria at the start of the test on both the leading and trailing edge must be equal to 3 or less in order to pass. The flap must have a rating of 4 or less. For a review grade to be given, the leading and trailing edge must have a rating between 3 and 3.5, and the flap must have a rating between 4 and 4.5. Any rating greater than 3.5 on the leading and trailing edge is considered a fail, while anything greater than 4.5 on the flap is a fail.

1. TEST PARAMETERS

2. VISUAL RATINGS AT START OF TEST

CRITERIA: LE / TE $\leq$ 3
Flap $\leq$ 4

$\leq$ 3, 3, 4	GOOD
> 3, 3, 4 to 3.5, 3.5, 4.5	REVIEW
> 3.5, 3.5, 4.5	BAD

3. VISUAL RATINGS AT ROTATION

CRITERIA: LE = 1

1	GOOD
1 to 1.5	REVIEW
> 1.5	BAD

4. LIFT LOSS AT 8°

CRITERIA:

$< -2\sigma$	< 5.4%	GOOD
-2σ to 2σ	5.4% to 9.2%	REVIEW
$> +2\sigma$	> 9.2%	BAD

OVERALL STATUS

IF ANY OF THE ABOVE CRITERIA ARE RED, TEST IS NOT ACCEPTABLE

THEREFORE WORST OF ABOVE 3 CRITERIA, ORDER IS:

GREEN
YELLOW
RED

Figure 2.11: Ice Pellet Test Analysis Criteria

2.12.2 Visual Ratings at Rotation

The visual contamination rating criteria at the time of rotation on the leading edge must be equal to 1 or less in order to pass. For a review grade to be given, the leading edge must have a rating between 1 and 1.5. Any rating on the leading edge greater than 1.5 is considered a fail.

2.12.3 Eight Degree Lift Loss

For a pass, the 8º lift loss must be less than 5.4 percent. A review grade was given should the lift loss be between 5.4 percent and 9.2 percent. Any lift loss greater than 9.2 percent is considered a fail.

2.12.4 Overall Test Status

After all objectives were analysed, an overall status was given a "good," "review," or "bad." This provided an overall summary for each test. The overall status was determined by the worst case scenario from any of the test objectives; if any of the criteria were given a "bad" grade, the overall status would be "bad" and the test is considered a fail.

2.12.5 Dry Wing Calibration

To ensure the accuracy of the testing results, a dry wing calibration test was conducted at the start of each day. The dry wing test allowed the research team to ensure that the model aerodynamics did not change due to mechanical, communication, or analytical errors. Dry wing tests were also conducted following any mechanical modification to the airfoil (i.e., after applying the ice phobic wing skins). During the winters of 2017-18 and 2018-19, the dry wing results demonstrated that the changes in dry wing performance were within the range of experimental error and did not indicate any repeatability issues with the model.

This page intentionally left blank.

Photo 2.1: Outside View of NRC Wind Tunnel Facility

Photo 2.2: Inside View of NRC Wind Tunnel Test Section

Photo 2.3: Thin High-Performance Wing Section Used for Testing

Photo 2.4: Grid Markings on Thin High-Performance Wing Section

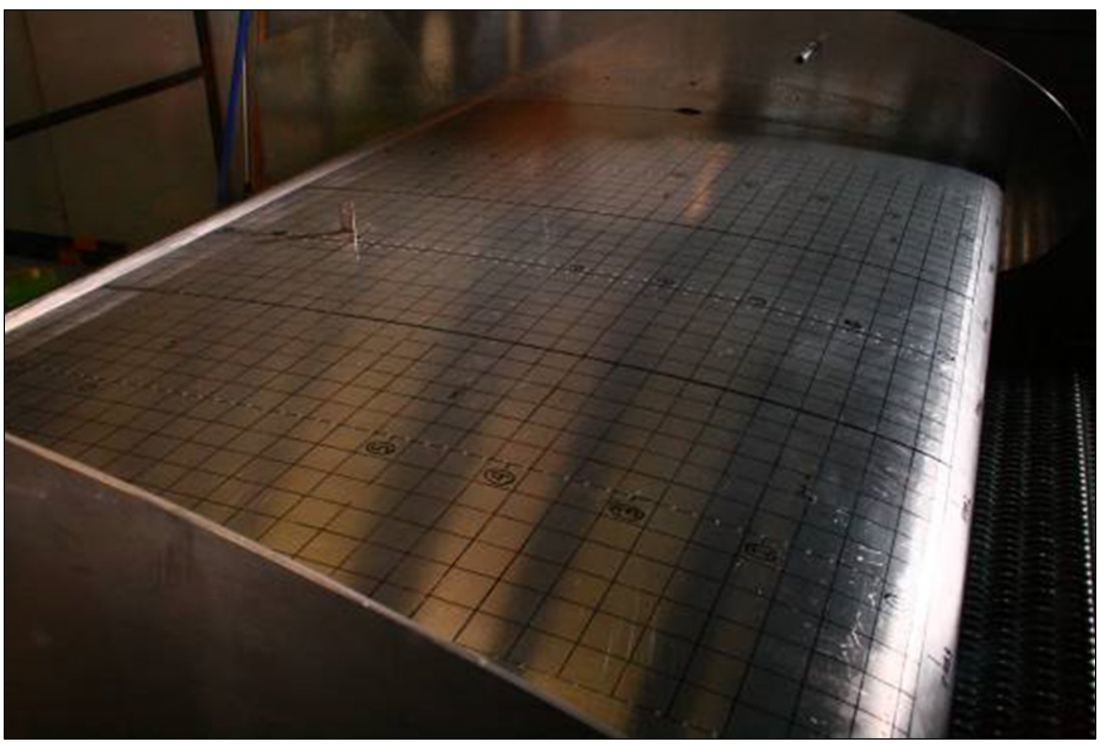


Photo 2.5: Refrigerated Truck Used for Manufacturing Ice Pellets

Photo 2.6: Calibrated Sieves Used to Obtain Desired Size Distribution

Photo 2.7: Ice Pellet Dispensers Operated by APS Personnel

Photo 2.8: Ceiling-Mounted Freezing Rain Sprayer

Photo 2.9: Wind Tunnel Setup for Flashes

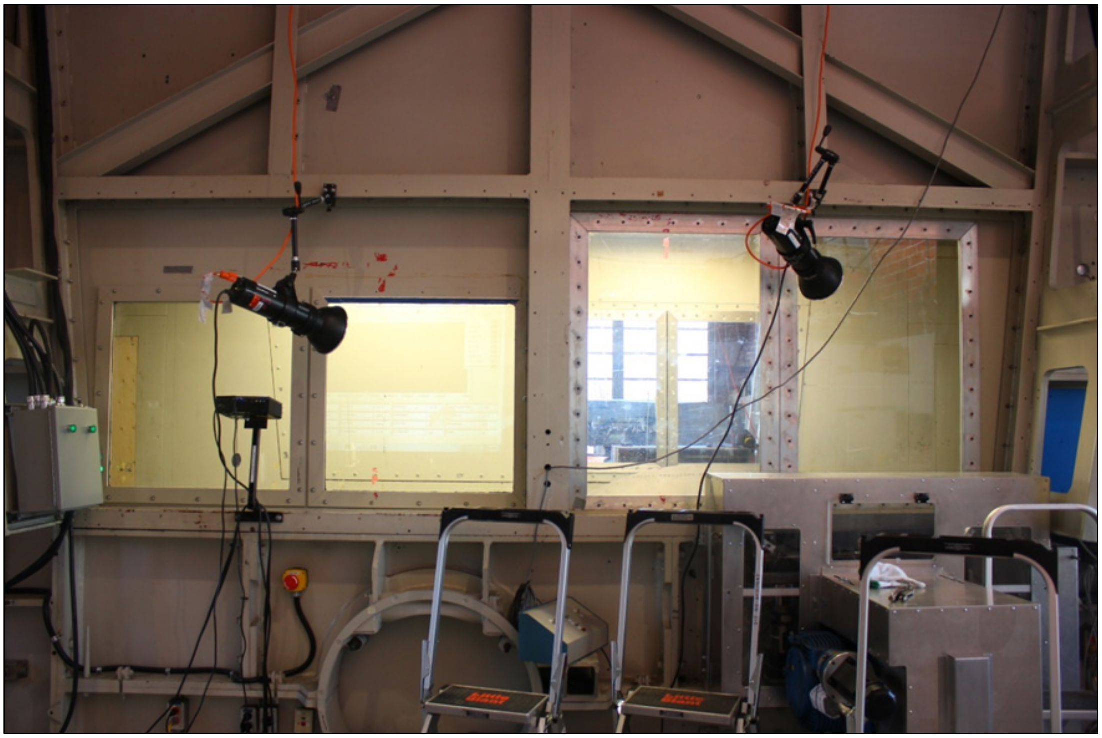


Photo 2.10: Wind Tunnel Setup for Digital Cameras

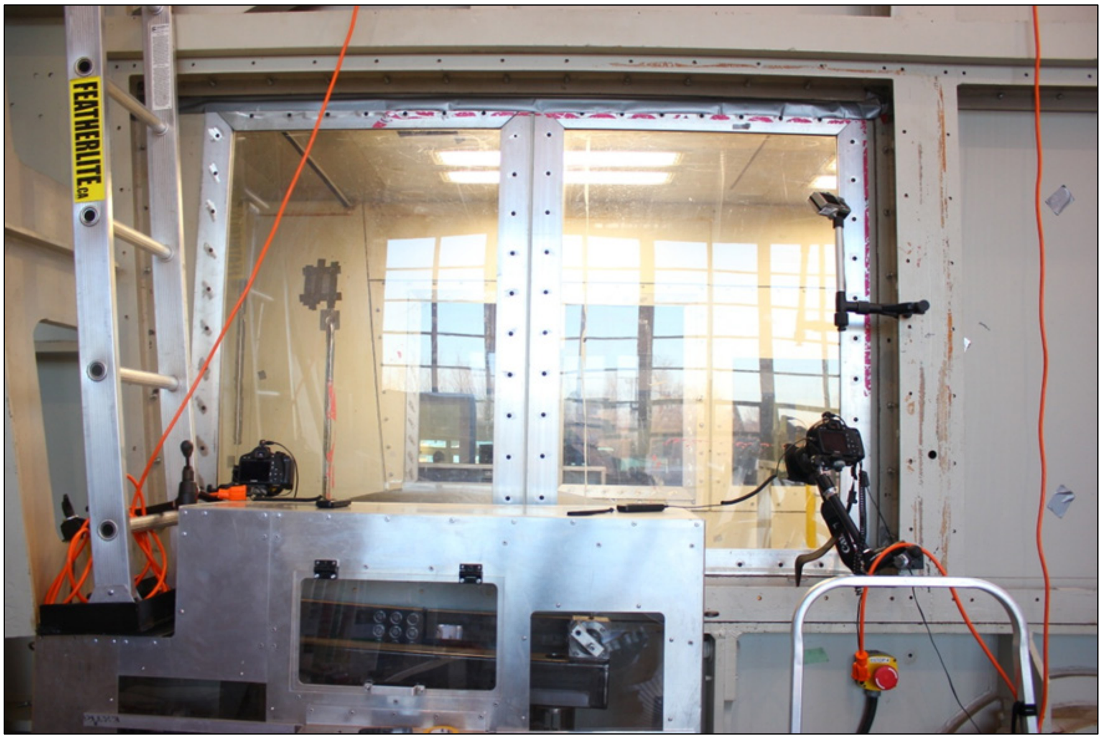


Photo 2.11: Fluid Pour Containers

Photo 2.12: 2017-18 Research Team

Photo 2.13: 2018-19 Research Team

Photo 2.14: Brookfield Digital Viscometer Model DV-1+

Photo 2.15: Stony Brook PDVdi-120 Falling Ball Viscometer

3. FULL-SCALE DATA COLLECTED

3.1 Test Log

A calendar of the tests conducted during the winters of 2017-18 and 2018-19 can be found in Table 2.1 and Table 2.2. A detailed log of the tests conducted in the NRC IWT during the winters of 2017-18 and 2018-19 are included in Appendix G and Appendix H for the LS-0417 and RJ wings tested in 2017-18, respectively, and in Appendix I for the RJ wing testing in 2018-19. Data pertaining to all test objectives (exploratory research objectives as well) is included in the respective logs. The logs provide relevant information for each of the tests, as well as final values used for the data analysis. Each column contains data specific to one test. The following is a brief description of the column headings for the logs included in Appendix G, Appendix H, and Appendix I.

Test #:	Exclusive number identifying each test run.
Test Year:	The year in which the test was conducted.
Objective:	Main objective of the test.
Test Condition:	Description of the simulated conditions for the test.
Fluid Name:	Aircraft anti-icing fluid used during the test.
Rotation Angle:	Maximum angle of rotation obtained during simulated takeoff run; began testing with a max 8º rotation angle and increased to 20º as testing progressed.
Flap Angle (0º, 20º):	Positioning of the flap during the precipitation period; either 0º (retracted) or 20º (extended). *Note: Flap was always extended at 20º during the takeoff run.*
Date:	Date when the test was conducted.
OAT Before Test (ºC):	Outside air temperature recorded just before the start of the simulated takeoff test, measured in degrees Celsius. *Note: This is not an important parameter as "Tunnel Temp. Before Test" was used as actual test temperature for analysis.*

Tunnel Temp. Before Test (°C): Static tunnel air temperature recorded just before the start of the simulated takeoff test, measured in degrees Celsius.
Note: This parameter was used as the actual test temperature for analysis.

Precipitation Rate (Type: [g/dm²/h]): Simulated freezing precipitation rate (or combination of different precipitation rates). "N/A" indicates that no precipitation was applied.

Exposure Time: Simulated precipitation period, recorded in minutes.

The visual contamination ratings are described below. Visual contamination ratings were typically reported as the average of the three observer ratings and rounded to the nearest decimal. The visual contamination ratings system is further described in Subsection 2.12.

Visual Contamination Rating Before Takeoff (LE, TE, Flap): Visual contamination rating determined before the start of the simulated takeoff:

1 - Contamination not very visible, fluid still clean;
2 - Contamination is visible, but lots of fluid still present;
3 - Contamination visible, spots of bridging contamination;
4 - Contamination visible, lots of dry bridging present; and
5 - Contamination visible, adherence of contamination.

Visual Contamination Rating at Rotation (LE, TE, Flap): Visual contamination rating determined at the time of rotation:

1 - Contamination not very visible, fluid still clean;
2 - Contamination is visible, but lots of fluid still present;
3 - Contamination visible, spots of bridging contamination;
4 - Contamination visible, lots of dry bridging present; and
5 - Contamination visible, adherence of contamination.

Visual Contamination Rating After Takeoff (LE, TE, Flap): Visual contamination rating determined at the end of the test:

1 - Contamination not very visible, fluid still clean;
2 - Contamination is visible, but lots of fluid still present;
3 - Contamination visible, spots of bridging contamination;
4 - Contamination visible, lots of dry bridging present; and
5 - Contamination visible, adherence of contamination.

Corrected for 3D Effects C_L at 8°: Calculated lift coefficient at the 8º wing rotation angle position and corrected for 3D effects; data provided by NRC.

Corrected for 3D Effects % Lift Loss On 8° C_L vs. Dry C_L: Percent lift loss calculated based on the comparison of the 8º lift coefficient during the test run versus the dry wing average lift coefficient.

Speed (kts): Maximum speed obtained during simulated takeoff run, recorded in knots.

This page intentionally left blank.

4. VALIDATION TESTING FOR NEW-TO-MARKET TYPE IV FLUIDS

The Type IV fluid Ice Pellet Allowance Times are developed based on data collected using commercially available Type IV fluids. The Type IV fluid Ice Pellet Allowance Times are generic and, therefore, conservative. As new fluids are developed and become commercially available, it is important to evaluate these fluids against the current allowance times to ensure the validity of the generic guidance. Systematic "spot-checking" is used in order to identify any potential issues. In addition, testing is recommended with all available fluids to obtain data close to the fluid LOUT; this further allows the aerodynamic effects of ice pellet contamination at colder temperatures to be determined. To meet these requirements, testing during the winters of 2017-18 and 2018-19 was conducted with the following Type IV EG and propylene glycol (PG) fluids:

1. CHEMCO Inc. ChemR EG IV;
2. Clariant Produkte (Deutschland) GmbH Max Flight AVIA;
3. Clariant Produkte (Deutschland) GmbH Max Flight SNEG;
4. Inland Technologies ECO-SHIELD®;
5. Oksayd Co. Ltd. Defrost ECO 4; and
6. Oksayd Co. Ltd. Defrost EG 4.

It should be noted that testing was also planned with the following fluid; however, due to shipping logistics, the fluid was not received in time for the testing:

1. Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH.

The fluid sample received late will be stored and made available for the next wind tunnel trials report expected in the winter of 2019-20.

The following sections will provide an overview of the analysis format and a summary of the results obtained for each of the fluids tested.

4.1 Allowance Time Table Analysis Format

For each fluid tested, a table has been included that provides a summary of the tests conducted. The results from the individual tests are included in a mock-up allowance time table indicating the current Ice Pellet Allowance Times as well as the individual test information in the respective cell. The individual test information has been included in the following format:

- AA(BB)CC[DD]E
  - AA is the static tunnel air temperature recorded just before the start of the simulated takeoff test, measured in degrees Celsius and rounded to the closest degree.
  - BB is the percentage lift loss calculated based on the comparison of the 8º lift coefficient during the test run versus the dry wing average lift coefficient.
  - CC is the exposure time of the test in minutes.
  - DD is the test number to reference the data in the test logs.
  - E is the status of the testing, either "G" for Good, "R" for Review, or "B" for Bad, as per the guidelines in Subsection 2.12.4. The highlighting is in a corresponding green, yellow, and red colour.
  - The test information is included in the cell for which the temperature band best corresponds to the temperature recorded during the test.

The purpose of these tables is to provide a quick reference of the test results vis-a-vis the current allowance times to better understand in which cells the times have been validated or where potential issues may be identified. For the detailed test results and data, reference the log of tests in Appendix G, Appendix H, and Appendix I.

4.2 CHEMCO Inc. ChemR EG IV Testing Results

A total of 14 allowance time tests were conducted with ChemR EG IV fluid. As this was an EG fluid, and it was expected that the fluid would perform well in specific conditions, so some tests were conducted for longer than published allowance times so the test could serve a dual purpose: validating the existing allowance times and potentially supporting the expansion of the table for EG fluids.

Table 4.1 provides a summary of the tests conducted that served strictly as validation tests (the exposure time of the test was equivalent to the current allowance times). All tests conducted were acceptable from a visual and aerodynamic perspective with the exception of one test (#39) run in Moderate Ice Pellets Mixed with Rain. During this test (#39), the flap was visually failed at the start of the test, and the contamination was not removed at the time of rotation; however, the aerodynamic performance was acceptable. In addition, the test temperature was -3.5ºC, which was well below the 0ºC limit specific for this allowance time; therefore, the test could be considered invalid.

Table 4.2 provides a summary of the tests conducted that served as expansion tests (the exposure time of the test exceeded the current allowance time). Most tests conducted were acceptable from a visual and aerodynamic perspective; however, three tests (#33, #32, #43) fell in the “review” or “bad” category. Upon further review, the tests demonstrated visual failure on the flap portion, which was in the deployed position for these tests and led to the “review” or “bad” ratings; the aerodynamic performance was acceptable in all three cases. If the three tests had been re-run with the flap in the retracted position, it is expected that the visual ratings would have improved.

Table 4.3 provides a summary of all the tests conducted combined. In general, the fluid met and exceeded the current allowance times. In the four cases where the results were in the “review” or “bad” category, the flap deployed position was the contributing factor, and previous research has shown that a significant improvement is expected if the test is conducted with the flap in the retracted position during the exposure time.

Based on these results, the allowance times were validated for this fluid, and the results indicate a good potential to increase the times for EG fluids.

Table 4.1: ChemR EG IV Allowance Time Validation Tests

Precipitation Type	**Outside Air Temperature**			
	-5°C and Above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3] -13(2.6)30[16]G	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes -8(2.5)15[12]G	15 minutes[3] -12(3.4)15[17]G	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes		**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -8(3.2)10[8]G	0 minutes	
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6]	10 minutes -10(1.9)10[13]G	10 minutes[3] -15(2.7)10[18]G	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8] -3(7.2)10[39]B*			

** The test temperature was -3.5ºC, which was well below the 0ºC limit specific for this allowance time; therefore, the test could be considered invalid.*

Table 4.2: ChemR EG IV Allowance Time Expansion Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes -7(1.3)50[40]G -9(1.8)50[31]G	30 minutes[3]	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes -5(3.7)50[33]R	15 minutes	15 minutes[3]	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes -6(5.4)30[32]R		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes	0 minutes -12(5.8)43[30]B	
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6]	10 minutes -10(2.3)25[42]G	10 minutes[3]	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes -8(2.4)7[9]G	Caution: No allowance times currently exist	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

Table 4.3: All ChemR EG IV Allowance Time Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes -7(1.3)50[40]G -9(1.8)50[31]G	30 minutes[3] -13(2.6)30[16]G	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes -5(3.7)50[33]R	15 minutes -8(2.5)15[12]G	15 minutes[3] -12(3.4)15[17]G	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes -6(5.4)30[32]R		Caution: No allowance times currently exist
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -8(3.2)10[8]G	0 minutes -12(5.8)30[43]B	
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6]	10 minutes -10(2.3)25[42]G -10(1.9)10[13]G	10 minutes[3] -15(2.7)10[18]G	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes -8(2.4)7[9]G	Caution: No allowance times currently exist	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8] -3(7.2)10[39]B			

4.3 Clariant Produkte (Deutschland) GmbH Max Flight AVIA Testing Results

A total of five allowance time tests were conducted with Clariant Produkte (Deutschland) GmbH Max Flight AVIA fluid. Table 4.4 provides a summary of the tests conducted. Of the tests conducted, three were acceptable from a visual and aerodynamic perspective; however, two tests (#15, #16) fell in the "review" category. Upon further review, the two tests demonstrated lift losses that were higher at 5.7 percent and 5.5 percent, just slightly above the 5.4 percent lower limit but still well below the 9.2 percent upper limit. It is common for fluids to demonstrate higher lift losses at colder temperatures; therefore, these results were not of concern.

It was observed that the lift losses were generally low for the three acceptable tests (#31, #41, #46); this is typical of EG fluids and supports the potential to expand the allowance times for EG fluids in specific conditions. Further testing is recommended to support this.

Based on these results, the allowance times were validated for this fluid, and the results indicate a good potential to increase the times for EG fluids.

Table 4.4: Clariant Produkte (Deutschland) GmbH Max Flight AVIA Allowance Time Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] -21(5.7)30[15]R
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes	15 minutes[3] -14(4.3)15[41]G	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -10(2.9)10[46]G		
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] -4(1.9)25[31]G	10 minutes	10 minutes[3]	10 minutes[7] -21(5.5)10[16]R
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	Caution: No allowance times currently exist	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

4.4 Clariant Produkte (Deutschland) GmbH Max Flight SNEG Testing Results

A total of seven allowance time tests were conducted with Clariant Produkte (Deutschland) GmbH Max Flight SNEG fluid. Table 4.5 provides a summary of the tests conducted. Of the tests conducted, two were acceptable from a visual and aerodynamic perspective; however, four tests (#13, #22, #28, #47) fell in the "review" category, and one test (#27) fell in the "bad" category. Upon further review, the four tests (#13, #28, #47, #22) demonstrated lift losses that were higher at 7.1 percent, 7.2 percent, 6.8 percent, and 8.1 percent, respectively. These results were above the 5.4 percent lower limit but still below the 9.2 percent upper limit; however, they were acceptable from a visual perspective. It is common for fluids to demonstrate higher lift losses at colder temperatures; therefore, these results were not of concern.

As for test #27, the lift losses exceeded the upper limit at 9.9 percent; however, further review indicated that the test was conducted at the lower end of the temperature range, and it was snowing during the test, so the snow was being sucked into the wind tunnel and was adhering to the leading edge. The test was re-run as #28 at 115 knots (instead of 100 knots), and it passed with a lift loss of 6.8 percent. Since the original test was conducted at a lower end of the temperature range, and due to the snow being sucked into the wind tunnel, we could consider disregarding the test results. If fluid is still available and similar conditions present themselves during the next wind tunnel test campaign, a re-run of the test should be considered.

Based on these results, the allowance times were validated for this fluid.

4.5 Inland Technologies ECO-SHIELD® Testing Results

A total of 11 allowance time tests were conducted with Inland Technologies ECO-SHIELD® fluid. Table 4.6 provides a summary of the tests conducted. As testing was nearing completion, it was discovered that the fluid samples submitted were not of mid-viscosity and instead were a combination of lowest and highest on-wing viscosity fluid samples, likely leftovers from previous fluid qualification testing. The results indicated that three tests were acceptable from a visual and aerodynamic perspective, and eight tests fell in the "review" category (some tests targeted longer allowance times to support a potential expansion). Unfortunately, because the fluid samples submitted were not of the required fluid viscosity, the results obtained were not valid. The fluid test results will need to be re-validated will need to be re-validated; however, recent communication with the fluid manufacturer has indicated that the fluid may no longer be commercialized. As such, the re-validation of these test results may not be necessary. Based on these results, the allowance times are not validated for this fluid; further testing is required if the manufacturer intends to commercialize this fluid again.

Table 4.5: Clariant Produkte (Deutschland) GmbH Max Flight SNEG Allowance Time Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] -20(7.1)30[13]R
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes -8(9.9)15[27]B	15 minutes[3] -9(6.8)15[28]R	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes -1(3.5)25[35]G	10 minutes -13(8.1)10[47]R		
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] -3(4.5)15[34]G	10 minutes	10 minutes[3] -14(7.2)10[22]R	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

Table 4.6: Inland Technologies ECO-SHIELD® Allowance Time Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes -8(6.5)50[41]R -7(4.8)30[5]G	30 minutes[3] -16(6.5)30[20]R	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes -5(5.0)15[11]R	15 minutes[3] -14(6.4)15[21]R	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -8(4.8)10[7]G		
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6]	10 minutes -7(5.6)15[3]R -8(8.9)10[34]R	10 minutes[3]	10 minutes[7] -17(8.8)10[22]R
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes -7(5.8)7[10]R	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8] -2(4.6)10[38]G			

4.6 Oksayd Co. Ltd. Defrost ECO 4 Testing Results

A total of seven allowance time tests were conducted with Oksayd Co. Ltd. Defrost ECO 4 fluid. Table 4.7 provides a summary of the tests conducted. Of the tests conducted, two were acceptable from a visual and aerodynamic perspective; however, five tests (#14, #23, #26, #40, #48) fell in the "review" category. Upon further review, the five tests (#14, #23, #26, #40, #48) demonstrated lift losses that were higher at 8.8 percent, 6.3 percent, 7.8 percent, 7.9 percent, and 7.1 percent, respectively. These results were above the 5.4 percent lower limit but still below the 9.2 percent upper limit, and they were acceptable from a visual perspective. It is common for fluids to demonstrate higher lift losses at colder temperatures; therefore, these results were not of concern.

Based on these results, the allowance times were validated for this fluid.

Table 4.7: Oksayd Co. Ltd. Defrost ECO 4 Allowance Time Tests

Precipitation Type	Outside Air Temperature			
	-5°C and Above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] -21(8.8)30[14]R
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes -9(7.8)15[26]R	15 minutes[3] -16(7.9)15[40]R	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	Caution: No allowance times currently exist	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -13(7.1)10[48]R		
Light Ice Pellets Mixed with Rain	25 minutes[4] 1(2.9)25[37]G			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] -3(3.5)15[33]G	10 minutes	10 minutes[3] -13(6.3)10[23]R	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	Caution: No allowance times currently exist	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

4.7 Oksayd Co. Ltd. Defrost EG 4 Testing Results

A total of six allowance time tests were conducted with Oksayd Co. Ltd. Defrost EG 4 fluid. Table 4.8 provides a summary of the tests conducted. Of the tests, four were acceptable from a visual and aerodynamic perspective; however, two tests (#17, #18) fell in the "review" category. Upon further review, the two tests demonstrated lift losses that were higher at 6.7 percent and 6.6 percent, respectively. These results were above the 5.4 percent lower limit but still below the 9.2 percent upper limit, and they were acceptable from a visual perspective. It is common for fluids to demonstrate higher lift losses at colder temperatures; therefore, these results were not of concern.

It was observed that the lift losses were generally low for the four acceptable tests (#32, #36, #42, #43); this is typical of EG fluids and supports the potential to expand the allowance times for EG fluids in specific conditions. Further testing is recommended to support this.

Based on these results, the allowance times were validated for this fluid, and the results indicate a good potential to increase the times for EG fluids.

Table 4.8: Oksayd Co. Ltd. Defrost EG 4 Allowance Time Tests

Precipitation Type	**Outside Air Temperature**			
	-5°C and Above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] -22(6.7)30[17]R
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes	15 minutes[3] -13(5.2)15[42]G	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes -10(4.4)10[43]G		
Light Ice Pellets Mixed with Rain	25 minutes[4] 1(1.4)25[36]G			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] -4(2.5)25[32]G	10 minutes	10 minutes[3]	10 minutes[7] -21(6.6)10[18]R
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

4.8 Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH Testing Results

Fluid samples of Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH were received late, and testing could not be completed as a result. It is recommended that the fluid samples be stored for testing during the next wind tunnel testing campaign, likely during the winter of 2019-20.

4.9 Summary of Results

Table 4.9 provides a summary of the results from the validation testing. A total of five fluids were validated based on the data collected:

1. CHEMCO Inc. ChemR EG IV;
2. Clariant Produkte (Deutschland) GmbH Max Flight AVIA;
3. Clariant Produkte (Deutschland) GmbH Max Flight SNEG;
4. Oksayd Co. Ltd. Defrost ECO 4; and
5. Oksayd Co. Ltd. Defrost EG 4.

Two fluids are still outstanding due to the circumstances outside of the control of the testing program. Of these two fluids, Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH should be tested during the next wind tunnel testing campaign, and Inland Technologies ECO-SHIELD may no longer be commercialized; therefore, testing may not be necessary.

Table 4.9: Summary of Ice Pellet Allowance Time Validation Tests

Fluid	Status	Comments
CHEMCO Inc. ChemR EG IV	Validated	Potential to extend allowance times. Further testing recommended in 2019-20.
Clariant Produkte (Deutschland) GmbH Max Flight AVIA	Validated	Potential to extend allowance times. Further expansion testing recommended in 2019-20.
Clariant Produkte (Deutschland) GmbH Max Flight SNEG	Validated	Consider re-running test in Light Ice Pellets Mixed with Snow in Below -5 to -10°C in 2019-20.
Inland Technologies ECO-SHIELD®	Not Validated	Incorrect fluid samples submitted. Manufacturer indicated may no longer commercialize; therefore, testing may not be required.
Oksayd Co. Ltd. Defrost ECO 4	Validated	None.
Oksayd Co. Ltd. Defrost EG 4	Validated	Potential to extend allowance times. Further expansion testing recommended in 2019-20.
Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH	Not Validated	Fluid received late; therefore, could not test. Testing recommended in 2019-20.

5. POSSIBLE EXTENSION OF ALLOWANCE TIMES FOR EG FLUIDS

Type IV Ice Pellet Allowance Times are intended to be conservative, and, therefore, generic guidance is developed based on data collected using commercially available Type IV fluids. Historically, Type IV PG and EG fluids have been grouped together; however, data has indicated that EG may have an operational advantage of longer Ice Pellet Allowance Times in specific conditions. The industry requested that the possibility of EG fluid-specific Ice Pellet Allowance Time tables be investigated due to potentially longer allowance times specific to these fluids. As such, an analysis of historical EG data was conducted, and some preliminary testing with EG fluids was performed, with the objective to identify or conduct tests which supported longer times for EG fluids.

5.1 Analysis of EG Fluid Allowance Times

An analysis was conducted based on the EG fluids tested during the winters of 2017-18 and 2018-19, as well as historical testing that occurred between 2009 to 2017. The data included a mix of tests that were done for allowance time development, validation, and expansion. The analysis included five fluids:

1. ChemR EG IV;
2. Max Flight AVIA;
3. UCAR™ Endurance EG106 De/Anti-Icing Fluid;
4. LNT E450; and
5. Defrost EG 4.

The analysis identified individual tests that either met or exceeded the existing allowance times and had good aerodynamic and visual performance indicating a potential margin for longer allowance times. All tests were performed with the RJ thin high-performance wing section. The individual fluid-specific results were analysed and then combined, as the objective aimed at developing a generic EG table (not EG fluid-specific tables).

Table 5.1 demonstrates, through highlighted colours, every allowance time cell where EG fluid data exists (either from one or multiple fluids). The coloured highlights describe the following:

1. The longest time tested that showed a positive result;
2. The "+" sign and green highlight indicate there was still capacity to go beyond the longest time tested. This is based on lift loss performance and visual evaluation of contamination (as per usual wind tunnel procedure); and

3. The "ok" and yellow highlight indicates the performance is nearing the ceiling for that cell.

It should be noted that there were no tests that failed aerodynamically or visually, and hence all tests fell within the "good" or "review" category based on the evaluation criteria described in Subsection 2.12. In fact, the lift losses recorded at the time of rotation were generally low and ranged from 1 percent to 7 percent, with the majority of the results falling below 5 percent.

The results of the analysis in Table 5.1 indicate that, from a generic EG fluid perspective, all of the cells indicate a potential for longer allowance times, with the exception of two cells (Moderate Ice Pellets -5°C and above and Below -16°C to -22°C) where the margin may be limited, and two cells where no data was available. In all other cells, the data collected was either conducted with an exposure time equal to the allowance time and indicated a margin to expand or was conducted with an exposure time longer than the allowance time and showed a margin to expand or, at a minimum, an acceptable result. Appendix J provides some more detailed information on the individual fluid test results.

Based on these preliminary results, a potential for longer allowance times for EG fluids exists in most of the allowance time cells. If there is an industry demand for this type of guidance, additional data and analysis will be required to substantiate these findings as the data collected to date is limited, and data at the failure points is required to understand the limits of the margins that exist.

Table 5.1: Analysis of All EG Fluid Tests Indicating Cells with Potential for Longer Allowance Times

Precipitation Type	**Outside Air Temperature**			
	-5°C and above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes 50+ minutes	30 minutes 50+ minutes	30 minutes[3] 30+ minutes	30 minutes[3] 50 minutes ok
Light Ice Pellets Mixed with Snow	40 minutes 50 minutes ok	15 minutes 15+ minutes	15 minutes[3] 25+ minutes	15+ minutes
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes 30+ minutes	10 minutes 30 minutes ok	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes 30+ minutes	10 minutes 20+ minutes		
Light Ice Pellets Mixed with Rain	25 minutes[4] 30+ minutes			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] 25 minutes ok	10 minutes 25+ minutes	10 minutes[3] 10+ minutes	10 minutes[7] 10 minutes ok
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes 10+ minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

6. LS-0417 AIRFOIL TESTING FOR DEVELOPING LOW-SPEED TYPE III ALLOWANCE TIMES

Type III fluid allowance times have recently been developed but are limited to use with aircraft with rotation speeds of 100 knots or greater. Type III fluids can often be used with lower rotation speed aircraft; therefore, there is a requirement to have these allowance times validated for use at these lower speeds. The LS-0417 is a more representative airfoil to conduct low-speed testing at 80 knots.

In order to develop low-speed allowance times for Type III fluids, it was first required to calibrate and characterize the LS-0417 wing section to understand the aerodynamic performance parameters and how they affect fluid flow-off properties. Once the wing model was calibrated and characterized, testing was required to validate the existing high-speed Type III IP allowance times using the LS-0417 wing model at the lower speed of 80 knots.

6.1 LS-0417 Wing Model Calibration and Characterization

This section briefly describes the work led by NASA and supported by APS and the NRC to verify the calibration and characterization of the LS-0417 wing section. This testing was primarily done without the use of de/anti-icing fluid. The results of this work are specific to the wing model tested and may not be representative of different model types.

The NASA-led research aimed at systematically subjecting the wing section to various conditions to better understand the performance characteristics and to increase confidence in the repeatability and accuracy in the results obtained. This was achieved through the following testing objectives, which are described in greater detail in Subsections 6.1.1 to 6.1.4:

1. Survey of Clean Wing Performance;
2. Boundary Layer Rake Test;
3. Sandpaper Roughness Tests; and
4. Lift Loss Scaling.

The data and more extensive analysis were presented by NASA at the SAE G-12 AWG in Dubrovnik in May 2019 and will be documented in a public NASA report (not yet published at the time of writing of this report). The following sections provide an overview of the general testing objectives.

6.1.1 Survey of Clean Wing Performance

Testing was conducted to verify the clean wing performance and to investigate the integrity and sensitivity of the data provided from the force balances supporting the wing. This was done through pitch-pause test runs whereby, at a constant airspeed, the wing was incrementally rotated to higher pitch angles and held for a few seconds; this was done to obtain lift data at static angles of attack. Dynamic angle sweep tests were also conducted where, at a constant speed, the wing was dynamically rotated simulating a takeoff. Both the pitch-pause and angle sweep tests were conducted to the stall angle as well as to the typical 8º rotation angles used for the Ice Pellet Allowance Time testing. The differences in results and the repeatability of the tests were analysed and compared. Photo 6.1 demonstrates the dry wing section during these tests.

6.1.2 Boundary Layer Rake

A boundary layer rake was installed on the wing with the purpose of identifying the boundary layer separation on the trailing edge section of the main wing section and on the flap. The boundary layer rake was fastened to the wing section using speed-tape and was re-positioned in different locations along the span of the trailing edge and flap. Testing was done using both angle sweeps and fixed pitch testing. Photo 6.2 shows the boundary layer rake installed mid-span on the trailing edge of the wing.

6.1.3 Sandpaper Roughness Tests

The objective of these tests was to determine the wing sensitivity to different levels of roughness simulating frost and to better understand how roughness relates to fluid flow-off. To do so, different grades of sandpaper were used (150, 40, and 80 grit) to simulate various levels of contamination. These tests were done with the full wing and flap covered in sandpaper, and then the sand paper was removed in incremental configurations starting from the leading edge simulating fluid flow-off. Photo 6.3 shows the “full wing minus leading edge 30 percent” sandpaper configuration tested.

6.1.4 Lift Loss Scaling

Fluid only testing was conducted with the LS-0417 wing section. The lift loss due to clean, uncontaminated anti-icing fluids measured on the NRC IWT wing at $\alpha = 8º$ were scaled to the percent reduction in maximum lift of the full-scale Dash 8 aircraft through the low-speed aerodynamic acceptance test. The results will be used to develop a lift loss criterion to help develop low-speed Ice Pellet Allowance Times for Type III fluids. Photo 6.4 shows an uncontaminated “fluid only” test.

Preliminary results indicate that the lift loss limits for low-speed testing with the LS-0417 wing section are as follows; however, they are a work in progress:

1. Less than 4.6 percent - Good;
2. 4.6 percent to 5.9 percent - Review; and
3. Greater than 5.9 percent - Bad.

These preliminary lift loss limits (which would replace the high-speed lift loss limits in Subsection 2.12.3) will need to be confirmed as research continues.

6.2 Low-Speed Type III Allowance Times

Based on previous allowance time testing with this EG Type III fluid, it was expected that the fluid would perform well in most conditions. Therefore, tests were conducted for longer than current published high-speed Type III allowance times so that the tests could serve a dual purpose: validating the allowance times for low-speed rotation and potentially expanding the allowance times.

A total of seven allowance time tests were conducted with the AllClear Systems LLC AeroClear MAX fluid. Table 6.1 provides a summary of the tests conducted, presented in the same format as described in Subsection 4.1, however with the recorded lift loss included as well. All tests conducted were acceptable from a visual perspective. The lift loss scaling results (see Subsection 6.1.4) are still pending; therefore, the tests could not be officially evaluated from an aerodynamic perspective. Nonetheless, when comparing the aerodynamic data to the preliminary lift loss limits determined from the lift loss scaling analysis, all results were well below the limits identified. These preliminary results indicate that the fluid can likely meet and exceed the allowance time and still perform adequately.

The results obtained to date indicate a good potential to develop low-speed allowance times for Type III fluids and a potential to extend the allowances to longer times. It is recommended that discussions with the SAE G-12 AWG continue in order to validate the lift loss scaling results for the LS-0417 wing section, so that guidance can then be developed based on the low-speed allowance time testing results.

Table 6.1: AllClear Systems LLC AeroClear MAX Low-Speed Allowance Time Tests

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[2]
Light Ice Pellets	10 minutes	10 minutes 53 (30 min) 2.3% G 62 (40 min) 1.9% G	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Snow	10 minutes	10 minutes 59 (20 min) 3.4% G	
Light Ice Pellets Mixed with Freezing Drizzle	7 minutes	5 minutes	
Light Ice Pellets Mixed with Freezing Rain	7 minutes	5 minutes 49 (15 min) 2.3% G 60 (20 min) 3.1% G	
Light Ice Pellets Mixed with Rain	7 minutes[3]		
Moderate Ice Pellets (or Small Hail)[4]	5 minutes	5 minutes 54 (20 min) 1.6% G 61 (20 min) 3.0% G	

Photo 6.1: Survey of Clean Wing Performance

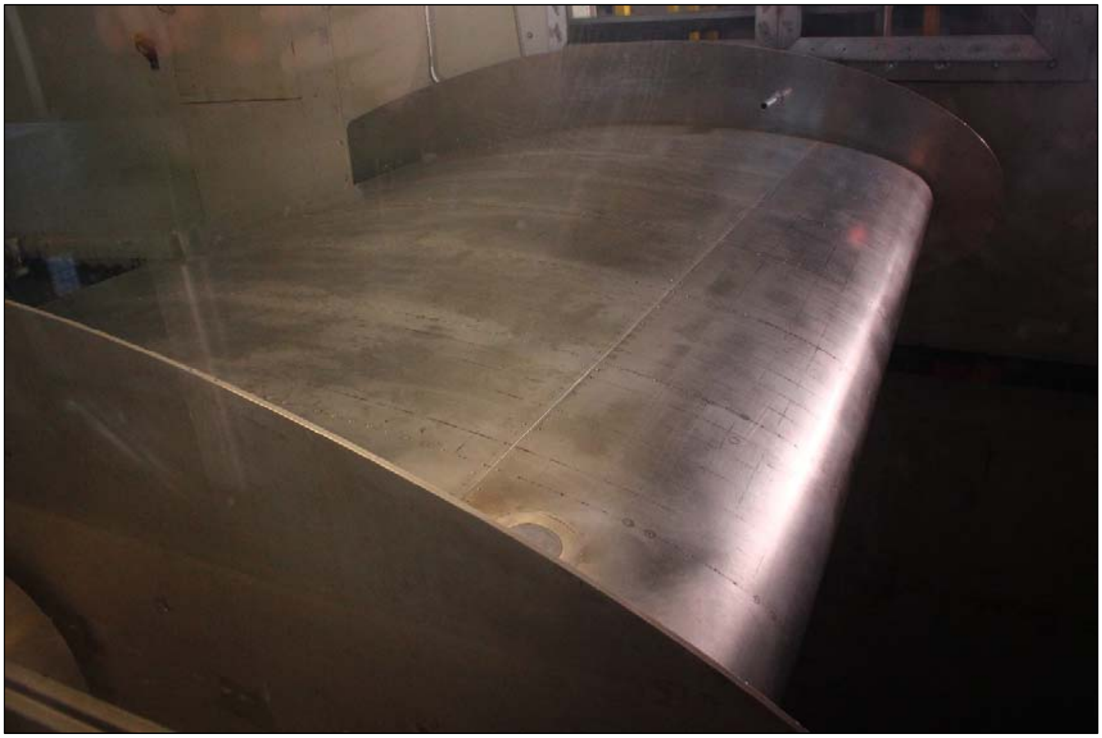


Photo 6.2: Boundary Layer Rake Tests

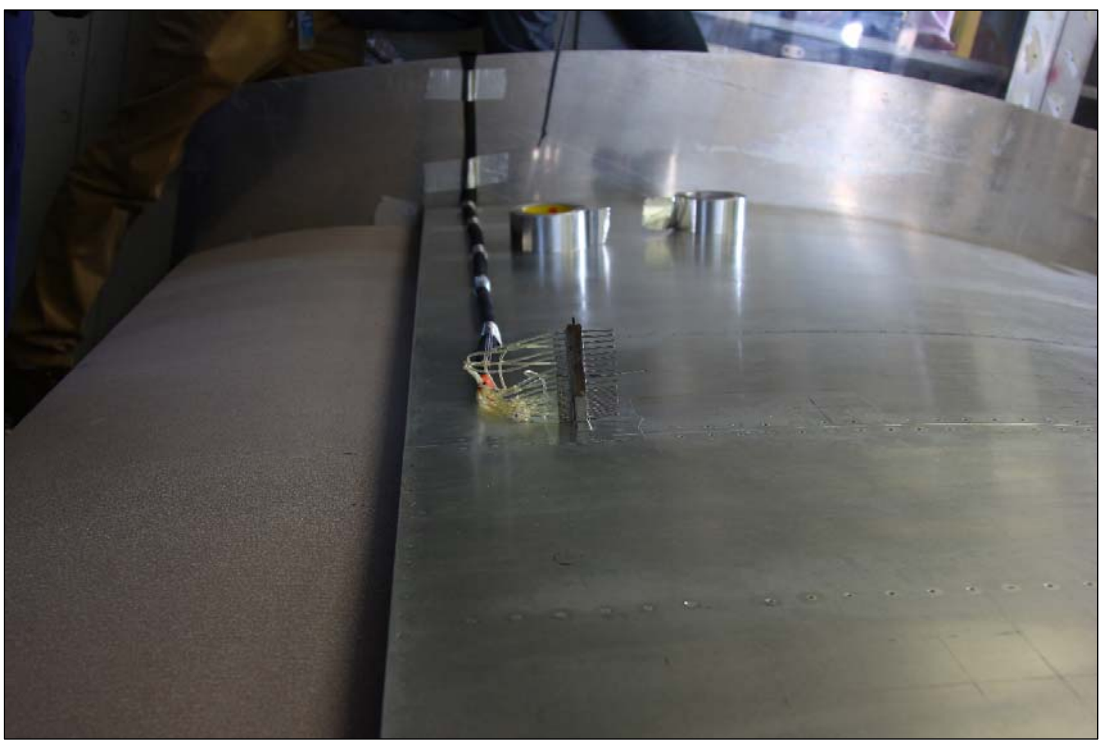


Photo 6.3: Sandpaper Roughness Tests

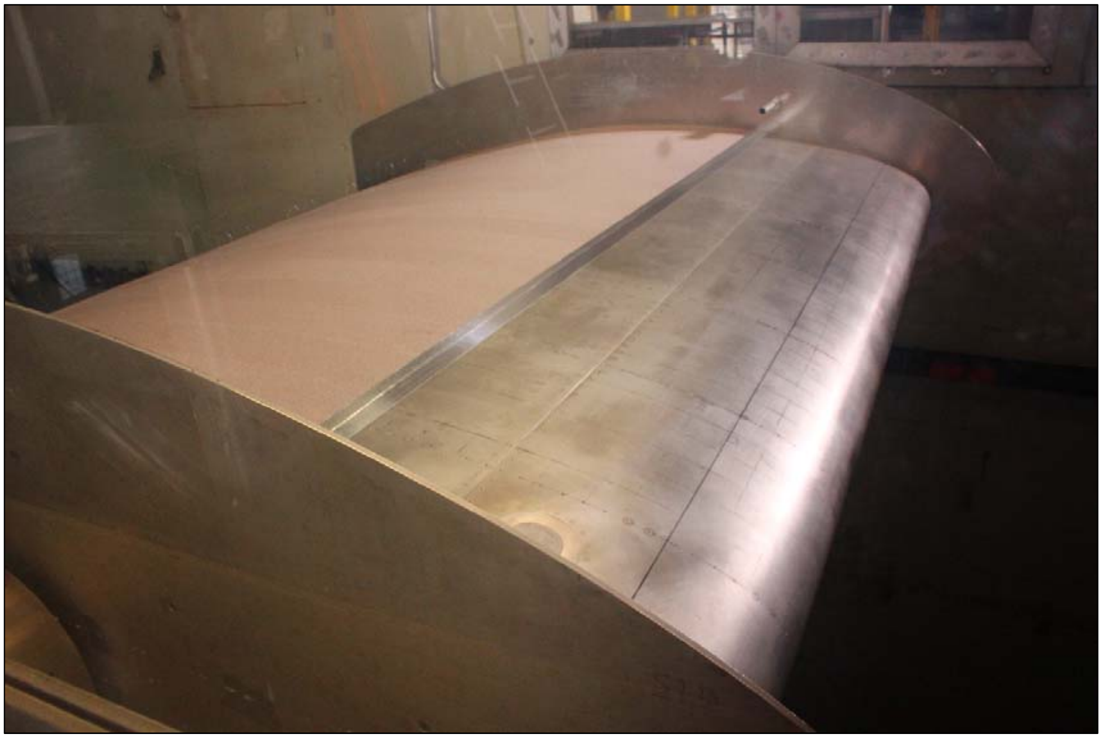
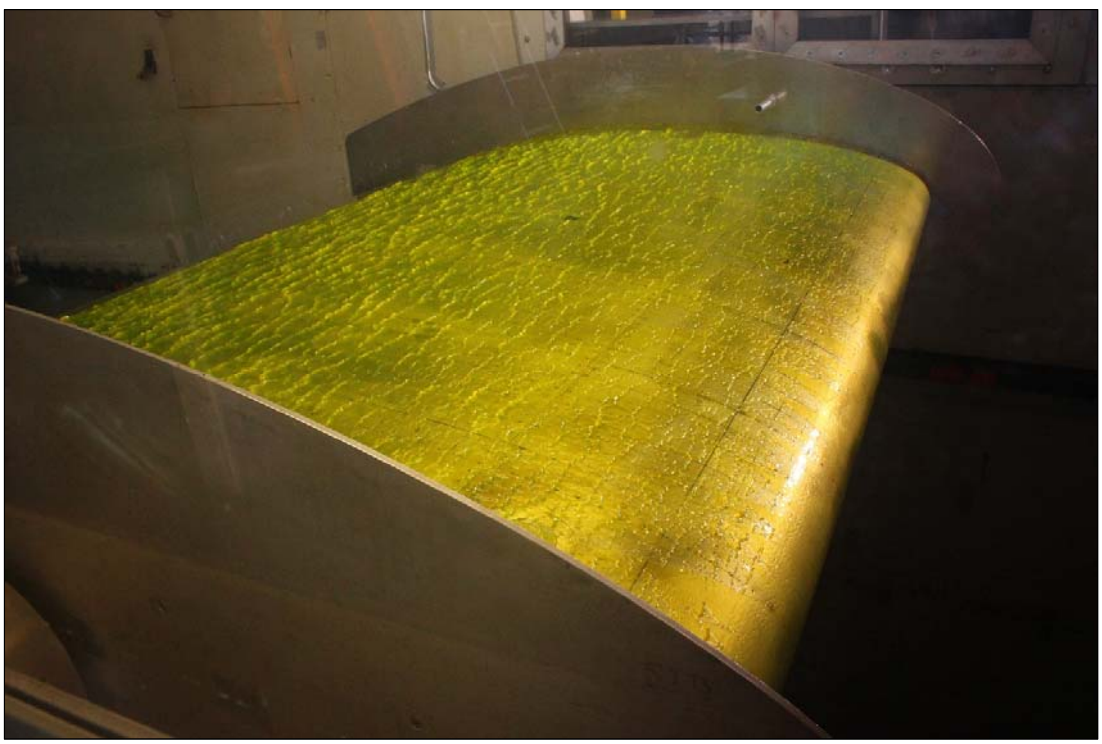


Photo 6.4: Fluid Only Test for Lift Loss Scaling



7. SNOW ALLOWANCE TIMES

HOT tables are published by TC and the FAA for anti-icing fluids based on a testing protocol that evaluates the time of visual failure of the fluid exposed to frozen or freezing precipitation. Visual failure represents the contamination of an anti-icing fluid with winter precipitation to the point that the frozen precipitation is no longer absorbed by the fluid and begins to accumulate on the surface of the fluid. In cases of freezing precipitation (freezing rain, etc.), the contamination may begin to adhere to the surface at, or shortly after, visual fluid failure. However, in the case of frozen precipitation like snow, adherence is not very likely when using thickened anti-icing fluids, although contamination may affect the flow-off performance during takeoff. As such, a potential margin of protection may exist beyond the time of visual fluid failure for anti-icing fluids in snow conditions.

Under contract to Airlines for America (A4A), APS, in collaboration with the NRC, completed an aircraft ground icing exploratory research project at the NRC IWT in Ottawa in January 2019. The purpose of this project was to investigate the feasibility of using aerodynamic data to evaluate the performance of the contaminated anti-icing fluid, rather than the traditional visual fluid failure indicators that are used to develop HOTs. A report titled *Evaluation of Visual Failure versus Aerodynamic Limit for a Snow Contaminated Anti-Iced Wing Section during Simulated Takeoff* (3) was prepared by APS and the NRC on behalf of A4A; a copy of this report can be obtained through the SAE website.

Although this research was conducted by APS on behalf of A4A, both TC and the FAA were invited by A4A to witness and participate in the testing. As this research was an industry initiative, TC and the FAA did not provide funding for the research conducted; however, they did support the participation of APS at the June 2019 A4A industry meeting in Washington in order to discuss the results and the potential operational benefits identified from this research. A copy of the presentation prepared by APS and the NRC for the A4A meeting can be requested through A4A.

It is expected that industry discussions about snow allowance times and the way forward will continue as part of the AWG in the SAE G-12 Fluids Committee.

This page intentionally left blank.

8. CONCLUSIONS AND RECOMMENDATIONS

These conclusions and recommendations were derived from the testing conducted during the winters of 2017-18 and 2018-19.

8.1 Validation Testing for New to Market Type IV Fluids

A total of five fluids were validated based on the data collected:

1. CHEMCO Inc. ChemR EG IV;
2. Clariant Produkte (Deutschland) GmbH Max Flight AVIA;
3. Clariant Produkte (Deutschland) GmbH Max Flight SNEG;
4. Oksayd Co. Ltd. Defrost ECO 4; and
5. Oksayd Co. Ltd. Defrost EG 4.

Two fluids are still outstanding due to circumstances outside of the control of the testing program. Of these two fluids, Clariant Produkte (Deutschland) GmbH Safewing EG IV NORTH should be tested during the next wind tunnel testing campaign, and Inland Technologies ECO-SHIELD may no longer be commercialized; therefore, additional testing may not be necessary.

8.2 Possible Extension of Allowance Times for EG Fluids

Based on preliminary results, a potential for longer allowance times for EG fluids exists in most of the allowance time cells. If there is an industry demand for this type of guidance, additional data and analysis will be required to substantiate these findings as the data collected to date is limited, and data at the failure points is required to understand the limits of the margins that exist.

8.3 LS-0417 Airfoil Testing for Developing Low-Speed Type III Allowance Times

The results obtained to date indicate a good potential to develop low-speed allowance times for Type III fluids and a potential to extend the allowances to longer times. Discussions with the SAE G-12 AWG should continue in order to validate the lift loss scaling results for the LS-0417 wing section, so that guidance can then be developed based on the low-speed allowance time testing results.

8.4 Snow Allowance Times

It is expected that industry discussions about snow allowance times and the way forward will continue as part of the AWG in the SAE G-12 Fluids Committee.

8.5 Changes to Ice Pellet Allowance Time Guidance

The results of the validation, EG expansion, and low-speed Type III testing did not require any changes to the current Ice Pellet Allowance Times or supporting guidance material. As such, no changes were issued to the Ice Pellet Allowance Times published in the HOT Guidelines for the winters of 2018-19 and 2019-20.

REFERENCES

1. Ruggi, M., *Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winters 2009-10 to 2012-13,* APS Aviation Inc., Transportation Development Centre, Montreal, November 2013, TP 15232E, XX (to be published).

2. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2017-18 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2018, TP 15398E, 42.

3. Clark, C., Ruggi, M., *Evaluation of Visual Failure versus Aerodynamic Limit for a Snow Contaminated Anti-Iced Wing Section during Simulated Takeoff*, SAE International, June 2019, doi:10.4271/2019-01-1972,10. Retrieved from https://www.sae.org/publications/technical-papers/content/2019-01-1972/

This page intentionally left blank.

APPENDIX A

TRANSPORT CANADA
STATEMENT OF WORK EXCERPT –
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2018-19

TRANSPORT CANADA
STATEMENT OF WORK EXCERPT – AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2018-19

7. Wind Tunnel Testing – Planning and Setup Activities Only

Note: The NRC facility costs associated with testing at M-46 are not included in this task and are dealt directly with TC through a M.O.U. agreement with NRC.

This budget associated with the project is only associated to tasks a and b. Tasks c, d, e, and f are budgeted as part of a separate project.

a) Coordinate with staff of NRC M-46 for scheduling and to organize any modifications to the wind tunnel, model, or related equipment. Review fluid requirements and request fluid samples from fluid manufacturers.

b) Develop a procedure and test plan, and coordinate with the NRC staff that operates the PIWT.

~~c) Perform pre-testing activities including the preparation of equipment, purchasing of equipment, training of personnel, and transportation and setup of equipment.~~

~~d) Perform wind tunnel tests (5 days) to validate the existing Type IV fluid allowance times for use with the newly certified anti-icing fluids, or with fluids for which data is lacking. It is anticipated that testing will be conducted during overnight hours over a period of two weeks. The typical procedure is described as follows, but may be modified to address specific testing objectives. Prior to starting each test event, correlation testing is required to calibrate the TC model and to demonstrate repeatability. Wind tunnel tests will be performed with ethylene glycol and propylene glycol anti-icing fluids at below freezing temperatures. Tests will simulate low speed or high speed takeoffs in accordance with the speed and angle of attack profiles provided by TC and airframe manufacturers. The simulated takeoff profile may target the clean wing stall angle as the maximum angle of attack in order to obtain CLmax data. During contaminated test runs, a baseline fluid only case may be run immediately before, or after the contaminated test run to provide a direct correlation of the results. High resolution photos will be taken of the fluid motion at the leading and trailing edges of the wing at a rate of about 3 frames per second, with lighting adequate to see the fluid waves and ripples of about 1mm in height, even when the wing is at maximum angle of attack. Observers will document the appearance of fluid on the wing during the simulated takeoff run and climb of the aircraft by analysing the photographic records. The testing team will collect, among other things, the following data during the tests: type~~

~~and amount of fluid applied, type and rate of contamination applied, and extent of fluid contamination prior to the test run.~~

~~e) Analyse data.~~

~~f) Report the findings, and prepare presentation material for the SAE G-12 meeting.~~

8. Wind Tunnel Testing – Type IV High Speed Validation of Allowance Times for New Fluids with Thin High Performance Wing (5 Days)

Note: The NRC facility costs associated with testing at M-46 are not included in this task and are dealt directly with TC through a M.O.U. agreement with NRC.

This budget associated with this project is only associated to tasks c, d, e, and f. Tasks a and b are budgeted as part of a separate project.

~~a) Coordinate with staff of NRC M-46 for scheduling and to organize any modifications to the wind tunnel, model, or related equipment. Review fluid requirements and request fluid samples from fluid manufacturers.~~

~~b) Develop a procedure and test plan and coordinate with the NRC staff that operates the PIWT.~~

c) Perform pre-testing activities including the preparation of equipment, purchasing of equipment, training of personnel, and transportation and setup of equipment.

d) Perform wind tunnel tests (5 days) to validate the existing Type IV fluid allowance times for use with the newly certified anti-icing fluids, or with fluids for which data is lacking. It is anticipated that testing will be conducted during overnight hours over a period of two weeks. The typical procedure is described as follows, but may be modified to address specific testing objectives. Prior to starting each test event, correlation testing is required to calibrate the TC model and to demonstrate repeatability. Wind tunnel tests will be performed with ethylene glycol and propylene glycol anti-icing fluids at below freezing temperatures. Tests will simulate low speed or high speed takeoffs in accordance with the speed and angle of attack profiles provided by TC and airframe manufacturers. The simulated take-off profile may target the clean wing stall angle as the maximum angle of attack in order to obtain CLmax data. During contaminated test runs, a baseline fluid only case may be run immediately before, or after the contaminated test run to provide a direct correlation of the results. High resolution photos will be taken of the fluid motion at the leading and trailing edges of the wing at a rate of about 3 frames per second, with lighting adequate to see the fluid waves and ripples of about 1mm in height, even when the wing is at maximum angle of attack. Observers will document the appearance of fluid on the wing during the simulated takeoff run and climb of the aircraft by analysing the photographic records. The testing team will collect, among other things, the following data during the tests: type and amount of fluid applied, type and rate of contamination applied, and extent of fluid contamination prior to the test run.

e) Analyse data.

f) Report the findings and prepare presentation material for the SAE G-12 meeting.

This page intentionally left blank.

APPENDIX B

PROCEDURE:
WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS
WINTER 2017-18

CM2480.004

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

Winter 2017-18

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro

August 6, 2018
Final Version 2.0

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

Winter 2017-18

1. BACKGROUND

In 2005-06, the inability for operators to release aircraft in ice pellet conditions led TC and FAA to begin a research campaign to develop allowance times for these conditions. Developing holdover times was not feasible due to the properties of the ice pellets; they remain embedded in the fluid and take long to dissolve as compared to snow which is immediately absorbed and dissolved. Research was initiated by live aircraft testing with the NRC Falcon 20 in Ottawa Ontario, and later evolved to testing in a more controlled environment with the NRC Propulsion Icing Wind Tunnel also in Ottawa Ontario.

The early testing in 2005-06 with the Falcon 20 primarily used visual observations to evaluate fluid flow off. During the Falcon 20 work the wing was anti-iced, exposed to contamination, and aborted take-off runs were performed allowing researchers on-board to observe and evaluate the fluid flow-off. Testing in 2006-07 began in the propulsion icing wind tunnel (PIWT) allowing aerodynamic data to be used for evaluating fluid flow-off performance. The PIWT also allowed for a more controlled environment less susceptible to the elements.

The work continued each year, and the test methods and equipment improved allowing for real-time data analysis, better repeatability, and overall greater confidence in the results. The work conducted by FAA/TC was presented by APS to G-12 AWG and HOT Committee yearly since 2006. Additional presentations were also given at the AWG in May 2012 and May 2013 by NASA and NRC which focused on the extensive calibration and characterization work performed with a generic thin high performance airfoil. This work also helped increase confidence in how the data was used to help support TC/FAA rule-making. A detailed account of the more recent work conducted is included in the report, TP 15232E*, "Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winter 2009-10 to 2012-13"* (1).

The Ice Pellet Allowance Time research has helped further develop and improve the PIWT facility. As a result, a new medium is now available for aerodynamic testing of aircraft ground icing fluids with or without contamination in a full-scale format. Several other ground deicing projects have been ongoing as a result of industry requests and are expected to continue. The PIWT has evolved into a multidisciplinary facility; however it continues to be the primary source for the development and further refinement of the ground deicing ice pellet allowance time guidance material.

Research at the PIWT with and without ice pellets has continued on a yearly or bi-yearly basis and is performed by APS, with support of the NRC, on behalf of TC/FAA.

For the Winter 2017-18, the primary focus of testing will be on ice pellet allowance time validation.

2. OBJECTIVES AND TIMING

The following describes the objectives and timing of the research. 15 days of testing are being planned, however only 10 days will be done. The selection of which objectives are targeted will be at the discretion of the TC/FAA research team and decided on-site.

2.1 Type IV Allowance Time Validation Testing

The objective of this testing is to conduct aerodynamic testing with a thin high performance airfoil to:

- Substantiate the current Type IV ice pellet allowance times with new fluids and at temperatures close to the lowest operational use temperature (LOUT).

To satisfy this objectives, a thin high performance wing section (Figure 2.1) will be subjected to a series of tests in the NRC PIWT. The dimensions indicated are in inches. This wing section was constructed by NRC in 2009 specifically for the conduct of these tests following extensive consultations with an airframe manufacturer to ensure a representative thin high performance design.

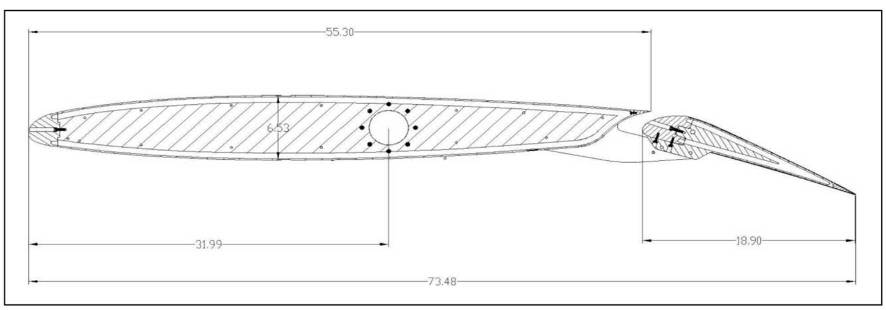


Figure 2.1: Thin High Performance Wing Section

Eight days of testing are required for the conduct of these tests.

2.2 Type IV Allowance Time Expansion for Ethylene Glycol (EG) Fluids

The objective of this testing is to conduct aerodynamic testing with a thin high performance airfoil to:

- Expand the current Type IV ice pellet allowance times for EG fluids.

To satisfy this objectives, a thin high performance wing section (described in Section 2.1 and shown in Figure 2.1) will be subjected to a series of tests in the NRC PIWT.

Two days of testing are required for the conduct of these tests.

2.3 Type III Low Speed Allowance Time Testing

Testing will be conducted to:

- Evaluate the current Type III ice pellet allowance times at 80 Knots using the LS-0417 low speed airfoil.

To satisfy this objective, the LS-0417 wing section (Figure 2.2) will be subjected to a series of tests in the NRC PIWT. The dimensions indicated are in inches. This wing section was constructed by NRC in the 1990's and was more recently used in 2008-09 for ice pellet wind tunnel testing. Time for the wing to be swapped is needed, testing efforts will be required to calibrate and characterize the wing section, and fluid only testing will be done prior to conducting any actual allowance time testing.

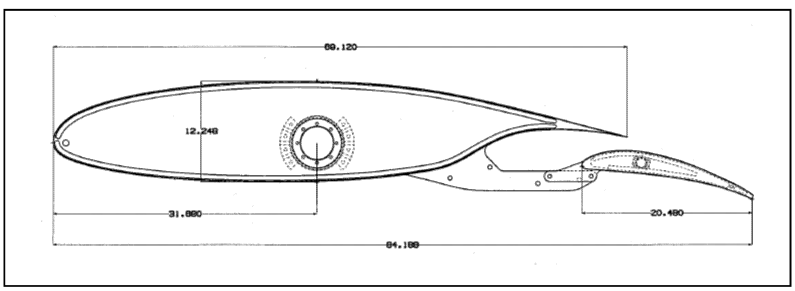


Figure 2.2: NASA LS-0417 Wing Section

An additional 5 days of testing are required for the conduct of these tests.

2.4 Timing

A total of 8 days are required for the "Type IV Allowance Time Validation Testing" (Section 2.1), 2 days are required for the "Type IV Allowance Time Expansion for EG Fluids" (Section 2.2) and an additional 5 days are required for the "Type III Low Speed Allowance Time Testing" (Section 2.3), time and funding permitting. This requires a total of 15 days of testing, however only 10 days of testing are available. The 10 days of testing will be conducted over a period of 3 weeks starting January 25th to February 9th (see Figure 2.3) Changing over of the wing sections may require some down-time which will need to be considered in the scheduling.

Testing will likely be conducted during overnight periods (i.e. 10 pm – 6 am), unless temperatures are suitable for day/evening testing. The weekends will be considered only if deemed necessary. The first 2 hours or more of the first day will be dedicated to setup and calibration of the rain sprayer and ice pellet and snow dispensers; time permitting testing will begin as per the test plan. The time required for the setup and calibration will be evenly deducted from the other objectives in order to still meet the 10 day testing plan. The precipitation conditions to be calibrated could include the following:

- ZR – 25g/dm²/h;
- R – 25g/dm²/h;
- R – 75g/dm²/h;
- ZD – 5g/dm²/h;
- ZD – 13g/dm²/h;
- SN – 10g/dm²/h;
- SN – 25g/dm²/h;
- IP – 25g/dm²/h; and
- IP – 75g/dm²/h.

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

JANUARY 2018

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jan 14	15	16	17	18	19	20
Jan 21	22	23 *Pack up truck in YUL*	24 *Leave YUL for YOW*	25 ***TEST DAY 1*** TESTING ACTIVITY TBD (only is Temps <-16C)	26 ***TEST DAY 2*** TESTING ACTIVITY TBD (only is Temps <-16C)	27
28	29 ***TEST DAY 3*** TESTING ACTIVITY TBD	30 ***TEST DAY 4*** TESTING ACTIVITY TBD	31 ***TEST DAY 5*** TESTING ACTIVITY TBD	February 1 ***TEST DAY 6*** TESTING ACTIVITY TBD	2 ***TEST DAY 7*** TESTING ACTIVITY TBD	3
4	5 ***TEST DAY 8*** TESTING ACTIVITY TBD	6 ***TEST DAY 9*** TESTING ACTIVITY TBD	7 ***TEST DAY 10*** TESTING ACTIVITY TBD	8 ***SPARE DAY 1*** **TBD**	9 ***SPARE DAY 2*** **TBD**	10

NOTES

Anticipate Mon-Fri testing, however, weekend may be considered due to temperature.
Testing will be conducted during overnight periods (10:00 pm - 6:00 am)
Testing team will be JD, MR, BB, CB, BG & YOW x 4
Spare days available (Feb 8-9) should rescheduling be needed due to temperatures.

TESTING ACTIVITIES

SETUP & CALIBRATION **of Rain Sprayer and IP/SN Dispensers** (Will be done on first day. Time req'd to be deducted evenlyfrom other activities)	***TEST DAY 1*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 2*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 3*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 4*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*	***TEST DAY 5*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*
	TEST DAY 6 **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*	***TEST DAY 7*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -16°C*	***TEST DAY 8*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -16°C*	***TEST DAY 9*** **EG IP EXPANSION (TIV)** *above -5ºC*	***TEST DAY 10*** **EG IP EXPANSION (TIV)** *below -5 to -16°C*
	TEST DAY 11 **Type III IP - LS0417 WING SWAP (done by NRC)** *Any temp*	***TEST DAY 12*** **TYPE III IP - LS0417 MODEL CALIBRATION & CHARACTERIZATION** *below 0ºC*	***TEST DAY 13*** **TYPE III IP - LS0417 MODEL CALIBRATION & CHARACTERIZATION** *below 0ºC*	***TEST DAY 14*** **TYPE III IP - LS0417 MODEL CALIBRATION & CHARACTERIZATION** **FLUID ONLY TESTING** *below 0ºC*	***TEST DAY 15*** **TYPE III IP VALIDATION AT 80KTS W/ LS0417** *above -5ºC*

Note: Each testing activity block represents one day of wind tunnel time.

Figure 2.3: Test Calendar

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Final Version 2.0\Wind Tunnel Final Version 2.0.docx
Final Version 2.0, August 18

Page 5

3. TEST PLAN

The NRC wind tunnel is an open circuit tunnel. The temperature inside the wind tunnel is dependent on the outside ambient temperature. Prior to testing, the weather should be monitored to ensure proper temperatures for testing.

Representative Type I/II/III/IV propylene and ethylene fluids in Neat form (standard mix for Type I) shall be evaluated against their uncontaminated performance.

A preliminary list of test objectives is shown in Table 3.1 (only Priority 1 and 2 objectives will be attempted unless indicated otherwise by TC/FAA directive). It should be noted that the order in which the tests will be carried out will be depend on weather conditions and TC/FAA directive. A detailed test matrix (subject to change) is shown in Table 3.2. As some of this testing is exploratory, changes to the test plan may be made at the time of testing and will be confirmed by TC/FAA.

NOTE: The numbering of the test runs will be done in a sequential order starting with number 1.

A rating system has been developed for fluid and contamination tests, and will be filled out by the on-site experts when applicable. The overall rating will provide insight into the severity of the conditions observed. A test failure (failure to shed the fluid at time of rotation) shall be determined by the on-site experts based on residual contamination.

Table 3.1: Preliminary List of Testing Objectives for Winter 2017-18 Wind Tunnel Testing

Item #	Objective	Priority	Description	# of Days
0	Setup and Precipitation Calibration	1	Setup of equipment and calibration of the rain sprayer and the ice pellet and snow dispensers (to be done on the first day of testing)	-
1	Dry Wing Baseline Repeatability	1	Baseline test at beginning of each day to ensure repeatability (part of NRC shakedown tests so no days allotted)	N/A
2	Type IV IP AT Validation (New Fluids)	1	Substantiate current times with new fluids	8
3	EG Type IV AT Expansion	2	Conduct allowance time testing with the objective of extending times and potentially add new cells for EG fluids	2
4.1	Type III IP – LS-0417 Wing Swap	2	Replace the wing section in the tunnel with the LS-0417 model	1
4.2	Type III IP – LS-0417 Model Calibration and Characterization	2	Calibrate and characterize the LS-0417 wing model to support low speed ice pellet allowance time testing at 80 knots.	2
4.3	Type III IP – LS-0417 Model Calibration and Characterization Fluid Only Testing	2	Fluid only testing will be done to support BLDT correlation.	1
4.4	Type III IP AT Validation at 80 Knots with LS-0417 Wing Section	2	Validate the existing Type III allowance times for use at 80 knots using the LS-0417 wing section	1
5	Other R&D Activities	3	Could be selected from item # 5.1 to 8.16	0
5.1	Type III Allowance Time Expansion		Expand the current Type III allowance times to have increased times, or more cells.	-
5.2	Snow Allowance Times Using Aerodynamic Data		Investigate feasibility of developing snow allowance times using the same aerodynamic based methodology used for ice pellets	
5.3	Development of EG Specific IP Allowance Times		Support the development of an EG fluid specific ice pellet allowance time table to benefit of potential longer times	-
5.4	Heavy Snow	-	Continue Heavy Snow Research comparing lift losses with Light/Moderate Snow vs. Heavy Snow	-
5.5	Heavy Contamination (Aero vs. Visual Failure)	-	Continue work looking at aerodynamic failure vs. HOT defined failure, and effect of surface roughness on lift degradation	-
5.6	Tunnel Test Section Cooling System Evaluation	-	Evaluate effectiveness of new wind tunnel cooling system and potential effects on data results	-
5.7	Fluid + Cont @ LOUT	-	Effect of contamination on fluid performance at LOUT with IP, SN, ZF, Frost etc.	-
5.8	Simulate Frost in Wind Tunnel	-	Attempt to simulate frost conditions in wind tunnel.	-
5.9	130-150 Knots IP Testing	-	Conduct IP testing at 130-150 knots or validate feasibility MAY NEED TO MODIFY TUNNEL	-
5.10	2nd Wave of Fluid During Rotation	-	Investigate the aero effects of the 2nd wave of fluid created from fluid at the stagnation point which flows over the LE during rotation	-
5.11	Other	-	Any potential suggestions from industry	

Total # of Days for Priority 1 and Priority 2 Tests	**15**

**Note only 10 days of testing are planned. The time required for the setup and precipitation calibration will be evenly deducted from the other Priority 1 and 2 objectives in order to still meet the ten day testing plan.*

Table 3.2: Proposed Test Plan

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P001	Baseline	1	Dry Wing	8	100	any	none	-	-	-	-	-	1	@start of day
	P002	Baseline	1	Dry Wing	22	80	any	none	-	-	-	-	-	1	@start of day
	P003	Type IV Validation and New Fuids	1	IP-	8	100	>-5	ChemR EG IV	25	-	-	-	50	1	
	P004	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	ChemR EG IV	25	10	-	-	40	1	
	P005	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	ChemR EG IV	25	-	13	-	25	2	
	P006	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	ChemR EG IV	25	-	25	-	25	1	
	P007	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	ChemR EG IV	25	-	-	25	25	2	
	P008	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	ChemR EG IV	75	-	-	-	25	1	
	P009	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	ChemR EG IV	75	-	13	-	10	1	
	P010	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	ChemR EG IV	75	-	-	75	10	2	
	P011	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	ChemR EG IV	25	-	-	-	30	2	
	P012	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	ChemR EG IV	25	10	-	-	15	2	
	P013	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	ChemR EG IV	25	-	13	-	10	2	
	P014	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	ChemR EG IV	25	-	25	-	10	1	
	P015	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	ChemR EG IV	75	-	-	-	10	2	
	P016	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	ChemR EG IV	75	-	13	-	7	1	
	P017	Type IV Validation and New Fuids	1	IP-	8	100	-10 to -16	ChemR EG IV	25	-	-	-	30	1	
	P018	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-10 to -16	ChemR EG IV	25	10	-	-	15	1	
	P019	Type IV Validation and New Fuids	1	IP Mod	8	100	-10 to -16	ChemR EG IV	75	-	-	-	10	1	
	P020	Type IV Validation and New Fuids	1	IP-	8	100	-16 to -22	ChemR EG IV	25	-	-	-	30	2	
	P021	Type IV Validation and New Fuids	1	IP Mod	8	100	-16 to -22	ChemR EG IV	75	-	-	-	10	2	
	P022	Type IV Validation and New Fuids	1	IP-	8	100	<-22	ChemR EG IV	25	-	-	-	30	2	
	P023	Type IV Validation and New Fuids	1	IP Mod	8	100	<-22	ChemR EG IV	75	-	-	-	10	2	
	P024	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	ChemR EG IV	-	-	-	-	-	1	Baseline Test
	P025	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	ChemR EG IV	-	-	-	-	-	1	Baseline Test
	P026	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	ChemR EG IV	-	-	-	-	-	1	Baseline Test

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate ($g/dm^2/h$)	SN Rate ($g/dm^2/h$)	ZR Rate ($g/dm^2/h$)	R Rate ($g/dm^2/h$)	Exposure Time	Test Priority	COMMENT
	P027	Type IV Validation and New Fuids	1	IP-	8	100	>-5	Max Flight AVIA	25	-	-	-	50	1	
	P028	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	Max Flight AVIA	25	10	-	-	40	1	
	P029	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	Max Flight AVIA	25	-	13	-	25	2	
	P030	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	Max Flight AVIA	25	-	25	-	25	1	
	P031	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	Max Flight AVIA	25	-	-	25	25	2	
	P032	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	Max Flight AVIA	75	-	-	-	25	1	
	P033	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	Max Flight AVIA	75	-	13	-	10	1	
	P034	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	Max Flight AVIA	75	-	-	75	10	2	
	P035	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	Max Flight AVIA	25	-	-	-	30	2	
	P036	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	Max Flight AVIA	25	10	-	-	15	2	
	P037	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	Max Flight AVIA	25	-	13	-	10	2	
	P038	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	Max Flight AVIA	25	-	25	-	10	1	
	P039	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	Max Flight AVIA	75	-	-	-	10	2	
	P040	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	Max Flight AVIA	75	-	13	-	7	1	
	P041	Type IV Validation and New Fuids	1	IP-	8	100	-10 to -16	Max Flight AVIA	25	-	-	-	30	1	
	P042	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-10 to -16	Max Flight AVIA	25	10	-	-	15	1	
	P043	Type IV Validation and New Fuids	1	IP Mod	8	100	-10 to -16	Max Flight AVIA	75	-	-	-	10	1	
	P044	Type IV Validation and New Fuids	1	IP-	8	100	-16 to -22	Max Flight AVIA	25	-	-	-	30	2	
	P045	Type IV Validation and New Fuids	1	IP Mod	8	100	-16 to -22	Max Flight AVIA	75	-	-	-	10	2	
	P046	Type IV Validation and New Fuids	1	IP-	8	100	<-22	Max Flight AVIA	25	-	-	-	30	2	
	P047	Type IV Validation and New Fuids	1	IP Mod	8	100	<-22	Max Flight AVIA	75	-	-	-	10	2	
	P048	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P049	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P050	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P051	Type IV Validation and New Fuids	1	IP-	8	100	>-5	Max Flight SNEG	25	-	-	-	50	1	

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (ºC)	Fluid	IP Rate ($g/dm^2/h$)	SN Rate ($g/dm^2/h$)	ZR Rate ($g/dm^2/h$)	R Rate ($g/dm^2/h$)	Exposure Time	Test Priority	COMMENT
	P052	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	Max Flight SNEG	25	10	-	-	40	1	
	P053	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	Max Flight SNEG	25	-	13	-	25	2	
	P054	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	Max Flight SNEG	25	-	25	-	25	1	
	P055	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	Max Flight SNEG	25	-	-	25	25	2	
	P056	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	Max Flight SNEG	75	-	-	-	15	1	15 min for PG
	P057	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	Max Flight SNEG	75	-	13	-	10	1	
	P058	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	Max Flight SNEG	75	-	-	75	10	2	
	P059	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	Max Flight SNEG	25	-	-	-	30	2	
	P060	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	Max Flight SNEG	25	10	-	-	15	2	
	P061	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	Max Flight SNEG	25	-	13	-	10	2	
	P062	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	Max Flight SNEG	25	-	25	-	10	1	
	P063	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	Max Flight SNEG	75	-	-	-	10	2	
	P064	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	Max Flight SNEG	75	-	13	-	7	1	
	P065	Type IV Validation and New Fuids	1	IP-	8	115	-10 to -16	Max Flight SNEG	25	-	-	-	30	1	115knts for PG
	P066	Type IV Validation and New Fuids	1	IP- / SN-	8	115	-10 to -16	Max Flight SNEG	25	10	-	-	15	1	115knts for PG
	P067	Type IV Validation and New Fuids	1	IP Mod	8	115	-10 to -16	Max Flight SNEG	75	-	-	-	10	1	115knts for PG
	P068	Type IV Validation and New Fuids	1	IP-	8	115	-16 to -22	Max Flight SNEG	25	-	-	-	30	2	115knts for PG
	P069	Type IV Validation and New Fuids	1	IP Mod	8	115	-16 to -22	Max Flight SNEG	75	-	-	-	0	2	No Allowance Time
	P070	Type IV Validation and New Fuids	1	IP-	8	115	<-22	Max Flight SNEG	25	-	-	-	30	2	115knts for PG
	P071	Type IV Validation and New Fuids	1	IP Mod	8	115	<-22	Max Flight SNEG	75	-	-	-	0	2	No Allowance Time
	P072	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	Max Flight SNEG	-	-	-	-	-	1	Baseline Test
	P073	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	Max Flight SNEG	-	-	-	-	-	1	Baseline Test
	P074	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	Max Flight SNEG	-	-	-	-	-	1	Baseline Test
	P075	Type IV Validation and New Fuids	1	IP-	8	100	>-5	ECO-SHIELD	25	-	-	-	50	1	
	P076	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	ECO-SHIELD	25	10	-	-	40	1	
	P077	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	ECO-SHIELD	25	-	13	-	25	2	

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P078	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	ECO-SHIELD	25	-	25	-	25	1	
	P079	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	ECO-SHIELD	25	-	-	25	25	2	
	P080	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	ECO-SHIELD	75	-	-	-	15	1	15 min for PG
	P081	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	ECO-SHIELD	75	-	13	-	10	1	
	P082	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	ECO-SHIELD	75	-	-	75	10	2	
	P083	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	ECO-SHIELD	25	-	-	-	30	2	
	P084	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	ECO-SHIELD	25	10	-	-	15	2	
	P085	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	ECO-SHIELD	25	-	13	-	10	2	
	P086	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	ECO-SHIELD	25	-	25	-	10	1	
	P087	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	ECO-SHIELD	75	-	-	-	10	2	
	P088	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	ECO-SHIELD	75	-	13	-	7	1	
	P089	Type IV Validation and New Fuids	1	IP-	8	115	-10 to -16	ECO-SHIELD	25	-	-	-	30	1	115knts for PG
	P090	Type IV Validation and New Fuids	1	IP- / SN-	8	115	-10 to -16	ECO-SHIELD	25	10	-	-	15	1	115knts for PG
	P091	Type IV Validation and New Fuids	1	IP Mod	8	115	-10 to -16	ECO-SHIELD	75	-	-	-	10	1	115knts for PG
	P092	Type IV Validation and New Fuids	1	IP-	8	115	-16 to -22	ECO-SHIELD	25	-	-	-	30	2	115knts for PG
	P093	Type IV Validation and New Fuids	1	IP Mod	8	115	-16 to -22	ECO-SHIELD	75	-	-	-	0	2	No Allowance Time
	P094	Type IV Validation and New Fuids	1	IP-	8	115	<-22	ECO-SHIELD	25	-	-	-	30	2	115knts for PG
	P095	Type IV Validation and New Fuids	1	IP Mod	8	115	<-22	ECO-SHIELD	75	-	-	-	0	2	No Allowance Time
	P096	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	ECO-SHIELD	-	-	-	-	-	1	Baseline Test
	P097	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	ECO-SHIELD	-	-	-	-	-	1	Baseline Test
	P098	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	ECO-SHIELD	-	-	-	-	-	1	Baseline Test
	P099	Type IV Validation and New Fuids	1	IP-	8	100	>-5	Defrost ECO 4	25	-	-	-	50	1	
	P100	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	Defrost ECO 4	25	10	-	-	40	1	
	P101	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	Defrost ECO 4	25	-	13	-	25	2	
	P102	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	Defrost ECO 4	25	-	25	-	25	1	
	P103	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	Defrost ECO 4	25	-	-	25	25	2	

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (ºC)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P104	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	Defrost ECO 4	75	-	-	-	15	1	15 min for PG
	P105	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	Defrost ECO 4	75	-	13	-	10	1	
	P106	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	Defrost ECO 4	75	-	-	75	10	2	
	P107	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	Defrost ECO 4	25	-	-	-	30	2	
	P108	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	Defrost ECO 4	25	10	-	-	15	2	
	P109	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	Defrost ECO 4	25	-	13	-	10	2	
	P110	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	Defrost ECO 4	25	-	25	-	10	1	
	P111	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	Defrost ECO 4	75	-	-	-	10	2	
	P112	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	Defrost ECO 4	75	-	13	-	7	1	
	P113	Type IV Validation and New Fuids	1	IP-	8	115	-10 to -16	Defrost ECO 4	25	-	-	-	30	1	115knts for PG
	P114	Type IV Validation and New Fuids	1	IP- / SN-	8	115	-10 to -16	Defrost ECO 4	25	10	-	-	15	1	115knts for PG
	P115	Type IV Validation and New Fuids	1	IP Mod	8	115	-10 to -16	Defrost ECO 4	75	-	-	-	10	1	115knts for PG
	P116	Type IV Validation and New Fuids	1	IP-	8	115	-16 to -22	Defrost ECO 4	25	-	-	-	30	2	115knts for PG
	P117	Type IV Validation and New Fuids	1	IP Mod	8	115	-16 to -22	Defrost ECO 4	75	-	-	-	0	2	No Allowance Time
	P118	Type IV Validation and New Fuids	1	IP-	8	115	<-22	Defrost ECO 4	25	-	-	-	30	2	115knts for PG
	P119	Type IV Validation and New Fuids	1	IP Mod	8	115	<-22	Defrost ECO 4	75	-	-	-	0	2	No Allowance Time
	P120	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	Defrost ECO 4	-	-	-	-	-	1	Baseline Test
	P121	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	Defrost ECO 4	-	-	-	-	-	1	Baseline Test
	P122	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	Defrost ECO 4	-	-	-	-	-	1	Baseline Test
	P123	Type IV Validation and New Fuids	1	IP-	8	100	>-5	Cleansurface IV	25	-	-	-	50	1	
	P124	Type IV Validation and New Fuids	1	IP- / SN-	8	100	>-5	Cleansurface IV	25	10	-	-	40	1	
	P125	Type IV Validation and New Fuids	1	IP- / ZD	8	100	>-5	Cleansurface IV	25	-	13	-	25	2	
	P126	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	>-5	Cleansurface IV	25	-	25	-	25	1	
	P127	Type IV Validation and New Fuids	1	IP- / R-	8	100	>0	Cleansurface IV	25	-	-	25	25	2	
	P128	Type IV Validation and New Fuids	1	IP Mod	8	100	>-5	Cleansurface IV	75	-	-	-	15	1	15 min for PG
	P129	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	>-5	Cleansurface IV	75	-	13	-	10	1	

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P130	Type IV Validation and New Fuids	1	IP Mod / R	8	100	>0	Cleansurface IV	75	-	-	75	10	2	
	P131	Type IV Validation and New Fuids	1	IP-	8	100	-5 to -10	Cleansurface IV	25	-	-	-	30	2	
	P132	Type IV Validation and New Fuids	1	IP- / SN-	8	100	-5 to -10	Cleansurface IV	25	10	-	-	15	2	
	P133	Type IV Validation and New Fuids	1	IP- / ZD	8	100	-5 to -10	Cleansurface IV	25	-	13	-	10	2	
	P134	Type IV Validation and New Fuids	1	IP- / ZR-	8	100	-5 to -10	Cleansurface IV	25	-	25	-	10	1	
	P135	Type IV Validation and New Fuids	1	IP Mod	8	100	-5 to -10	Cleansurface IV	75	-	-	-	10	2	
	P136	Type IV Validation and New Fuids	1	IP Mod/ZD	8	100	-5 to -10	Cleansurface IV	75	-	13	-	7	1	
	P137	Type IV Validation and New Fuids	1	IP-	8	115	-10 to -16	Cleansurface IV	25	-	-	-	30	1	115knts for PG
	P138	Type IV Validation and New Fuids	1	IP- / SN-	8	115	-10 to -16	Cleansurface IV	25	10	-	-	15	1	115knts for PG
	P139	Type IV Validation and New Fuids	1	IP Mod	8	115	-10 to -16	Cleansurface IV	75	-	-	-	10	1	115knts for PG
	P140	Type IV Validation and New Fuids	1	IP-	8	115	-16 to -22	Cleansurface IV	25	-	-	-	30	2	115knts for PG
	P141	Type IV Validation and New Fuids	1	IP Mod	8	115	-16 to -22	Cleansurface IV	75	-	-	-	0	2	No Allowance Time
	P142	Type IV Validation and New Fuids	1	IP-	8	115	<-22	Cleansurface IV	25	-	-	-	30	2	115knts for PG
	P143	Type IV Validation and New Fuids	1	IP Mod	8	115	<-22	Cleansurface IV	75	-	-	-	0	2	No Allowance Time
	P144	Type IV Validation and New Fuids	1	Fluid Only	8	100	-5 to -10	Cleansurface IV	-	-	-	-	-	1	Baseline Test
	P145	Type IV Validation and New Fuids	1	Fluid Only	8	100	-16 to -22	Cleansurface IV	-	-	-	-	-	1	Baseline Test
	P146	Type IV Validation and New Fuids	1	Fluid Only	8	100	<-22	Cleansurface IV	-	-	-	-	-	1	Baseline Test
	P147	Type III LS Allowance Times	2	IP-	8	80	>-5	AeroClear MAX - Cold	25	-	-	-	10	1	
	P148	Type III LS Allowance Times	2	IP- / SN-	8	80	>-5	AeroClear MAX - Cold	25	10	-	-	10	1	
	P149	Type III LS Allowance Times	2	IP- / ZR-	8	80	>-5	AeroClear MAX - Cold	25	-	25	-	7	1	
	P150	Type III LS Allowance Times	2	IP- / R-	8	80	>0	AeroClear MAX - Cold	25	-	-	25	7	2	
	P151	Type III LS Allowance Times	2	IP Mod	8	80	>-5	AeroClear MAX - Cold	75	-	-	-	5	1	
	P152	Type III LS Allowance Times	2	IP-	8	80	-5 to -10	AeroClear MAX - Cold	25	-	-	-	10	1	
	P153	Type III LS Allowance Times	2	IP- / SN-	8	80	-5 to -10	AeroClear MAX - Cold	25	10	-	-	10	1	
	P154	Type III LS Allowance Times	2	IP- / ZR-	8	80	-5 to -10	AeroClear MAX - Cold	25	-	25	-	5	1	
	P155	Type III LS Allowance Times	2	IP Mod	8	80	-5 to -10	AeroClear MAX - Cold	75	-	-	-	5	1	

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate ($g/dm^2/h$)	SN Rate ($g/dm^2/h$)	ZR Rate ($g/dm^2/h$)	R Rate ($g/dm^2/h$)	Exposure Time	Test Priority	COMMENT
	P156	Type III LS Allowance Times	2	IP-	8	80	-10 to -16	AeroClear MAX - Cold	25	-	-	-	10	2	
	P157	Type III LS Allowance Times	2	IP Mod	8	80	-10 to -16	AeroClear MAX - Cold	75	-	-	-	5	2	
	P158	Type III LS Allowance Times	2	IP-	8	80	-16 to -22	AeroClear MAX - Cold	25	-	-	-	10	2	
	P159	Type III LS Allowance Times	2	IP Mod	8	80	-16 to -22	AeroClear MAX - Cold	75	-	-	-	5	2	
	P160	Type III LS Allowance Times	2	IP-	8	80	<-22	AeroClear MAX - Cold	25	-	-	-	10	2	
	P161	Type III LS Allowance Times	2	IP Mod	8	80	<-22	AeroClear MAX - Cold	75	-	-	-	5	2	
	P162	Type III LS Allowance Times	2	Fluid Only	8	80	-5 to -10	AeroClear MAX - Cold	-	-	-	-	-	1	Baseline Test
	P163	Type III LS Allowance Times	2	Fluid Only	8	80	-16 to -22	AeroClear MAX - Cold	-	-	-	-	-	1	Baseline Test
	P164	Type III LS Allowance Times	2	IP-	8	100	>-5	AeroClear MAX - Cold	25	-	-	-	10	1	To be done with RJ wing
	P165	Type III LS Allowance Times	2	IP-	8	100	-5 to -10	AeroClear MAX - Cold	25	-	-	-	10	1	To be done with RJ wing
	P166	Type III LS Allowance Times	2	IP-	8	100	-10 to -16	AeroClear MAX - Cold	25	-	-	-	10	2	To be done with RJ wing
	P167	Type III LS Allowance Times	2	Fluid Only	8	100	-5 to -10	AeroClear MAX - Cold	-	-	-	-	-	1	To be done with RJ wing
	P168	Type III LS Allowance Times	2	Fluid Only	8	100	-16 to -22	AeroClear MAX - Cold	-	-	-	-	-	1	To be done with RJ wing
	P169	EG Type IV Expansion	2	IP-	8	100	>-5	ChemR EG IV	25	-	-	-	70	1	Current AT is 50 min
	P170	EG Type IV Expansion	2	IP- / SN-	8	100	>-5	ChemR EG IV	25	10	-	-	50	1	Current AT is 40 min
	P171	EG Type IV Expansion	2	IP- / ZD	8	100	>-5	ChemR EG IV	25	-	13	-	40	2	Current AT is 25 min
	P172	EG Type IV Expansion	2	IP- / ZR-	8	100	>-5	ChemR EG IV	25	-	25	-	40	1	Current AT is 25 min
	P173	EG Type IV Expansion	2	IP- / R-	8	100	>0	ChemR EG IV	25	-	-	25	40	2	Current AT is 25 min
	P174	EG Type IV Expansion	2	IP Mod	8	100	>-5	ChemR EG IV	75	-	-	-	35	1	Current AT is 25 min
	P175	EG Type IV Expansion	2	IP Mod/ZD	8	100	>-5	ChemR EG IV	75	-	13	-	20	1	Current AT is 10 min
	P176	EG Type IV Expansion	2	IP Mod / R	8	100	>0	ChemR EG IV	75	-	-	75	20	2	Current AT is 10 min
	P177	EG Type IV Expansion	2	IP-	8	100	-5 to -10	ChemR EG IV	25	-	-	-	50	2	Current AT is 30 min
	P178	EG Type IV Expansion	2	IP- / SN-	8	100	-5 to -10	ChemR EG IV	25	10	-	-	30	2	Current AT is 15 min
	P179	EG Type IV Expansion	2	IP- / ZD	8	100	-5 to -10	ChemR EG IV	25	-	13	-	30	2	Current AT is 10 min
	P180	EG Type IV Expansion	2	IP- / ZR-	8	100	-5 to -10	ChemR EG IV	25	-	25	-	30	1	Current AT is 10 min
	P181	EG Type IV Expansion	2	IP Mod	8	100	-5 to -10	ChemR EG IV	75	-	-	-	25	2	Current AT is 10 min

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P182	EG Type IV Expansion	2	IP Mod/ZD	8	100	-5 to -10	ChemR EG IV	75	-	13	-	10	1	Current AT is 7 min
	P183	EG Type IV Expansion	2	IP-	8	100	-10 to -16	ChemR EG IV	25	-	-	-	50	1	Current AT is 30 min
	P184	EG Type IV Expansion	2	IP- / SN-	8	100	-10 to -16	ChemR EG IV	25	10	-	-	30	1	Current AT is 15 min
	P185	EG Type IV Expansion	2	IP Mod	8	100	-10 to -16	ChemR EG IV	75	-	-	-	25	1	Current AT is 10 min
	P186	EG Type IV Expansion	2	IP-	8	100	-16 to -22	ChemR EG IV	25	-	-	-	50	2	Current AT is 30 min
	P187	EG Type IV Expansion	2	IP- / SN-	8	100	-16 to -22	ChemR EG IV	25	10	-	-	30	1	No AT exists currently
	P188	EG Type IV Expansion	2	IP Mod	8	100	-16 to -22	ChemR EG IV	75	-	-	-	25	2	Current AT is 30 min
	P189	EG Type IV Expansion	2	IP-	8	100	<-22	ChemR EG IV	25	-	-	-	50	2	Current AT is 10 min
	P190	EG Type IV Expansion	2	IP Mod	8	100	<-22	ChemR EG IV	75	-	-	-	25	2	Current AT is - min
	P191	EG Type IV Expansion	2	Fluid Only	8	100	-5 to -10	ChemR EG IV	-	-	-	-	-	1	Baseline Test
	P192	EG Type IV Expansion	2	Fluid Only	8	100	-16 to -22	ChemR EG IV	-	-	-	-	-	1	Baseline Test
	P193	EG Type IV Expansion	2	Fluid Only	8	100	<-22	ChemR EG IV	-	-	-	-	-	1	Baseline Test
	P194	EG Type IV Expansion	2	IP-	8	100	>-5	Max Flight AVIA	25	-	-	-	70	1	Current AT is 50 min
	P195	EG Type IV Expansion	2	IP- / SN-	8	100	>-5	Max Flight AVIA	25	10	-	-	50	1	Current AT is 40 min
	P196	EG Type IV Expansion	2	IP- / ZD	8	100	>-5	Max Flight AVIA	25	-	13	-	40	2	Current AT is 25 min
	P197	EG Type IV Expansion	2	IP- / ZR-	8	100	>-5	Max Flight AVIA	25	-	25	-	40	1	Current AT is 25 min
	P198	EG Type IV Expansion	2	IP- / R-	8	100	>0	Max Flight AVIA	25	-	-	25	40	2	Current AT is 25 min
	P199	EG Type IV Expansion	2	IP Mod	8	100	>-5	Max Flight AVIA	75	-	-	-	35	1	Current AT is 25 min
	P200	EG Type IV Expansion	2	IP Mod/ZD	8	100	>-5	Max Flight AVIA	75	-	13	-	20	1	Current AT is 10 min
	P201	EG Type IV Expansion	2	IP Mod / R	8	100	>0	Max Flight AVIA	75	-	-	75	20	2	Current AT is 10 min
	P202	EG Type IV Expansion	2	IP-	8	100	-5 to -10	Max Flight AVIA	25	-	-	-	50	2	Current AT is 30 min
	P203	EG Type IV Expansion	2	IP- / SN-	8	100	-5 to -10	Max Flight AVIA	25	10	-	-	30	2	Current AT is 15 min
	P204	EG Type IV Expansion	2	IP- / ZD	8	100	-5 to -10	Max Flight AVIA	25	-	13	-	30	2	Current AT is 10 min
	P205	EG Type IV Expansion	2	IP- / ZR-	8	100	-5 to -10	Max Flight AVIA	25	-	25	-	30	1	Current AT is 10 min
	P206	EG Type IV Expansion	2	IP Mod	8	100	-5 to -10	Max Flight AVIA	75	-	-	-	25	2	Current AT is 10 min
	P207	EG Type IV Expansion	2	IP Mod/ZD	8	100	-5 to -10	Max Flight AVIA	75	-	13	-	10	1	Current AT is 7 min

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P208	EG Type IV Expansion	2	IP-	8	100	-10 to -16	Max Flight AVIA	25	-	-	-	50	1	Current AT is 30 min
	P209	EG Type IV Expansion	2	IP- / SN-	8	100	-10 to -16	Max Flight AVIA	25	10	-	-	30	1	Current AT is 15 min
	P210	EG Type IV Expansion	2	IP Mod	8	100	-10 to -16	Max Flight AVIA	75	-	-	-	25	1	Current AT is 10 min
	P211	EG Type IV Expansion	2	IP-	8	100	-16 to -22	Max Flight AVIA	25	-	-	-	50	2	Current AT is 30 min
	P212	EG Type IV Expansion	2	IP- / SN-	8	100	-16 to -22	Max Flight AVIA	25	10	-	-	30	1	No AT exists currently
	P213	EG Type IV Expansion	2	IP Mod	8	100	-16 to -22	Max Flight AVIA	75	-	-	-	25	2	Current AT is 30 min
	P214	EG Type IV Expansion	2	IP-	8	100	<-22	Max Flight AVIA	25	-	-	-	50	2	Current AT is 10 min
	P215	EG Type IV Expansion	2	IP Mod	8	100	<-22	Max Flight AVIA	75	-	-	-	25	2	Current AT is - min
	P216	EG Type IV Expansion	2	Fluid Only	8	100	-5 to -10	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P217	EG Type IV Expansion	2	Fluid Only	8	100	-16 to -22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P218	EG Type IV Expansion	2	Fluid Only	8	100	<-22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test
	P219	Type III HS Allowance Times	3	IP-	8	100	>-5	AeroClear MAX - Cold	25	-	-	-	20	1	Current AT x2. To Revisit
	P220	Type III HS Allowance Times	3	IP- / SN-	8	100	>-5	AeroClear MAX - Cold	25	10	-	-	20	1	Current AT x2. To Revisit
	P221	Type III HS Allowance Times	3	IP- / ZR-	8	100	>-5	AeroClear MAX - Cold	25	-	25	-	14	1	Current AT x2. To Revisit
	P222	Type III HS Allowance Times	3	IP- / R-	8	100	>0	AeroClear MAX - Cold	25	-	-	25	14	2	Current AT x2. To Revisit
	P223	Type III HS Allowance Times	3	IP Mod	8	100	>-5	AeroClear MAX - Cold	75	-	-	-	10	1	Current AT x2. To Revisit
	P224	Type III HS Allowance Times	3	IP-	8	100	-5 to -10	AeroClear MAX - Cold	25	-	-	-	20	1	Current AT x2. To Revisit
	P225	Type III HS Allowance Times	3	IP- / SN-	8	100	-5 to -10	AeroClear MAX - Cold	25	10	-	-	20	1	Current AT x2. To Revisit
	P226	Type III HS Allowance Times	3	IP- / ZR-	8	100	-5 to -10	AeroClear MAX - Cold	25	-	25	-	10	1	Current AT x2. To Revisit
	P227	Type III HS Allowance Times	3	IP Mod	8	100	-5 to -10	AeroClear MAX - Cold	75	-	-	-	10	1	Current AT x2. To Revisit
	P228	Type III HS Allowance Times	3	IP-	8	100	-10 to -16	AeroClear MAX - Cold	25	-	-	-	20	2	Current AT x2. To Revisit
	P229	Type III HS Allowance Times	3	IP Mod	8	100	-10 to -16	AeroClear MAX - Cold	75	-	-	-	10	2	Current AT x2. To Revisit
	P230	Type III HS Allowance Times	3	IP-	8	100	-16 to -22	AeroClear MAX - Cold	25	-	-	-	20	2	Current AT x2. To Revisit
	P231	Type III HS Allowance Times	3	IP Mod	8	100	-16 to -22	AeroClear MAX - Cold	75	-	-	-	10	2	Current AT x2. To Revisit
	P232	Type III HS Allowance Times	3	IP-	8	100	<-22	AeroClear MAX - Cold	25	-	-	-	20	2	Current AT x2. To Revisit
	P233	Type III HS Allowance Times	3	IP Mod	8	100	<-22	AeroClear MAX - Cold	75	-	-	-	10	2	Current AT x2. To Revisit

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P234	Type III HS Allowance Times	3	Fluid Only	8	100	-5 to -10	AeroClear MAX - Cold	-	-	-	-	-	1	Baseline Test, needed for LS
	P235	Type III HS Allowance Times	3	Fluid Only	8	100	-16 to -22	AeroClear MAX - Cold	-	-	-	-	-	1	Baseline Test, needed for LS
	P236	R&D	3	TIII Expansion	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	TIII IP AT Expansion
	P237	R&D	3	Snow Aero	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Snow Allowance Times
	P238	R&D	3	EG Aero	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	EG Fluid Allowance Times
	P239	R&D	3	S+++	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Heavy snow
	P240	R&D	3	Heavy Cont	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Heavy contamination
	P241	R&D	3	Tunnel Cooling	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Tunnel Cooling Effects
	P242	R&D	3	LOUT w/ Cont.	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Test w/ contamination @ LOUT
	P243	R&D	3	Sim. Frost	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	Simulated Frost
	P244	R&D	3	IP @ >130kts	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	IP testing a higher speeds
	P245	R&D	3	2nd Wave	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	2	2nd wave of fluid at rot.
	P246	Clean Wing		None	8	100	any	none							1.1
	P247	Clean Wing		None	8	100	any	none							1.6 (repeat)
	P248	Clean Wing		None	8	80	any	none							1.2
	P249	Clean Wing		None	8	80	any	none							1.6 (repeat)
	P250	Clean Wing		None	8, then stall	80	any	none							1.3
	P251	Clean Wing		None	8, then stall	80	any	none							1.6 (repeat)
	P252	Clean Wing		None	stall	80	any	none							1.4
	P253	Clean Wing		None	stall	80	any	none							1.6 (repeat)
	P254	Clean Wing		None	stall -4 to stall +4 PP@1	80	any	none							1.5
	P255	Clean Wing		None	stall -4 to stall +4 PP@1	80	any	none							1.6 (repeat)
	P256	Oil Flow Visualization		Oil	8 static	80	any	none							2.1
	P257	Oil Flow Visualization		Oil	4 or 6 static	80	any	none							2.2
	P258	Oil Flow Visualization		Oil	stall, static	80	any	none							2.3

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P259	Oil Flow Visualization		Oil	stall-1, static	80	any	none							2.3
	P260	Oil Flow Visualization		Oil	stall-2, static	80	any	none							2.3
	P261	Oil Flow Visualization		Oil	stall-4, static	80	any	none							2.3
	P262	Oil Flow Visualization		Oil	stall-8, static	80	any	none							2.3
	P263	Roughness (Trips)		40-grit	stall	80	any	none							3.1
	P264	Roughness (Trips)		40-grit	stall -4 to stall +4 PP@1	80	any	none							3.1
	P265	Roughness (Trips)		150-grit	stall	80	any	none							3.2
	P266	Roughness (Trips)		150-grit	stall -4 to stall +4 PP@1	80	any	none							3.2
	P267	Roughness (Trips)		80-grit	stall	80	any	none							3.3
	P268	Roughness (Trips)		80-grit	stall -4 to stall +4 PP@1	80	any	none							3.3
	P269	Roughness (Trips)		Full Wing Grit (80?)	stall	80	any	none							3.4
	P270	Roughness (Trips)		Full Wing Grit (80?)	stall -4 to stall +4 PP@1	80	any	none							3.4
	P271	Roughness (Trips)		Grit (-30% grit on LE)	stall	80	any	none							3.5
	P272	Roughness (Trips)		Grit (-30% grit on LE)	stall -4 to stall +4 PP@1	80	any	none							3.5
	P273	Roughness (Trips)		Grit (-60% grit on LE)	stall	80	any	none							3.6
	P274	Roughness (Trips)		Grit (-60% grit on LE)	stall -4 to stall +4 PP@1	80	any	none							3.6
	P275	Roughness (Trips)		Grit (Flap Only)	stall	80	any	none							3.7

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (ºC)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P276	Roughness (Trips)		Grit (Flap Only)	stall -4 to stall +4 PP@1	80	any	none							3.7
	P277	Roughness (Trips)		Diff. Grit (Flap Only)	stall	80	any	none							3.8
	P278	Roughness (Trips)		Diff. Grit (Flap Only)	stall -4 to stall +4 PP@1	80	any	none							3.8
	P279	Boundary-layer Rake Measurments		BL Rake TE Center	-2 to stall	TBD	TBD	none							4.1
	P280	Boundary-layer Rake Measurments		BL Rake TE Center -3ft	-2 to stall	TBD	TBD	none							4.2
	P281	Boundary-layer Rake Measurments		BL Rake TE Center +3ft	-2 to stall	TBD	TBD	none							4.3
	P282	Boundary-layer Rake Measurments		BL Rake Flap Center	-2 to stall	TBD	TBD	none							4.4
	P283	Boundary-layer Rake Measurments		BL Rake Flap Center - 3ft	-2 to stall	TBD	TBD	none							4.5
	P284	Boundary-layer Rake Measurments		BL Rake Flap Center +3ft	-2 to stall	TBD	TBD	none							4.6
	P285	Fluid Tests - Repeatibility		Fluid Only	8	100	TBD	2017-18 TIV #1?							5.1
	P286	Fluid Tests - Repeatibility		Fluid Only	8	100	TBD	2017-18 TIV #2?							5.1
	P287	Fluid Tests - Repeatibility		Fluid Only	8	100	TBD	AllClear TIII (100)							5.1
	P288	Fluid Tests - Repeatibility		IP-	8	100	TBD	2017-18 TIV #1?							5.2
	P289	Fluid Tests - Repeatibility		IP-	8	100	TBD	2017-18 TIV #2?							5.2
	P290	Fluid Tests - Repeatibility		IP-	8	100	TBD	AllClear TIII (100)							5.2
	P291	Fluid Tests - New BLDT		Fluid Only	8	80	below -25	AllClear TIII (100)							5.3
	P292	Fluid Tests - New BLDT		Fluid Only	8	80	below -25	AllClear TIII (100)							5.3
	P293	Fluid Tests - New BLDT		Fluid Only	8	80	below -20	AllClear TIII (100)							5.3
	P294	Fluid Tests - New BLDT		Fluid Only	8	80	below -20	AllClear TIII (100)							5.3

Table 3.2: Proposed Test Plan (Cont'd)

Test #	Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT
	P295	Fluid Tests - New BLDT		Fluid Only	8	80	-15 to -20	AllClear TIII (100)							5.3
	P296	Fluid Tests - New BLDT		Fluid Only	8	80	-15 to -20	AllClear TIII (100)							5.3
	P297	Fluid Tests - New BLDT		Fluid Only	8	80	-10 to -15	AllClear TIII (100)							5.3
	P298	Fluid Tests - New BLDT		Fluid Only	8	80	-10 to -15	AllClear TIII (100)							5.3
	P299	Fluid Tests - Repeatibility		Fluid Only	Stall, pause at 8	100	TBD	2017-18 TIV #1?							5.4
	P300	Fluid Tests - Repeatibility		Fluid Only	Stall, pause at 8	100	TBD	2017-18 TIV #2?							5.4
	P301	Fluid Tests - Repeatibility		Fluid Only	Stall, pause at 8	100	TBD	AllClear TIII (100)							5.4
	P302	Fluid Tests - Repeatibility		IP-	Stall, pause at 8	100	TBD	2017-18 TIV #1?							5.4
	P303	Fluid Tests - Repeatibility		IP-	Stall, pause at 8	100	TBD	2017-18 TIV #2?							5.4
	P304	Fluid Tests - Repeatibility		IP-	Stall, pause at 8	100	TBD	AllClear TIII (100)							5.4
	P305	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	2017-18 TIV #1?							5.5
	P306	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	2017-18 TIV #2?							5.5
	P307	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	AllClear TIII (100)							5.5
	P308	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	2017-18 TIV #1?							5.5
	P309	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	2017-18 TIV #2?							5.5
	P310	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	AllClear TIII (100)							5.5
	P311	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	2017-18 TIV #1?							5.6
	P312	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	2017-18 TIV #2?							5.6
	P313	Fluid Tests - Repeatibility		Fluid Only	Stall	100	TBD	AllClear TIII (100)							5.6
	P314	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	2017-18 TIV #1?							5.6
	P315	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	2017-18 TIV #2?							5.6
	P316	Fluid Tests - Repeatibility		IP-	Stall	100	TBD	AllClear TIII (100)							5.6

4. PRE-TESTING SETUP ACTIVITIES

The activities to be performed for planning and preparation, on the first day of testing, and prior to each testing day thereafter, have been detailed in a list included in Attachment 1.

5. DATA FORMS

The following data forms are required for the January 2018 wind tunnel tests:

- Attachment 2: General Form;
- Attachment 3: Wing Temperature, Fluid Thickness and Fluid Brix Form;
- Attachment 4: Example Ice Pellet Dispensing Form;
- Attachment 5: Example Snow Dispensing Form;
- Attachment 6: Example Snow Dispensing Form (Manual Method);
- Attachment 7: Visual Evaluation Rating Form;
- Attachment 8: Fluid Receipt Form (Electronic Form); and
- Attachment 9: Log of Fluid Sample Bottles.

When and how the data forms will be used is described throughout Section 6.

6. PROCEDURE

The following sections describe the tasks to be performed during each test conducted. It should be noted that some sections (i.e. fluid application and contamination application) will be omitted depending on the objective of the test.

6.1 Initial Test Conditions Survey

- Record ambient conditions of the test (Attachment 2); and
- Record wing temperature (Attachment 3).

6.2 Fluid Application (Pour)

- Hand pour 20L of anti-icing fluid over the test area (fluid can be poured directly out of pails or transferred into smaller 3L jugs);

- Record fluid application times and quantities (Attachment 2);
- Let fluid settle for 5 minutes (as the wing section is relatively flat, last winter it required tilting the wing for 1-minute to enable fluid to be uniform);
- Measure fluid thickness at pre-determined locations on the wing (Attachment 3);
- Record wing temperature (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Photograph and videotape the appearance of the fluid on the wing; and
- Begin the time-lapse camera to gather photos of the precipitation application phase.

Note: At the request of TC/FAA, a standard aluminum test plate can be positioned on the wing in order to run a simultaneous endurance time test.

6.3 Application of Contamination

6.3.1 Ice Pellet/Snow Dispenser Calibration and Set-Up

Calibration work was performed during the winter of 2007-08 on the modified ice pellet/snow dispensers prior to testing with the Falcon 20. The purpose of this calibration work was to attain the dispenser's distribution footprint for both ice pellets and snow. A series of tests were performed in various conditions:

- Ice Pellets, Low Winds (0 to 5 km/h);
- Ice Pellets, Moderate Winds (10 km/h);
- Snow, Low Wind (0 to 5 km/h); and
- Snow, Moderate Wind (10 km/h).

These tests were conducted using 121 collection pans, each measuring 6 x 6 inches, over an area 11 x 11 feet. Pre-measured amounts of ice pellets/snow were dispersed over this area and the amount collected by each pan was recorded. A distribution footprint of the dispenser was attained and efficiency for the dispenser was computed.

6.3.2 Dispensing Ice Pellets/Snow for Wind Tunnel Tests

Using the results from these calibration tests, a decision was made to use two dispensers on each of the leading and trailing edges of wing; each of the four dispensers are moved to four different positions along each edge during the dispensing process. Figure 6.1, Figure 6.2, and Figure 6.3 demonstrate the setup of the dispensers in relation to the wing. Attachment 4 and Attachment 5 display the data sheets that will be used during testing in the wind tunnel. These data sheets will provide all the necessary information related to the amount of ice pellets/snow needed, effective rates and dispenser positions. During the winter of 2009-10, snow was also dispensed manually using sieves. This technique was used when higher rates of precipitation were required (for heavy snow) or when winds in the tunnel made dispensing difficult. The efficiency of this technique was estimated at 90% based on how much of the precipitation actually made it onto the wing and a form to be used for this dispensing process along with dispensing instructions is included in Attachment 6.

Note: Dispensing forms should be filled out and saved for each run and pertinent information shall be included in the general form (Attachment 2). Any comments regarding dispensing activities should be documented directly on the form.

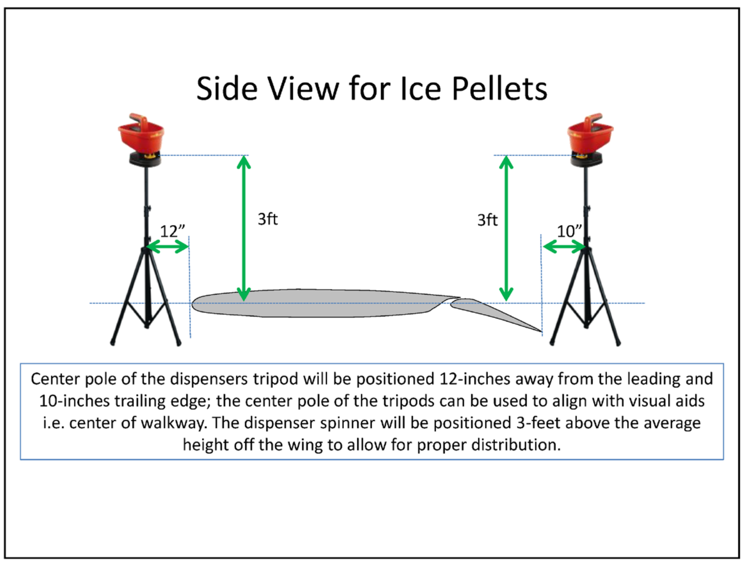


Figure 6.1: Side View of Positioning of Dispensers Relative to the Wing – Ice Pellets

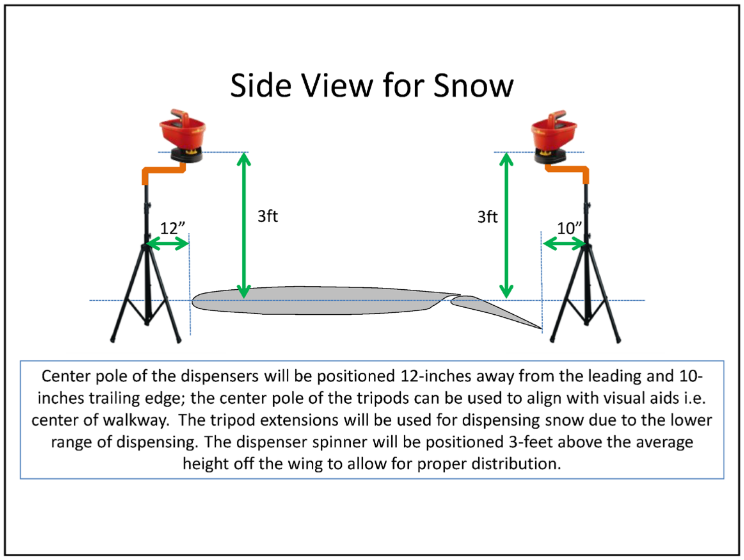


Figure 6.2: Side View of Positioning of Dispensers Relative to the Wing – Snow

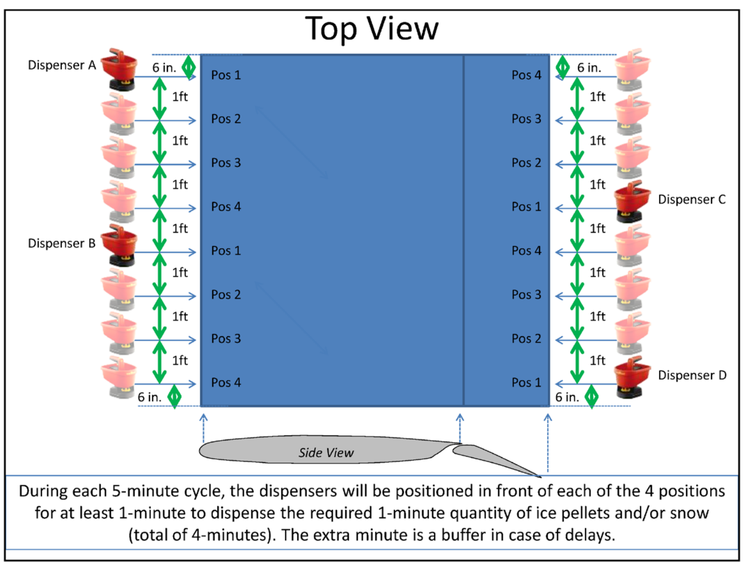


Figure 6.3: Top View of Positioning of Dispensers Relative to the Wing

6.3.3 New Ice Pellets/Snow Dispensing Systems for 2014 Onwards

Simulated ice pellets are distributed over a test surface using an ice pellet pitcher. The original ice pellet pitcher (Yardworks) was a modified handheld fertilizer dispenser. The rate of precipitation was controlled with the speed of rotation of the motor, as well as the size of the opening of the dispenser reservoir drop feeder.

In the winter of 2012-13, seed spreaders historically modified and used for applying ice pellets during wind tunnel and flat plate testing, were no longer available as the manufacturer stopped production of the model. A new replacement seed spreader system (Wolf Garten) was found which is similar (but not identical). Some calibration work was required to demonstrate an equivalency in the two systems; testing was conducted at the NRC CEF prior to the wind tunnel testing to verify the distribution of the historical system versus the new replacement system the details of which are included in the TC report TP 15230E Aircraft Ground Icing General Research Activities During the 2012-13 Winter (4).

The data collected demonstrated that the new system is very similar to old system; some small variation was present in distribution within the footprint, but equivalent efficiency on the overall footprint. Based on this it was concluded that for ice pellets, the new system can be used as a direct replacement. For snow, the new system was more efficient, therefore a reduction of 10% should be used for the snow mass requested.

Comparative wind tunnel testing was conducted in the winter of 2013-14 to further validate the equivalency of the systems, the details of which are included in the TC report TP 15274E Exploratory Wind Tunnel Aerodynamic Research. The results indicated that the differences in recorded lift losses were generally very small (less than 1.3%) when comparing back-to-back tests with no bias towards one system or the other. The differences were even smaller when looking at the average of the four comparative sequential tests (Test #330 to #337) which was 0.1%. In addition, the tests were visually evaluated to verify that the distribution of the ice pellets was similar, further supporting the similarity in aerodynamic results between the two dispenser systems.

In general, the wind tunnel results further supported the original distribution equivalency work conducted during the winter of 2012-13 and demonstrated that the new generation dispensers are suitable replacements for the older model dispensers.

6.4 Prior to Engines-On Wind Tunnel Test

- Measure fluid thickness at the pre-determined locations on the wing (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Record wing temperatures (Attachment 3);
- Record start time of test (Attachment 2); and
- Fill out visual evaluation rating form (Attachment 7).

Note: In order to minimize the measurement time post precipitation, temperature should be measured 5-minutes before the end of precipitation, thickness measured 3-minutes before the end of precipitation, and Brix measured when the precipitation ends. Also consideration has been given to reducing the number of measurements that are taken for this phase (i.e. locations 2 and 5 only).

6.5 During Wind Tunnel Test

- Take still pictures and video the behavior of the fluid on the wing during the takeoff run, capturing any movement of fluid/contamination;
- Fill out visual evaluation rating form at the time of rotation (Attachment 7); and
- Record wind tunnel operation start and stop times.

6.6 After the Wind Tunnel Test

- Measure fluid thickness at the pre-determined locations on the wing (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Record wing temperatures (Attachment 3);
- Observe and record the status of the fluid/contamination (Attachment 3);
- Fill out visual evaluation rating form (Attachment 7);
- Obtain lift data (excel file) from NRC; and
- Update APS test log with pertinent information.

6.7 Fluid Sample Collection for Viscosity Testing

Two liters of each fluid to be tested are to be collected on the first day of testing. The fluid receipt form (Attachment 8) should be completed indicating quantity of fluid and date received. Any samples extracted for viscosity purposes should be documented in the log of fluid samples data form (Attachment 9). A falling ball viscosity test should be performed on site to confirm that fluid viscosity is appropriate before testing.

6.8 At the End of Each Test Session

If required, APS personnel will collect the waste solution. At the end of the testing period, NRC will organize for a glycol recovery service provider to safely dispose of the waste glycol fluid.

6.9 Camera Setup

It is anticipated that the camera setup will be similar to the setup used during the winter of 2013-14. Modifications may be necessary and will be dealt with on-site. The flashes will be positioned on the control-room side of the tunnel, and the cameras will be positioned on the opposite side. The final positioning of the cameras and flashes should be documented to identify any deviation from the previous year's setup.

6.10 Demonstration of a Typical Wind Tunnel Test Sequence

Table 6.1 demonstrates a typical Wind Tunnel test sequence of activities, assuming the test starts at 08:00:00. Figure 6.4 demonstrates a typical wind tunnel run timeline.

Table 6.1: Typical Wind Tunnel Test

TIME	TASK
8:30:00	START OF TEST. ALL EQUIPMENT READY.
8:30:00	- Record test conditions.
8:35:00	- Prepare wing for fluid application (clean wing, etc).
8:45:00	- Measure wing temperature. - Ensure clean wing for fluid application
8:50:00	- Pour fluid over test area.
9:00:00	- Measure Brix, thickness, wing temperature. - Photograph test area.
9:05:00	- Apply contamination over test area. (i.e. 30 min)
9:35:00	- Measure Brix, thickness, wing temperature. - Photograph test area.
9:40:00	- Clear area and start wind tunnel
9:55:00	- Wind tunnel stopped
10:05:00	- Measure Brix, thickness, wing temperature. - Photograph test area. - Record test observations.
10:35:00	END OF TEST

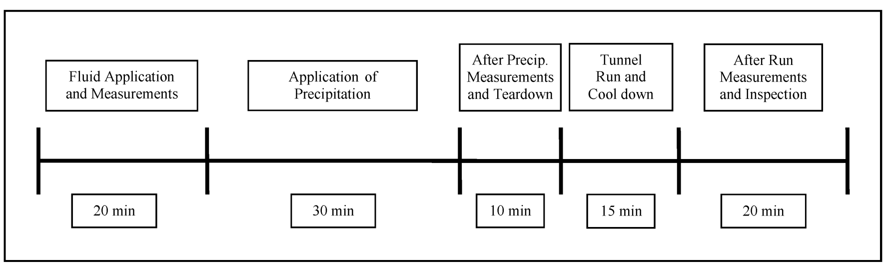


Figure 6.4: Typical Wind Tunnel Run Timeline

6.11 Procedures for Testing Objectives

Details for the testing objectives have been included in the following attachments:

- Attachment 10: Procedure - Dry Wing Performance;
- Attachment 11: Procedure – Type IV Ice Pellet Allowance Time Validation with New Fluids;
- Attachment 12: Procedure – Development of EG Specific Ice Pellet Allowance Time Table;
- Attachment 13: Procedure – Type III Low Speed Allowance Time Testing LS-0417 Wing Model Calibration and Characterization;
- Attachment 14: Procedure – Type III Ice Pellet Allowance Time Validation at 80 Knots with LS-0417 Wing Section;
- Attachment 15: Procedure – Type III Ice Pellet Allowance Time Expansion;
- Attachment 16: Procedure – Snow Allowance Times Using Aerodynamic Data;
- Attachment 17: Procedure - Heavy Snow;
- Attachment 18: Procedure - Heavy Contamination;
- Attachment 19: Procedure - Wind Tunnel Test Section Cooling;
- Attachment 20: Procedure - Fluid and Contamination at LOUT;
- Attachment 21: Procedure - Frost Simulation in the Wind Tunnel;
- Attachment 22: Procedure - Feasibility of Ice Pellet Testing at Higher Speeds; and
- Attachment 23: Procedure - 2nd Wave of Fluid during Rotation.

7. EQUIPMENT

Equipment to be employed is shown in Table 7.1.

Table 7.1: Equipment List

EQUIPMENT	STATUS		EQUIPMENT	STATUS
General Support and Testing Equipment			**Camera Equipment**	
20L containers x 12			AA Batteries x 48	
Adherence Probes Kit			C2032 Batteries x 10	
Barrel Opener (steel)			Digital still cameras x3 (two suitcases)	
Black Shelving Unit (or plastic)			Flashes and tripods (in APS storage)	
Blow Horns x 4			GoPro Cameras x 3 and related hardware	
Electrical tape x 5				
Envelopes and labels				
Exacto Knives x 2			**Ice Pellets Fabrication Equipment**	
Extension cords (power bars x 6 + reels x 4)			Blenders x 12 in good condition	
Falling Ball Viscometer			Folding tables (2 large, 1 small)	
Fluid pouring jugs x 60			Ice bags	
Fluids (ORDER and SHIP to Ottawa)			Ice bags storage freezer x 3	
Funnels(1 big + 1 small)			Ice pellets sieves (base, 1.4 mm, 4 mm)	
Gloves - black and yellow			Ice pellets Styrofoam containers x20	
Gloves - cotton (1 box)			Measuring cups (1L and smaller ones for dispensing)	
Gloves - latex (2 boxes)			NCAR Scale x 1	
Grid Section + Location docs			Refrigerated Truck	
Hard water chemicals x 3 premixes			Rubber Mats x all	
Horse and tap for fluid barrel x all			Wooden Spoons	
Hot Plate x 3 and Large Pots with rubber handles for Type III				
Ice pellet box supports for railing x4			**Freezing Rain Equipment**	
Ice Pellet control wires and boxes (all for new and old)			APS PC equipped with rate station software	
Ice pellets dispersers x 12 (6 new and 6 old)			NRC Freezing rain sprayer (NRC will provide)	
Inclinometer (yellow level) x 2			Rubber suction cup feet for wooden boards	
Isopropyl x 24			White plastic rate pans (1 to 8 x 2)	
Large and small tape measure			Wooden boards for rate pans (x8)	
Large Sharpies for Grid Section				
Long Ruler for marking wing x 2				
Marker for waste x 2			**Office Equipment**	
Paper towel x 48			APS Laptops x 6 with mouse and chargers	
Protective clothing (all) and personnel clothing			APS tuques x 10	
Sample bottles for viscosity measurement x 8			Calculators x 3	
Sartorius Weigh Scale x 1			Clip boards x 8	
Scrapers x 5			Data Forms	
Shop Vac			Dry eraser markers	
Speed tape x 1 small			Envelopes (9x12) x box	
Squeegees (5 small + 3 large floor)			File box x 2	
Stands for ice pellets dispensing devices x 6			Hard drive with all WT Photos	
Stop Watches x 4			Hard Drive x 2	
Temperature probes: immersion x 3			Pencils + sharpies/markers	
Temperature probes: surface x 3			Projector for laptop	
Temperature readers x 2 + spare batteries			Scissors	
Test Plate x 1			Small 90º aluminum ruler for wing	
Thermometer for Reefer Truck			Test Procedures x 8, printer paper	
Thickness Gauges (5 small, 5 big)			YOW employee contracts	
Vise grip (large) + rubber opener for containers				
Walkie Talkies x 12				
Water (2 x 18L) for hard water				
Watmans Paper and conversion charts				
Red Thermoses for Type III Transport				

8. FLUIDS

Mid-viscosity samples of ethylene glycol and propylene glycol IV fluid will be used in the wind tunnel tests. Although the number of tests conducted will be determined based on the results obtained, the fluid quantities available are shown in Table 8.1 (quantities to be confirmed once fluid is received). Up to 2960L of 100/0 Type IV and Type III fluid are expected to be available; an additional 404L of other fluids are also available if needed. Fluid application will be performed by pouring the fluid (rather than spraying) to reduce any shearing to the fluid.

Table 8.1: Fluid Available for Wind Tunnel Tests

FLUID	Type	DILUTION	ORDERED (L)	IN STOCK (L)	Estimated Remaining (L)	Full Containers	Partial Containers
ChemR EG IV	IV	100/0	400				
Max Flight AVIA	IV	100/0	400				
Max Flight SNEG	IV	100/0	300				
ECO-SHIELD	IV	100/0	300				
Defrost ECO 4	IV	100/0	300				
Cleansurface IV	IV	100/0	300				
UCAR™ FlightGuard AD-49	IV	100/0		180		6	3
ABC-S Plus	IV	100/0		200		5	3
Polar Guard® Advance	IV	100/0		140		5	2
AeroClear MAX	III	100/0	400	40		0	2
Safewing MP II FLIGHT	II	100/0		150		4	1
UCAR™ FlightGuard AD-49	IV	75/25		140		7	0
Polar Guard® Advance	IV	50/50		100		5	0
Lift-Off E-188	I	Brix 26.25		14		0	1 (at YUL site)

3600 L ordered for 2009-10 testing (18 days)
3200 L ordered for 2010-11 testing (15 days)
1800 L ordered for 2011-12 testing (7 of 15 days will be fluid testing)
4200 L ordered for 2012-13 testing (15 days)
1300L ordered for 2013-14 testing (15 days), 1900L previously in stock
1700L available for 2015-16 Testing (10 days)

9. PERSONNEL

Five APS staff members are required for the tests at the NRC wind tunnel. Four additional persons (with one back-up) will be required from Ottawa for making and dispensing the ice pellets and snow. One additional person from Ottawa will be required to photograph the testing. Table 9.1 demonstrates the personnel required and their associated tasks.

Fluid and ice pellets applications will be performed by APS/YOW personnel at the NRC wind tunnel. NRC personnel will operate the NRC wind tunnel and operate the freezing rain/drizzle sprayer (if requested).

Table 9.1: Personnel List

Wind Tunnel 2015-16 - Tentative	
Person	**Responsibility**
John	Director
Marco	Lead Engineer and Project Coordinator
Chloë	Data documentation (forms, logs, camera setup, etc) / IP Manager
Ben B	Data Collection / Fluid Manager (inventory and application) / YOW Pers. Manager
YOW Personnel	
Ben G	Photography / Camera Documentation
Steve	Fluids / IP / Dispensing / General Support
YOW 1	Fluids / IP / Dispensing
YOW 2	Fluids / IP / Dispensing
YOW 3	Fluids / IP / Dispensing
YOW 4	Back-up

NRC Institute of Aerospace Research Contacts

- Cory Bates: (613) 913-9720; and
- Marc MacMaster: (613) 998-6932.

10. SAFETY

- A safety briefing will be done on the first day of testing;
- Personnel should be familiar with NRC emergency procedures i.e. DO NOT CALL 9-1-1, instead call the NRC Emergency Center as they will contact and direct the necessary services;
- All personnel must be familiar with the Material Safety Data Sheets (MSDS) for fluids;
- Prior to operating the wind tunnel, loose objects should be removed from the vicinity;
- When wind tunnel is operating, ensure that ear plugs are worn if necessary and personnel keep safe distances;

- When working on ladders, ensure equipment is stable;
- CSA approved footwear and appropriate clothing for frigid temperatures are to be worn by all personnel;
- Caution should be taken when walking in the test section due to slippery floors, and dripping fluid from the wing section;
- If fluid comes into contact with skin, rinse hands under running water; and
- If fluid comes into contact with eyes, flush with the portable eye wash station.

Attachment 1: Task List for Setup and Actual Tests

No.	Task	Person	Status
	Planning and Preparation		
1	Co-ordinate with NRC wind tunnel personnel	MR/JD	
2	Ensure fluid is received by NRC and is stored outdoors	MR/JD	
3	Check with NRC the status of the testing site, tunnel etc	MR	
4	Arrange for hotel accommodations for APS personnel	ST	
5	Arrange truck rental	BB	
6	Arrange for ice and freezer delivery	ST	
7	Organize personnel travel to Ottawa;	MR	
8	Hire YOW personnel	CB	
9	Complete contract for YOW personnel	CB	
10	Co-ordinate with APS photographer	MR	
11	Ensure availability of freezing rain sprayer equipment;	MR	
12	Prepare and Arrange Office Materials for YOW	CB	
13	Prepare Data forms and procedure	CB	
14	Back up hard drives with all TC projects	CB	
15	Prepare Test Log and Merge Historical Logs for Reference	CB	
16	Prepare historical falling ball records spreadsheet	CB	
17	Finalize and complete list of equipment/materials required	MR	
18	Prepare and Arrange Site Equipment for YOW	BB/DY	
19	Ensure proper functioning of ice pellet dispenser equipment;	MR	
20	Review IP/ZR/SN dispersal techniques and location	CB/MR	
21	Update IP/SN Order Form (if necessary)	CB/MR	
22	Check weather prior to finalizing test dates and Day vs. Night Shift, Start Time	MR/JD	
23	Arrange for pallets to lift up 1000L totes (if applicable)	MR	
24	Purchase new 20 L containers (as necessary)	BB	
25	Complete purchase list and shopping	CB	
26	Pack and leave YUL for YOW	APS	
	Testing Day 1		
27	Safety Briefing & Training (APS/YOW)	MR	
28	Unload Truck and organize equipment in lower, middle, or office area	APS	
29	Verify and Organize Fluid Received (labels and fluid receipt forms)	BB/STB	
30	Transfer Fluids from 1000 L Totes to 20 L containers	BB/STB	
31	Collect fluid samples for viscosity at APS office and for Falling Ball	BB/CB	
32	Conduct falling ball verification	BB/CB	
33	Confirm ice and freezer delivery	BB	
34	Setup general office and testing equipment	CB	
35	Setup Projector	CB	
36	Setup Printer	CB	
37	Setup rate station (if necessary)	CB	
38	Setup IP/SN manufacturing material in reefer truck	BB/STB	
39	Test and prepare IP dispensing equipment	BB/STB	
40	Train IP making personnel (ongoing)	STB/YOW	
41	Co-ordinate fabrication of ice pellets/snow	CB/STB	
42	IP/SN/ZR Calibration (if necessary)	BB/CB/MR	
43	Start IP manufacturing	STB	
44	Mark wing (only if requested);	CB	
45	Setup Still and Video Cameras	BG/YOW	
46	Verify photo and video angles, resolution, etc,	BG/STBD/MR	
47	Document new final camera and flash locations	CB/BG/STBD	
48	General safety briefing and update on testing	APS/NRC/YOW	
49	Dry Run of tests with APS and NRC (if necessary)	APS/NRC	
50	Start Testing (Dry wing tests may be possible while setup occurs)	APS/NRC	
	Each Testing Day		
51	Check with NRC the status of the testing site, tunnel, weather etc	MR	
52	Deicide personnel requirements for following day for 24hr notice	MR/WU	
53	Prepare equipment and fluid to be used for test	BB	
54	Manufacture ice pellets	STB/YOW	
55	Prepare photography equipment	BG	
56	Prepare data forms for test	CB	
57	Conduct tests based on test plan	APS	
58	Modify test plan based on results obtained	WU/JD/MR	
59	Update ice pellet, snow, raw ice, and fluid Inventory (end of day)	CB/STB	
60	Update Test Log and Test Plan (ongoing and end of day)	CB	

Attachment 2: General Form

GENERAL FORM (EVERY TEST)

DATE: ____________ FLUID APPLIED: ____________ RUN # (Plan #): ____________

AIR TEMPERATURE (°C) BEFORE TEST: ____________ AIR TEMPERATURE (°C) AFTER TEST: ____________

TUNNEL TEMPERATURE (°C) BEFORE TEST: ____________ TUNNEL TEMPERATURE (°C) AFTER TEST: ____________

WIND TUNNEL START TIME: ____________ PROJECTED SPEED (S/KTS): ____________

ROTATION ANGLE: ____________ EXTRA RUN INFO: ____________

FLAP SETTING (20°, 0°): ____________

☐ Check if additional notes provided on a separate sheet

FLUID APPLICATION

Actual start time: ____________ Actual End Time: ____________

Fluid Brix: ____________ Amount of Fluid (L): ____________

Fluid Temperature (°C): ____________ Fluid Application Method: POUR

ICE PELLETS APPLICATION (if applicable)

Actual start time: ____________ Actual End Time: ____________

Rate of Ice Pellets Applied (g/dm²/h): ____________ Ice Pellets Size (mm): 1.4 - 4.0 mm

Exposure Time: ____________

Total IP Required per Dispenser: ____________

FREEZING RAIN/DRIZZLE APPLICATION (if applicable)

Actual start time: ____________ Actual End Time: ____________

Rate of Precipitation Applied (g/dm²/h): ____________ Droplet Size (mm): ____________

Exposure Time: ____________ Needle: ____________

Flow: ____________

Pressure: ____________

SNOW APPLICATION (if applicable)

Actual start time: ____________ Actual End Time: ____________

Rate of Snow Applied (g/dm²/h): ____________ Snow Size (mm): <1.4 mm

Exposure Time: ____________ Method: ☐ Dispenser ☐ Sieve

Total SN Required per Dispenser: ____________

COMMENTS

MEASUREMENTS BY: ____________ **HANDWRITTEN BY:** ____________

Attachment 3: Wing Temperature, Fluid Thickness and Fluid Brix Form

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

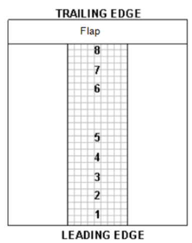
Date: ______________________   Run: ________________

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2				
T5				
TU				
Time:				

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

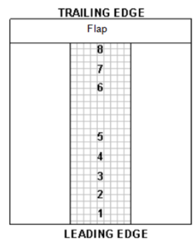
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

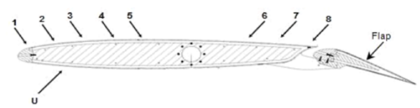


Comments: ____________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____________________

OBSERVER: ____________________

ASSISTED BY: ____________________

Attachment 4: Example Ice Pellet Dispensing Form

WING TRAILING EDGE

8 ft = 24.4 dm

6 ft = 18.3 dm

DISPENSER #3								DISPENSER #4							
1 ←	1ft	→ 2 ←	1ft	→ 3 ←	1ft	→ 4		1 ←	1ft	→ 2 ←	1ft	→ 3 ←	1ft	→ 4	
14.9	16.5	18.2	17.4	18.5	17.6	18.5	17.6	18.5	17.6	18.5	17.6	17.2	17.2	16.3	13.3
20.3	24.1	26.2	26.4	27.3	26.9	27.5	26.9	27.5	26.9	27.5	26.9	26.9	25.8	24.2	18.6
20.3	25.4	27.4	28.7	29.0	29.4	29.0	29.4	29.0	29.4	29.0	29.3	28.3	27.7	24.4	19.3
19.1	23.8	25.6	25.6	29.2	29.6	29.3	29.6	29.3	29.6	29.3	29.5	28.6	27.4	24.3	19.2
18.8	23.5	27.2	27.9	29.4	28.8	29.5	28.8	29.5	28.8	29.5	28.8	28.7	26.8	24.1	18.5
18.4	24.0	26.9	28.7	29.0	29.6	29.1	29.6	29.1	29.6	29.1	29.4	28.4	27.2	23.5	18.5
18.5	23.5	27.2	28.4	29.4	29.1	29.6	29.1	29.6	29.1	29.6	29.0	28.7	26.9	24.0	18.4
18.5	24.1	26.8	28.7	28.8	29.5	28.8	29.5	28.8	29.5	28.8	29.4	27.9	27.2	23.5	18.8
19.2	24.3	27.4	28.6	29.5	29.3	29.6	29.3	29.6	29.3	29.6	29.2	25.6	25.6	23.8	19.1
19.3	24.4	27.7	28.3	29.3	29.0	29.4	29.0	29.4	29.0	29.4	29.0	28.7	27.4	25.4	20.3
18.6	24.2	25.8	26.9	26.9	27.5	26.9	27.5	26.9	27.5	26.9	27.3	26.4	26.2	24.1	20.3
13.3	16.3	17.2	17.2	17.6	18.5	17.6	18.5	17.6	18.5	17.6	18.5	17.4	18.2	16.5	14.9
	4 ←	1ft	→ 3 ←	1ft	→ 2 ←	1ft	→ 1		4 ←	1ft	→ 3 ←	1ft	→ 2 ←	1ft	→ 1
	DISPENSER #2								DISPENSER #1						

WING LEADING EDGE

Precipitation Type	IP

Date	

Run #	

* ***Field to be manipulated***

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate (+/-)	5	g/dm²/h

IP needed per 5min

In each position	81	g
In each Dispenser	323	g

IP needed for entire test

Total amount of IP in Each Dispenser	323	g
Total Amount IP Needed for Entire Test	1291	g

1. Enter "Date" and "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of IP Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of IP in Each Dispenser" in grams. **(Each Dispenser must be emptied at 5-minute intervals.)**
6. Dictate amount of IP needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispenser has completed its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals). (e.g: Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

NOTE:

- Leading Edge (LE): Centre Pole of the Dispenser Stands must be 1-foot (12 inches) from the Leading Edge (LE)

-Trailing Edge (TE): Centre Pole of the Dispenser Stands must be 10-inches from the Trailing Edge (TE) Flap.

- Dispenser Spinner must be 3-feet above the average height of the wing.

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

Attachment 5: Example Snow Dispensing Form

WING TRAILING EDGE

8 ft = 24.4 dm (width); 6 ft = 18.3 dm (depth)

DISPENSER #3								DISPENSER #4							
1	1ft	2	1ft	3	1ft	4		1	1ft	2	1ft	3	1ft	4	
23.1	24.8	27.2	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.4	26.6	19.7
27.1	35.5	34.9	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.0	36.3	33.9	29.8
24.6	39.4	36.4	41.4	36.8	41.5	36.8	41.5	36.8	41.5	36.8	41.5	36.7	41.1	35.5	35.2
14.4	26.3	25.3	28.6	25.7	28.7	25.7	28.7	25.7	28.7	25.7	28.7	25.6	28.4	24.7	24.3
8.8	15.2	16.4	17.4	17.0	17.6	17.2	17.6	17.2	17.6	17.2	17.6	17.0	17.2	15.9	14.2
6.1	9.4	10.6	11.2	11.1	11.4	11.2	11.4	11.2	11.4	11.2	11.3	11.0	10.9	9.8	7.9
7.9	9.8	10.9	11.0	11.3	11.2	11.4	11.2	11.4	11.2	11.4	11.1	11.2	10.6	9.4	6.1
14.2	15.9	17.2	17.0	17.6	17.2	17.6	17.2	17.6	17.2	17.6	17.0	17.4	16.4	15.2	8.8
24.3	24.7	28.4	25.6	28.7	25.7	28.7	25.7	28.7	25.7	28.7	25.7	28.6	25.3	26.3	14.4
35.2	35.5	41.1	36.7	41.5	36.8	41.5	36.8	41.5	36.8	41.5	36.8	41.4	36.4	39.4	24.6
29.8	33.9	36.3	35.0	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.1	36.7	34.9	35.5	27.1
19.7	26.6	25.4	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.2	24.8	23.1
	4	1ft	3	1ft	2	1ft	1		4	1ft	3	1ft	2	1ft	1
	DISPENSER #2								DISPENSER #1						

WING LEADING EDGE

Precipitation Type	Snow	Date		Run #	

* ***Field to be manipulated***

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate	10	g/dm²/h

Snow needed per 5 minutes

In each position	84	76	g
In each Dispenser	336	305	g

Snow needed for entire test

In each Dispenser	336	305	g
Total Amount Snow Needed for Entire Test	1344	1222	g


1. Enter "Date" and "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of Snow Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of Snow in Each Dispensor" in grams. **(Each Dispensor must be emptied at 5-minute intervals.)**
6. Dictate amount of Snow needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispenser has completed its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals).

(e.g: Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

NOTE:

- Leading Edge (LE): Centre Pole of the Dispenser Stands must be 1-foot (12 inches) from the Leading Edge (LE)

-Trailing Edge (TE): Centre Pole of the Dispenser Stands must be 10-inches from the Trailing Edge (TE) Flap. The use of Dispensor Stand Extention is needed.

- Dispenser Spinner must be 3-feet above the average height of the wing.

Attachment 6: Example Snow Dispensing Form (Manual Method)

Precipitation Type	Sifted Snow

Date	

Run #	

* *Field to be manipulated*

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate	10	g/dm²/h

Snow needed per 5 minutes

In each position	66
In each Dispenser	265

Snow needed for entire test

In each Dispenser	265
Total Amount Snow Needed for Entire Test	1062

1. Enter "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of Snow Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of Snow in Each Dispenser" in grams. **(Each Dispenser must be emptied at 5-minute intervals.)**
6. Dictate amount of Snow needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispensor has completed its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals).

(e.g: Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

- Since dispensing is done using a sieve, the percentage of snow loss is reduced. This efficiency is estimated at 90%, as per visual analysis in 2009-10.

Attachment 7: Visual Evaluation Rating Form

VISUAL EVALUATION RATING OF CONDITION OF WING

Date: ____________________ Run Number: _______

Ratings:
1 - Contamination not very visible, fluid still clean.
2 - Contamination is visible, but lots of fluid still present
3 - Contamination visible, spots of bridging contamination
4 - Contamination visible, lots of dry bridging present
5 - Contamination visible, adherence of contamination

Note: Ratings can include decimals i.e. 1.4 or 3.5

Before Take-off Run

Area	Visual Severity Rating (1-5)	
Leading Edge		*>3 = Review, >3.5=Bad*
Trailing Edge		*>3 = Review, >3.5=Bad*
Flap		*>4 = Review, >4.5=Bad*

At Rotation

Area	Visual Severity Rating (1-5)	
Leading Edge		*>1= Review >1.5 = Bad*
Trailing Edge		
Flap		

Expected Lift Loss (%) *>5.4 = Review* *>9.2 = Bad*

After Take-off Run

Area	Visual Severity Rating (1-5)
Leading Edge	
Trailing Edge	
Flap	

Additional Observations: ______________________________

____

____

OBSERVER:______________________

Attachment 8: Fluid Receipt Form (Electronic Form)

FORM 1

GENERAL FORM FOR RECEIVING FLUID

Receiving Location: ☐ APS Site ☐ Other: ________________ **Date of Receipt:** ________________

Fluid Characteristics: Type: ___________ Colour: ____________ **Date of Production:** ________________

Manufacturer: ________________________________ **Batch #:** ________________

Fluid Name: ________________________________ **Project Task:** ________________

Fluid Quantities / Fluid Brix / Falling Ball Info:

Fluid Dilution: ____________	Fluid Dilution: ____________	Fluid Dilution: ____________
Fluid Quantity: ____ x ____ L = 0 L	Fluid Quantity: ____ x ____ L = 0 L	Fluid Quantity: ____ x ____ L = 0 L
Fluid Brix: _____°	Fluid Brix: _____°	Fluid Brix: _____°
Falling Ball Time: ___:___:___ (mm:ss:cs)	Falling Ball Time: ___:___:___ (mm:ss:cs)	Falling Ball Time: ___:___:___ (mm:ss:cs)
Falling Ball Temp: _____°C	Falling Ball Temp: _____°C	Falling Ball Temp: _____°C
Sample Collected From Container #: _____	Sample Collected From Container #: _____	Sample Collected From Container #: _____

Sample Collection:

HOT Fluids:	Extract 3 L 100 / 75 / 50 and 2 L Type I
Other Fluids:	Extract 2 L 100 / 75 / 50 / Type I

Sample Distribution:

Viscosity:	1 L 100 / 75 / 50 to third party for viscosity testing
WSET:	1 L 100 / 75 / 50 / Type I to AMIL for WSET (HOT samples only)
Office:	1 L 100 / 75 / 50 / Type I to be retained in office

Photo Documentation: (take photos of all that apply)

☐ Palette (as received) ☐ 100/0 MNF Fluid Label ☐ 75/25 MNF Fluid Label ☐ 50/50 MNF Fluid Label ☐ Type I MNF Fluid Label

Additional Info/Notes: (additional information included on fluid containers, paperwork received, etc.)

Received by: ______________________ **Date:** ______________________

Fluid Receipt Form (Nov 2017)

Attachment 9: Log of Fluid Sample Bottles

Date of Extraction	Fluid and Dilution	Batch #	Sample Source (i.e. drum)	Falling Ball Fluid Temp (°C)	Falling Ball Time (sec)	Comments

Attachment 10: Procedure - Dry Wing Performance

Background

A significant amount of work has been done in conjunction with NASA and NRC in order to calibrate and characterize the wind tunnel and airfoil model during the last two winter seasons. This work has further increased the confidence in the data produced, however ongoing verification is necessary in order to identify potential changes in the system performance.

Objective

Verify that clean model aerodynamic data agree with the data acquired in previous years with the same model. Given the various issues with repeatability and angle of attack offsets in the past, this is an important step prior to fluids testing.

Methodology

- Ensure the wing is clean and dry;
- Conduct a dry wing test using the regular take-off profile;
- Conduct a dry wing test using a take-off profile with rotation to stall;
- Compare lift performance to historical data; and
- Address potential discrepancies accordingly.

Test Plan

This testing should be conducted at the start of each testing day.

Attachment 11: Procedure – Type IV Ice Pellet Allowance Time Validation with New Fluids

Background

The Type IV ice pellet allowance times are conservative, generic guidance developed based on data collected using commercially available Type IV fluids. As new fluids are developed and become commercially available, it is important to evaluate these fluids against the current allowance times to ensure the validity of the generic guidance. Systematic "spot-checking" is used in order to identify any potential issues. In addition, testing is recommended with all fluids available to obtain data close to the fluid LOUT to determine the aerodynamic effects of ice pellet contamination at these colder temperatures.

Objective

To evaluate newly commercialized Type IV fluids against the existing allowance times, and to collect data close to the fluid LOUT.

Methodology

- Conduct testing with any new commercially available Type IV fluids in each of the cells of the ice pellet allowance times table;
- Record lift data, visual observations, and manually collected data;
- Adjust testing plan accordingly based on aerodynamic data collected; and
- Weather permitting, conduct testing close to the fluid LOUT (-25 to -30°C) with appropriate conditions to address data gaps.

Test Plan

Eight days of testing are planned.

Attachment 12: Procedure – Development of EG Specific Ice Pellet Allowance Time Table

Background

Type IV ice pellet allowance times are also intended to be conservative, and therefore generic guidance is developed based on data collected using commercially available Type IV fluids. Historically both Type IV PG and EG fluids have been grouped together, however data has indicated that EG may have an operational advantage of longer ice pellet allowance times in specific conditions. The industry requested that EG specific fluid ice pellet allowance time tables be generated to be able to benefit from any potential linger allowance times specific to Type EG fluids.

Objective

To conduct testing to investigate the feasibility of developing an EG specific ice pellet allowance time table.

Methodology

- Determine what EG data exists and any potential data gaps which need to be filled;
- Conduct testing with commercially available EG Type IV fluids in each of the cells of the ice pellet allowance times table, as required;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

Two days of testing are planned.

Attachment 13: Procedure – Type III Low Speed Allowance Time Testing LS-0417 Wing Model Calibration and Characterization

Background

Type III fluid allowance times have recently been developed but are limited to use with aircraft with rotation speeds of 100 knots or greater. Type III fluids can often be used with lower rotation speed aircraft, therefore there is a requirement to have these allowance times validated for use at these lower speeds. The LS-0417 is a more representative airfoil to conduct low speed testing at 80 knots, however the characteristics of the airfoil have yet to be fully investigated.

Objective

Determine the baseline aerodynamic characteristics of the LS-0417 wing model configuration to improve the understanding and general applicability of the fluids and contamination tested on this wing model configuration for use with ice pellet allowance time testing at 80 knots.

Methodology

Testing will include a subset of the following:

- Thoroughly survey the clean wing performance through pitch pause, angle sweeps, and stall runs, and verify repeatability;
- Perform oil flow visualization to better understand boundary layer separation and uniformity of flow;
- Install boundary layer trips to establish wing sensitivity;
- Conduct fluid testing with and without contamination to evaluate repeatability of results; and
- Install larger end plates to evaluate potential 3D effects.

Test Plan

Three days of testing are planned, one of which will be fluid only testing. An additional day may be required to swap out the existing wing section in the wind tunnel for the LS-0417 wing.

Attachment 14: Procedure – Type III Ice Pellet Allowance Time Validation at 80 Knots with LS-0417 Wing Section

Background

Type III fluid allowance times have recently been developed but are limited to use with aircraft with rotation speeds of 100 knots or greater. Type III fluids can often be used with lower rotation speed aircraft, therefore these allowance times need to be validated for use at these lower speeds. The LS-0417 is a more representative airfoil to conduct low speed testing at 80 knots, therefore it is recommended that the Type III IP allowance times be validated using the LS-0417 wing model at lower speeds (80 knots).

Objective

To evaluate the Type III allowance times for use with lower rotation speeds (80 knots).

Methodology

- Conduct testing in each of the cells of the ice pellet allowance times table with commercially available Type III fluids in each of the cells of the ice pellet allowance times table at 80 knots rotation speed with the LS-0417 wing section;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

One day of testing is planned. This testing can only be completed once the LS-0417 wing section calibration and characterization work has been completed.

Attachment 15: Procedure – Type III Ice Pellet Allowance Time Expansion

Background

Allowance times for Type III fluids have just recently been developed. Similar to the Type IV ice pellet allowance times, the Type III allowance times are also intended to be conservative, generic guidance developed based on data collected using commercially available Type III fluids. In cases where the allowance times are too restrictive, additional data may be used to support an increase to the existing times, or new cells at different temperatures. This testing can be done at both 80 knots and 100 knots.

Objective

To conduct testing to support the expansion of the Type III ice pellet allowance times.

Methodology

- Conduct testing with commercially available Type III fluids in each of the cells of the ice pellet allowance times table at 80 knots and 100 knots rotation speed;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

Ten to twenty tests are anticipated.

Attachment 16: Procedure – Snow Allowance Times Using Aerodynamic Data

Background

Holdover times are developed based on a visual evaluation of fluid failure on test plate surfaces measuring 30x50cm (12x20in.). The industry requested an investigation into the feasibility of using the same aerodynamic testing methodology used to develop ice pellet allowance times, to develop snow allowance times. It is believed that using this methodology would provide longer "snow allowance times" as compared to the current existing snow holdover times.

Objective

To conduct testing to investigate the feasibility of developing snow allowance times.

Methodology

- Conduct testing with commercially available Type IV fluids using the current methodology used to develop ice pellet allowance times;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

Ten to twenty tests are anticipated.

Attachment 17: Procedure - Heavy Snow

Background

As a direct result of the ice pellet research conducted, the use of HOTs for determining the protection time provided by anti-icing fluids was questioned. The focus has turned towards “aerodynamic failure” which can be defined as a significant lift loss resulting from contaminated anti-icing fluid. Heavy snow conditions have been selected for this study for two reasons. First, snow conditions account for the most significant portion of de-icing operations globally. Secondly, there has been a recent industry interest for holdover time for heavy snow conditions. Preliminary aerodynamic testing was conducted during the winters of 2006-07 and 2008-2011.

Objective

To investigate the fluid aerodynamic flow-off characteristics of anti-icing fluid contaminated with simulated heavy snow versus moderate snow.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical snow condition tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating moderate snow conditions (rate of 25 g/dm²/h) for an exposure time derived from the HOT table based on the tunnel temperature at the time of the test;
- Record lift data, visual observations, and manually collected data;
- Conduct two comparative tests simulating heavy snow conditions (rate of 50 g/dm²/h or higher) for the same exposure time used during the moderate snow test;

  NOTE: Previous testing has indicated that using half, to ¾ of the moderate snow HOT generates similar end conditions; whereas using the full moderate HOT for heavy snow conditions generates a more sever fluid failure which behaves worse aerodynamically.
- Record lift data, visual observations, and manually collected data;
- Compare the heavy snow results to the moderate snow results. If the heavy snow results are worse, repeat the heavy snow test with a reduced exposure time, if the results are better, repeat the heavy snow test with an increased exposure time;
- Repeat until similar lift data, and visual observations are achieved for both heavy snow and moderate snow; and
- Document the percentage of the moderate snow HOT that is acceptable for heavy snow conditions.

Test Plan

Two to four comparative tests are anticipated. See previous reports for suggested test plan.

Attachment 18: Procedure - Heavy Contamination

Background

Previous testing in the wind tunnel demonstrated that although very heavy ice pellet and/or snow contamination was applied to a fluid covered wing section, significant lift losses were not apparent. The initial testing indicated that after a certain level of contamination, the dry loose ice pellets or snow no longer absorb into the fluid and easily fly off during the acceleration. The protection is due to a thin layer of fluid present underneath the contamination that prevents adherence. Questions of which point the lift losses become detrimental have been raised.

Objective

To continue previous research investigating heavy contamination effects on fluid flow off.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical ice pellet tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating ice pellets, snow, or freezing rain, for an exposure time far exceeding the recommended HOT or allowance time;
- Record lift data, visual observations, and manually collected data; and
- Compare aerodynamic performance results to fluid only or fluid and contamination tests at the same temperature.

Test Plan

One to four tests are anticipated. Previous work should be referenced to identify starting levels of heavy contamination.

Attachment 19: Procedure - Wind Tunnel Test Section Cooling

Background

Recent wind tunnel research has been limited by the ambient temperature in wind tunnel test section; in sunny conditions, the radiation will raise the temperature in the test section making testing difficult. To mitigate this effect, testing is often conducted overnight, however in some cases, even body heat from people working in the test area (specifically during long precipitation exposure tests) can affect the temperature. A new cooling system has been installed by the NRC to mitigate the effects of the radiation warming as well as from the heat generated by the personnel working in the test section. It was recommended that testing be conducted to evaluate the effects of the new cooling system on the test results.

Objective

To evaluate the effect of the cooling system on the aerodynamic test results produced.

Methodology

- Conduct a fluid only test without the cooling system. Have personnel standing on scaffolding for 20-minutes following fluid application to generate extra heat prior to running the wind tunnel;
- Conduct a second comparative fluid only test with the cooling system. Have personnel standing on scaffolding for 20-minutes following fluid application to generate extra heat prior to running the wind tunnel;
- Conduct a third comparative test at a suitable ambient temperature where the expected test area temperature with the cooling system is equal to the test area temperature of the test conducted without the cooling system; and
- Compare aerodynamic performance results.

EXAMPLE OF COMPARATIVE DATA TO BE COLLECTED

Test #	Cooling System Status	OAT ºC	Test Area Temp ºC	Lift Loss %
1	Off	-18	-14	6.3
2	On	-18	-17	7.5
3	On	-15*	-14	5.7

* To be selected based on efficiency of cooling system based on test #2

Test Plan

Three tests at a minimum are expected.

Attachment 20: Procedure - Fluid and Contamination at LOUT

Background

Recent changes to the frost HOT guidance material allowing fluids to be used to the LOUT have raised concerns about whether or not this is an appropriate practice. In frost the major concern was the effect of radiation cooling and how it could affect the LOUT, however the concern also includes contamination at LOUT. This issue was also raised from the AWG for the ice pellet testing which allows fluids to be used to LOUT: will the added ice pellet contamination at the LOUT not bust BLDT? It was recommended that some testing be conducted at the fluid LOUT to investigate how contamination can affect the aerodynamic performance of the fluid.

Objective

To investigate the fluid aerodynamic flow-off characteristics of anti-icing fluid with contamination at the LOUT.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical ice pellet tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating ice pellets, snow, freezing fog, or frost, for an exposure time derived from the HOT table at the fluid LOUT;
- Record lift data, visual observations, and manually collected data;
- Conduct a fluid only baseline test at the same temperature (at LOUT); and
- Compare the aerodynamic performance.

Test Plan

Four or more tests are anticipated at a minimum. If LOUT temperatures for neat fluids are not likely to occur, investigate the possibility of using diluted fluids to obtain a higher LOUT.

Attachment 21: Procedure - Frost Simulation in the Wind Tunnel

Background

Frost is an important consideration in aircraft deicing. The irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. This potential hazard is amplified by the frequent occurrence of frost accretion in winter operations. Frost is an area of research that has yet to be fully explored. Discussions regarding the aerodynamic effects of frost have been raised, and the possibility of doing wind tunnel testing has been considered. It was recommended that initial testing be performed to investigate whether it would be feasible to simulate frost conditions in the PIWT.

Objective

To investigate the feasibility of simulating frost conditions in the PIWT.

Methodology

This work is exploratory, so no exact procedure exists. It is recommended that the frost generating parameters be explored to try and stimulate frost accretion. This can be done by causing a negative temperature differential between the wing and the ambient air i.e. air is warmer than skin. A more specific methodology may be determined on site following a brain-storm with on-site technicians.

Test Plan

One or two tests are anticipated.

Attachment 22: Procedure - Feasibility of Ice Pellet Testing at Higher Speeds

Background

Historically, the ice pellet allowance time testing conducted in the wind tunnel simulated typical aircraft rotation of 100 knots, and more recently some limited work at 115 knots. As a result of some of the higher lift losses observed at colder temperatures with PG fluids applied to a thin high performance airfoil, it was recommended that higher speed testing be conducted to verify if the limitations in the allowance times would need to be applied to commercial aircraft with rotation speeds well above 115 knots. It was recommended that 130-150 knots be targeted, however modifications to the wind tunnel may be required as those higher speeds may increase stress on the wind tunnel engine and other structural systems.

Objective

To investigate the feasibility of conducting ice pellet testing at higher speeds of 130-150 knots.

Methodology

This work is exploratory, so no exact procedure exists. A more specific methodology may be determined on site following a brain-storm with on-site technicians. It is expected that a series of tests may be conducted to try and achieve speeds above 115 knots without rotating the wing model.

Test Plan

One or two tests are anticipated, however more tests may be required based on the results.

Attachment 23: Procedure - 2nd Wave of Fluid during Rotation

Background

Previous wind tunnel testing has shown that during a simulated take-off roll following de/anti-icing, fluid will shear off the wing section; however a small amount of fluid can remain trapped along the leading edge at the stagnation point. This “trapped” fluid begins to flow over the wing only once the wing is rotated; the stagnation point shifts below the leading edge, and the “trapped” fluid begins to shear off as a second wave. Previous testing was simulated in a static model using strips of speed tape and cork tape strategically located on the leading edge of the wing section (along the span where the separation bubble will typically occur). A separate set of dynamic tests simulated the second wave with actual anti-icing fluid; sheared fluid prior to rotation was left only in select areas either below or above the stagnation point and then the flow was observed during a typical rotation. The results showed the stalling characteristics of the wing with fluid (or fluid with contamination) appear to be driven by secondary wave effects near the leading edge; these effects are difficult to interpret on the two-dimensional model relative to a fully three-dimensional wing and should not be used in developing allowance times. Additional testing may be useful to better understand this effect.

Objective

To investigate the aerodynamic effects of the second wave of fluid flow during rotation.

Methodology

- Simulate the 2nd wave of fluid using strips of tape applied at specific areas at different thicknesses on the wing, or with fluid; and
- Compare the different results.

Test Plan

One to four tests are anticipated.

This page intentionally left blank.

APPENDIX C

PROCEDURE:
WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS
WINTER 2018-19

300293

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

Winter 2018-19

Prepared for

Innovation Centre
Transport Canada

Prepared by: Marco Ruggi

Reviewed by: John D'Avirro

August 21, 2019
Final Version 1.2

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

Winter 2018-19

1. BACKGROUND

In 2005-06, the inability of operators to release aircraft in ice pellet conditions led Transport Canada (TC) and the Federal Aviation Administration (FAA) to begin a research campaign to develop allowance times for these conditions. Developing holdover times was not feasible due to the properties of the ice pellets; they remain embedded in the fluid and take long to dissolve as compared to snow which is immediately absorbed and dissolved. Research was initiated by live aircraft testing with the National Research Council (Canada) (NRC) Falcon 20 in Ottawa Ontario, and later evolved to testing in a more controlled environment with the NRC Propulsion Icing Wind Tunnel also in Ottawa Ontario.

Early testing in 2005-06 with the Falcon 20 primarily used visual observations to evaluate fluid flow-off. During the Falcon 20 work the wing was anti-iced, exposed to contamination, and aborted takeoff runs were performed allowing researchers on-board to observe and evaluate the fluid flow-off. Testing in 2006-07 began in the propulsion icing wind tunnel (PIWT) allowing aerodynamic data to be used for evaluating fluid flow-off performance. The PIWT also allowed for a more controlled environment less susceptible to the elements.

The work continued each year, and the test methods and equipment improved allowing for real-time data analysis, better repeatability, and overall greater confidence in the results. The work conducted by TC/FAA was presented by APS Aviation Inc. (APS) to the SAE International (SAE) G-12 Aerodynamic Working Group (AWG) and Holdover Time (HOT) Committee yearly since 2006. Additional presentations were also given at the AWG in May 2012 and May 2013 by the National Aeronautics and Space Administration (NASA) and the NRC, which focused on the extensive calibration and characterization work performed with a generic thin high performance airfoil. This work also helped increase confidence in how the data were used to help support TC/FAA rule-making. A detailed account of the more recent work conducted is included in the TC report, TP 15232E*, Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winter 2009-10 to 2012-13*.

The Ice Pellet Allowance Time research has helped further develop and improve the PIWT facility. As a result, a new medium is now available for aerodynamic testing of aircraft ground icing fluids with or without contamination in a full-scale format. Several other ground deicing projects have been ongoing as a result of industry requests and are expected to continue. The PIWT has evolved into a multidisciplinary facility; however, it continues to be the primary source for the development and further refinement of the ground deicing ice pellet allowance time guidance material. Research at the PIWT with and without ice pellets has continued on a yearly or bi-yearly basis and is performed by APS, with support of the NRC, on behalf of TC/FAA.

For the Winter 2018-19, the primary focus of testing will be on ice pellet allowance time validation.

2. OBJECTIVES AND TIMING

The following describes the objectives and timing of the research. 15 days of testing are being planned, however, it is expected that only 5 days will be done, dependent on TC/FAA funding resources. The selection of which objectives are targeted will be at the discretion of the TC/FAA research team and decided on-site.

2.1 Type IV Allowance Time Validation Testing

The objective of this testing is to conduct aerodynamic testing with a thin high performance airfoil to:

- Substantiate the current Type IV ice pellet allowance times with new fluids and at temperatures close to the lowest operational use temperature (LOUT).

To satisfy this objectives, a thin high performance wing section (Figure 2.1) will be subjected to a series of tests in the NRC PIWT. The dimensions indicated are in inches. This wing section was constructed by NRC in 2009 specifically for the conduct of these tests following extensive consultations with an airframe manufacturer to ensure a representative thin high performance design.

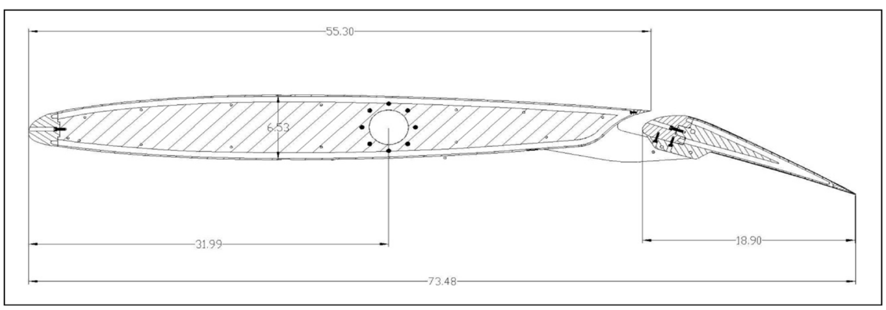


Figure 2.1: Thin High Performance Wing Section

Eight days of testing are required for the conduct of these tests.

2.2 Type IV Allowance Time Expansion for Ethylene Glycol (EG) Fluids

The objective of this testing is to conduct aerodynamic testing with a thin high performance airfoil to:

- Expand the current Type IV ice pellet allowance times for EG fluids.

To satisfy this objectives, a thin high performance wing section (described in Section 2.1 and shown in Figure 2.1) will be subjected to a series of tests in the NRC PIWT.

Two days of testing are required for the conduct of these tests.

2.3 Type III Low Speed Allowance Time Testing

Testing will be conducted to:

- Evaluate the current Type III ice pellet allowance times at 80 Knots using the LS-0417 low speed airfoil.

To satisfy this objective, the LS-0417 wing section (Figure 2.2) will be subjected to a series of tests in the NRC PIWT. The dimensions indicated are in inches. This wing section was constructed by NRC in the 1990s and was more recently used in 2008-09 and 2017-18 for ice pellet wind tunnel testing. Time for the wing to be swapped is needed, some testing efforts may be required to calibrate and characterize the wing section, and fluid only testing will be done prior to conducting any actual allowance time testing.

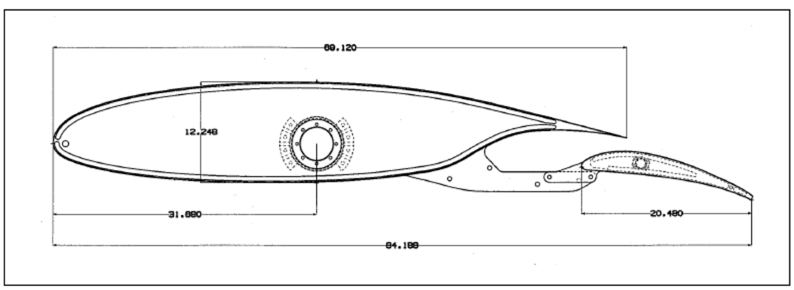


Figure 2.2: NASA LS-0417 Wing Section

An additional 5 days of testing are required for the conduct of these tests.

2.4 Timing

A total of 8 days are required for the “Type IV Allowance Time Validation Testing” (Section 2.1), 2 days are required for the “Type IV Allowance Time Expansion for EG Fluids” (Section 2.2), and 5 days are required for the “Type III Low Speed Allowance Time Testing” (Section 2.3). This requires a total of 15 days of testing, however, the actual number of testing days will be dependent on TC/FAA funding resources.

At the time of writing this procedure, it is expected that only 5 days of testing starting January 20th will be attempted based on available funding resources. Changing over of the wing sections, if necessary, may require some down-time which will need to be considered in the scheduling. In addition, Airlines for America (A4A) will be conducting testing (as part of a separate contract) on the days following the TC/FAA wind tunnel testing, starting January 28th; see Figure 2.3 for details.

Testing will likely be conducted during overnight periods (i.e. 10 pm – 6 am), unless temperatures are suitable for day/evening testing. The weekends will be considered only if deemed necessary. The first 2 hours or more of the first day will be dedicated to setup and calibration of the rain sprayer and ice pellet and snow dispensers; time permitting testing will begin as per the test plan. The time required for the setup and calibration will be evenly deducted from the other objectives in order to still meet the 5-day testing plan. The precipitation conditions to be calibrated could include the following:

- ZR – 25g/dm²/h;
- R – 25g/dm²/h;
- R – 75g/dm²/h;
- ZD – 5g/dm²/h;
- ZD – 13g/dm²/h;
- SN – 10g/dm²/h;
- SN – 25g/dm²/h;
- IP – 25g/dm²/h; and
- IP – 75g/dm²/h.

WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS

JANUARY 2019

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jan 13	14	15	16	17 *Pack up truck in YUL*	18 *Leave YUL for YOW for Preliminary Setup*	19
Jan 20	21 ***TEST DAY 1*** TESTING ACTIVITY TBD	22 ***TEST DAY 2*** TESTING ACTIVITY TBD	23 ***TEST DAY 3*** TESTING ACTIVITY TBD	24 ***TEST DAY 4*** TESTING ACTIVITY TBD	25 ***TEST DAY 5*** TESTING ACTIVITY TBD	26
Jan 27	28 ***A4A Day 1*** TESTING ACTIVITY TBD	29 ***A4A Day 2*** TESTING ACTIVITY TBD	30 ***SPARE DAY 1*** TESTING ACTIVITY TBD	31 NRC Staff Reassigned	Feb 1	2
Feb 3	4	5	6	7	8	9

NOTES

Anticipate Mon-Fri testing, however, weekend may be considered due to temperature.
Testing will be conducted during overnight periods (10:00 pm - 6:00 am) i.e. Monday test day has a Sunday 10:00pm start.
Testing team will be JD, MR, BB, CB, BG & YOW x 4
Spare days available (Feb 4-8) should rescheduling be needed due to temperatures.

TESTING ACTIVITIES

SETUP & CALIBRATION **of Rain Sprayer and IP/SN Dispensers** (Will be done on first day. Time req'd to be deducted evenlyfrom other activities)	***TEST DAY 1*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 2*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 3*** **IP VALIDATION - NEW FLUIDS (TIV)** *above -5°C*	***TEST DAY 4*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*	***TEST DAY 5*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*
	TEST DAY 6 **IP VALIDATION - NEW FLUIDS (TIV)** *below -5 to 16°C*	***TEST DAY 7*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -16°C*	***TEST DAY 8*** **IP VALIDATION - NEW FLUIDS (TIV)** *below -16°C*	***TEST DAY 9*** **EG IP EXPANSION (TIV)** *above -5°C*	***TEST DAY 10*** **EG IP EXPANSION (TIV)** *below -5 to -16°C*
	TEST DAY 11 **Type III IP - LS0417 WING SWAP (done by NRC)** *Any temp*	***TEST DAY 12*** **TYPE III IP - EXTRA LS0417 CALIBRATION & CHARACTERIZATION** *below 0ºC*	***TEST DAY 13*** **TYPE III IP VALIDATION AT 80KTS W/ LS0417** *above -5ºC*	***TEST DAY 14*** **TYPE III IP VALIDATION AT 80KTS W/ LS0417** *below -5ºC to -16ºC*	***TEST DAY 15*** **TYPE III IP VALIDATION AT 80KTS W/ LS0417** *below -16ºC*

Note: Each testing activity block represents one day of wind tunnel time.

Figure 2.3: Test Calendar

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Final Version 1.2\Wind Tunnel 2018-19 Final Version 1.2.docx
Final Version 1.2, August 19

5

3. TEST PLAN

The NRC wind tunnel is an open circuit tunnel. The temperature inside the wind tunnel is dependent on the outside ambient temperature. Prior to testing, the weather should be monitored to ensure proper temperatures for testing.

Representative Type I/II/III/IV propylene and ethylene fluids in Neat form (standard mix for Type I) shall be evaluated against their uncontaminated performance.

A preliminary list of test objectives is shown in Table 3.1 (only Priority 1 and 2 objectives will be attempted unless indicated otherwise by TC/FAA directive). It should be noted that the order in which the tests will be carried out will depend on weather conditions and TC/FAA directive. A detailed test matrix (subject to change) is shown in Table 3.2. As some of this testing is exploratory, changes to the test plan may be made at the time of testing and will be confirmed by TC/FAA.

NOTE: The numbering of the test runs will be done in a sequential order starting with number 1.

A rating system has been developed for fluid and contamination tests, and will be filled out by the on-site experts when applicable. The overall rating will provide insight into the severity of the conditions observed. A test failure (failure to shed the fluid at time of rotation) shall be determined by the on-site experts based on residual contamination.

Table 3.1: Preliminary List of Testing Objectives for Winter 2018-19 Wind Tunnel Testing

Item #	Objective	Priority	Description	# of Days
0	Setup and Precipitation Calibration	1	Setup of equipment and calibration of the rain sprayer and the ice pellet and snow dispensers (to be done on the first day of testing)	-
1	Dry Wing Baseline Repeatability	1	Baseline test at beginning of each day to ensure repeatability (part of NRC shakedown tests so no days allotted)	N/A
2	Type IV IP AT Validation (New Fluids)	1	Substantiate current times with new fluids	8
3	EG Type IV AT Expansion	2	Conduct allowance time testing with the objective of extending times and potentially add new cells for EG fluids	2
4.1	Type III IP – LS-0417 Wing Swap	2	Replace the wing section in the tunnel with the LS-0417 model	1
4.2	Type III IP – Extra LS-0417 Calibration and Characterization	2	Collect additional data with the LS-0417 wing model to support calibration and characterization efforts from 2017-18	1
4.3	Type III IP AT Validation at 80 Knots with LS-0417 Wing Section	2	Validate the existing Type III allowance times for use at 80 knots using the LS-0417 wing section	3
5	Other R&D Activities	3	Could be selected from item # 5.1 to 5.11	0
5.1	Type III Allowance Time Expansion		Expand the current Type III allowance times to have increased times, or more cells.	-
5.2	Snow Allowance Times Using Aerodynamic Data		Investigate feasibility of developing snow allowance times using the same aerodynamic based methodology used for ice pellets	
5.3	Development of EG Specific IP Allowance Times		Support the development of an EG fluid specific ice pellet allowance time table to benefit of potential longer times	-
5.4	Heavy Snow	-	Continue Heavy Snow Research comparing lift losses with Light/Moderate Snow vs. Heavy Snow	-
5.5	Heavy Contamination (Aero vs. Visual Failure)	-	Continue work looking at aerodynamic failure vs. HOT defined failure, and effect of surface roughness on lift degradation	-
5.6	Tunnel Test Section Cooling System Evaluation	-	Evaluate effectiveness of new wind tunnel cooling system and potential effects on data results	-
5.7	Fluid + Cont @ LOUT	-	Effect of contamination on fluid performance at LOUT with IP, SN, ZF, Frost etc.	-
5.8	Simulate Frost in Wind Tunnel	-	Attempt to simulate frost conditions in wind tunnel.	-
5.9	130-150 Knots IP Testing	-	Conduct IP testing at 130-150 knots or validate feasibility MAY NEED TO MODIFY TUNNEL	-
5.10	2nd Wave of Fluid During Rotation	-	Investigate the aero effects of the 2nd wave of fluid created from fluid at the stagnation point which flows over the LE during rotation	-
5.11	Other	-	Any potential suggestions from industry	

Total # of Days for Priority 1 and Priority 2 Tests	**15**

**Note only 5 days of testing are planned. The time required for the setup and precipitation calibration will be evenly deducted from the other Priority 1 and 2 objectives in order to still meet the five day testing plan.*

Table 3.2: Proposed Test Plan

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate $(g/dm^2/h)$	SN Rate $(g/dm^2/h)$	ZR Rate $(g/dm^2/h)$	R Rate $(g/dm^2/h)$	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P001	Baseline	1	Dry Wing	8	100	any	none	-	-	-	-	-	1	@start of day		
P002	Baseline	1	Dry Wing	22	80	any	none	-	-	-	-	-	1	@start of day		
P003	Type IV Validation and New Fluids	1	IP-	8	100	>-5	Max Flight AVIA	25	-	-	-	50	1		12910	
P004	Type IV Validation and New Fluids	1	IP- / SN-	8	100	>-5	Max Flight AVIA	25	10	-	-	40	1		10328	4304
P005	Type IV Validation and New Fluids	1	IP- / ZD	8	100	>-5	Max Flight AVIA	25	-	13	-	25	2		6455	
P006	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	>-5	Max Flight AVIA	25	-	25	-	25	1		6455	
P007	Type IV Validation and New Fluids	1	IP- / R-	8	100	>0	Max Flight AVIA	25	-	-	25	25	2		6455	
P008	Type IV Validation and New Fluids	1	IP Mod	8	100	>-5	Max Flight AVIA	75	-	-	-	25	1		19365	
P009	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	>-5	Max Flight AVIA	75	-	13	-	10	1		7746	
P010	Type IV Validation and New Fluids	1	IP Mod / R	8	100	>0	Max Flight AVIA	75	-	-	75	10	2		7746	
P011	Type IV Validation and New Fluids	1	IP-	8	100	-5 to -10	Max Flight AVIA	25	-	-	-	30	2		7746	
P012	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-5 to -10	Max Flight AVIA	25	10	-	-	15	2		3873	1614
P013	Type IV Validation and New Fluids	1	IP- / ZD	8	100	-5 to -10	Max Flight AVIA	25	-	13	-	10	2		2582	
P014	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	-5 to -10	Max Flight AVIA	25	-	25	-	10	1		2582	
P015	Type IV Validation and New Fluids	1	IP Mod	8	100	-5 to -10	Max Flight AVIA	75	-	-	-	10	2		7746	
P016	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	-5 to -10	Max Flight AVIA	75	-	13	-	7	1		5422	
P017	Type IV Validation and New Fluids	1	IP-	8	100	-10 to -16	Max Flight AVIA	25	-	-	-	30	1		7746	
P018	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-10 to -16	Max Flight AVIA	25	10	-	-	15	1		3873	1614
P019	Type IV Validation and New Fluids	1	IP Mod	8	100	-10 to -16	Max Flight AVIA	75	-	-	-	10	1		7746	
P020	Type IV Validation and New Fluids	1	IP-	8	100	-16 to -22	Max Flight AVIA	25	-	-	-	30	2		7746	
P021	Type IV Validation and New Fluids	1	IP Mod	8	100	-16 to -22	Max Flight AVIA	75	-	-	-	10	2		7746	
P022	Type IV Validation and New Fluids	1	IP-	8	100	<-22	Max Flight AVIA	25	-	-	-	30	2		7746	
P023	Type IV Validation and New Fluids	1	IP Mod	8	100	<-22	Max Flight AVIA	75	-	-	-	10	2		7746	
P024	Type IV Validation and New Fluids	1	Fluid Only	8	100	>-5	Max Flight AVIA	-	-	-	-	-	2	Baseline Test		
P025	Type IV Validation and New Fluids	1	Fluid Only	8	100	-5 to -10	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P026	Type IV Validation and New Fluids	1	Fluid Only	8	100	-10 to -16	Max Flight AVIA	-	-	-	-	-	2	Baseline Test		
P027	Type IV Validation and New Fluids	1	Fluid Only	8	100	-16 to -22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P028	Type IV Validation and New Fluids	1	Fluid Only	8	100	<-22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P029	Type IV Validation and New Fluids	1	IP-	8	100	>-5	Max Flight SNEG	25	-	-	-	50	1		12910	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate $(g/dm^2/h)$	SN Rate $(g/dm^2/h)$	ZR Rate $(g/dm^2/h)$	R Rate $(g/dm^2/h)$	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P030	Type IV Validation and New Fluids	1	IP- / SN-	8	100	>-5	Max Flight SNEG	25	10	-	-	40	1		10328	4304
P031	Type IV Validation and New Fluids	1	IP- / ZD	8	100	>-5	Max Flight SNEG	25	-	13	-	25	2		6455	
P032	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	>-5	Max Flight SNEG	25	-	25	-	25	1		6455	
P033	Type IV Validation and New Fluids	1	IP- / R-	8	100	>0	Max Flight SNEG	25	-	-	25	25	2		6455	
P034	Type IV Validation and New Fluids	1	IP Mod	8	100	>-5	Max Flight SNEG	75	-	-	-	15	1	15 min for PG	11619	
P035	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	>-5	Max Flight SNEG	75	-	13	-	10	1		7746	
P036	Type IV Validation and New Fluids	1	IP Mod / R	8	100	>0	Max Flight SNEG	75	-	-	75	10	2		7746	
P037	Type IV Validation and New Fluids	1	IP-	8	100	-5 to -10	Max Flight SNEG	25	-	-	-	30	2		7746	
P038	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-5 to -10	Max Flight SNEG	25	10	-	-	15	2		3873	1614
P039	Type IV Validation and New Fluids	1	IP- / ZD	8	100	-5 to -10	Max Flight SNEG	25	-	13	-	10	2		2582	
P040	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	-5 to -10	Max Flight SNEG	25	-	25	-	10	1		2582	
P041	Type IV Validation and New Fluids	1	IP Mod	8	100	-5 to -10	Max Flight SNEG	75	-	-	-	10	2		7746	
P042	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	-5 to -10	Max Flight SNEG	75	-	13	-	7	1		5422	
P043	Type IV Validation and New Fluids	1	IP-	8	115	-10 to -16	Max Flight SNEG	25	-	-	-	30	1	115knts for PG	7746	
P044	Type IV Validation and New Fluids	1	IP- / SN-	8	115	-10 to -16	Max Flight SNEG	25	10	-	-	15	1	115knts for PG	3873	1614
P045	Type IV Validation and New Fluids	1	IP Mod	8	115	-10 to -16	Max Flight SNEG	75	-	-	-	10	1	115knts for PG	7746	
P046	Type IV Validation and New Fluids	1	IP-	8	115	-16 to -22	Max Flight SNEG	25	-	-	-	30	2	115knts for PG	7746	
P047	Type IV Validation and New Fluids	1	IP Mod	8	115	-16 to -22	Max Flight SNEG	75	-	-	-	0	2	No Allowance Time	0	
P048	Type IV Validation and New Fluids	1	IP-	8	115	<-22	Max Flight SNEG	25	-	-	-	30	2	115knts for PG	7746	
P049	Type IV Validation and New Fluids	1	IP Mod	8	115	<-22	Max Flight SNEG	75	-	-	-	0	2	No Allowance Time	0	
P050	Type IV Validation and New Fluids	1	Fluid Only	8	100	>-5	Max Flight SNEG	-	-	-	-	-	2	Baseline Test		
P051	Type IV Validation and New Fluids	1	Fluid Only	8	100	-5 to -10	Max Flight SNEG	-	-	-	-	-	1	Baseline Test		
P052	Type IV Validation and New Fluids	1	Fluid Only	8	100	-10 to -16	Max Flight SNEG	-	-	-	-	-	2	Baseline Test		
P053	Type IV Validation and New Fluids	1	Fluid Only	8	100	-16 to -22	Max Flight SNEG	-	-	-	-	-	1	Baseline Test		
P054	Type IV Validation and New Fluids	1	Fluid Only	8	100	<-22	Max Flight SNEG	-	-	-	-	-	1	Baseline Test		
P055	Type IV Validation and New Fluids	1	IP-	8	100	>-5	Safewing EG IV NORTH	25	-	-	-	50	1		12910	
P056	Type IV Validation and New Fluids	1	IP- / SN-	8	100	>-5	Safewing EG IV NORTH	25	10	-	-	40	1		10328	4304
P057	Type IV Validation and New Fluids	1	IP- / ZD	8	100	>-5	Safewing EG IV NORTH	25	-	13	-	25	2		6455	
P058	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	>-5	Safewing EG IV NORTH	25	-	25	-	25	1		6455	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P059	Type IV Validation and New Fluids	1	IP- / R-	8	100	>0	Safewing EG IV NORTH	25	-	-	25	25	2		6455	
P060	Type IV Validation and New Fluids	1	IP Mod	8	100	>-5	Safewing EG IV NORTH	75	-	-	-	25	1		19365	
P061	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	>-5	Safewing EG IV NORTH	75	-	13	-	10	1		7746	
P062	Type IV Validation and New Fluids	1	IP Mod / R	8	100	>0	Safewing EG IV NORTH	75	-	-	75	10	2		7746	
P063	Type IV Validation and New Fluids	1	IP-	8	100	-5 to -10	Safewing EG IV NORTH	25	-	-	-	30	2		7746	
P064	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-5 to -10	Safewing EG IV NORTH	25	10	-	-	15	2		3873	1614
P065	Type IV Validation and New Fluids	1	IP- / ZD	8	100	-5 to -10	Safewing EG IV NORTH	25	-	13	-	10	2		2582	
P066	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	-5 to -10	Safewing EG IV NORTH	25	-	25	-	10	1		2582	
P067	Type IV Validation and New Fluids	1	IP Mod	8	100	-5 to -10	Safewing EG IV NORTH	75	-	-	-	10	2		7746	
P068	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	-5 to -10	Safewing EG IV NORTH	75	-	13	-	7	1		5422	
P069	Type IV Validation and New Fluids	1	IP-	8	100	-10 to -16	Safewing EG IV NORTH	25	-	-	-	30	1		7746	
P070	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-10 to -16	Safewing EG IV NORTH	25	10	-	-	15	1		3873	1614
P071	Type IV Validation and New Fluids	1	IP Mod	8	100	-10 to -16	Safewing EG IV NORTH	75	-	-	-	10	1		7746	
P072	Type IV Validation and New Fluids	1	IP-	8	100	-16 to -22	Safewing EG IV NORTH	25	-	-	-	30	2		7746	
P073	Type IV Validation and New Fluids	1	IP Mod	8	100	-16 to -22	Safewing EG IV NORTH	75	-	-	-	10	2		7746	
P074	Type IV Validation and New Fluids	1	IP-	8	100	<-22	Safewing EG IV NORTH	25	-	-	-	30	2		7746	
P075	Type IV Validation and New Fluids	1	IP Mod	8	100	<-22	Safewing EG IV NORTH	75	-	-	-	10	2		7746	
P076	Type IV Validation and New Fluids	1	Fluid Only	8	100	>-5	Safewing EG IV NORTH	-	-	-	-	-	2	Baseline Test		
P077	Type IV Validation and New Fluids	1	Fluid Only	8	100	-5 to -10	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P078	Type IV Validation and New Fluids	1	Fluid Only	8	100	-10 to -16	Safewing EG IV NORTH	-	-	-	-	-	2	Baseline Test		
P079	Type IV Validation and New Fluids	1	Fluid Only	8	100	-16 to -22	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P080	Type IV Validation and New Fluids	1	Fluid Only	8	100	<-22	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P081	Type IV Validation and New Fluids	1	IP-	8	100	>-5	Defrost ECO 4	25	-	-	-	50	1		12910	
P082	Type IV Validation and New Fluids	1	IP- / SN-	8	100	>-5	Defrost ECO 4	25	10	-	-	40	1		10328	4304
P083	Type IV Validation and New Fluids	1	IP- / ZD	8	100	>-5	Defrost ECO 4	25	-	13	-	25	2		6455	
P084	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	>-5	Defrost ECO 4	25	-	25	-	25	1		6455	
P085	Type IV Validation and New Fluids	1	IP- / R-	8	100	>0	Defrost ECO 4	25	-	-	25	25	2		6455	
P086	Type IV Validation and New Fluids	1	IP Mod	8	100	>-5	Defrost ECO 4	75	-	-	-	15	1	15 min for PG	11619	
P087	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	>-5	Defrost ECO 4	75	-	13	-	10	1		7746	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (ºC)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P088	Type IV Validation and New Fluids	1	IP Mod / R	8	100	>0	Defrost ECO 4	75	-	-	75	10	2		7746	
P089	Type IV Validation and New Fluids	1	IP-	8	100	-5 to -10	Defrost ECO 4	25	-	-	-	30	2		7746	
P090	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-5 to -10	Defrost ECO 4	25	10	-	-	15	2		3873	1614
P091	Type IV Validation and New Fluids	1	IP- / ZD	8	100	-5 to -10	Defrost ECO 4	25	-	13	-	10	2		2582	
P092	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	-5 to -10	Defrost ECO 4	25	-	25	-	10	1		2582	
P093	Type IV Validation and New Fluids	1	IP Mod	8	100	-5 to -10	Defrost ECO 4	75	-	-	-	10	2		7746	
P094	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	-5 to -10	Defrost ECO 4	75	-	13	-	7	1		5422	
P095	Type IV Validation and New Fluids	1	IP-	8	115	-10 to -16	Defrost ECO 4	25	-	-	-	30	1	115knts for PG	7746	
P096	Type IV Validation and New Fluids	1	IP- / SN-	8	115	-10 to -16	Defrost ECO 4	25	10	-	-	15	1	115knts for PG	3873	1614
P097	Type IV Validation and New Fluids	1	IP Mod	8	115	-10 to -16	Defrost ECO 4	75	-	-	-	10	1	115knts for PG	7746	
P098	Type IV Validation and New Fluids	1	IP-	8	115	-16 to -22	Defrost ECO 4	25	-	-	-	30	2	115knts for PG	7746	
P099	Type IV Validation and New Fluids	1	IP Mod	8	115	-16 to -22	Defrost ECO 4	75	-	-	-	0	2	No Allowance Time	0	
P100	Type IV Validation and New Fluids	1	IP-	8	115	<-22	Defrost ECO 4	25	-	-	-	30	2	115knts for PG	7746	
P101	Type IV Validation and New Fluids	1	IP Mod	8	115	<-22	Defrost ECO 4	75	-	-	-	0	2	No Allowance Time	0	
P102	Type IV Validation and New Fluids	1	Fluid Only	8	100	>-5	Defrost ECO 4	-	-	-	-	-	2	Baseline Test		
P103	Type IV Validation and New Fluids	1	Fluid Only	8	100	-5 to -10	Defrost ECO 4	-	-	-	-	-	1	Baseline Test		
P104	Type IV Validation and New Fluids	1	Fluid Only	8	100	-10 to -16	Defrost ECO 4	-	-	-	-	-	2	Baseline Test		
P105	Type IV Validation and New Fluids	1	Fluid Only	8	100	-16 to -22	Defrost ECO 4	-	-	-	-	-	1	Baseline Test		
P106	Type IV Validation and New Fluids	1	Fluid Only	8	100	<-22	Defrost ECO 4	-	-	-	-	-	1	Baseline Test		
P107	Type IV Validation and New Fluids	1	IP-	8	100	>-5	Defrost EG 4	25	-	-	-	50	1		12910	
P108	Type IV Validation and New Fluids	1	IP- / SN-	8	100	>-5	Defrost EG 4	25	10	-	-	40	1		10328	4304
P109	Type IV Validation and New Fluids	1	IP- / ZD	8	100	>-5	Defrost EG 4	25	-	13	-	25	2		6455	
P110	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	>-5	Defrost EG 4	25	-	25	-	25	1		6455	
P111	Type IV Validation and New Fluids	1	IP- / R-	8	100	>0	Defrost EG 4	25	-	-	25	25	2		6455	
P112	Type IV Validation and New Fluids	1	IP Mod	8	100	>-5	Defrost EG 4	75	-	-	-	25	1		19365	
P113	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	>-5	Defrost EG 4	75	-	13	-	10	1		7746	
P114	Type IV Validation and New Fluids	1	IP Mod / R	8	100	>0	Defrost EG 4	75	-	-	75	10	2		7746	
P115	Type IV Validation and New Fluids	1	IP-	8	100	-5 to -10	Defrost EG 4	25	-	-	-	30	2		7746	
P116	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-5 to -10	Defrost EG 4	25	10	-	-	15	2		3873	1614

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P117	Type IV Validation and New Fluids	1	IP- / ZD	8	100	-5 to -10	Defrost EG 4	25	-	13	-	10	2		2582	
P118	Type IV Validation and New Fluids	1	IP- / ZR-	8	100	-5 to -10	Defrost EG 4	25	-	25	-	10	1		2582	
P119	Type IV Validation and New Fluids	1	IP Mod	8	100	-5 to -10	Defrost EG 4	75	-	-	-	10	2		7746	
P120	Type IV Validation and New Fluids	1	IP Mod/ZD	8	100	-5 to -10	Defrost EG 4	75	-	13	-	7	1		5422	
P121	Type IV Validation and New Fluids	1	IP-	8	100	-10 to -16	Defrost EG 4	25	-	-	-	30	1		7746	
P122	Type IV Validation and New Fluids	1	IP- / SN-	8	100	-10 to -16	Defrost EG 4	25	10	-	-	15	1		3873	1614
P123	Type IV Validation and New Fluids	1	IP Mod	8	100	-10 to -16	Defrost EG 4	75	-	-	-	10	1		7746	
P124	Type IV Validation and New Fluids	1	IP-	8	100	-16 to -22	Defrost EG 4	25	-	-	-	30	2		7746	
P125	Type IV Validation and New Fluids	1	IP Mod	8	100	-16 to -22	Defrost EG 4	75	-	-	-	10	2		7746	
P126	Type IV Validation and New Fluids	1	IP-	8	100	<-22	Defrost EG 4	25	-	-	-	30	2		7746	
P127	Type IV Validation and New Fluids	1	IP Mod	8	100	<-22	Defrost EG 4	75	-	-	-	10	2		7746	
P128	Type IV Validation and New Fluids	1	Fluid Only	8	100	>-5	Defrost EG 4	-	-	-	-	-	2	Baseline Test		
P129	Type IV Validation and New Fluids	1	Fluid Only	8	100	-5 to -10	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P130	Type IV Validation and New Fluids	1	Fluid Only	8	100	-10 to -16	Defrost EG 4	-	-	-	-	-	2	Baseline Test		
P131	Type IV Validation and New Fluids	1	Fluid Only	8	100	-16 to -22	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P132	Type IV Validation and New Fluids	1	Fluid Only	8	100	<-22	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P133	EG Type IV Expansion	1	IP-	8	100	>-5	Max Flight AVIA	25	-	-	-	70	1	Current AT is 50 min	18074	
P134	EG Type IV Expansion	1	IP- / SN-	8	100	>-5	Max Flight AVIA	25	10	-	-	50	1	Current AT is 40 min	12910	5380
P135	EG Type IV Expansion	1	IP- / ZD	8	100	>-5	Max Flight AVIA	25	-	13	-	40	2	Current AT is 25 min	10328	
P136	EG Type IV Expansion	1	IP- / ZR-	8	100	>-5	Max Flight AVIA	25	-	25	-	40	1	Current AT is 25 min	10328	
P137	EG Type IV Expansion	1	IP- / R-	8	100	>0	Max Flight AVIA	25	-	-	25	40	2	Current AT is 25 min	10328	
P138	EG Type IV Expansion	1	IP Mod	8	100	>-5	Max Flight AVIA	75	-	-	-	35	1	Current AT is 25 min	27111	
P139	EG Type IV Expansion	1	IP Mod/ZD	8	100	>-5	Max Flight AVIA	75	-	13	-	20	1	Current AT is 10 min	15492	
P140	EG Type IV Expansion	1	IP Mod / R	8	100	>0	Max Flight AVIA	75	-	-	75	20	2	Current AT is 10 min	15492	
P141	EG Type IV Expansion	1	IP-	8	100	-5 to -10	Max Flight AVIA	25	-	-	-	50	2	Current AT is 30 min	12910	
P142	EG Type IV Expansion	1	IP- / SN-	8	100	-5 to -10	Max Flight AVIA	25	10	-	-	30	2	Current AT is 15 min	7746	3228
P143	EG Type IV Expansion	1	IP- / ZD	8	100	-5 to -10	Max Flight AVIA	25	-	13	-	30	2	Current AT is 10 min	7746	
P144	EG Type IV Expansion	1	IP- / ZR-	8	100	-5 to -10	Max Flight AVIA	25	-	25	-	30	1	Current AT is 10 min	7746	
P145	EG Type IV Expansion	1	IP Mod	8	100	-5 to -10	Max Flight AVIA	75	-	-	-	25	2	Current AT is 10 min	19365	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P146	EG Type IV Expansion	1	IP Mod/ZD	8	100	-5 to -10	Max Flight AVIA	75	-	13	-	10	1	Current AT is 7 min	7746	
P147	EG Type IV Expansion	1	IP-	8	100	-10 to -16	Max Flight AVIA	25	-	-	-	50	1	Current AT is 30 min	12910	
P148	EG Type IV Expansion	1	IP- / SN-	8	100	-10 to -16	Max Flight AVIA	25	10	-	-	30	1	Current AT is 15 min	7746	3228
P149	EG Type IV Expansion	1	IP Mod	8	100	-10 to -16	Max Flight AVIA	75	-	-	-	25	1	Current AT is 10 min	19365	
P150	EG Type IV Expansion	1	IP-	8	100	-16 to -22	Max Flight AVIA	25	-	-	-	50	2	Current AT is 30 min	12910	
P151	EG Type IV Expansion	1	IP- / SN-	8	100	-16 to -22	Max Flight AVIA	25	10	-	-	30	1	No AT exists currently	7746	3228
P152	EG Type IV Expansion	1	IP Mod	8	100	-16 to -22	Max Flight AVIA	75	-	-	-	25	2	Current AT is 30 min	19365	
P153	EG Type IV Expansion	1	IP-	8	100	<-22	Max Flight AVIA	25	-	-	-	50	2	Current AT is 10 min	12910	
P154	EG Type IV Expansion	1	IP Mod	8	100	<-22	Max Flight AVIA	75	-	-	-	25	2	Current AT is - min	19365	
P155	EG Type IV Expansion	1	Fluid Only	8	100	>-5	Max Flight AVIA	-	-	-	-	-	2	Baseline Test		
P156	EG Type IV Expansion	1	Fluid Only	8	100	-5 to -10	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P157	EG Type IV Expansion	1	Fluid Only	8	100	-10 to -16	Max Flight AVIA	-	-	-	-	-	2	Baseline Test		
P158	EG Type IV Expansion	1	Fluid Only	8	100	-16 to -22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P159	EG Type IV Expansion	1	Fluid Only	8	100	<-22	Max Flight AVIA	-	-	-	-	-	1	Baseline Test		
P160	EG Type IV Expansion	1	IP-	8	100	>-5	Safewing EG IV NORTH	25	-	-	-	70	1	Current AT is 50 min	18074	
P161	EG Type IV Expansion	1	IP- / SN-	8	100	>-5	Safewing EG IV NORTH	25	10	-	-	50	1	Current AT is 40 min	12910	5380
P162	EG Type IV Expansion	1	IP- / ZD	8	100	>-5	Safewing EG IV NORTH	25	-	13	-	40	2	Current AT is 25 min	10328	
P163	EG Type IV Expansion	1	IP- / ZR-	8	100	>-5	Safewing EG IV NORTH	25	-	25	-	40	1	Current AT is 25 min	10328	
P164	EG Type IV Expansion	1	IP- / R-	8	100	>0	Safewing EG IV NORTH	25	-	-	25	40	2	Current AT is 25 min	10328	
P165	EG Type IV Expansion	1	IP Mod	8	100	>-5	Safewing EG IV NORTH	75	-	-	-	35	1	Current AT is 25 min	27111	
P166	EG Type IV Expansion	1	IP Mod/ZD	8	100	>-5	Safewing EG IV NORTH	75	-	13	-	20	1	Current AT is 10 min	15492	
P167	EG Type IV Expansion	1	IP Mod / R	8	100	>0	Safewing EG IV NORTH	75	-	-	75	20	2	Current AT is 10 min	15492	
P168	EG Type IV Expansion	1	IP-	8	100	-5 to -10	Safewing EG IV NORTH	25	-	-	-	50	2	Current AT is 30 min	12910	
P169	EG Type IV Expansion	1	IP- / SN-	8	100	-5 to -10	Safewing EG IV NORTH	25	10	-	-	30	2	Current AT is 15 min	7746	3228
P170	EG Type IV Expansion	1	IP- / ZD	8	100	-5 to -10	Safewing EG IV NORTH	25	-	13	-	30	2	Current AT is 10 min	7746	
P171	EG Type IV Expansion	1	IP- / ZR-	8	100	-5 to -10	Safewing EG IV NORTH	25	-	25	-	30	1	Current AT is 10 min	7746	
P172	EG Type IV Expansion	1	IP Mod	8	100	-5 to -10	Safewing EG IV NORTH	75	-	-	-	25	2	Current AT is 10 min	19365	
P173	EG Type IV Expansion	1	IP Mod/ZD	8	100	-5 to -10	Safewing EG IV NORTH	75	-	13	-	10	1	Current AT is 7 min	7746	
P174	EG Type IV Expansion	1	IP-	8	100	-10 to -16	Safewing EG IV NORTH	25	-	-	-	50	1	Current AT is 30 min	12910	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P175	EG Type IV Expansion	1	IP- / SN-	8	100	-10 to -16	Safewing EG IV NORTH	25	10	-	-	30	1	Current AT is 15 min	7746	3228
P176	EG Type IV Expansion	1	IP Mod	8	100	-10 to -16	Safewing EG IV NORTH	75	-	-	-	25	1	Current AT is 10 min	19365	
P177	EG Type IV Expansion	1	IP-	8	100	-16 to -22	Safewing EG IV NORTH	25	-	-	-	50	2	Current AT is 30 min	12910	
P178	EG Type IV Expansion	1	IP- / SN-	8	100	-16 to -22	Safewing EG IV NORTH	25	10	-	-	30	1	No AT exists currently	7746	3228
P179	EG Type IV Expansion	1	IP Mod	8	100	-16 to -22	Safewing EG IV NORTH	75	-	-	-	25	2	Current AT is 30 min	19365	
P180	EG Type IV Expansion	1	IP-	8	100	< -22	Safewing EG IV NORTH	25	-	-	-	50	2	Current AT is 10 min	12910	
P181	EG Type IV Expansion	1	IP Mod	8	100	< -22	Safewing EG IV NORTH	75	-	-	-	25	2	Current AT is - min	19365	
P182	EG Type IV Expansion	1	Fluid Only	8	100	> -5	Safewing EG IV NORTH	-	-	-	-	-	2	Baseline Test		
P183	EG Type IV Expansion	1	Fluid Only	8	100	-5 to -10	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P184	EG Type IV Expansion	1	Fluid Only	8	100	-10 to -16	Safewing EG IV NORTH	-	-	-	-	-	2	Baseline Test		
P185	EG Type IV Expansion	1	Fluid Only	8	100	-16 to -22	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P186	EG Type IV Expansion	1	Fluid Only	8	100	< -22	Safewing EG IV NORTH	-	-	-	-	-	1	Baseline Test		
P187	EG Type IV Expansion	1	IP-	8	100	> -5	Defrost EG 4	25	-	-	-	70	1	Current AT is 50 min	18074	
P188	EG Type IV Expansion	1	IP- / SN-	8	100	> -5	Defrost EG 4	25	10	-	-	50	1	Current AT is 40 min	12910	5380
P189	EG Type IV Expansion	1	IP- / ZD	8	100	> -5	Defrost EG 4	25	-	13	-	40	2	Current AT is 25 min	10328	
P190	EG Type IV Expansion	1	IP- / ZR-	8	100	> -5	Defrost EG 4	25	-	25	-	40	1	Current AT is 25 min	10328	
P191	EG Type IV Expansion	1	IP- / R-	8	100	> 0	Defrost EG 4	25	-	-	25	40	2	Current AT is 25 min	10328	
P192	EG Type IV Expansion	1	IP Mod	8	100	> -5	Defrost EG 4	75	-	-	-	35	1	Current AT is 25 min	27111	
P193	EG Type IV Expansion	1	IP Mod/ZD	8	100	> -5	Defrost EG 4	75	-	13	-	20	1	Current AT is 10 min	15492	
P194	EG Type IV Expansion	1	IP Mod / R	8	100	> 0	Defrost EG 4	75	-	-	75	20	2	Current AT is 10 min	15492	
P195	EG Type IV Expansion	1	IP-	8	100	-5 to -10	Defrost EG 4	25	-	-	-	50	2	Current AT is 30 min	12910	
P196	EG Type IV Expansion	1	IP- / SN-	8	100	-5 to -10	Defrost EG 4	25	10	-	-	30	2	Current AT is 15 min	7746	3228
P197	EG Type IV Expansion	1	IP- / ZD	8	100	-5 to -10	Defrost EG 4	25	-	13	-	30	2	Current AT is 10 min	7746	
P198	EG Type IV Expansion	1	IP- / ZR-	8	100	-5 to -10	Defrost EG 4	25	-	25	-	30	1	Current AT is 10 min	7746	
P199	EG Type IV Expansion	1	IP Mod	8	100	-5 to -10	Defrost EG 4	75	-	-	-	25	2	Current AT is 10 min	19365	
P200	EG Type IV Expansion	1	IP Mod/ZD	8	100	-5 to -10	Defrost EG 4	75	-	13	-	10	1	Current AT is 7 min	7746	
P201	EG Type IV Expansion	1	IP-	8	100	-10 to -16	Defrost EG 4	25	-	-	-	50	1	Current AT is 30 min	12910	
P202	EG Type IV Expansion	1	IP- / SN-	8	100	-10 to -16	Defrost EG 4	25	10	-	-	30	1	Current AT is 15 min	7746	3228
P203	EG Type IV Expansion	1	IP Mod	8	100	-10 to -16	Defrost EG 4	75	-	-	-	25	1	Current AT is 10 min	19365	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P204	EG Type IV Expansion	1	IP-	8	100	-16 to -22	Defrost EG 4	25	-	-	-	50	2	Current AT is 30 min	12910	
P205	EG Type IV Expansion	1	IP- / SN-	8	100	-16 to -22	Defrost EG 4	25	10	-	-	30	1	No AT exists currently	7746	3228
P206	EG Type IV Expansion	1	IP Mod	8	100	-16 to -22	Defrost EG 4	75	-	-	-	25	2	Current AT is 30 min	19365	
P207	EG Type IV Expansion	1	IP-	8	100	<-22	Defrost EG 4	25	-	-	-	50	2	Current AT is 10 min	12910	
P208	EG Type IV Expansion	1	IP Mod	8	100	<-22	Defrost EG 4	75	-	-	-	25	2	Current AT is - min	19365	
P209	EG Type IV Expansion	1	Fluid Only	8	100	>-5	Defrost EG 4	-	-	-	-	-	2	Baseline Test		
P210	EG Type IV Expansion	1	Fluid Only	8	100	-5 to -10	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P211	EG Type IV Expansion	1	Fluid Only	8	100	-10 to -16	Defrost EG 4	-	-	-	-	-	2	Baseline Test		
P212	EG Type IV Expansion	1	Fluid Only	8	100	-16 to -22	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P213	EG Type IV Expansion	1	Fluid Only	8	100	<-22	Defrost EG 4	-	-	-	-	-	1	Baseline Test		
P214	LS 0417 Calibration/Characterization		None	8	TBD	TBD	TBD							Clean Wing		
P215	LS 0417 Calibration/Characterization		Oil	8 static	TBD	TBD	TBD							Oil Flow Visualization		
P216	LS 0417 Calibration/Characterization		Grut Paper	stall	TBD	TBD	TBD							Roughness (Trips)		
P217	LS 0417 Calibration/Characterization		BL Rake	-2 to stall	TBD	TBD	TBD							Boundary-layer Rake Measurments		
P218	LS 0417 Calibration/Characterization		Fluid Only	8	TBD	TBD	TBD							Fluid Tests - Repeatibility		
P219	LS 0417 Calibration/Characterization		Fluid Only	8	TBD	TBD	TBD							Fluid Tests - New BLDT		
P220	Type III LS Allowance Times	2	IP-	8	80	>-5	Type III Fluid	25	-	-	-	10	1		2582	
P221	Type III LS Allowance Times	2	IP- / SN-	8	80	>-5	Type III Fluid	25	10	-	-	10	1		2582	1076
P222	Type III LS Allowance Times	2	IP- / ZR-	8	80	>-5	Type III Fluid	25	-	25	-	7	1		1807	
P223	Type III LS Allowance Times	2	IP- / R-	8	80	>0	Type III Fluid	25	-	-	25	7	2		1807	
P224	Type III LS Allowance Times	2	IP Mod	8	80	>-5	Type III Fluid	75	-	-	-	5	1		3873	
P225	Type III LS Allowance Times	2	IP-	8	80	-5 to -10	Type III Fluid	25	-	-	-	10	1		2582	
P226	Type III LS Allowance Times	2	IP- / SN-	8	80	-5 to -10	Type III Fluid	25	10	-	-	10	1		2582	1076
P227	Type III LS Allowance Times	2	IP- / ZR-	8	80	-5 to -10	Type III Fluid	25	-	25	-	5	1		1291	
P228	Type III LS Allowance Times	2	IP Mod	8	80	-5 to -10	Type III Fluid	75	-	-	-	5	1		3873	
P229	Type III LS Allowance Times	2	IP-	8	80	-10 to -16	Type III Fluid	25	-	-	-	10	2		2582	
P230	Type III LS Allowance Times	2	IP Mod	8	80	-10 to -16	Type III Fluid	75	-	-	-	5	2		3873	
P231	Type III LS Allowance Times	2	IP-	8	80	-16 to -22	Type III Fluid	25	-	-	-	10	2		2582	

Table 3.2: Proposed Test Plan (cont'd)

Test Plan #	Objective	Objective Priority	Test Condition	Rotation Angle	Ramp (s/kts)	Target OAT (°C)	Fluid	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time	Test Priority	COMMENT	IP QUANTITIES (g)	SN QUANTITIES (g)
P232	Type III LS Allowance Times	2	IP Mod	8	80	-16 to -22	Type III Fluid	75	-	-	-	5	2		3873	
P233	Type III LS Allowance Times	2	IP-	8	80	<-22	Type III Fluid	25	-	-	-	10	2		2582	
P234	Type III LS Allowance Times	2	IP Mod	8	80	<-22	Type III Fluid	75	-	-	-	5	2		3873	
P235	Type III LS Allowance Times	2	Fluid Only	8	80	-5 to -10	Type III Fluid	-	-	-	-	-	1	Baseline Test		
P236	Type III LS Allowance Times	2	Fluid Only	8	80	-16 to -22	Type III Fluid	-	-	-	-	-	1	Baseline Test		
P237	Type III LS Allowance Times	2	IP-	8	100	>-5	Type III Fluid	25	-	-	-	10	1	To be done with RJ wing	2582	
P238	Type III LS Allowance Times	2	IP-	8	100	-5 to -10	Type III Fluid	25	-	-	-	10	1	To be done with RJ wing	2582	
P239	Type III LS Allowance Times	2	IP-	8	100	-10 to -16	Type III Fluid	25	-	-	-	10	2	To be done with RJ wing	2582	
P240	Type III LS Allowance Times	2	Fluid Only	8	100	-5 to -10	Type III Fluid	-	-	-	-	-	1	To be done with RJ wing		
P241	Type III LS Allowance Times	2	Fluid Only	8	100	-16 to -22	Type III Fluid	-	-	-	-	-	1	To be done with RJ wing		
P242	R&D	2	TIII Expansion	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Expand TIII Times		
P243	R&D	2	Snow Aero	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Snow Allowance Times		
P244	R&D	2	EG Specific	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	EG Specific Allowance Times		
P245	R&D	3	S+++	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Heavy snow		
P246	R&D	3	Heavy Cont	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Heavy contamination		
P247	R&D	3	Tunnel Cool	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Tunnel Cooling System		
P248	R&D	3	LOUT w/ Cont.	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Test w/ contamination @ LOUT		
P249	R&D	3	Frost	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Simulated Frost		
P250	R&D	4	IP @ >130kts	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	IP testing a higher speeds		
P251	R&D	4	2nd Wave	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	2nd wave of fluid at rot.		
P252	R&D	4	Other	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	3	Other		

4. PRE-TESTING SETUP ACTIVITIES

The activities to be performed for planning and preparation, on the first day of testing, and prior to each testing day thereafter, have been detailed in a list included in Attachment 1.

5. DATA FORMS

The following data forms are required for the January 2019 wind tunnel tests:

- Attachment 2: General Form;
- Attachment 3: Wing Temperature, Fluid Thickness and Fluid Brix Form;
- Attachment 4: Example Ice Pellet Dispensing Form;
- Attachment 5: Example Snow Dispensing Form;
- Attachment 6: Example Snow Dispensing Form (Manual Method);
- Attachment 7: Visual Evaluation Rating Form;
- Attachment 8: Fluid Receipt Form (Electronic Form); and
- Attachment 9: Log of Fluid Sample Bottles.

When and how the data forms will be used is described throughout Section 6.

6. PROCEDURE

The following sections describe the tasks to be performed during each test conducted. It should be noted that some sections (i.e. fluid application and contamination application) will be omitted depending on the objective of the test.

6.1 Initial Test Conditions Survey

- Record ambient conditions of the test (Attachment 2); and
- Record wing temperature (Attachment 3).

6.2 Fluid Application (Pour)

- Hand pour 20L of anti-icing fluid over the test area (fluid can be poured directly out of pails or transferred into smaller 3L jugs);

- Record fluid application times and quantities (Attachment 2);
- Let fluid settle for 5 minutes (as the wing section is relatively flat, last winter it required tilting the wing for 1-minute to enable fluid to be uniform);
- Measure fluid thickness at pre-determined locations on the wing (Attachment 3);
- Record wing temperature (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Photograph and videotape the appearance of the fluid on the wing; and
- Begin the time-lapse camera to gather photos of the precipitation application phase.

Note: At the request of TC/FAA, a standard aluminum test plate can be positioned on the wing in order to run a simultaneous endurance time test.

6.3 Application of Contamination

6.3.1 Ice Pellet/Snow Dispenser Calibration and Set-Up

Calibration work was performed during the winter of 2007-08 on the modified ice pellet/snow dispensers prior to testing with the Falcon 20. The purpose of this calibration work was to attain the dispenser's distribution footprint for both ice pellets and snow. A series of tests were performed in various conditions:

- Ice Pellets, Low Winds (0 to 5 km/h);
- Ice Pellets, Moderate Winds (10 km/h);
- Snow, Low Wind (0 to 5 km/h); and
- Snow, Moderate Wind (10 km/h).

These tests were conducted using 121 collection pans, each measuring 6 x 6 inches, over an area 11 x 11 feet. Pre-measured amounts of ice pellets/snow were dispersed over this area and the amount collected by each pan was recorded. A distribution footprint of the dispenser was attained and efficiency for the dispenser was computed.

6.3.2 Dispensing Ice Pellets/Snow for Wind Tunnel Tests

Using the results from these calibration tests, a decision was made to use two dispensers on each of the leading and trailing edges of wing; each of the four dispensers are moved to four different positions along each edge during the dispensing process. Figure 6.1, Figure 6.2, and Figure 6.3 demonstrate the setup of the dispensers in relation to the wing. Attachment 4 and Attachment 5 display the data sheets that will be used during testing in the wind tunnel. These data sheets will provide all the necessary information related to the amount of ice pellets/snow needed, effective rates and dispenser positions. During the winter of 2009-10, snow was also dispensed manually using sieves. This technique was used when higher rates of precipitation were required (for heavy snow) or when winds in the tunnel made dispensing difficult. The efficiency of this technique was estimated at 90 percent based on how much of the precipitation actually made it onto the wing and a form to be used for this dispensing process along with dispensing instructions is included in Attachment 6.

Note: Dispensing forms should be filled out and saved for each run and pertinent information shall be included in the general form (Attachment 2). Any comments regarding dispensing activities should be documented directly on the form.

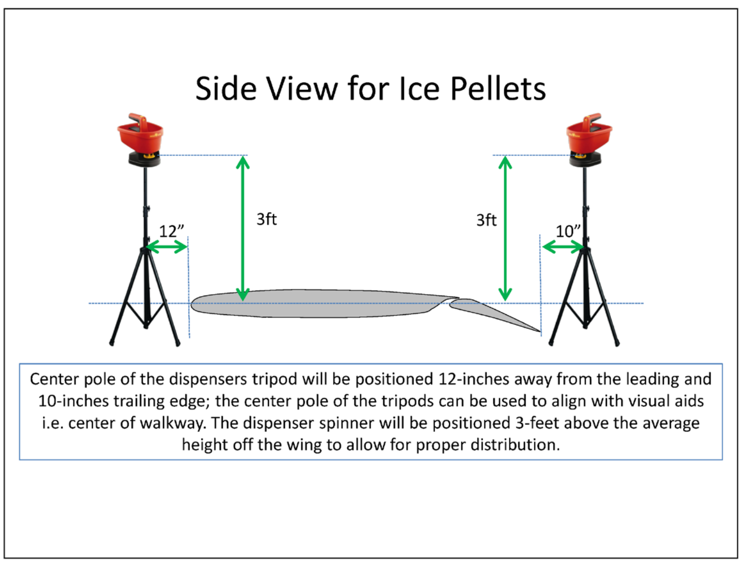


Figure 6.1: Side View of Positioning of Dispensers Relative to the Wing – Ice Pellets

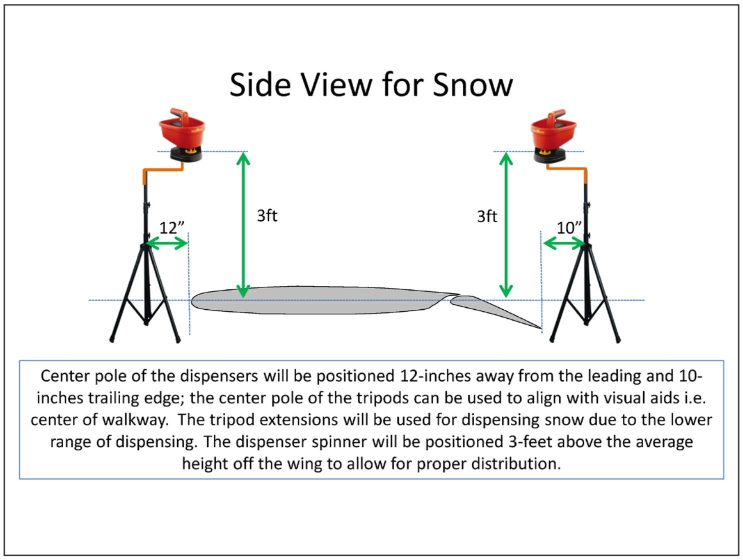


Figure 6.2: Side View of Positioning of Dispenser Relative to the Wing – Snow

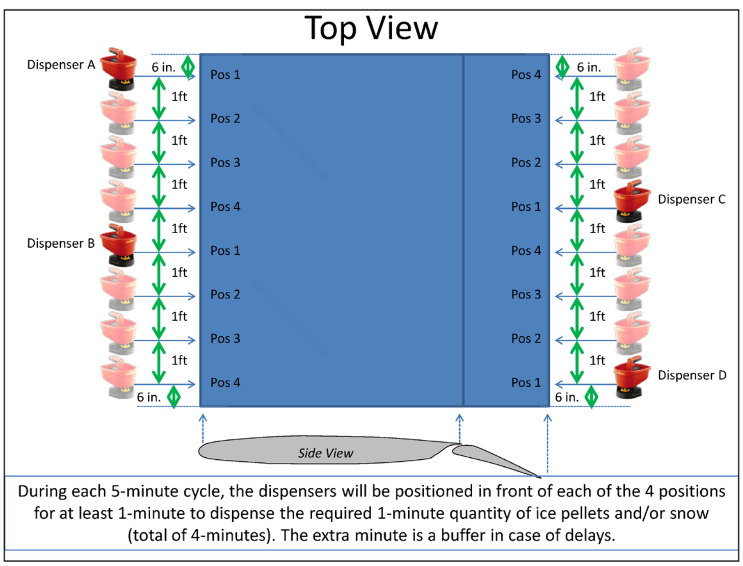


Figure 6.3: Top View of Positioning of Dispenser Relative to the Wing

6.3.3 New Ice Pellets/Snow Dispensing Systems for 2014 Onwards

Simulated ice pellets are distributed over a test surface using an ice pellet pitcher. The original ice pellet pitcher (Yardworks) was a modified handheld fertilizer dispenser. The rate of precipitation was controlled with the speed of rotation of the motor, as well as the size of the opening of the dispenser reservoir drop feeder.

In the winter of 2012-13, seed spreaders historically modified and used for applying ice pellets during wind tunnel and flat plate testing, were no longer available as the manufacturer stopped production of the model. A new replacement seed spreader system (Wolf Garten) was found which is similar (but not identical). Some calibration work was required to demonstrate an equivalency in the two systems; testing was conducted at the NRC CEF prior to the wind tunnel testing to verify the distribution of the historical system versus the new replacement system the details of which are included in the TC report, TP 15230E, *Aircraft Ground Icing General Research Activities During the 2012-13 Winter*.

The data collected demonstrated that the new system is very similar to old system; some small variation was present in distribution within the footprint, but equivalent efficiency on the overall footprint. Based on this it was concluded that for ice pellets, the new system can be used as a direct replacement. For snow, the new system was more efficient, therefore a reduction of 10 percent should be used for the snow mass requested.

Comparative wind tunnel testing was conducted in the winter of 2013-14 to further validate the equivalency of the systems, the details of which are included in the TC report, TP 15274E, *Exploratory Wind Tunnel Aerodynamic Research Winter 2013-14*. The results indicated that the differences in recorded lift losses were generally very small (less than 1.3 percent) when comparing back-to-back tests with no bias towards one system or the other. The differences were even smaller when looking at the average of the four comparative sequential tests (Test #330 to #337) which was 0.1 percent. In addition, the tests were visually evaluated to verify that the distribution of the ice pellets was similar, further supporting the similarity in aerodynamic results between the two dispenser systems.

In general, the wind tunnel results further supported the original distribution equivalency work conducted during the winter of 2012-13 and demonstrated that the new generation dispensers are suitable replacements for the older model dispensers.

6.4 Prior to Engines-On Wind Tunnel Test

- Measure fluid thickness at the pre-determined locations on the wing (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Record wing temperatures (Attachment 3);
- Record start time of test (Attachment 2); and
- Fill out visual evaluation rating form (Attachment 7).

Note: In order to minimize the measurement time post precipitation, temperature should be measured 5-minutes before the end of precipitation, thickness measured 3-minutes before the end of precipitation, and Brix measured when the precipitation ends. Also consideration has been given to reducing the number of measurements that are taken for this phase (i.e. locations 2 and 5 only).

6.5 During Wind Tunnel Test

- Take still pictures and video the behaviour of the fluid on the wing during the takeoff run, capturing any movement of fluid/contamination;
- Fill out visual evaluation rating form at the time of rotation (Attachment 7); and
- Record wind tunnel operation start and stop times.

6.6 After the Wind Tunnel Test

- Measure fluid thickness at the pre-determined locations on the wing (Attachment 3);
- Measure fluid Brix value (Attachment 3);
- Record wing temperatures (Attachment 3);
- Observe and record the status of the fluid/contamination (Attachment 3);
- Fill out visual evaluation rating form (Attachment 7);
- Obtain lift data (excel file) from NRC; and
- Update APS test log with pertinent information.

6.7 Fluid Sample Collection for Viscosity Testing

Two liters of each fluid to be tested are to be collected on the first day of testing. The fluid receipt form (Attachment 8) should be completed indicating quantity of fluid and date received. Any samples extracted for viscosity purposes should be documented in the fluid receipt form (Attachment 8), however an additional form (Attachment 9) is available if required. A falling ball viscosity test should be performed on site to confirm that fluid viscosity is appropriate before testing.

6.8 At the End of Each Test Session

If required, APS personnel will collect the waste solution. At the end of the testing period, NRC will organize for a glycol recovery service provider to safely dispose of the waste glycol fluid.

6.9 Camera Setup

It is anticipated that the camera setup will be similar to the setup used during the winter of 2013-14. Modifications may be necessary and will be dealt with on-site. The flashes will be positioned on the control-room side of the tunnel, and the cameras will be positioned on the opposite side. The final positioning of the cameras and flashes should be documented to identify any deviation from the previous year's setup.

6.10 Demonstration of a Typical Wind Tunnel Test Sequence

Table 6.1 demonstrates a typical Wind Tunnel test sequence of activities, assuming the test starts at 08:00:00. Figure 6.4 demonstrates a typical wind tunnel run timeline.

Table 6.1: Typical Wind Tunnel Test

TIME	TASK
8:30:00	START OF TEST. ALL EQUIPMENT READY.
8:30:00	- Record test conditions.
8:35:00	- Prepare wing for fluid application (clean wing, etc).
8:45:00	- Measure wing temperature.
	- Ensure clean wing for fluid application
8:50:00	- Pour fluid over test area.
9:00:00	- Measure Brix, thickness, wing temperature.
	- Photograph test area.
9:05:00	- Apply contamination over test area. (i.e. 30 min)
9:35:00	- Measure Brix, thickness, wing temperature.
	- Photograph test area.
9:40:00	- Clear area and start wind tunnel
9:55:00	- Wind tunnel stopped
10:05:00	- Measure Brix, thickness, wing temperature.
	- Photograph test area.
	- Record test observations.
10:35:00	END OF TEST

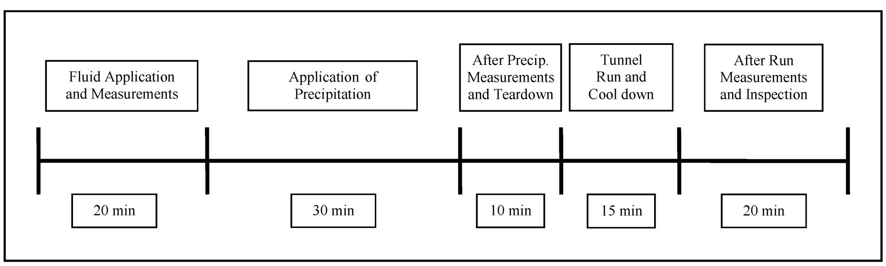


Figure 6.4: Typical Wind Tunnel Run Timeline

6.11 Procedures for Testing Objectives

Details for the testing objectives have been included in the following attachments:

- Attachment 10: Procedure - Dry Wing Performance;
- Attachment 11: Procedure – Type IV Ice Pellet Allowance Time Validation with New Fluids;
- Attachment 12: Procedure – Development of EG Specific Ice Pellet Allowance Time Table;
- Attachment 13: Procedure – Type III Low Speed Allowance Time Testing LS-0417 Wing Model Calibration and Characterization;
- Attachment 14: Procedure – Type III Ice Pellet Allowance Time Validation at 80 Knots with LS-0417 Wing Section;
- Attachment 15: Procedure – Type III Ice Pellet Allowance Time Expansion;
- Attachment 16: Procedure – Snow Allowance Times Using Aerodynamic Data;
- Attachment 17: Procedure - Heavy Snow;
- Attachment 18: Procedure - Heavy Contamination;
- Attachment 19: Procedure - Wind Tunnel Test Section Cooling;
- Attachment 20: Procedure - Fluid and Contamination at LOUT;
- Attachment 21: Procedure - Frost Simulation in the Wind Tunnel;
- Attachment 22: Procedure - Feasibility of Ice Pellet Testing at Higher Speeds; and
- Attachment 23: Procedure - 2nd Wave of Fluid during Rotation.

7. EQUIPMENT

Equipment to be employed is shown in Table 7.1.

Table 7.1: Equipment List

EQUIPMENT	STATUS		EQUIPMENT	STATUS
General Support and Testing Equipment			**Camera Equipment**	
20L clean containers x 12 (if expecting totes)			AA Batteries x 48	
Adherence Probes Kit			C2032 Batteries x 10	
Barrel Opener (steel)			Digital still cameras x3 (two suitcases)	
Black Shelving Unit (or plastic)			Flashes and tripods (in APS storage)	
Blow Horns x 4			GoPro Cameras x 3 and related hardware	
Electrical tape x 5				
Envelopes and labels				
Exacto Knives x 2			**Ice Pellets Fabrication Equipment**	
Extension cords (power bars x 6 + reels x 4)			Blenders x 12 in good condition	
Falling Ball Viscometer			Folding tables (2 large, 1 small)	
Fluid pouring jugs x 60			Ice bags	
Fluids (ORDER and SHIP to Ottawa)			Ice bags storage freezer x 3	
Funnels(1 big + 1 small)			Ice pellets sieves (base, 1.4 mm, 4 mm)	
Gloves - black and yellow			Ice pellets Styrofoam containers x40	
Gloves - cotton (1 box)			Measuring cups (1L and smaller ones for dispensing)	
Gloves - latex (2 boxes)			NCAR Scale x 1	
Grid Section + Location docs			Refrigerated Truck	
Hard water chemicals x 3 premixes			Rubber Mats x all	
Horse and tap for fluid barrel x all			Wooden Spoons	
Hot Plate x 3 and Large Pots with rubber handles for Type III				
Ice pellet box supports for railing x4			**Freezing Rain Equipment**	
Ice Pellet control wires and boxes			APS PC equipped with rate station software	
Ice pellets dispersers x 12 and stands x4			NRC Freezing rain sprayer (NRC will provide)	
Inclinometer (yellow level) x 2			Rubber suction cup feet for wooden boards	
Isopropyl x 24			White plastic rate pans (1 to 8 x 2)	
Large and small tape measure			Wooden boards for rate pans (x8)	
Large Sharpies for Grid Section				
Long Ruler for marking wing x 2				
Marker for waste x 2			**Office Equipment**	
Paper towel (blue shop towel) x 48			APS Laptops x 6 with mouse and chargers	
Protective clothing (all) and personnel clothing			APS tuques x 10	
Sample bottles for viscosity (x 3 per fluid)			Calculators x 3	
Sartorius Weigh Scale x 1			Clip boards x 8	
Scrapers x 5			Data Forms	
Shop Vac			Dry eraser markers	
Speed tape x 1 small			Envelopes (9x12) x box	
Squeegees (5 small + 3 large floor)			File box x 2	
Stands for ice pellets dispensing devices x 6			Hard drive with all WT Photos	
Stop Watches x 4			Hard Drive x 2	
Temperature probes: immersion x 3			Pencils + sharpies/markers	
Temperature probes: surface x 3			Projector for laptop	
Temperature readers x 2 + spare batteries			Scissors	
Test Plate x 1			Small 90° aluminum ruler for wing	
Thermometer for Reefer Truck			Test Procedures x 8, printer paper	
Thickness Gauges (5 small, 5 big)			YOW employee contracts	
Vise grip (large) + rubber opener for containers			Extra laptop for dispenser instructions PPT	
Walkie Talkies x 12				
Water (2 x 18L) for hard water				
Watmans Paper and conversion charts				
Red Thermoses for Type III Transport				

8. FLUIDS

Mid-viscosity samples of ethylene glycol and propylene glycol IV fluid will be used in the wind tunnel tests. Although the number of tests conducted will be determined based on the results obtained, the fluid quantities available are shown in Table 8.1 (quantities to be confirmed once fluid is received). Up to 2880L of 100/0 Type IV and Type III fluid are expected to be available; an additional 365L of other fluids are also available if needed. Fluid application will be performed by pouring the fluid (rather than spraying) to reduce any shearing to the fluid.

Table 8.1: Fluid Available for Wind Tunnel Tests

FLUID	TYPE	DILUTION	ORDERED (L)	IN STOCK (L)
ChemR EG IV	IV	100/0		100
Max Flight AVIA	IV	100/0		400
Max Flight SNEG	IV	100/0		400
Safewing EG NORTH	IV	100/0	400	
ECO-SHIELD (BAD BATCH - DO NOT USE)	IV	100/0		60
Defrost ECO 4	IV	100/0	300	
Defrost EG 4	IV	100/0	400	
UCAR™ FlightGuard AD-49	IV	100/0		180
ABC-S Plus	IV	100/0		200
Polar Guard® Advance	IV	100/0		140
AeroClear MAX	III	100/0		300
Safewing MP II FLIGHT	II	100/0		125
UCAR™ FlightGuard AD-49	IV	75/25		140
Polar Guard® Advance	IV	50/50		100

3600 L ordered for 2009-10 testing (18 days)
3200 L ordered for 2010-11 testing (15 days)
1800 L ordered for 2011-12 testing (7 of 15 days will be fluid testing)
4200 L ordered for 2012-13 testing (15 days)
1300L ordered for 2013-14 testing (15 days), 1900L previously in stock
1700L available for 2015-16 Testing (10 days)
3364 L available for 2017-18 Testing (10 days)

9. PERSONNEL

Five APS staff members are required for the tests at the NRC wind tunnel. Four additional persons (with one back-up) will be required from Ottawa for making and dispensing the ice pellets and snow. One additional person from Ottawa will be required to photograph the testing. Table 9.1 demonstrates the personnel required and their associated tasks.

Fluid and ice pellets applications will be performed by APS/YOW personnel at the NRC wind tunnel. NRC personnel will operate the NRC wind tunnel and operate the freezing rain/drizzle sprayer (if requested).

Table 9.1: Personnel List

Wind Tunnel 2015-16 - Tentative	
Person	**Responsibility**
John D'Avirro (JD)	Director
Marco Ruggi (MR)	Lead Engineer and Project Coordinator
Chloë Bernier (CB)	Data documentation (forms, logs, camera setup, etc) / IP Manager
Benjamin Bernier (BB)	Data Collection / Fluid Manager (inventory and application) / YOW Pers. Manager
YOW Personnel	
Ben Guthrie (BG)	Photography / Camera Documentation
Steve Baker (STB)	Fluids / IP / Dispensing / General Support
YOW 1	Fluids / IP / Dispensing
YOW 2	Fluids / IP / Dispensing
YOW 3	Fluids / IP / Dispensing
YOW 4	IP Manufacturing

NRC Aerospace Research Centre Contacts

- Catherine Clark: (613) 990-6796; and
- Cory Bates: (613) 913-9720.

10. SAFETY

- A safety briefing will be done on the first day of testing;
- Personnel should be familiar with NRC emergency procedures i.e. DO NOT CALL 9-1-1, instead call the NRC Emergency Center as they will contact and direct the necessary services;
- All personnel must be familiar with the Material Safety Data Sheets (MSDS) for fluids;
- Prior to operating the wind tunnel, loose objects should be removed from the vicinity;
- When wind tunnel is operating, ensure that ear plugs are worn if necessary and personnel keep safe distances;

- When working on ladders, ensure equipment is stable;
- CSA approved footwear and appropriate clothing for frigid temperatures are to be worn by all personnel;
- Caution should be taken when walking in the test section due to slippery floors, and dripping fluid from the wing section;
- If fluid comes into contact with skin, rinse hands under running water; and
- If fluid comes into contact with eyes, flush with the portable eye wash station.

Attachment 1: Task List for Setup and Actual Tests

No.	Task	Person	Status
	Planning and Preparation		
1	Co-ordinate with NRC wind tunnel personnel	MR/JD	
2	Ensure fluid is received by NRC and is stored outdoors	MR/JD	
3	Check with NRC the status of the testing site, tunnel etc	MR	
4	Arrange for hotel accommodations for APS personnel	JS	
5	Arrange truck rental	BB	
6	Arrange for ice and freezer delivery	JS	
7	Organize personnel travel to Ottawa;	MR	
8	Hire YOW personnel	CB	
9	Complete contract for YOW personnel	CB	
10	Co-ordinate with APS photographer	MR	
11	Ensure availability of freezing rain sprayer equipment;	MR	
12	Prepare and Arrange Office Materials for YOW	CB	
13	Prepare Data forms and procedure	CB	
14	Back up hard drives with all TC projects	CB	
15	Prepare Test Log and Merge Historical Logs for Reference	CB	
16	Update (as necessary) fluid viscosity log, and have available	CB	
17	Finalize and complete list of equipment/materials required	MR	
18	Prepare and Arrange Site Equipment for YOW	BB	
19	Ensure proper functioning of ice pellet dispenser equipment;	MR	
20	Purchase, and label fluid pouring pitchers	CB	
21	Review IP/ZR/SN dispersal techniques and location	CB/MR	
22	Update IP/SN Order Form (if necessary)	CB/MR	
23	Check weather prior to finalizing test dates and Day vs. Night Shift, Start Time	MR/JD	
24	Arrange for pallets to lift up 1000L totes (if applicable)	MR	
25	Purchase new 20 L containers (as necessary)	BB	
26	Complete purchase list and shopping	CB	
27	Pack and leave YUL for YOW	APS	
	Testing Day 1		
28	Safety Briefing & Training (APS/YOW)	MR	
29	Unload Truck and organize equipment in lower, middle, or office area	APS	
30	Verify and Organize Fluid Received (labels and fluid receipt forms)	BB/STB	
31	Transfer Fluids from 1000 L Totes to 20 L containers	BB/STB	
32	Collect fluid samples for viscosity at APS office and for Falling Ball	BB/CB	
33	Conduct falling ball verification	BB/CB	
34	Confirm ice and freezer delivery	BB	
35	Setup general office and testing equipment	CB	
36	Setup Projector	CB	
37	Setup Printer	CB	
38	Setup rate station (if necessary)	CB	
39	Setup IP/SN manufacturing material in reefer truck	BB/STB	
40	Test and prepare IP dispensing equipment	BB/STB	
41	Train IP making personnel (ongoing)	STB/YOW	
42	Co-ordinate fabrication of ice pellets/snow	CB/STB	
43	IP/SN/ZR Calibration (if necessary)	BB/CB/MR	
44	Start IP manufacturing	STB	
45	Mark wing (only if requested);	CB	
46	Setup Still and Video Cameras	BG/YOW	
47	Verify photo and video angles, resolution, etc,	BG/STBD/MR	
48	Document new final camera and flash locations	CB/BG/STBD	
49	General safety briefing and update on testing	APS/NRC/YOW	
50	Dry Run of tests with APS and NRC (if necessary)	APS/NRC	
51	Start Testing (Dry wing tests may be possible while setup occurs)	APS/NRC	
	Each Testing Day		
52	Check with NRC the status of the testing site, tunnel, weather etc	MR	
53	Deicide personnel requirements for following day for 24hr notice	MR	
54	Prepare equipment and fluid to be used for test	BB	
55	Manufacture ice pellets	STB/YOW	
56	Prepare photography equipment	BG	
57	Prepare data forms for test	CB	
58	Conduct tests based on test plan	APS	
59	Modify test plan based on results obtained	TC/FAA/JD/MR	
60	Update ice pellet, snow, raw ice, and fluid Inventory (end of day)	CB/STB	
61	Update Test Log and Test Plan (ongoing and end of day)	CB	

Attachment 2: General Form

GENERAL FORM (EVERY TEST)

DATE: ____________ FLUID APPLIED: ____________ RUN # (Plan #): ____________

AIR TEMPERATURE (°C) BEFORE TEST: ____________ AIR TEMPERATURE (°C) AFTER TEST: ____________

TUNNEL TEMPERATURE (°C) BEFORE TEST: ____________ TUNNEL TEMPERATURE (°C) AFTER TEST: ____________

WIND TUNNEL START TIME: ____________ PROJECTED SPEED (S/KTS): ____________

ROTATION ANGLE: ____________ EXTRA RUN INFO: ____________

FLAP SETTING (20°, 0°): ____________

■ Check if additional notes provided on a separate sheet

FLUID APPLICATION

Actual start time:	Actual End Time:
Fluid Brix:	Amount of Fluid (L):
Fluid Temperature (°C):	Fluid Application Method: POUR

ICE PELLETS APPLICATION (if applicable)

Actual start time:	Actual End Time:
Rate of Ice Pellets Applied (g/dm²/h):	Ice Pellets Size (mm): 1.4 - 4.0 mm
Exposure Time:	
Total IP Required per Dispenser:	

FREEZING RAIN/DRIZZLE APPLICATION (if applicable)

Actual start time:	Actual End Time:
Rate of Precipitation Applied (g/dm²/h):	Droplet Size (mm):
Exposure Time:	Needle:
	Flow:
	Pressure

SNOW APPLICATION (if applicable)

Actual start time:	Actual End Time:
Rate of Snow Applied (g/dm²/h):	Snow Size (mm): <1.4 mm
Exposure Time:	Method: ☐ Dispenser ☐ Sieve
Total SN Required per Dispenser:	

COMMENTS

MEASUREMENTS BY: ____________ **HANDWRITTEN BY:** ____________

Attachment 3: Wing Temperature, Fluid Thickness and Fluid Brix Form

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

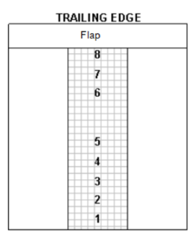
Date: ____________________ Run: ____________

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2				
T5				
TU				
Time:				

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

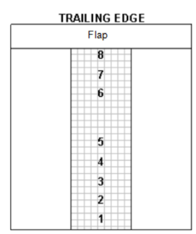
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition
Before the Takeoff Run
Time: __________

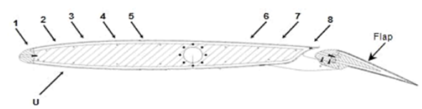


Comments:____________________

Wing and Plate Condition
After the Takeoff Run
Time: __________



Comments:____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____________________

OBSERVER: ____________________

ASSISTED BY: ____________________

Attachment 4: Example Ice Pellet Dispensing Form

WING TRAILING EDGE

← 8 ft = 24.4 dm →

6 ft = 18.3 dm

DISPENSER #3								DISPENSER #4							
1 ←	1ft	→ 2 ←	1ft	→ 3 ←	1ft	→ 4		1 ←	1ft	→ 2 ←	1ft	→ 3 ←	1ft	→ 4	
14.9	16.5	18.2	17.4	18.5	17.6	18.5	17.6	18.5	17.6	18.5	17.6	17.2	17.2	16.3	13.3
20.3	24.1	26.2	26.4	27.3	26.9	27.5	26.9	27.5	26.9	27.5	26.9	26.9	25.8	24.2	18.6
20.3	25.4	27.4	28.7	29.0	29.4	29.0	29.4	29.0	29.4	29.0	29.3	28.3	27.7	24.4	19.3
19.1	23.8	25.6	25.6	29.2	29.6	29.3	29.6	29.3	29.6	29.3	29.5	28.6	27.4	24.3	19.2
18.8	23.5	27.2	27.9	29.4	28.8	29.5	28.8	29.5	28.8	29.5	28.8	28.7	26.8	24.1	18.5
18.4	24.0	26.9	28.7	29.0	29.6	29.1	29.6	29.1	29.6	29.1	29.4	28.4	27.2	23.5	18.5
18.5	23.5	27.2	28.4	29.4	29.1	29.6	29.1	29.6	29.1	29.6	29.0	28.7	26.9	24.0	18.4
18.5	24.1	26.8	28.7	28.8	29.5	28.8	29.5	28.8	29.5	28.8	29.4	27.9	27.2	23.5	18.8
19.2	24.3	27.4	28.6	29.5	29.3	29.6	29.3	29.6	29.3	29.6	29.2	25.6	25.6	23.8	19.1
19.3	24.4	27.7	28.3	29.3	29.0	29.4	29.0	29.4	29.0	29.4	29.0	28.7	27.4	25.4	20.3
18.6	24.2	25.8	26.9	26.9	27.5	26.9	27.5	26.9	27.5	26.9	27.3	26.4	26.2	24.1	20.3
13.3	16.3	17.2	17.2	17.6	18.5	17.6	18.5	17.6	18.5	17.6	18.5	17.4	18.2	16.5	14.9
	4 ←	1ft	→ 3 ←	1ft	→ 2 ←	1ft	→ 1		4 ←	1ft	→ 3 ←	1ft	→ 2 ←	1ft	→ 1
	DISPENSER #2								DISPENSER #1						

WING LEADING EDGE

Precipitation Type	IP

Date	

Run #	

* ***Field to be manipulated***

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate (+/-)	5	g/dm²/h

IP needed per 5min

In each position	81	g
In each Dispenser	323	g

IP needed for entire test

Total amount of IP in Each Dispenser	323	g
Total Amount IP Needed for Entire Test	1291	g

1. Enter "Date" and "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of IP Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of IP in Each Dispenser" in grams. **(Each Dispenser must be emptied at 5-minute intervals.)**
6. Dictate amount of IP needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispenser has complested its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals). (e.g: Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

NOTE:

- Leading Edge (LE): Centre Pole of the Dispenser Stands must be 1-foot (12 inches) from the Leading Edge (LE)

-Trailing Edge (TE): Centre Pole of the Dispenser Stands must be 10-inches from the Trailing Edge (TE) Flap.

- Dispenser Spinner must be 3-feet above the average height of the wing.

Attachment 5: Example Snow Dispensing Form

WING TRAILING EDGE

← 8 ft = 24.4 dm →

6 ft = 18.3 dm

DISPENSER #3								DISPENSER #4							
1	← 1ft →	2	← 1ft →	3	← 1ft →	4		1	← 1ft →	2	← 1ft →	3	← 1ft →	4	
23.1	24.8	27.2	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.4	26.6	19.7
27.1	35.5	34.9	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.0	36.3	33.9	29.8
24.6	39.4	36.4	41.4	36.8	41.5	36.8	41.5	36.8	41.5	36.8	41.5	36.7	41.1	35.5	35.2
14.4	26.3	25.3	28.6	25.7	28.7	25.7	28.7	25.7	28.7	25.7	28.7	25.6	28.4	24.7	24.3
8.8	15.2	16.4	17.4	17.0	17.6	17.2	17.6	17.2	17.6	17.2	17.6	17.0	17.2	15.9	14.2
6.1	9.4	10.6	11.2	11.1	11.4	11.2	11.4	11.2	11.4	11.2	11.3	11.0	10.9	9.8	7.9
7.9	9.8	10.9	11.0	11.3	11.2	11.4	11.2	11.4	11.2	11.4	11.1	11.2	10.6	9.4	6.1
14.2	15.9	17.2	17.0	17.6	17.2	17.6	17.2	17.6	17.2	17.6	17.0	17.4	16.4	15.2	8.8
24.3	24.7	28.4	25.6	28.7	25.7	28.7	25.7	28.7	25.7	28.7	25.7	28.6	25.3	26.3	14.4
35.2	35.5	41.1	36.7	41.5	36.8	41.5	36.8	41.5	36.8	41.5	36.8	41.4	36.4	39.4	24.6
29.8	33.9	36.3	35.0	36.7	35.1	36.7	35.1	36.7	35.1	36.7	35.1	36.7	34.9	35.5	27.1
19.7	26.6	25.4	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.4	25.5	27.2	24.8	23.1
	4	← 1ft →	3	← 1ft →	2	← 1ft →	1		4	← 1ft →	3	← 1ft →	2	← 1ft →	1
	DISPENSER #2								DISPENSER #1						

WING LEADING EDGE

Precipitation Type	Snow	Date		Run #	

* ***Field to be manipulated***

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate	10	g/dm²/h

Snow needed per 5 minutes

In each position	84	76	g
In each Dispenser	336	305	g

Snow needed for entire test

In each Dispenser	336	305	g
Total Amount Snow Needed for Entire Test	1344	1222	g

1. Enter "Date" and "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of Snow Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of Snow in Each Dispensor" in grams. **(Each Dispensor must be emptied at 5-minute intervals.)**
6. Dictate amount of Snow needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispenser has completed its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals).

(e.g. Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

NOTE:

- Leading Edge (LE): Centre Pole of the Dispenser Stands must be 1-foot (12 inches) from the Leading Edge (LE)

-Trailing Edge (TE): Centre Pole of the Dispenser Stands must be 10-inches from the Trailing Edge (TE) Flap. The use of Dispensor Stand Extention is needed.

- Dispenser Spinner must be 3-feet above the average height of the wing.

Attachment 6: Example Snow Dispensing Form (Manual Method)

Precipitation Type	Sifted Snow	Date		Run #	

* *Field to be manipulated*

Target Rate	**25**	**g/dm²/h**
Duration	**5**	**minutes**

Footprint Rate	25	g/dm²/h
Stdev of Rate	10	g/dm²/h

Snow needed per 5 minutes

In each position	66
In each Dispenser	265

Snow needed for entire test

In each Dispenser	265
Total Amount Snow Needed for Entire Test	1062

1. Enter "Run #".
2. Manipulate desired "Target Rate" for test event.
3. Manipulate desired "Duration" for test event.
4. Prepare "Total Amount of Snow Needed for Entire Test" in grams.
5. Prepare 4 boxes for "Total Amount of Snow in Each Dispenser" in grams. **(Each Dispenser must be emptied at 5-minute intervals.)**
6. Dictate amount of Snow needed "In each Position" in grams. **(Each Position must be emptied at approximately 1-minute intervals.)**
7. Once a Position is emptied of its contents (1-minute intervals), move the Dispenser 1-foot to the left.
8. Once a Dispensor has completed its cycle at Position #4, start next cycle at Position #4 and move 1-Foot to the right at (1-minute intervals).

(e.g: Position #1 -> Pos #2 -> Pos #3 -> Pos #4 -> Pos #4 -> Pos #3 -> Pos #2 -> Pos #1 -> Pos #1...)

- Since dispensing is done using a sieve, the percentage of snow loss is reduced. This efficiency is estimated at 90%, as per visual analysis in 2009-10.

Attachment 7: Visual Evaluation Rating Form

VISUAL EVALUATION RATING OF CONDITION OF WING

Date: ______________________ Run Number: ________

Ratings:
1 - Contamination not very visible, fluid still clean.
2 - Contamination is visible, but lots of fluid still present
3 - Contamination visible, spots of bridging contamination
4 - Contamination visible, lots of dry bridging present
5 - Contamination visible, adherence of contamination

Note: Ratings can include decimals i.e. 1.4 or 3.5

Before Take-off Run

Area	Visual Severity Rating (1-5)	
Leading Edge		*>3 = Review, >3.5=Bad*
Trailing Edge		*>3 = Review, >3.5=Bad*
Flap		*>4 = Review, >4.5=Bad*

At Rotation

Area	Visual Severity Rating (1-5)	
Leading Edge		*>1= Review >1.5 = Bad*
Trailing Edge		
Flap		

Expected Lift Loss (%) *>5.4 = Review* *>9.2 = Bad*

After Take-off Run

Area	Visual Severity Rating (1-5)
Leading Edge	
Trailing Edge	
Flap	

Additional Observations: ____

____

____

OBSERVER:__________________________

Attachment 8: Fluid Receipt Form (Electronic Form)

FORM 1

GENERAL FORM FOR RECEIVING FLUID

Receiving Location: ☐ APS Site ☐ Other: ______________ **Date of Receipt:** ____________________

Fluid Characteristics: Type: Colour: **Date of Production:** ____________________

Manufacturer: ____________________________________ **Batch #:** ____________________

Fluid Name: ____________________________________ **Project Task:**

Fluid Quantities / Fluid Brix / Falling Ball Info:

Fluid Dilution:	Fluid Dilution: ____________	Fluid Dilution: ____________
Fluid Code: ____________	Fluid Code: ____________	Fluid Code: ____________
Fluid Quantity: ____ x ____ L = ____ L	Fluid Quantity: ____ x ____ L = ____ L	Fluid Quantity: ____ x ____ L = ____ L
Fluid Brix: ______°	Fluid Brix: ______°	Fluid Brix: ______°
Falling Ball Time: ___:___:___ (mm:ss:cs)	Falling Ball Time: ___:___:___ (mm:ss:cs)	Falling Ball Time: ___:___:___ (mm:ss:cs)
Falling Ball Temp: _____°C	Falling Ball Temp: _____°C	Falling Ball Temp: _____°C
Sample from Container #: _____ of _____	Sample from Container #: _____ of _____	Sample from Container #: _____ of _____

Sample Collection:

HOT Fluids:	Extract 4 L 100 / 75 / 50 and 2 L Type I
Other Fluids:	Extract 3 L 100 / 75 / 50 / Type I

Sample Distribution:

Viscosity:	2 L 100 / 75 / 50	to third party and in-house for testing
WSET:	1 L 100 / 75 / 50 / Type I	to AMIL for WSET (HOT samples only)
Office:	1 L 100 / 75 / 50 / Type I	to be retained in office

Photo Documentation: (take photos of all that apply)

☐ Palette (as received) ☐ 100/0 MFR Fluid Label ☐ 75/25 MFR Fluid Label ☐ 50/50 MFR Fluid Label ☐ Type I MFR Fluid Label

Additional Info/Notes: (additional information included on fluid containers, paperwork received, etc.)

Received by: ______________________ **Date:** ______________________ **Verified by:** ______________________

Fluid Receipt Form (Oct 2018)

Attachment 9: Log of Fluid Sample Bottles

Date of Extraction	*Fluid and Dilution*	*Batch #*	*Sample Source (i.e. drum)*	*Falling Ball Fluid Temp (°C)*	*Falling Ball Time (sec)*	*Comments*

Attachment 10: Procedure - Dry Wing Performance

Background

A significant amount of work has been done in conjunction with NASA and NRC in order to calibrate and characterize the wind tunnel and airfoil model during the last two winter seasons. This work has further increased the confidence in the data produced, however ongoing verification is necessary in order to identify potential changes in the system performance.

Objective

Verify that clean model aerodynamic data agree with the data acquired in previous years with the same model. Given the various issues with repeatability and angle of attack offsets in the past, this is an important step prior to fluids testing.

Methodology

- Ensure the wing is clean and dry;
- Conduct a dry wing test using the regular takeoff profile;
- Conduct a dry wing test using a takeoff profile with rotation to stall;
- Compare lift performance to historical data; and
- Address potential discrepancies accordingly.

Test Plan

This testing should be conducted at the start of each testing day.

Attachment 11: Procedure – Type IV Ice Pellet Allowance Time Validation with New Fluids

Background

The Type IV ice pellet allowance times are conservative, generic guidance developed based on data collected using commercially available Type IV fluids. As new fluids are developed and become commercially available, it is important to evaluate these fluids against the current allowance times to ensure the validity of the generic guidance. Systematic “spot-checking” is used in order to identify any potential issues. In addition, testing is recommended with all fluids available to obtain data close to the fluid LOUT to determine the aerodynamic effects of ice pellet contamination at these colder temperatures.

Objective

To evaluate newly commercialized Type IV fluids against the existing allowance times, and to collect data close to the fluid LOUT.

Methodology

- Conduct testing with any new commercially available Type IV fluids in each of the cells of the ice pellet allowance times table;
- Record lift data, visual observations, and manually collected data;
- Adjust testing plan accordingly based on aerodynamic data collected; and
- Weather permitting, conduct testing close to the fluid LOUT (-25 to -30°C) with appropriate conditions to address data gaps.

Test Plan

Eight days of testing are planned.

Attachment 12: Procedure – Development of EG Specific Ice Pellet Allowance Time Table

Background

Type IV ice pellet allowance times are also intended to be conservative, and therefore generic guidance is developed based on data collected using commercially available Type IV fluids. Historically both Type IV PG and EG fluids have been grouped together, however data has indicated that EG may have an operational advantage of longer ice pellet allowance times in specific conditions. The industry requested that EG specific fluid ice pellet allowance time tables be generated to be able to benefit from any potential linger allowance times specific to Type EG fluids.

Objective

To conduct testing to investigate the feasibility of developing an EG specific ice pellet allowance time table.

Methodology

- Determine what EG data exists and any potential data gaps which need to be filled;
- Conduct testing with commercially available EG Type IV fluids in each of the cells of the ice pellet allowance times table, as required;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

Two days of testing are planned.

Attachment 13: Procedure – Type III Low Speed Allowance Time Testing LS-0417 Wing Model Calibration and Characterization

Background

Type III fluid allowance times have recently been developed but are limited to use with aircraft with rotation speeds of 100 knots or greater. Type III fluids can often be used with lower rotation speed aircraft, therefore there is a requirement to have these allowance times validated for use at these lower speeds. The LS-0417 is a more representative airfoil to conduct low speed testing at 80 knots. Testing to characterize the LS-0417 wing section was first performed in the winter of 2017-18, and analysis is still ongoing.

Objective

Conduct additional calibration and characterization testing, as required, with the LS-0417 wing to support a better understanding of the aerodynamic effects and how it pertains to ice pellet allowance time testing at 80 knots.

Methodology

Testing will include a subset of the following:

- Thoroughly survey the clean wing performance through pitch pause, angle sweeps, and stall runs, and verify repeatability;
- Perform oil flow visualization to better understand boundary layer separation and uniformity of flow;
- Install boundary layer trips to establish wing sensitivity;
- Conduct fluid testing with and without contamination to evaluate repeatability of results; and
- Install larger end plates to evaluate potential 3D effects.

Test Plan

One day of testing is planned. An additional day may be required to swap out the existing wing section in the wind tunnel for the LS-0417 wing.

Attachment 14: Procedure – Type III Ice Pellet Allowance Time Validation at 80 Knots with LS-0417 Wing Section

Background

Type III fluid allowance times have recently been developed but are limited to use with aircraft with rotation speeds of 100 knots or greater. Type III fluids can often be used with lower rotation speed aircraft, therefore these allowance times need to be validated for use at these lower speeds. The LS-0417 is a more representative airfoil to conduct low speed testing at 80 knots, therefore it is recommended that the Type III IP allowance times be validated using the LS-0417 wing model at lower speeds (80 knots).

Objective

To evaluate the Type III allowance times for use with lower rotation speeds (80 knots).

Methodology

- Conduct testing in each of the cells of the ice pellet allowance times table with commercially available Type III fluids in each of the cells of the ice pellet allowance times table at 80 knots rotation speed with the LS-0417 wing section;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

One day of testing is planned. An additional day may be required to swap out the existing wing section in the wind tunnel for the LS-0417 wing.

Attachment 15: Procedure – Type III Ice Pellet Allowance Time Expansion

Background

Allowance times for Type III fluids have just recently been developed. Similar to the Type IV ice pellet allowance times, the Type III allowance times are also intended to be conservative, generic guidance developed based on data collected using commercially available Type III fluids. In cases where the allowance times are too restrictive, additional data may be used to support an increase to the existing times, or new cells at different temperatures. This testing can be done at both 80 knots and 100 knots.

Objective

To conduct testing to support the expansion of the Type III ice pellet allowance times.

Methodology

- Conduct testing with commercially available Type III fluids in each of the cells of the ice pellet allowance times table at 80 knots and 100 knots rotation speed;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

Ten to twenty tests would provide a suitable dataset for analysis.

Attachment 16: Procedure – Snow Allowance Times Using Aerodynamic Data

Background

Holdover times are developed based on a visual evaluation of fluid failure on test plate surfaces measuring 30x50cm (12x20in.). The industry requested an investigation into the feasibility of using the same aerodynamic testing methodology used to develop ice pellet allowance times, to develop snow allowance times. It is believed that using this methodology would provide longer "snow allowance times" as compared to the current existing snow holdover times.

Objective

To conduct testing to investigate the feasibility of developing snow allowance times.

Methodology

- Conduct testing with commercially available Type IV fluids using the current methodology used to develop ice pellet allowance times;
- Record lift data, visual observations, and manually collected data; and
- Adjust testing plan accordingly based on aerodynamic data collected.

Test Plan

No tests are anticipated.

Attachment 17: Procedure - Heavy Snow

Background

As a direct result of the ice pellet research conducted, the use of HOTs for determining the protection time provided by anti-icing fluids was questioned. The focus has turned towards "aerodynamic failure" which can be defined as a significant lift loss resulting from contaminated anti-icing fluid. Heavy snow conditions have been selected for this study for two reasons. First, snow conditions account for the most significant portion of deicing operations globally. Secondly, there has been a recent industry interest for holdover time for heavy snow conditions. Preliminary aerodynamic testing was conducted during the winters of 2006-07 and 2008-2011.

Objective

To investigate the fluid aerodynamic flow-off characteristics of anti-icing fluid contaminated with simulated heavy snow versus moderate snow.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical snow condition tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating moderate snow conditions (rate of 25 g/dm^2/h) for an exposure time derived from the HOT table based on the tunnel temperature at the time of the test;
- Record lift data, visual observations, and manually collected data;
- Conduct two comparative tests simulating heavy snow conditions (rate of 50 g/dm^2/h or higher) for the same exposure time used during the moderate snow test;

  NOTE: Previous testing has indicated that using half, to ¾ of the moderate snow HOT generates similar end conditions; whereas using the full moderate HOT for heavy snow conditions generates a more sever fluid failure which behaves worse aerodynamically.
- Record lift data, visual observations, and manually collected data;
- Compare the heavy snow results to the moderate snow results. If the heavy snow results are worse, repeat the heavy snow test with a reduced exposure time, if the results are better, repeat the heavy snow test with an increased exposure time;
- Repeat until similar lift data, and visual observations are achieved for both heavy snow and moderate snow; and
- Document the percentage of the moderate snow HOT that is acceptable for heavy snow conditions.

Test Plan

Two to four comparative tests would provide a suitable dataset for analysis. See previous reports for suggested test plan.

Attachment 18: Procedure - Heavy Contamination

Background

Previous testing in the wind tunnel demonstrated that although very heavy ice pellet and/or snow contamination was applied to a fluid covered wing section, significant lift losses were not apparent. The initial testing indicated that after a certain level of contamination, the dry loose ice pellets or snow no longer absorb into the fluid and easily fly off during the acceleration. The protection is due to a thin layer of fluid present underneath the contamination that prevents adherence. Questions of which point the lift losses become detrimental have been raised.

Objective

To continue previous research investigating heavy contamination effects on fluid flow-off.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical ice pellet tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating ice pellets, snow, or freezing rain, for an exposure time far exceeding the recommended HOT or allowance time;
- Record lift data, visual observations, and manually collected data; and
- Compare aerodynamic performance results to fluid only or fluid and contamination tests at the same temperature.

Test Plan

One to four tests would provide a suitable dataset for analysis. Previous work should be referenced to identify starting levels of heavy contamination.

Attachment 19: Procedure - Wind Tunnel Test Section Cooling

Background

Recent wind tunnel research has been limited by the ambient temperature in wind tunnel test section; in sunny conditions, the radiation will raise the temperature in the test section making testing difficult. To mitigate this effect, testing is often conducted overnight, however in some cases, even body heat from people working in the test area (specifically during long precipitation exposure tests) can affect the temperature. A new cooling system has been installed by the NRC to mitigate the effects of the radiation warming as well as from the heat generated by the personnel working in the test section. It was recommended that testing be conducted to evaluate the effects of the new cooling system on the test results.

Objective

To evaluate the effect of the cooling system on the aerodynamic test results produced.

Methodology

- Conduct a fluid only test without the cooling system. Have personnel standing on scaffolding for 20-minutes following fluid application to generate extra heat prior to running the wind tunnel;
- Conduct a second comparative fluid only test with the cooling system. Have personnel standing on scaffolding for 20-minutes following fluid application to generate extra heat prior to running the wind tunnel;
- Conduct a third comparative test at a suitable ambient temperature where the expected test area temperature with the cooling system is equal to the test area temperature of the test conducted without the cooling system; and
- Compare aerodynamic performance results.

EXAMPLE OF COMPARATIVE DATA TO BE COLLECTED

Test #	Cooling System Status	OAT ºC	Test Area Temp ºC	Lift Loss %
1	Off	-18	-14	6.3
2	On	-18	-17	7.5
3	On	-15*	-14	5.7

* To be selected based on efficiency of cooling system based on test #2

Test Plan

Three tests at a minimum would provide a suitable dataset for analysis.

Attachment 20: Procedure - Fluid and Contamination at LOUT

Background

Recent changes to the frost HOT guidance material allowing fluids to be used to the LOUT have raised concerns about whether or not this is an appropriate practice. In frost the major concern was the effect of radiation cooling and how it could affect the LOUT, however the concern also includes contamination at LOUT. This issue was also raised from the AWG for the ice pellet testing which allows fluids to be used to LOUT: will the added ice pellet contamination at the LOUT not bust BLDT? It was recommended that some testing be conducted at the fluid LOUT to investigate how contamination can affect the aerodynamic performance of the fluid.

Objective

To investigate the fluid aerodynamic flow-off characteristics of anti-icing fluid with contamination at the LOUT.

Methodology

The general methodology to be used during these tests is in accordance with the methodologies used for typical ice pellet tests conducted in the wind tunnel.

- For a chosen fluid, conduct a test simulating ice pellets, snow, freezing fog, or frost, for an exposure time derived from the HOT table at the fluid LOUT;
- Record lift data, visual observations, and manually collected data;
- Conduct a fluid only baseline test at the same temperature (at LOUT); and
- Compare the aerodynamic performance.

Test Plan

Four or more tests would provide a suitable dataset for analysis. If LOUT temperatures for neat fluids are not likely to occur, investigate the possibility of using diluted fluids to obtain a higher LOUT.

Attachment 21: Procedure - Frost Simulation in the Wind Tunnel

Background

Frost is an important consideration in aircraft deicing. The irregular and rough frost accretion patterns can result in a significant loss of lift on critical aircraft surfaces. This potential hazard is amplified by the frequent occurrence of frost accretion in winter operations. Frost is an area of research that has yet to be fully explored. Discussions regarding the aerodynamic effects of frost have been raised, and the possibility of doing wind tunnel testing has been considered. It was recommended that initial testing be performed to investigate whether it would be feasible to simulate frost conditions in the PIWT.

Objective

To investigate the feasibility of simulating frost conditions in the PIWT.

Methodology

This work is exploratory, so no exact procedure exists. It is recommended that the frost generating parameters be explored to try and stimulate frost accretion. This can be done by causing a negative temperature differential between the wing and the ambient air i.e. air is warmer than skin. A more specific methodology may be determined on site following a brain-storm with on-site technicians.

Test Plan

One or two tests would provide a suitable dataset for analysis.

Attachment 22: Procedure - Feasibility of Ice Pellet Testing at Higher Speeds

Background

Historically, the ice pellet allowance time testing conducted in the wind tunnel simulated typical aircraft rotation of 100 knots, and more recently some limited work at 115 knots. As a result of some of the higher lift losses observed at colder temperatures with PG fluids applied to a thin high performance airfoil, it was recommended that higher speed testing be conducted to verify if the limitations in the allowance times would need to be applied to commercial aircraft with rotation speeds well above 115 knots. It was recommended that 130-150 knots be targeted, however modifications to the wind tunnel may be required as those higher speeds may increase stress on the wind tunnel engine and other structural systems.

Objective

To investigate the feasibility of conducting ice pellet testing at higher speeds of 130-150 knots.

Methodology

This work is exploratory, so no exact procedure exists. A more specific methodology may be determined on site following a brain-storm with on-site technicians. It is expected that a series of tests may be conducted to try and achieve speeds above 115 knots without rotating the wing model.

Test Plan

One or two tests would provide a suitable dataset for analysis, however more tests may be required based on the results.

Attachment 23: Procedure - 2nd Wave of Fluid during Rotation

Background

Previous wind tunnel testing has shown that during a simulated takeoff roll following de/anti-icing, fluid will shear off the wing section; however a small amount of fluid can remain trapped along the leading edge at the stagnation point. This "trapped" fluid begins to flow over the wing only once the wing is rotated; the stagnation point shifts below the leading edge, and the "trapped" fluid begins to shear off as a second wave. Previous testing was simulated in a static model using strips of speed tape and cork tape strategically located on the leading edge of the wing section (along the span where the separation bubble will typically occur). A separate set of dynamic tests simulated the second wave with actual anti-icing fluid; sheared fluid prior to rotation was left only in select areas either below or above the stagnation point and then the flow was observed during a typical rotation. The results showed the stalling characteristics of the wing with fluid (or fluid with contamination) appear to be driven by secondary wave effects near the leading edge; these effects are difficult to interpret on the two-dimensional model relative to a fully three-dimensional wing and should not be used in developing allowance times. Additional testing may be useful to better understand this effect.

Objective

To investigate the aerodynamic effects of the second wave of fluid flow during rotation.

Methodology

- Simulate the 2nd wave of fluid using strips of tape applied at specific areas at different thicknesses on the wing, or with fluid; and
- Compare the different results.

Test Plan

One to four tests would provide a suitable dataset for analysis.

This page intentionally left blank.

APPENDIX D

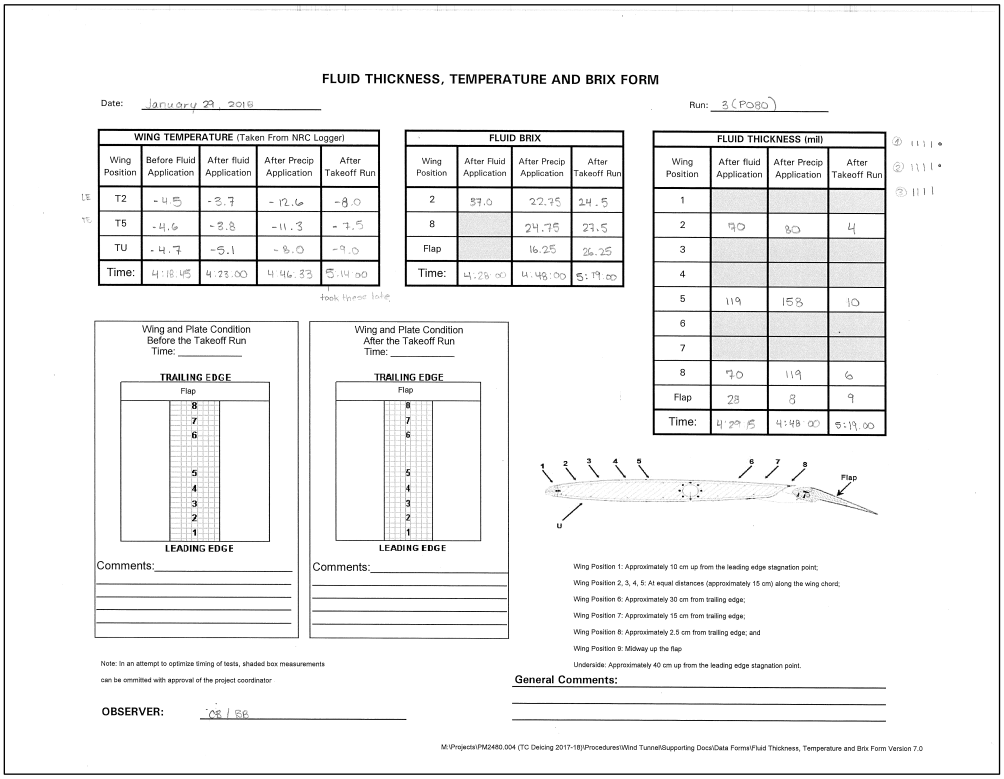
HIGH SPEED TESTING 2017-18
FLUID THICKNESS, TEMPERATURE, AND BRIX DATA FORMS

No Data Available

Figure D1: Run # 1

No Data Available

Figure D2: Run # 2



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2018

Run: 3 (P080)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-4.5	-3.7	-12.6	-8.0
T5	-4.6	-3.8	-11.3	-7.5
TU	-4.7	-5.1	-8.0	-9.0
Time:	4:18:45	4:23:00	4:46:33	5:14:00

LE (beside T2), TE (beside T5); "took these late" (under After Takeoff Run)

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.0	22.75	24.5
8		24.75	27.5
Flap		16.25	26.25
Time:	4:28:00	4:48:00	5:19:00

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70	80	4
3			
4			
5	119	158	10
6			
7			
8	70	119	6
Flap	28	8	9
Time:	4:29:15	4:48:00	5:19:00

① IIII ∘
② IIII ∘
③ IIII

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D3: Run # 3

No Data Available

Figure D4: Run # 4

No Data Available

Figure D5: Run # 5

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2018

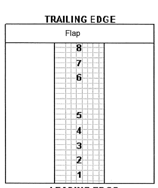
Run: 6 (P083)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-6.9	-6.2	-11.1	-10.0
T5	-6.5	-6.1	-10.4	-9.7
TU	-7.0	-6.9	-8.7	-9.6
Time:	22:05	22:10	22:47	22:56

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.5	23.0	24.0
8		23.25	28.0
Flap		16.75	27.5
Time:	22:15	22:50	23:11

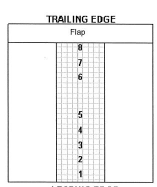
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70	65	6
3			
4			
5	104	158	7
6			
7			
8	80	96	11
Flap	28	7	8
Time:	22:16	22:49	23:11

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

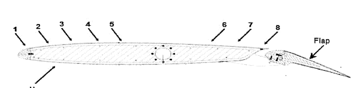


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D6: Run # 6

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2018

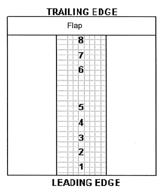
Run: 7 (P086)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.9	-6.8	-7.9	-9.5
T5	-7.7	-6.7	-6.3	-9.6
TU	-8.4	-8.4	-8.1	-9.4
Time:	23:25	23:31	23:48	23:57

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.75	29.5	31.25
8		24.75	32.5
Flap		19.0	29.5
Time:	23:35	23:49	03:30

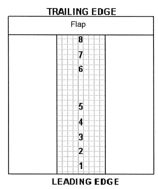
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	8
3			
4			
5	127	150	7
6			
7			
8	80	104	11
Flap	35	26	10
Time:	23:35	23:49	03:30

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

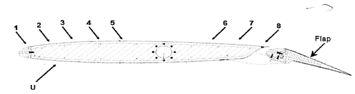


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D7: Run # 7

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2018

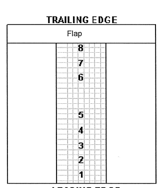
Run: 8 (P014)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.6	-7.2	-9.5	-9.2
T5	-7.6	-7.1	-7.9	-9.4
TU	-8.4	-8.3	-8.0	-9.0
Time:	00:24	00:29	00:48	00:58

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	26.0	33.5
8		27.5	34.25
Flap		15.25	32.25
Time:	00:31	00:51	1:05

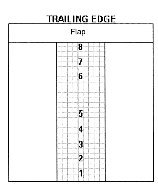
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	96	2
3			
4			
5	134	158	8
6			
7			
8	96	112	9
Flap	40	11	5
Time:	00:31	00:51	1:05

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

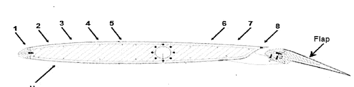


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D8: Run # 8

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

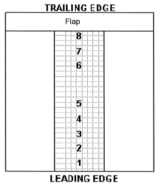
Date: January 30, 2018 Run: 9 (P016)

WING TEMPERATURE (Taken From NRC Logger)					
	Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
LE	T2	-8.1	-7.2	-13.7	-9.5
TE	T5	-8.3	-7.2	-11.5	-9.4
U	TU	-8.8	-8.5	-8.8	-9.4
	Time:	1:17	1:23	1:38	1:49

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	85.25	22.25	33.0
8		23.25	30.25
Flap		18.25	29.75
Time:	1:26	1:40	

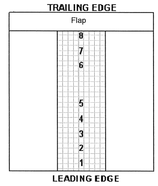
FLUID THICKNESS (mil)				
Wing Position	After fluid Application	After Precip Application	After Takeoff Run	
1				1111
2	80	80	<1	1111
3				
4				
5	119	158	5	
6				
7				
8	80	127	10	
Flap	40	24	6	
Time:	1:26	1:40		

Wing and Plate Condition Before the Takeoff Run
Time: ___________

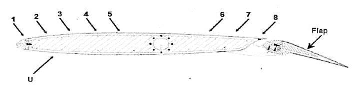


Comments: ___________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D9: Run # 9

36.75
6.4

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

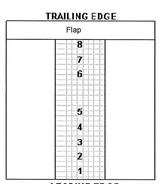
Date: January 30, 2018 Run: 10 (P088)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.2	-7.3	-11.6	-9.9
T5	-7.8	-7.1	-10.1	-9.7
TU	-8.8	-8.6	-8.6	-9.6
Time:	2:08	2:12	2:36	2:45

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.75	24.75	28.25
8		29.0	30.25
Flap		20.0	29.25
Time:	2:18	2:37	2:52

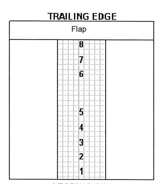
FLUID THICKNESS (mil)				
Wing Position	After fluid Application	After Precip Application	After Takeoff Run	
1				1111
2	70	96	5	1111
3				
4				
5	127	158	10	
6				
7				
8	80	119	10	
Flap	30	30	12	
Time:	2:19	2:37	2:52	

Wing and Plate Condition Before the Takeoff Run
Time: ___________

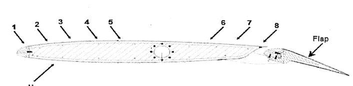


Comments: ___________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Pos 1, 2, 3 – TE Port side slightly light on ice pellets.

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D10: Run # 10

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

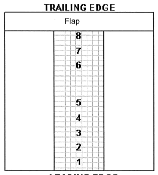
Date: January 30, 2018 Run: 11 (P084)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.6	-7.3	-12.0	-9.8
T5	-8.5	-7.2	-10.6	-9.7
TU	-9.0	-8.8	-8.0	-9.5
Time:	3:03	3:09	3:35	3:44

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.5	25.25	28.0
8		29.5	29.25
Flap		19.0	29.5
Time:	3:14	3:36	3:50

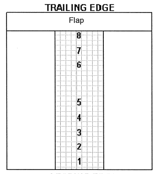
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	104	10
3			
4			
5	127	158	9
6			
7			
8	80	112	12
Flap	30	30	18
Time:	3:14	3:36	3:50

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

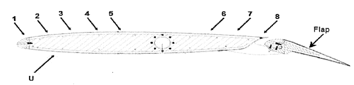


Comments: ___________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D11: Run # 11

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

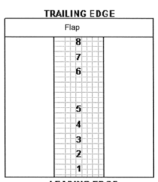
Date: January 30, 2018 Run: 12 (P012)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.9	-6.9	-13.9	-9.9
T5	-7.2	-6.7	-11.9	-9.7
TU	-8.4	-8.2	-9.0	-9.9
Time:	4:04	4:14	4:33	4:44

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	22.5	32.0
8		25.75	32.25
Flap		20.25	29.75
Time:	4:14	4:35	4:50

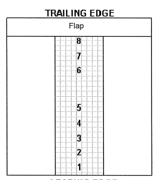
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	65	80	>1
3			
4			
5	112	142	2
6			
7			
8	96	119	7
Flap	35	20	7
Time:	4:14	4:35	4:50

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

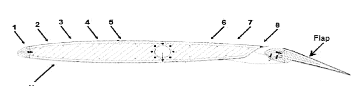


Comments: ___________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

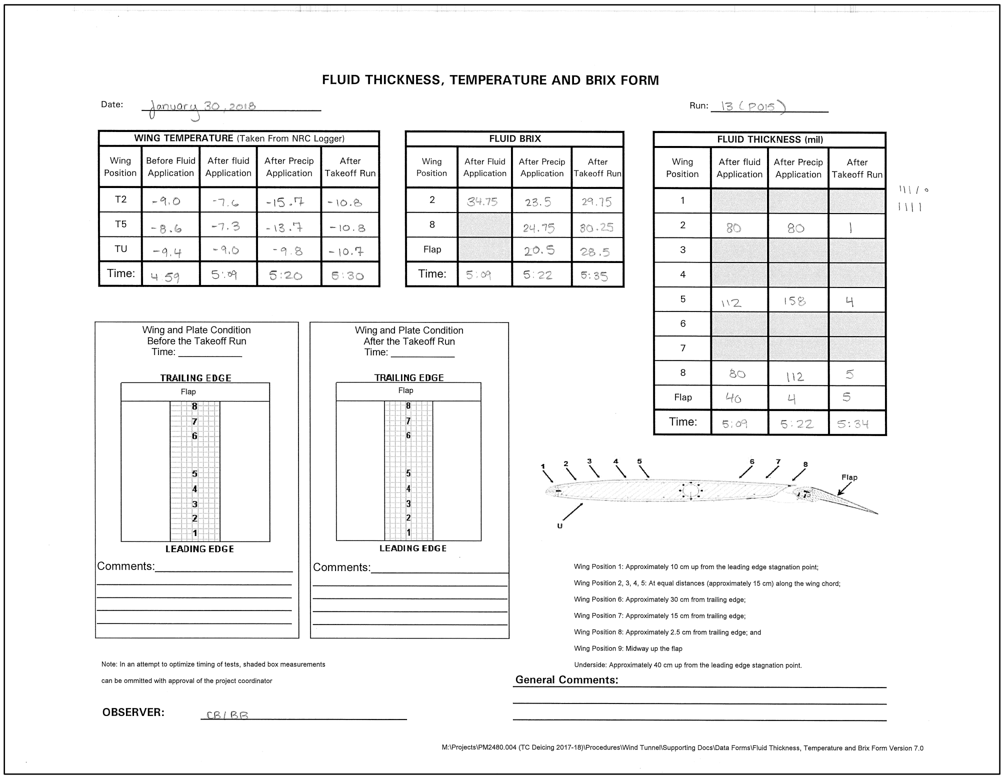
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D12: Run # 12



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2018

Run: 13 (P015)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-9.0	-7.6	-15.7	-10.8
T5	-8.6	-7.3	-13.7	-10.8
TU	-9.4	-9.0	-9.8	-10.7
Time:	4:59	5:09	5:20	5:30

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	23.5	29.75
8		24.75	30.25
Flap		20.5	28.5
Time:	5:09	5:22	5:35

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	1
3			
4			
5	112	158	4
6			
7			
8	80	112	5
Flap	40	4	5
Time:	5:09	5:22	5:34

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

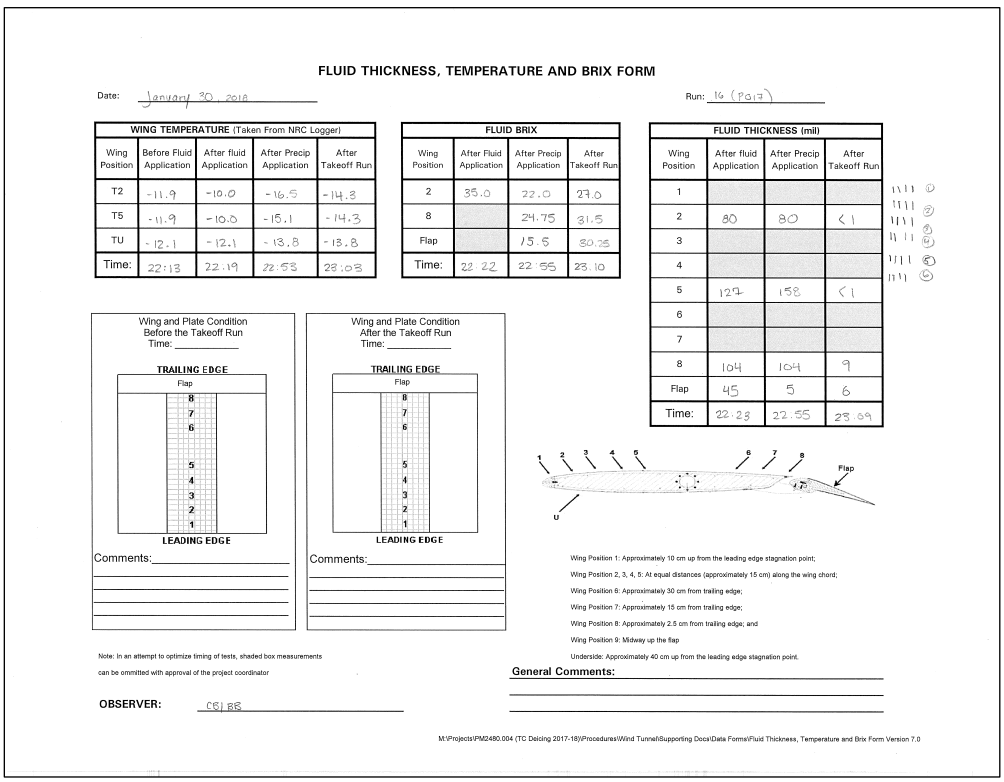
Figure D13: Run # 13

No Data Available

Figure D14: Run # 14

No Data Available

Figure D15: Run # 15



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2018

Run: 16 (P017)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-11.9	-10.0	-16.5	-14.3
T5	-11.9	-10.0	-15.1	-14.3
TU	-12.1	-12.1	-13.8	-13.8
Time:	22:13	22:19	22:53	23:03

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	22.0	27.0
8		24.75	31.5
Flap		15.5	30.25
Time:	22:22	22:55	23:10

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	<1
3			
4			
5	127	158	<1
6			
7			
8	104	104	9
Flap	45	5	6
Time:	22:23	22:55	23:09

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D16: Run # 16

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2018 Run: 17 (P018)

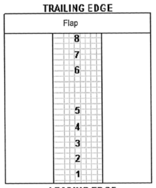
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.2	-11.2	-17.1	-14.8
T5	-13.2	-11.2	-15.3	-15.0
TU	-13.7	-13.7	-13.3	-14.6
Time:	23:20	23:26	23:47	23:56

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.25	27.5	29.25
8		22.0	33.0
Flap		21.5	29.0
Time:	23:30	23:48	00:03

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	104	1
3			
4			
5	134	158	4
6			
7			
8	96	119	9
Flap	45	3	6
Time:	23:30	23:48	00:03

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE

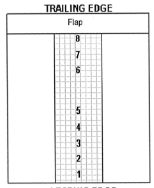


LEADING EDGE

Comments:

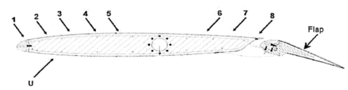
Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D17: Run # 17

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 18 (P019)

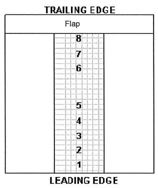
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.6	-11.4	-18.7	-15.5
T5	-13.6	-11.3	-16.6	-15.5
TU	-14.1	-14.0	-14.6	-15.3
Time:	00:12	00:17	00:32	00:40

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	24.25	27.75
8		29.5	30.5
Flap		23.0	29.75
Time:	00:21	00:32	00:45

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96	104	3
3			
4			
5	119	158	7
6			
7			
8	96	112	11
Flap	40	4	11
Time:	00:21	00:32	00:45

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE

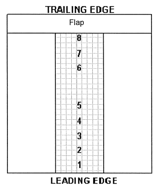


LEADING EDGE

Comments:

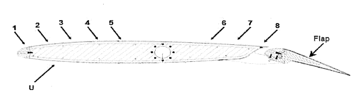
Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D18: Run # 18

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 19 (P025)

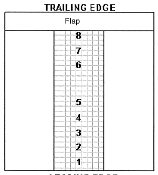
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-14.5	-11.7		-15.0
T5	-14.2	-11.4		-15.4
TU	-14.7	-14.7		-15.0
Time:	00:54	00:58		1:12

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.25		35.75
8			35.75
Flap			35.75
Time:	1:03		1:18

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80		2
3			
4			
5	134		14
6			
7			
8	96		14
Flap	40		22
Time:	1:04		1:18

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE

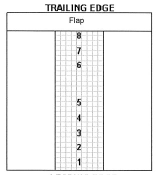


LEADING EDGE

Comments: ___________

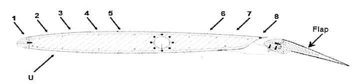
Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid Only Run

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D19: Run # 19

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 20 (P089)

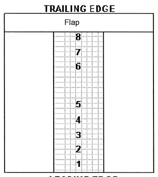
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.8	-11.5	-15.9	-16.3
T5	-13.8	-11.3	-15.4	-16.5
TU	-14.5	-14.4	-15.0	-16.2
Time:	1:29	1:33	2:12	2:20

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.0	28.5	31.75
8		31.5	32.25
Flap		24.5	30.75
Time:	1:37	2:13	2:25

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	96	2
3			
4			
5	127	158	11
6			
7			
8	80	119	10
Flap	30	17	11
Time:	1:38	2:12	2:25

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE

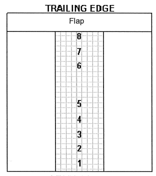


LEADING EDGE

Comments: ___________

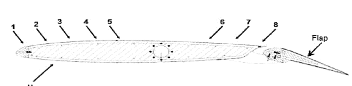
Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D20: Run # 20

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

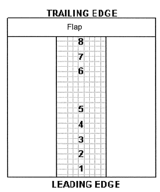
Date: January 31, 2018 Run: 21 (P090)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.3	-11.9	-15.9	-16.4
T5	-15.2	-11.8	-15.0	-16.8
TU	-15.7	-15.5	-14.3	-16.3
Time:	2:41	2:47	3:08	3:19

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.75	27.25	31.75
8		28.5	30.25
Flap		23.0	32.0
Time:	2:50	3:08	3:27

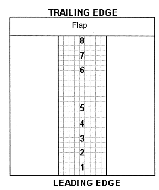
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96	80	5
3			
4			
5	119	150	14
6			
7			
8	80	96	14
Flap	30	6	7
Time:	2:50	3:08	3:27

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

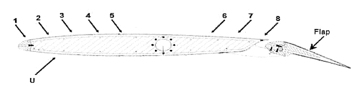


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D21: Run # 21

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

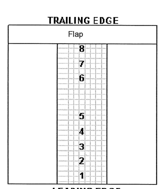
Date: January 31, 2018 Run: 22 (P091)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.3	-12.9	-17.7	-17.0
T5	-15.8	-13.0	-16.3	-17.1
TU	-16.0	-15.6	-16.1	-16.8
Time:	3:36	3:48	4:01	4:09

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.25	31.0	32.25
8		34.0	33.75
Flap		29.25	32.5
Time:	3:47	4:02	4:16

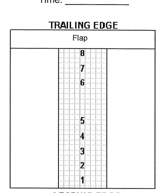
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	112	1
3			
4			
5	134	115	5
6			
7			
8	96	127	9
Flap	28	11	10
Time:	3:47	4:02	4:16

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

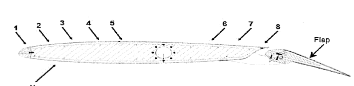


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

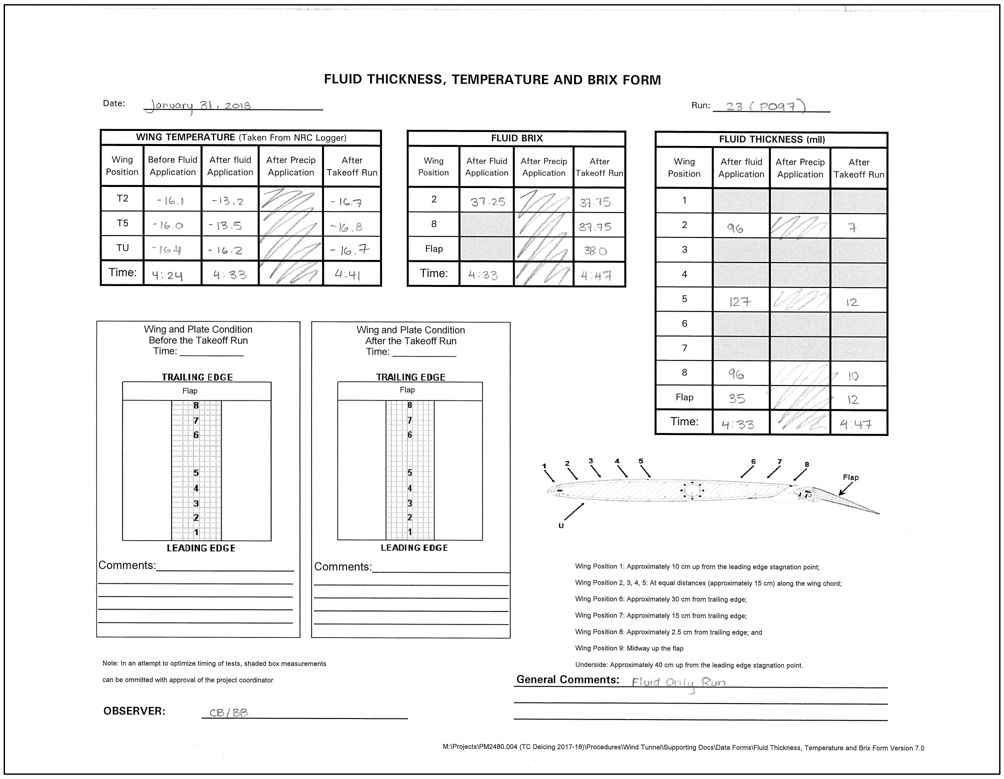
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D22: Run # 22



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 23 (P097)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-16.1	-13.2		-16.7
T5	-16.0	-13.5		-16.8
TU	-16.4	-16.2		-16.7
Time:	4:24	4:33		4:41

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.25		37.75
8			37.75
Flap			38.0
Time:	4:33		4:47

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96		7
3			
4			
5	127		12
6			
7			
8	96		10
Flap	35		12
Time:	4:33		4:47

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ___

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ___

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

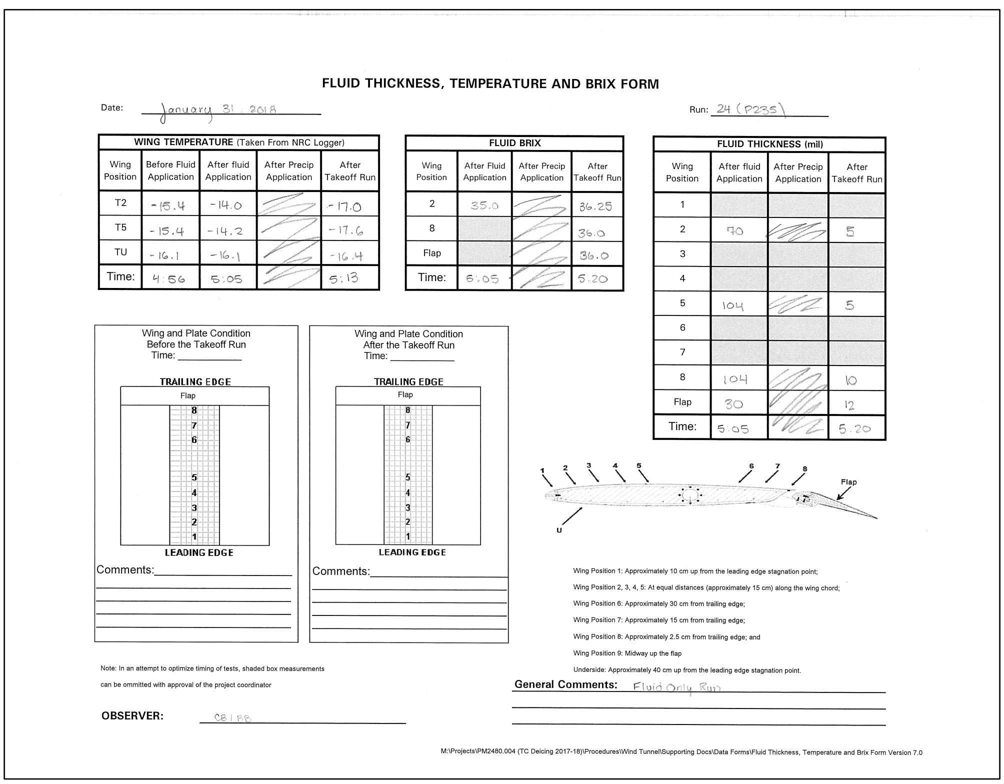
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid Only Run

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D23: Run # 23



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31 2018 Run: 24 (P235)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.4	-14.0		-17.0
T5	-15.4	-14.2		-17.6
TU	-16.1	-16.1		-16.4
Time:	4:56	5:05		5:13

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0		36.25
8			36.0
Flap			36.0
Time:	5:05		5:20

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70		5
3			
4			
5	104		5
6			
7			
8	104		10
Flap	30		12
Time:	5:05		5:20

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ___

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ___

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid Only Run

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D24: Run # 24

No Data Available

Figure D25: Run # 25

No Data Available

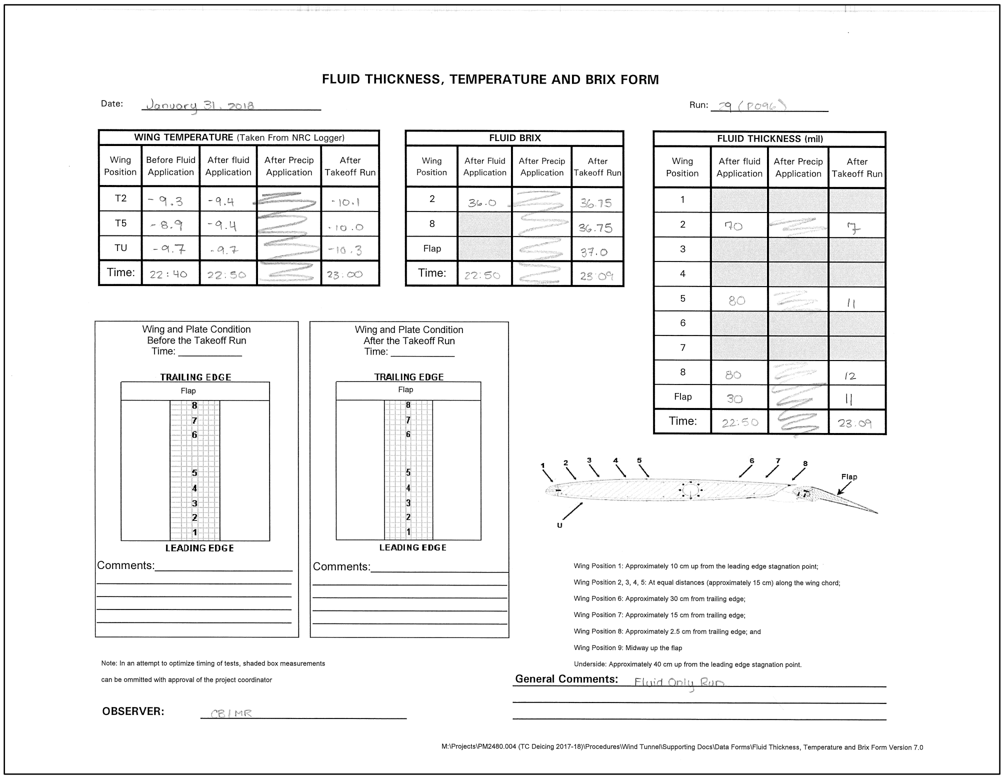
Figure D26: Run # 26

No Data Available

Figure D27: Run # 27

No Data Available

Figure D28: Run # 28



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 29 (P096)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-9.3	-9.4		-10.1
T5	-8.9	-9.4		-10.0
TU	-9.7	-9.7		-10.3
Time:	22:40	22:50		23:00

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.0		36.75
8			36.75
Flap			37.0
Time:	22:50		23:09

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70		7
3			
4			
5	80		11
6			
7			
8	80		12
Flap	30		11
Time:	22:50		23:09

Wing and Plate Condition Before the Takeoff Run Time: ___

TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ___

TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

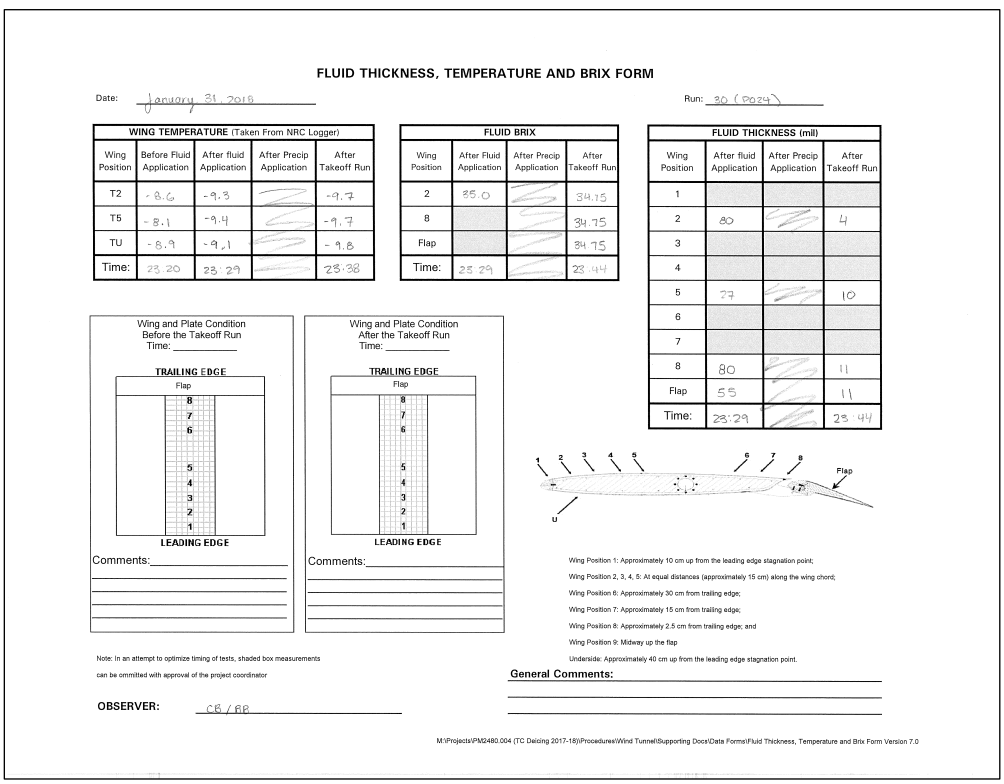
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid Only Run

OBSERVER: CB/MR

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D29: Run # 29



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 30 (P024)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.6	-9.3		-9.7
T5	-8.1	-9.4		-9.7
TU	-8.9	-9.1		-9.8
Time:	23:20	23:29		23:38

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0		34.75
8			34.75
Flap			34.75
Time:	23:29		23:44

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80		4
3			
4			
5	27		10
6			
7			
8	80		11
Flap	55		11
Time:	23:29		23:44

Wing and Plate Condition Before the Takeoff Run Time: ___

TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ___

TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

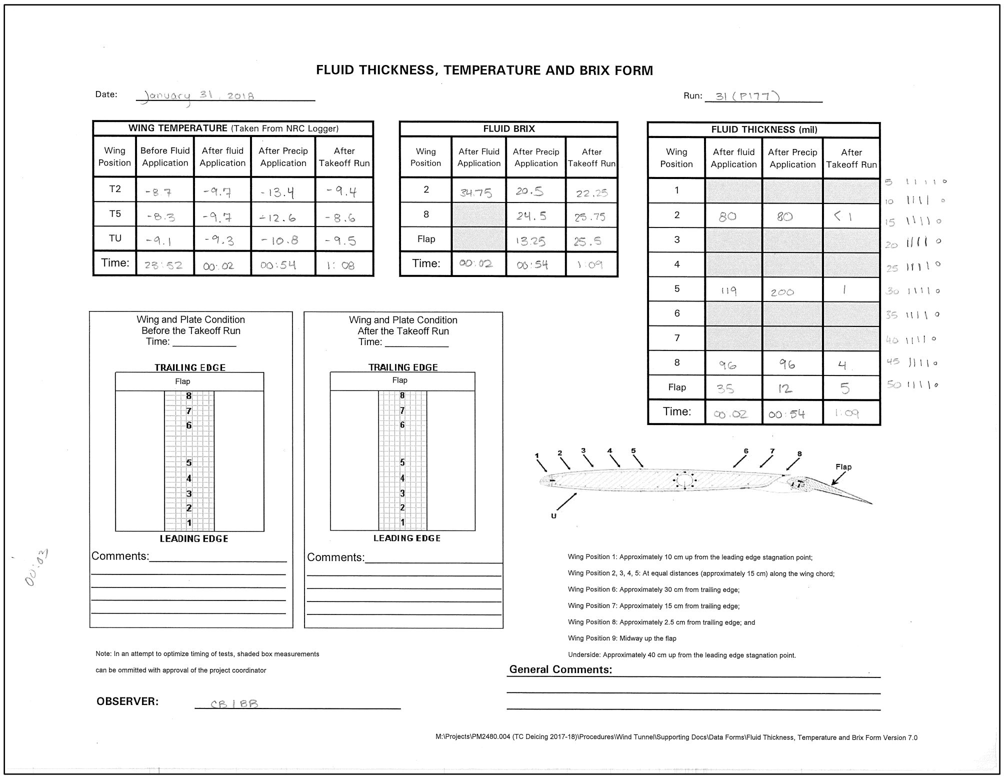
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D30: Run # 30



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 31, 2018 Run: 31 (P177)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.7	-9.7	-13.4	-9.4
T5	-8.3	-9.7	-12.6	-8.6
TU	-9.1	-9.3	-10.8	-9.5
Time:	23:52	00:02	00:54	1:08

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	20.5	22.25
8		24.5	25.75
Flap		13.25	25.5
Time:	00:02	00:54	1:09

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	<1
3			
4			
5	119	200	1
6			
7			
8	96	96	4
Flap	35	12	5
Time:	00:02	00:54	1:09

Wing and Plate Condition Before the Takeoff Run Time: ___

TRAILING EDGE / Flap / LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ___

TRAILING EDGE / Flap / LEADING EDGE

Comments:

00:03

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

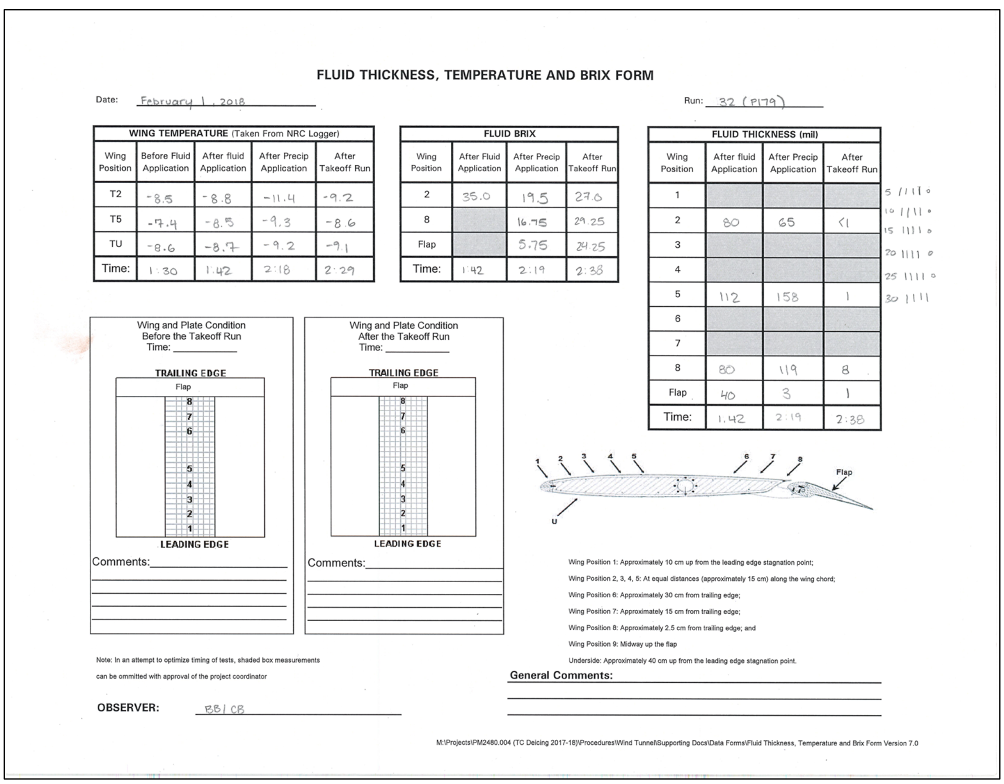
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D31: Run # 31



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018 Run: 32 (P179)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.5	-8.8	-11.4	-9.2
T5	-7.4	-8.5	-9.3	-8.6
TU	-8.6	-8.7	-9.2	-9.1
Time:	1:30	1:42	2:18	2:29

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	19.5	27.0
8		16.75	29.25
Flap		5.75	24.25
Time:	1:42	2:19	2:38

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	65	<1
3			
4			
5	112	158	1
6			
7			
8	80	119	8
Flap	40	3	1
Time:	1.42	2:19	2:38

Wing and Plate Condition Before the Takeoff Run Time: ___

TRAILING EDGE / Flap / LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ___

TRAILING EDGE / Flap / LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

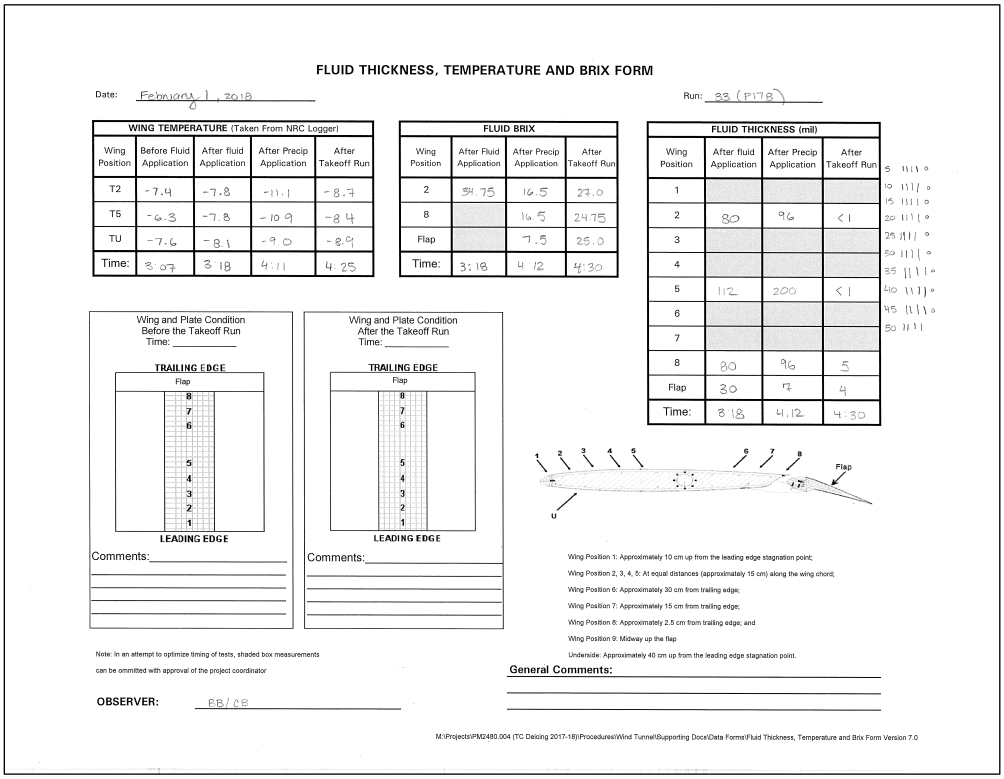
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D32: Run # 32



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018 Run: 33 (P178)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.4	-7.8	-11.1	-8.7
T5	-6.3	-7.8	-10.9	-8.4
TU	-7.6	-8.1	-9.0	-8.9
Time:	3:07	3:18	4:11	4:25

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	16.5	27.0
8		16.5	24.75
Flap		7.5	25.0
Time:	3:18	4:12	4:30

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	96	<1
3			
4			
5	112	200	<1
6			
7			
8	80	96	5
Flap	30	7	4
Time:	3:18	4:12	4:30

Wing and Plate Condition Before the Takeoff Run Time: ______ — TRAILING EDGE, Flap, 8 7 6 5 4 3 2 1, LEADING EDGE — Comments:

Wing and Plate Condition After the Takeoff Run Time: ______ — TRAILING EDGE, Flap, 8 7 6 5 4 3 2 1, LEADING EDGE — Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

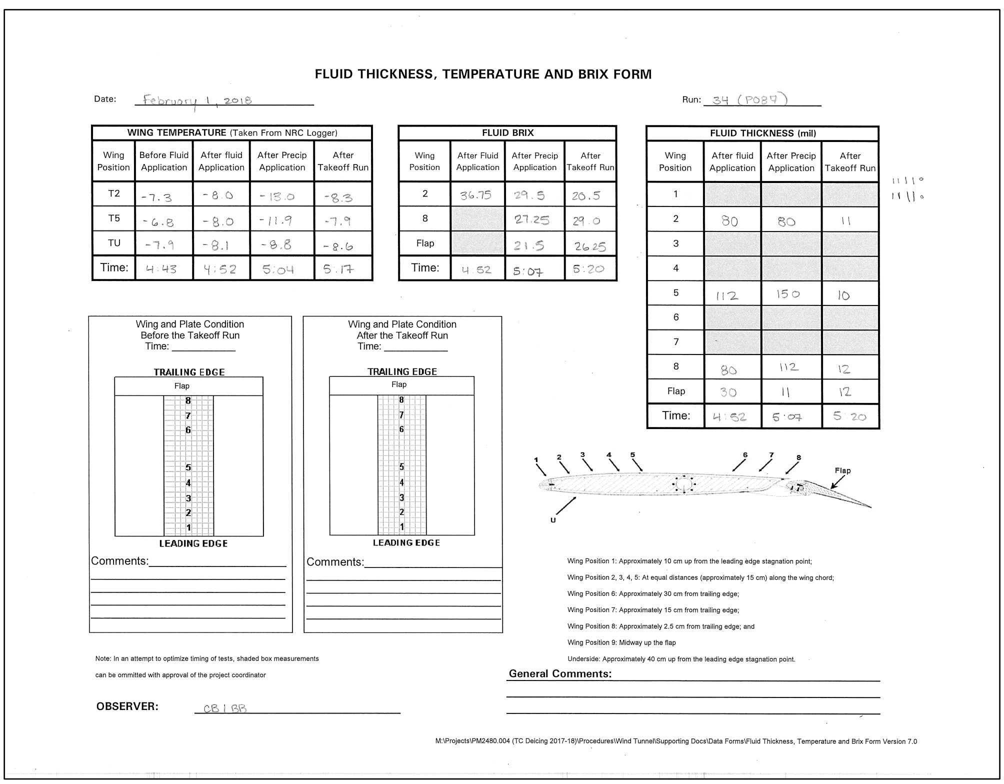
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB/CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D33: Run # 33



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018 Run: 34 (P087)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.3	-8.0	-13.0	-8.3
T5	-6.8	-8.0	-11.9	-7.9
TU	-7.9	-8.1	-8.8	-8.6
Time:	4:43	4:52	5:04	5:17

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.75	29.5	20.5
8		27.25	29.0
Flap		21.5	26.25
Time:	4:52	5:07	5:20

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	11
3			
4			
5	112	150	10
6			
7			
8	80	112	12
Flap	30	11	12
Time:	4:52	5:07	5:20

Wing and Plate Condition Before the Takeoff Run Time: ______ — TRAILING EDGE, Flap, 8 7 6 5 4 3 2 1, LEADING EDGE — Comments:

Wing and Plate Condition After the Takeoff Run Time: ______ — TRAILING EDGE, Flap, 8 7 6 5 4 3 2 1, LEADING EDGE — Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

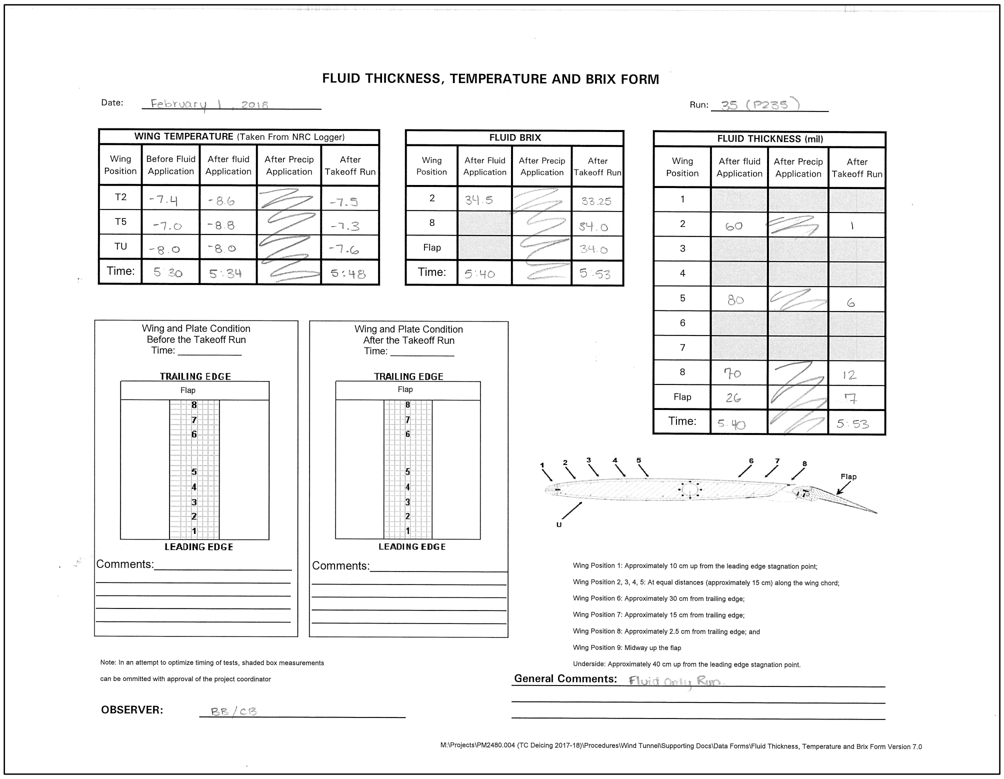
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D34: Run # 34



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018

Run: 35 (P235)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.4	-8.6		-7.5
T5	-7.0	-8.8		-7.3
TU	-8.0	-8.0		-7.6
Time:	5:30	5:34		5:48

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5		33.25
8			34.0
Flap			34.0
Time:	5:40		5:53

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	60		1
3			
4			
5	80		6
6			
7			
8	70		12
Flap	26		7
Time:	5:40		5:53

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid Only Run.

OBSERVER: BB/CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D35: Run # 35

No Data Available

Figure D36: Run # 36

No Data Available

Figure D37: Run # 37

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018

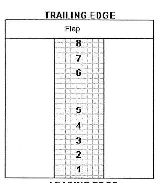
Run: 38 (P082)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-0.4	-2.6	-6.8	-2.8
T5	-0.7	-2.5	-5.1	-2.4
TU	-0.7	-1.3	-2.6	-3.0
Time:	19:03	19:13	19:26	19:41

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.5	15.5	24.25
8		16.0	36.0
Flap		13.5	24.5
Time:	19:13	19:27	19:43

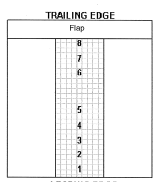
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	70	1
3			
4			
5	112	158	3
6			
7			
8	70	80	3
Flap	30	11	4
Time:	19:13	19:27	19:43

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

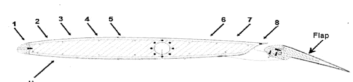


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:___________________

OBSERVER: CB/R.B.

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D38: Run # 38

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018

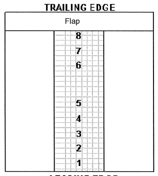
Run: 39 (P010)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-3.2	-4.5	-9.1	-5.0
T5	-3.1	-4.8	-6.9	-4.5
TU	-3.5	-3.7	-5.0	-5.0
Time:	19:56	20:03	20:19	20:31

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	15.75	29.25
8		15.25	28.25
Flap		12.0	28.0
Time:	20:05	20:19	20:35

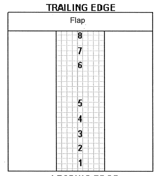
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	55	<1
3			
4			
5	112	150	<1
6			
7			
8	104	80	4
Flap	30	10	1
Time:	20:05	20:20	20:35

Wing and Plate Condition Before the Takeoff Run
Time: ____________

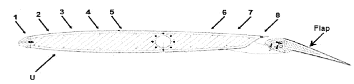


Comments:____________________

Wing and Plate Condition After the Takeoff Run
Time: ____________



Comments:____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Temps were a little colder than desired.

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D39: Run # 39

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 1, 2018

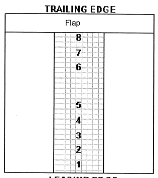
Run: 40 (P003)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-4.7	-5.2	-11.9	-7.9
T5	-4.5	-5.2	-10.8	-7.9
TU	-4.9	-5.2	-8.8	-8.0
Time:	20:55	21:04	21:54	22:04

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	16.5	29.75
8		16.75	28.25
Flap		13.75	28.75
Time:	21:04	21:55	22:10

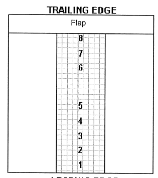
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	1
3			
4			
5	112	158	<1
6			
7			
8	80	80	2
Flap	40	2	2
Time:	21:04	21:55	22:09

Wing and Plate Condition Before the Takeoff Run
Time: ____________

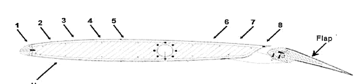


Comments:____________________

Wing and Plate Condition After the Takeoff Run
Time: ____________



Comments:____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____________________

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D40: Run # 40

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

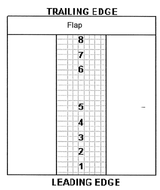
Date: February 1, 2018   Run: 41 (P075)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.5	-7.4	-11.1	-9.3
T5	-7.5	-7.4	-10.7	-8.9
TU	-7.9	-8.0	-9.1	-9.4
Time:	22:22	22:31	23:21	23:37

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.75	22.0	25.5
8		21.25	26.0
Flap		17.0	26.0
Time:	22:31	23:21	

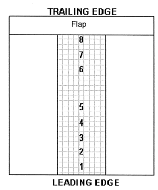
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	5
3			
4			
5	127	200	10
6			
7			
8	80	96	12
Flap	30	5	11
Time:	22:31	23:21	23:40

Wing and Plate Condition Before the Takeoff Run
Time: ___________

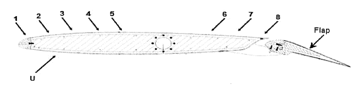


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D41: Run # 41

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

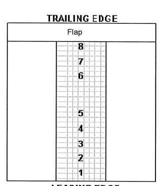
Date: February 2, 2018   Run: 42 (F181)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.7	-7.8	-15.9	-11.5
T5	-8.6	-7.6	-14.9	-11.1
TU	-9.1	-8.8	-11.9	-11.4
Time:	00:05	00:14	00:40	00:53

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	19.25	30.5
8		20.75	26.75
Flap		17.0	27.0
Time:	00:15	00:40	00:57

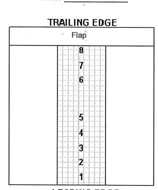
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	119	1
3			
4			
5	134	250	2
6			
7			
8	80	134	11
Flap	30	4	4
Time:	00:15	00:40	00:57

Wing and Plate Condition Before the Takeoff Run
Time: ___________

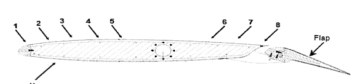


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure D42: Run # 42

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 2, 2018

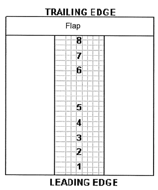
Run: 43 (P1B1)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-10.8	-9.8	-11.2	-12.2
T5	-10.7	-9.9	-9.3	-11.6
TU	-11.1	-11.2	-11.6	-12.2
Time:	1:16	1:21	2:03	2:18

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	19.75	30.25
8		18.25	30.5
Flap		ice	29.5
Time:	1:25	2:04	2:22

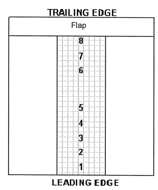
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	50	<1
3			
4			
5	112	200	5
6			
7			
8	96	80	9
Flap	45	ice	3 (just above line of ice)
Time:	1:25	2:04	2:22

Wing and Plate Condition Before the Takeoff Run
Time: ___________

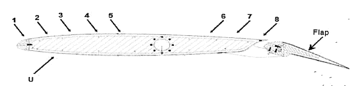


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

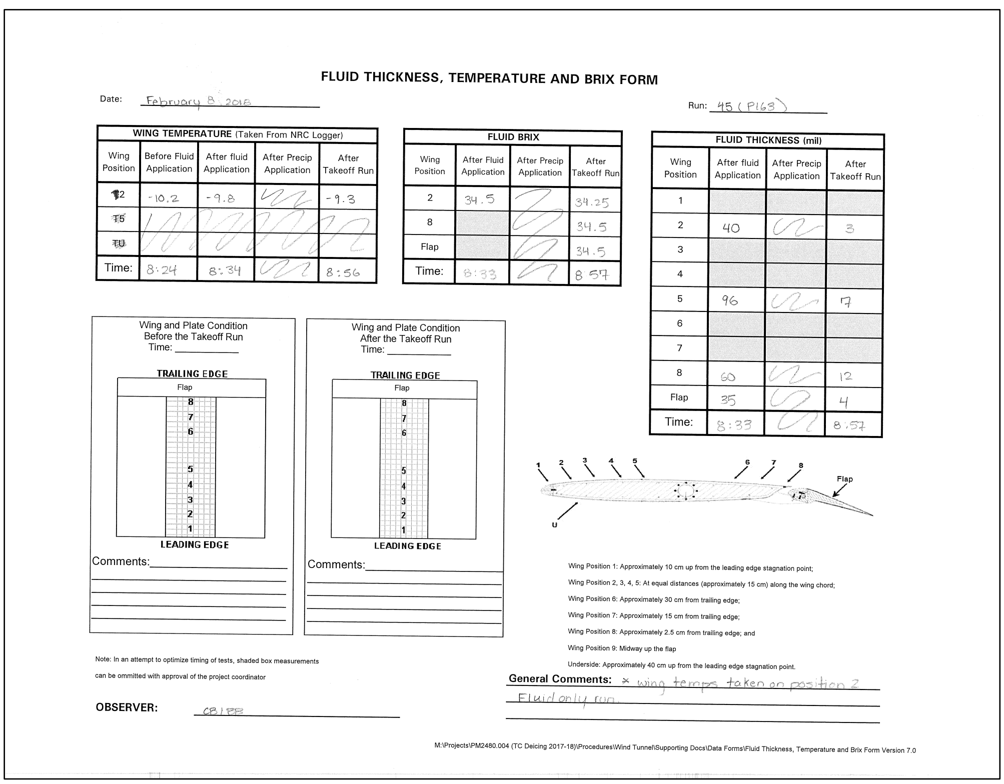
Figure D43: Run # 43

APPENDIX E

LOW SPEED TESTING 2017-18
FLUID THICKNESS, TEMPERATURE, AND BRIX DATA FORMS

No Data Available

Figure E1: Runs # 1 to 44



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

Run: 45 (P163)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
~~1~~2	-10.2	-9.8		-9.3
~~T5~~				
~~TU~~				
Time:	8:24	8:34		8:56

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5		34.25
8			34.5
Flap			34.5
Time:	8:33		8:57

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	40		3
3			
4			
5	96		7
6			
7			
8	60		12
Flap	35		4
Time:	8:33		8:57

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2
Fluid only run.

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E2: Run # 45

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

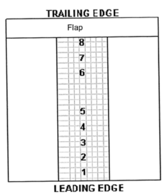
Date: February 8, 2018 Run: 46 (P163)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-9.7	-9.0		-9.6
T5				
TU				
Time:	9:09	9:18		9:34

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75		34.5
8			34.75
Flap			34.5
Time:	9:19		9:35

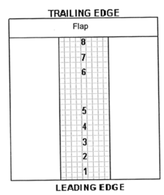
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	50		4
3			
4			
5	112		7
6			
7			
8	50		12
Flap	35		5
Time:	9:19		9:35

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

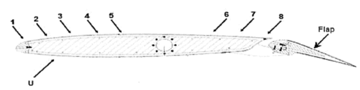


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E3: Run # 46

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

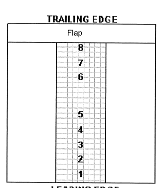
Date: February 8, 2018 Run: 47 (P163)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
~~T~~2	-8.6	-7.9		
~~T5~~				
~~TU~~				
Time:	10:17	10:25		

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75		
8			
Flap			
Time:	10:26		

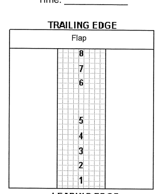
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	45		
3			
4			
5	96		
6			
7			
8	45		
Flap	30		
Time:	10:26		

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

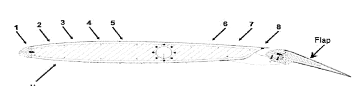


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2
skip post measurements due to bad run

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E4: Run # 47

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

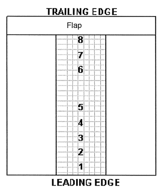
Run: 48 (P163)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.8	-7.1		-6.7
~~T5~~				
~~TU~~				
Time:	10:48	10:58		11:10

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5		35.25
8			34.75
Flap			35.0
Time:	10:58		11:10

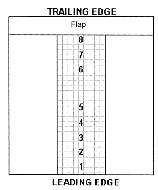
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35		4
3			
4			
5	96		9
6			
7			
8	45		18
Flap	30		5
Time:	10:58		11:10

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

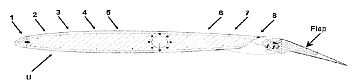


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E5: Run # 48

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

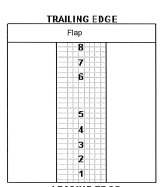
Run: 49 (P149)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-6.1	-5.3	-8.0	-6.7
~~T5~~				
~~TU~~				
Time:	11:27	11:40	12:00	12:17

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	18.25	32.75
8		15.75	25.5
Flap		18.25	27.0
Time:	11:40	12:00	12:16

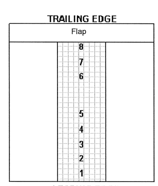
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	40	34	<1
3			
4			
5	96	80	1
6			
7			
8	40	20	7
Flap	30	12	1
Time:	11:40	12:00	12:16

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

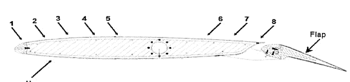


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E6: Run # 49

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

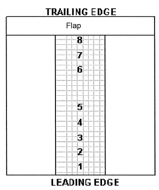
Run: 50 (P169)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-6.7	-6.6	—	-6.3
T5	—	—	—	—
TU	—	—	—	—
Time:	12:28	12:37	—	12:49

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	—	37.0
8		—	35.5
Flap		—	36.25
Time:	12:37	—	12:49

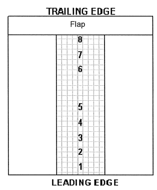
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35	—	1
3			
4			
5	96	—	8
6			
7			
8	40	—	11
Flap	30	—	5
Time:	12:37	—	12:49

Wing and Plate Condition Before the Takeoff Run
Time: ___________

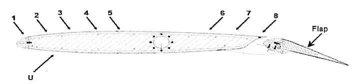


Comments: ____________________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments: ____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: * wing temps taken on position 2

OBSERVER: BB/CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E7: Run # 50

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

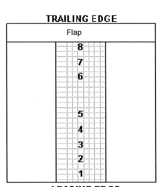
Run: 51 (P025)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.6	-6.4	—	-5.5
T5	—	—	—	—
TU	—	—	—	—
Time:	13:01	13:15	—	

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	—	36.25
8		—	35.5
Flap		—	36.5
Time:	13:16	—	13:30

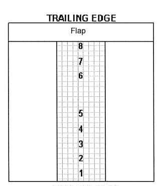
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70	—	4
3			
4			
5	119	—	6
6			
7			
8	70	—	20
Flap	55	—	6
Time:	13:16	—	13:30

Wing and Plate Condition Before the Takeoff Run
Time: ___________

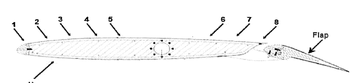


Comments: ____________________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments: ____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

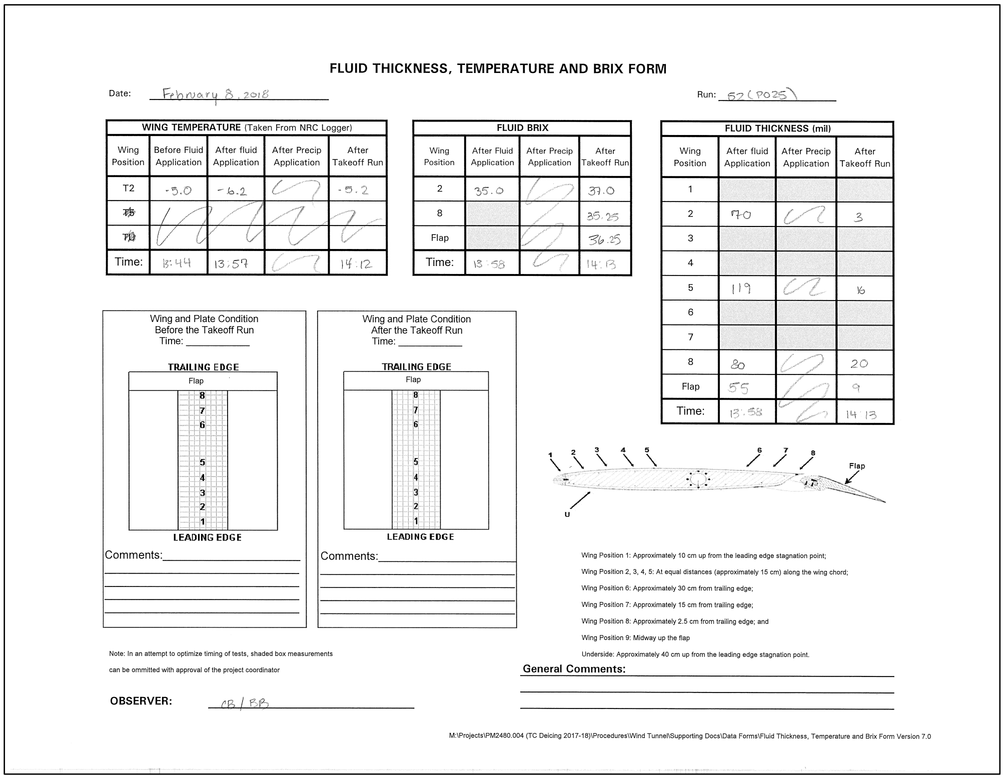
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Fluid only run

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E8: Run # 51



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018 Run: 52 (P025)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.0	-6.2		-5.2
~~T5~~				
~~T10~~				
Time:	13:44	13:57		14:12

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0		37.0
8			35.25
Flap			36.25
Time:	13:58		14:13

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70		3
3			
4			
5	119		16
6			
7			
8	80		20
Flap	55		9
Time:	13:58		14:13

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

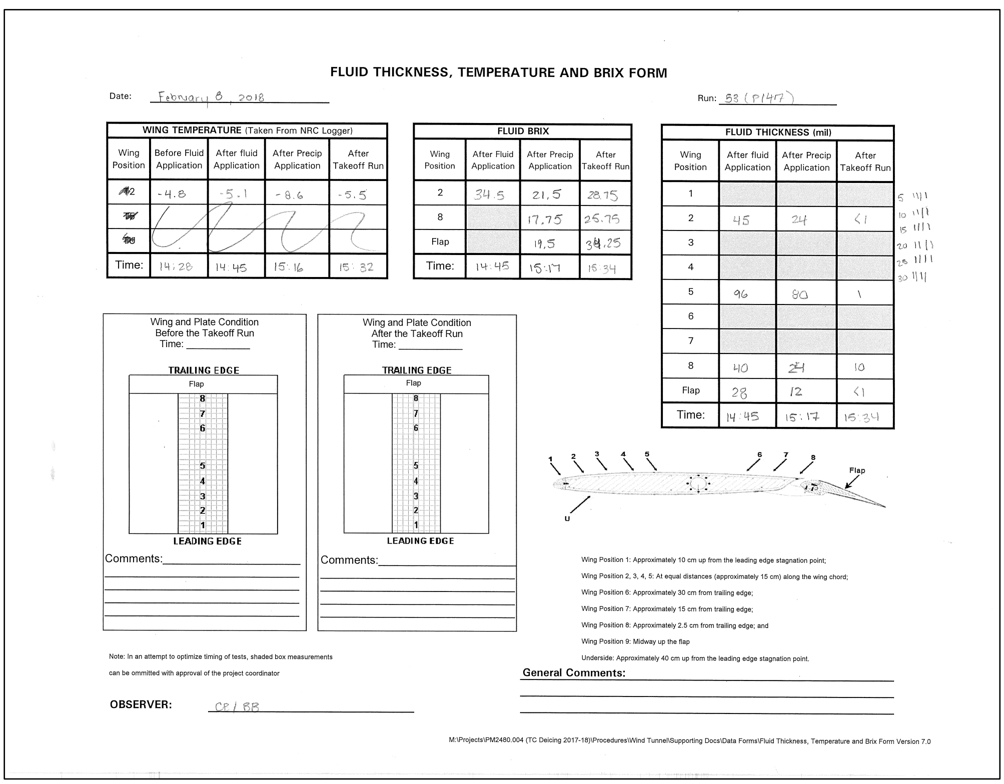
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E9: Run # 52



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018 Run: 53 (P147)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-4.8	-5.1	-8.6	-5.5
~~T5~~				
~~T10~~				
Time:	14:28	14:45	15:16	15:32

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5	21.5	28.75
8		17.75	25.75
Flap		19.5	34.25
Time:	14:45	15:17	15:34

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	45	24	<1
3			
4			
5	96	80	1
6			
7			
8	40	24	10
Flap	28	12	<1
Time:	14:45	15:17	15:34

5 ||||
10 ||||
15 ||||
20 ||||
25 ||||
30 ||||

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

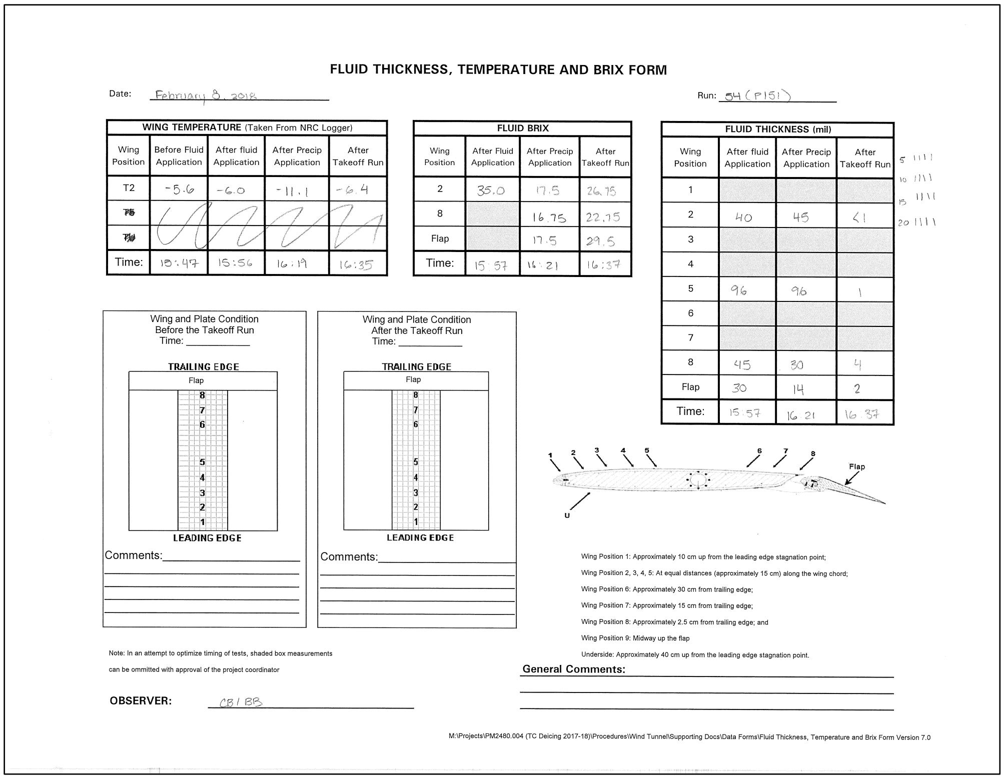
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E10: Run # 53



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 8, 2018

Run: 54 (P151)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.6	-6.0	-11.1	-6.4
T5				
T4				
Time:	15:47	15:56	16:19	16:35

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	17.5	26.75
8		16.75	22.75
Flap		17.5	29.5
Time:	15:57	16:21	16:37

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	40	45	<1
3			
4			
5	96	96	1
6			
7			
8	45	30	4
Flap	30	14	2
Time:	15:57	16:21	16:37

5 ||||
10 ||||
15 ||||
20 ||||

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E11: Run # 54

No Data Available

Figure E12: Run # 55

No Data Available

Figure E13: Run # 56

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018

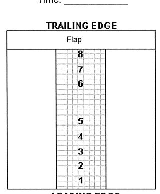
Run: 57 (P163)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-6.9	-6.9		-8.5
T5				
TU				
Time:	8:06	8:14		8:27

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5		35.5
8			35.25
Flap			35.0
Time:	8:15		8:28

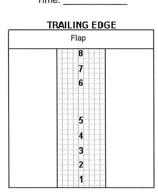
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	40		2
3			
4			
5	80		7
6			
7			
8	45		14
Flap	30		5
Time:	8:15		8:28

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

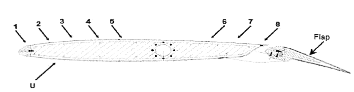


Comments: ____________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____________________

OBSERVER: CB | BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E14: Run # 57

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018 Run: 58 (P168)

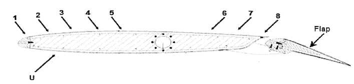
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-8.0	-7.9		-8.2
T5				
TU				
Time:	8:40	8:48		9:02

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5		35.5
8			35.25
Flap			35.25
Time:	8:49		9:03

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35		1
3			
4			
5	196		2
6			
7			
8	40		10
Flap	30		2
Time:	8:49		9:03

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E15: Run # 58

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018 Run: 59 (P153)

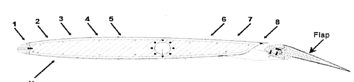
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.8	-7.9	-12.5	-9.2
T5				
TU				
Time:	9:14	9:22	9:44	

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	22.0	27.0
8		20.25	26.0
Flap		20.0	24.75
Time:	9:22	9:45	10:03

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	40	30	<1
3			
4			
5	96	104	<1
6			
7			
8	40	24	5
Flap	30	12	1
Time:	9:22	9:45	10:03

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E16: Run # 59

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018

Run: 60 (P154)

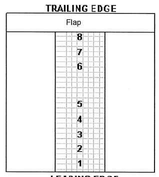
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
2	-8.7	-7.9	-8.3	-7.7
Time:	10:09	10:21	10:46	11:03

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	15.75	24.0
8		13.25	21.5
Flap		12.25	29.25
Time:	10:22	10:47	11:04

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35	20	<1
3			
4			
5	96	80	1
6			
7			
8	40	16	3
Flap	30	8	<1
Time:	10:22	10:47	11.04

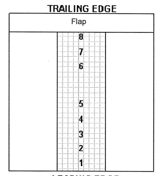
5 ||||o
10 ||||o
15 ||||o
20 ||
25

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

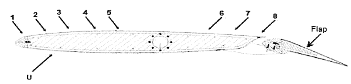


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Wing temp measurements taken on position 2

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E17: Run # 60

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018

Run: 61 (P155)

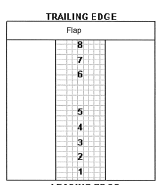
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
2	-6.8	-6.6	-11.9	-9.0
Time:	11:15	11:24	11:47	12.12

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	18.5	26.0
8		17.25	22.0
Flap		17.5	28.0
Time:	11:24	11:48	12:12

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35	35	<1
3			
4			
5	96	80	1
6			
7			
8	35	9	4
Flap	30	1	<1
Time:	11:24	11:48	12:12

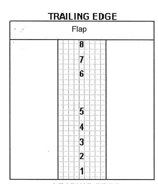
5 ||||o
10 ||||o
15 ||||o
20 ||||o
~~25~~

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

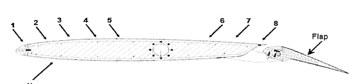


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: Wing temp measurements taken on position 2

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E18: Run # 61

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9 2018

Run: 62 (P152)

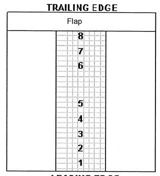
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-7.1	-7.0	-10.1	
T5				
TU				
Time:	12:19	12:28	13:12	13:34

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75	18.25	27.0
8		15.75	24.25
Flap		15.75	27.5
Time:	13:13	13:13	13:34

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35	18	<1
3			
4			
5	96	64	<1
6			
7			
8	35	14	6
Flap	30	7	<1
Time:	12:28	13:13	13:34

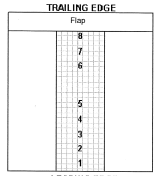
5 ||||
10 ||||
15 ||||
20 ||||
25 ||||
30 ||||
35 ||||
40 ||||

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

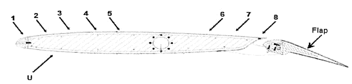


Comments:

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E19: Run # 62

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9 2018

Run: 63 (P240)

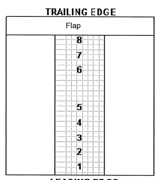
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-6.5	-5.3	-7.0	
T5				
TU				
Time:	13:55	14:07	14:46	

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.5	not possible	
8		" "	
Flap		" "	
Time:	14:07	14:46	

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	30	see pics	
3			
4			
5	112	1cm+ see pics	
6			
7			
8	35	1cm see pics	
Flap	30	0.5cm see pics	
Time:		14:46	

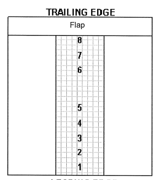
5 ||||
10 ||||
15 ||||
20 ||||
25 ||||

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

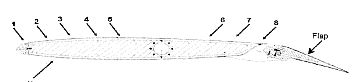


Comments:

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: skipping post measurements

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E20: Run # 63

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: February 9, 2018

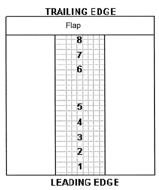
Run: 64 (P162)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.6	-5.0		-4.6
T5				
TU				
Time:	15:10	15:22		15:35

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.75		29.75
8			34.75
Flap			35.25
Time:	15:22		15:35

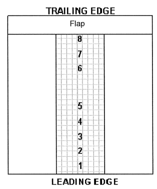
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	35		1
3			
4			
5	96		7
6			
7			
8	35		10
Flap	30		4
Time:	15:22		15:35

Wing and Plate Condition Before the Takeoff Run
Time: ___________

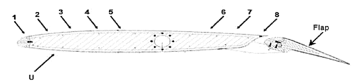


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure E21: Run # 64

This page intentionally left blank.

APPENDIX F

HIGH SPEED TESTING 2018-19
FLUID THICKNESS, TEMPERATURE, AND BRIX DATA FORMS

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

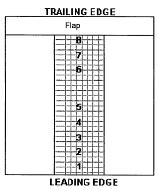
Run: 1 (P001) NRC 68
2 (P002) NRC 69

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
L T2	-16.0			-21.7
T T5	-17.7			-23.5
TU	-17.0			-22.2
Time:	00:47			00:55

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

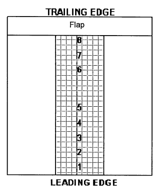
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

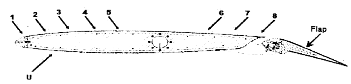


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F1: Runs # 1 to 2

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

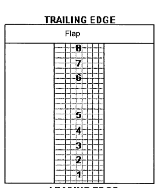
Run: 3 (P027)
NRC 70

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
L T2	-21.4	-19.6		-22.5
T T5	-22.9	-20.9		-23.0
U TU	-21.9	-21.8		-23.7
Time:	1:03	1:20		1:29

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.5		32.5
8			34.0
Flap			34.25
Time:	1:20		1:35

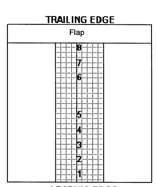
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	112		9
3			
4			
5	150		7
6			
7			
8	158		9
Flap	50		7
Time:	1:21		1:35

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

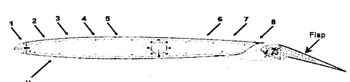


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

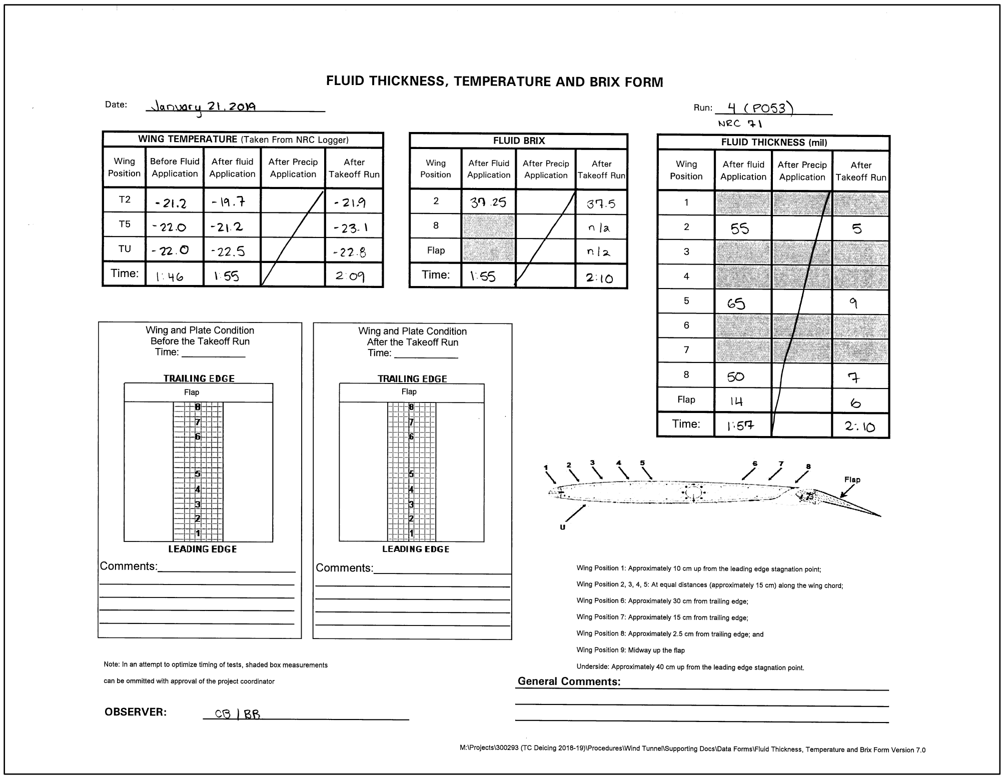
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB / BB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F2: Run # 3



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 4 (P053) NRC 71

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.2	-19.7		-21.9
T5	-22.0	-21.2		-23.1
TU	-22.0	-22.5		-22.8
Time:	1:46	1:55		2:09

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.25		37.5
8			n/a
Flap			n/a
Time:	1:55		2:10

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	55		5
3			
4			
5	65		9
6			
7			
8	50		7
Flap	14		6
Time:	1:57		2:10

Wing and Plate Condition Before the Takeoff Run Time: ____
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run Time: ____
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

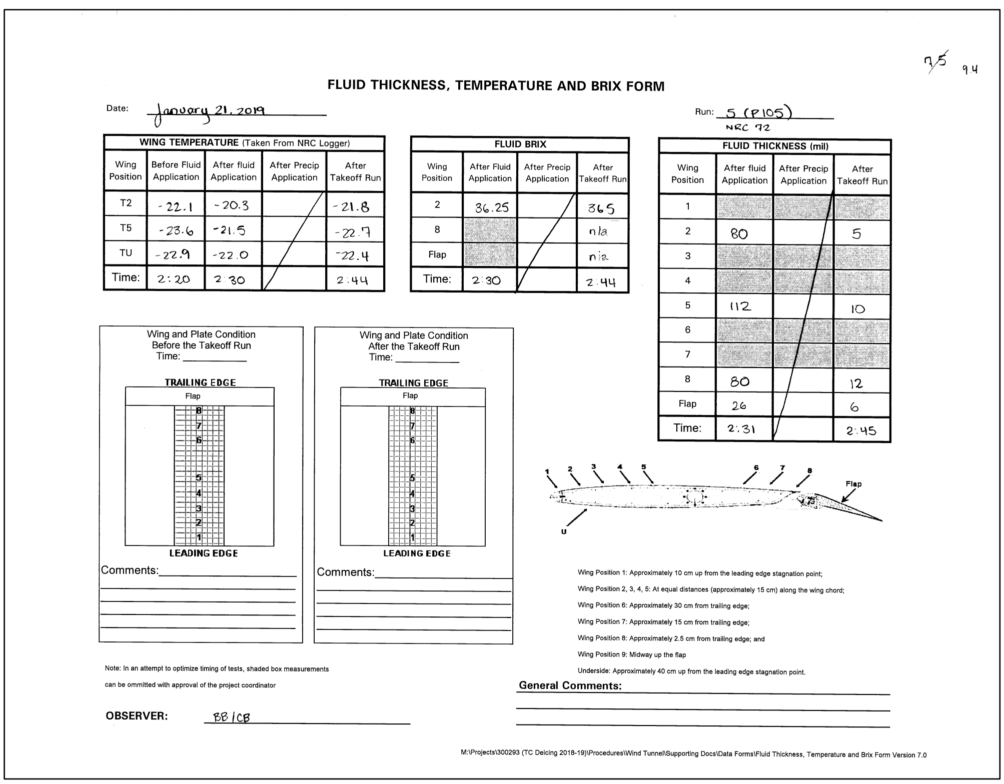
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB / BB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F3: Run # 4



7.5 9.4

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 5 (P105) NRC 72

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-22.1	-20.3		-21.8
T5	-23.6	-21.5		-22.7
TU	-22.9	-22.0		-22.4
Time:	2:20	2:30		2:44

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.25		36.5
8			n/a
Flap			n/a
Time:	2:30		2:44

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80		5
3			
4			
5	112		10
6			
7			
8	80		12
Flap	26		6
Time:	2:31		2:45

Wing and Plate Condition Before the Takeoff Run Time: ____
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run Time: ____
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

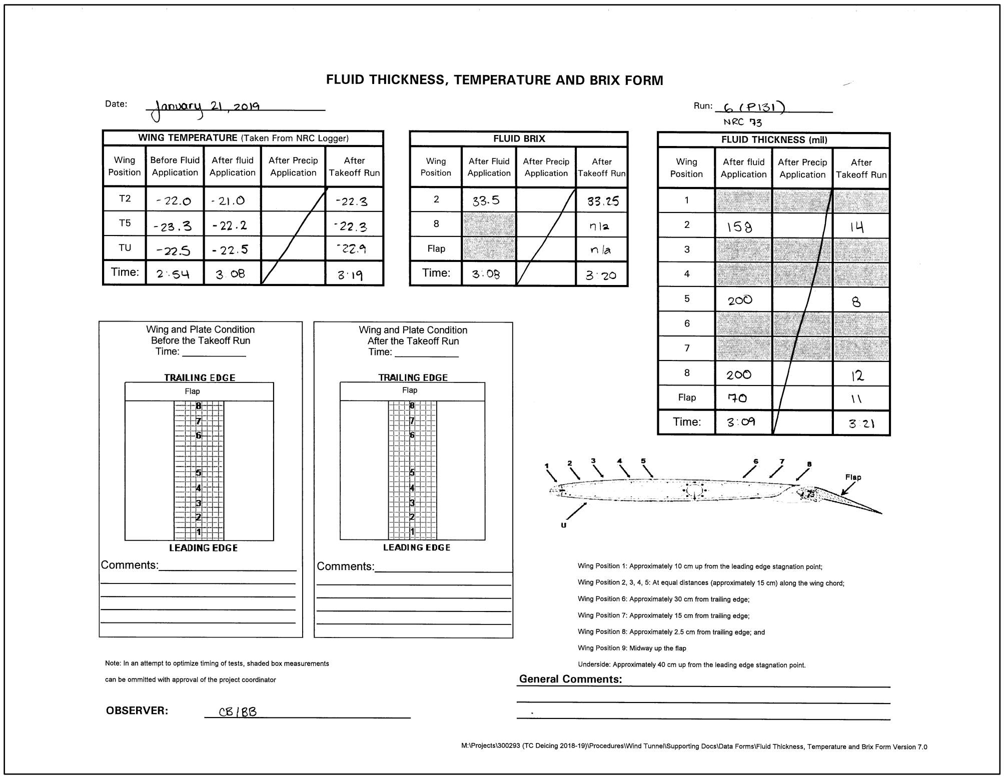
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F4: Run # 5



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 6 (P131) NRC 73

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-22.0	-21.0		-22.3
T5	-23.3	-22.2		-22.3
TU	-22.5	-22.5		-22.9
Time:	2:54	3:08		3:19

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.5		33.25
8			n/a
Flap			n/a
Time:	3:08		3:20

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	158		14
3			
4			
5	200		8
6			
7			
8	200		12
Flap	70		11
Time:	3:09		3:21

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

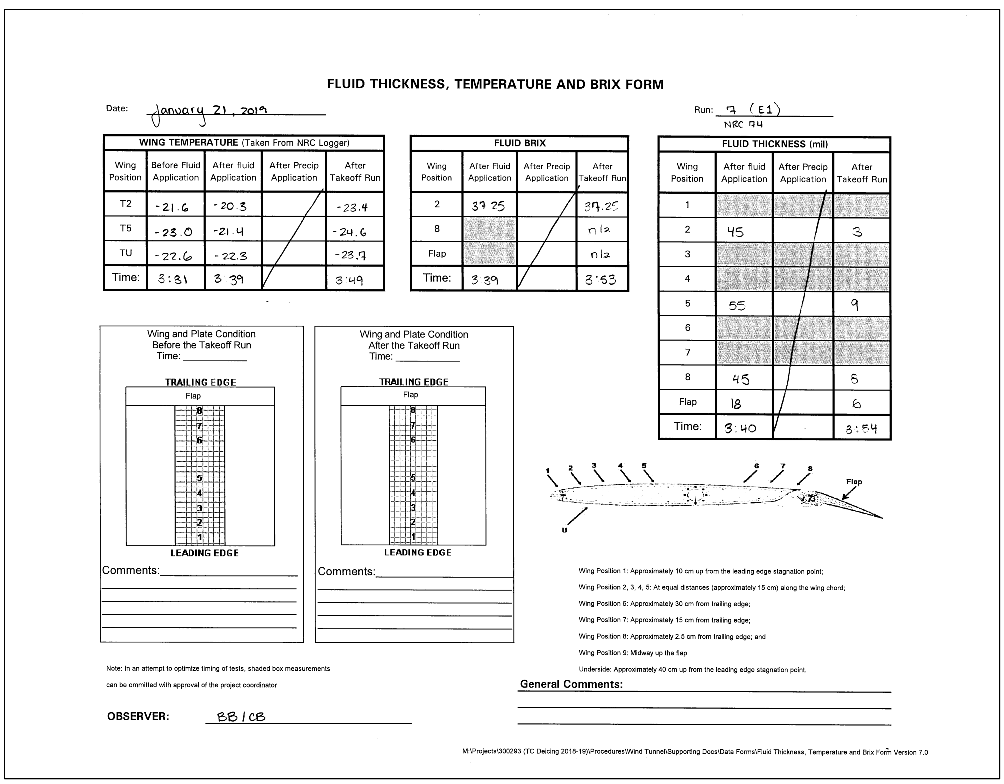
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB/BB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F5: Run # 6



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 7 (E1) NRC 74

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.6	-20.3		-23.4
T5	-23.0	-21.4		-24.6
TU	-22.6	-22.3		-23.7
Time:	3:31	3:39		3:49

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.25		37.25
8			n/a
Flap			n/a
Time:	3:39		3:53

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	45		3
3			
4			
5	55		9
6			
7			
8	45		8
Flap	18		6
Time:	3:40		3:54

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
LEADING EDGE
Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

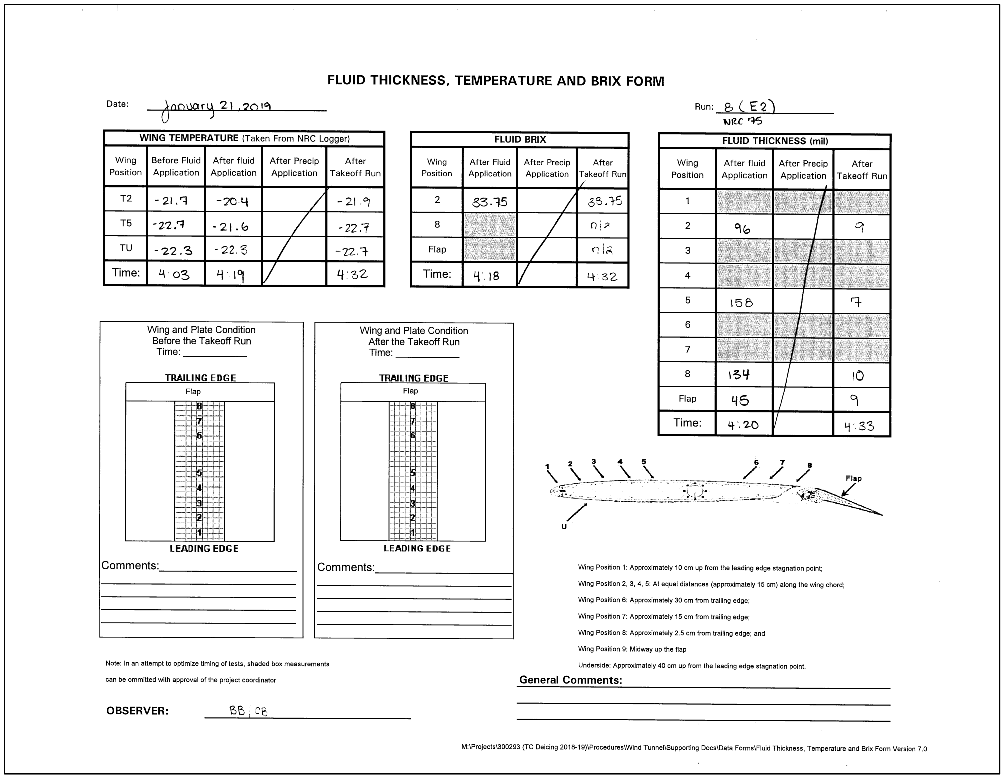
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB/CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F6: Run # 7



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 8 (E2)
NRC 75

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.7	-20.4		-21.9
T5	-22.7	-21.6		-22.7
TU	-22.3	-22.3		-22.7
Time:	4:03	4:19		4:32

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.75		33.75
8			n/a
Flap			n/a
Time:	4:18		4:32

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96		9
3			
4			
5	158		7
6			
7			
8	134		10
Flap	45		9
Time:	4:20		4:33

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

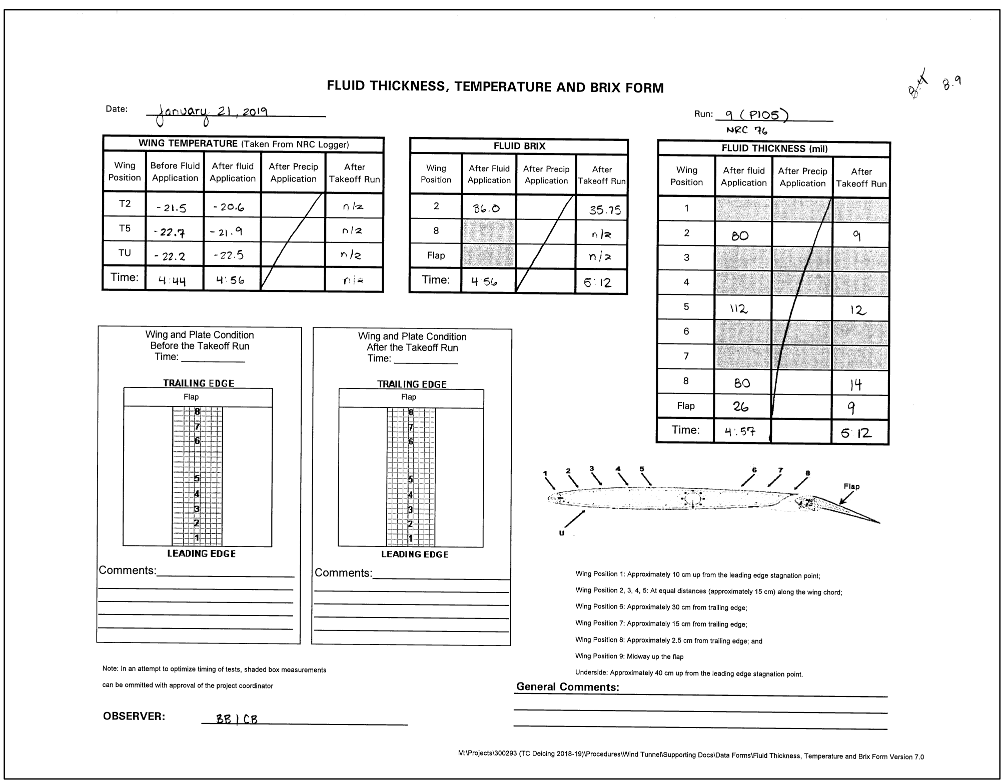
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB, CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F7: Run # 8



8.9

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 9 (P105)
NRC 76

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.5	-20.6		n/a
T5	-22.7	-21.9		n/a
TU	-22.2	-22.5		n/a
Time:	4:44	4:56		n/a

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.0		35.75
8			n/a
Flap			n/a
Time:	4:56		5:12

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80		9
3			
4			
5	112		12
6			
7			
8	80		14
Flap	26		9
Time:	4:57		5:12

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

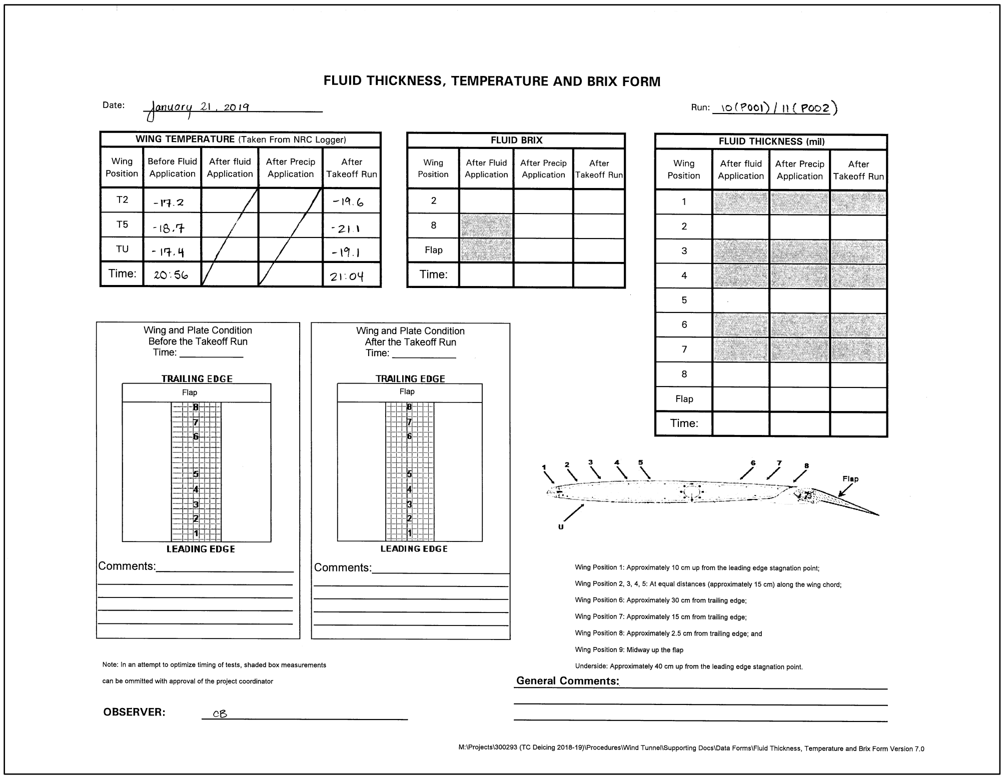
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB, CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F8: Run # 9



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019 Run: 10 (P001) / 11 (P002)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-17.2	/	/	-19.6
T5	-18.7	/	/	-21.1
TU	-17.4	/	/	-19.1
Time:	20:56	/	/	21:04

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition Before the Takeoff Run Time: ____ TRAILING EDGE Flap LEADING EDGE Comments:

Wing and Plate Condition After the Takeoff Run Time: ____ TRAILING EDGE Flap LEADING EDGE Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

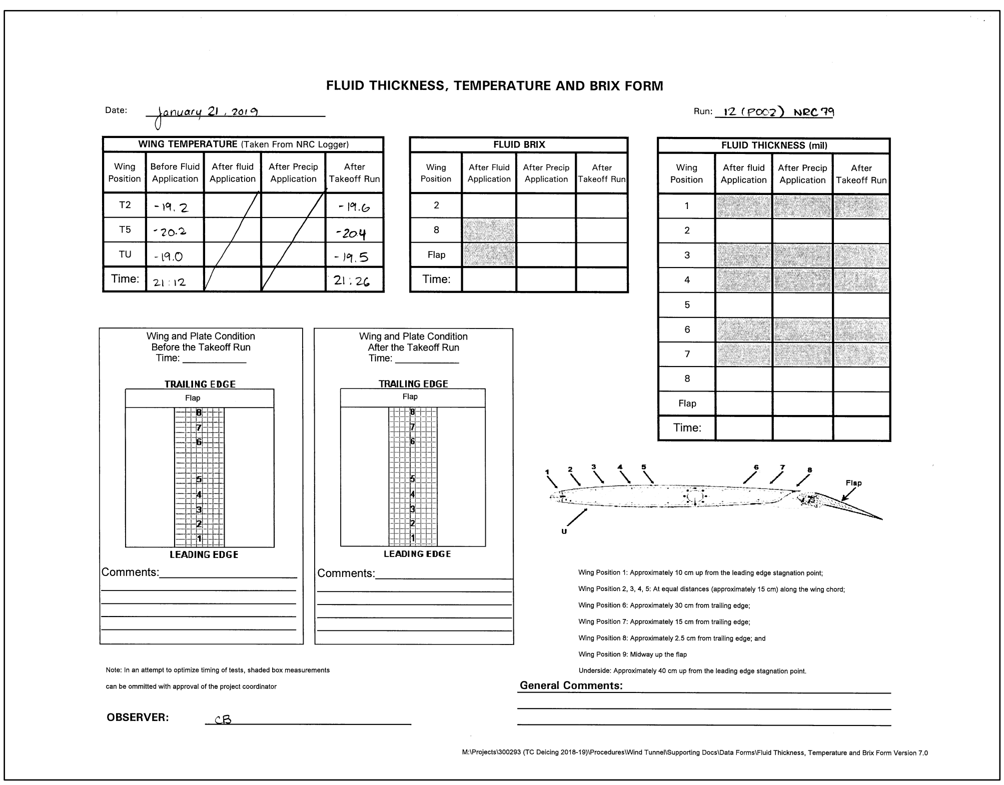
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F9: Runs # 10 to 11



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019 Run: 12 (P002) NRC 79

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-19.2	/	/	-19.6
T5	-20.2	/	/	-20.4
TU	-19.0	/	/	-19.5
Time:	21:12	/	/	21:26

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition Before the Takeoff Run Time: ____ TRAILING EDGE Flap LEADING EDGE Comments:

Wing and Plate Condition After the Takeoff Run Time: ____ TRAILING EDGE Flap LEADING EDGE Comments:

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

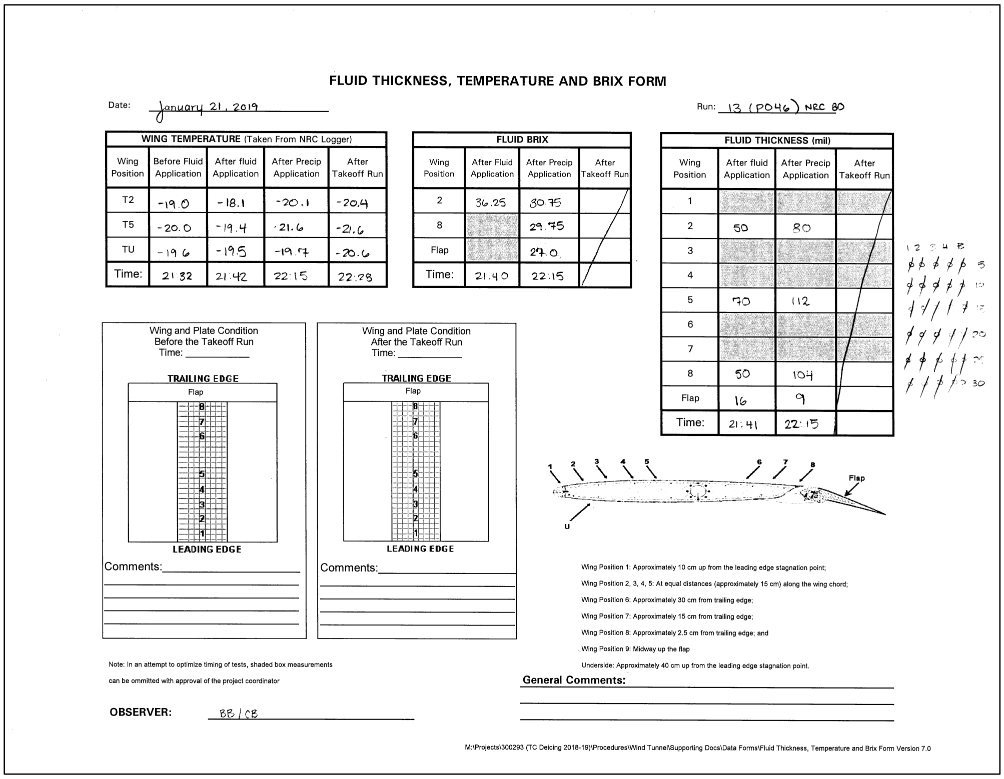
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F10: Run # 12



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 13 (P046) NRC 80

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-19.0	-18.1	-20.1	-20.4
T5	-20.0	-19.4	-21.6	-21.6
TU	-19.6	-19.5	-19.7	-20.6
Time:	21:32	21:42	22:15	22:28

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.25	30.75	
8		29.75	
Flap		27.0	
Time:	21:40	22:15	

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	50	80	
3			
4			
5	70	112	
6			
7			
8	50	104	
Flap	16	9	
Time:	21:41	22:15	

Wing and Plate Condition Before the Takeoff Run Time: ____ TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ____ TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

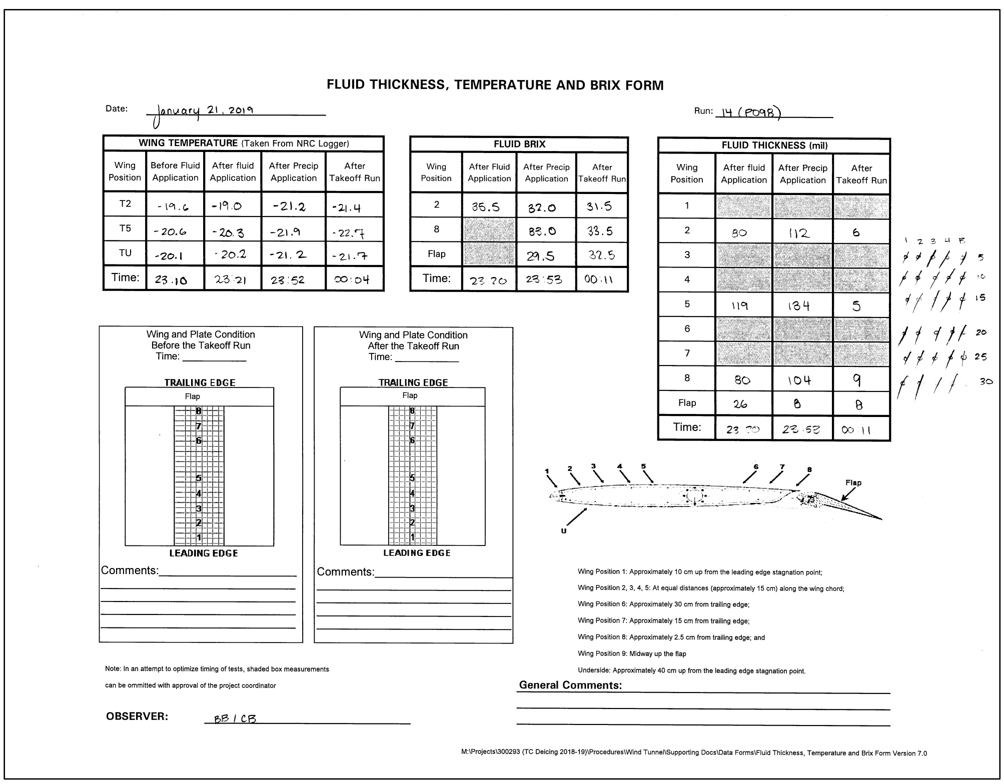
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F11: Run # 13



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 21, 2019

Run: 14 (P098)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-19.6	-19.0	-21.2	-21.4
T5	-20.6	-20.3	-21.9	-22.7
TU	-20.1	-20.2	-21.2	-21.7
Time:	23:10	23:21	23:52	00:04

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.5	32.0	31.5
8		33.0	33.5
Flap		29.5	32.5
Time:	23:20	23:53	00:11

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	112	6
3			
4			
5	119	134	5
6			
7			
8	80	104	9
Flap	26	8	8
Time:	23:20	23:53	00:11

Wing and Plate Condition Before the Takeoff Run Time: ____ TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run Time: ____ TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F12: Run # 14

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

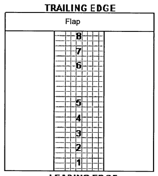
Run: 15 (P020)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-20.8	-19.9	-22.5	-21.1
T5	-21.8	-21.2	-23.3	-22.2
TU	-21.3	-21.2	-22.0	-22.1
Time:	00:23	00:36	1:06	1:22

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.5	27.0	30.25
8		27.25	29.75
Flap		24.25	30.5
Time:	00:35	1:08	1:25

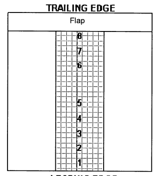
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	119	158	2
3			
4			
5	150	200	9
6			
7			
8	134	158	11
Flap	50	12	6
Time:	00:35	1:07	1:25

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

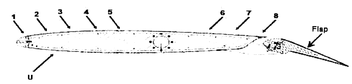


Comments: ___________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F13: Run # 15

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

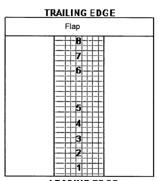
Run: 16 (P021)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.7	-20.4	-23.6	-21.9
T5	-22.9	-21.5	-23.6	-22.8
TU	-22.2	-22.2	-22.1	-22.1
Time:	1:34	1:43	1:57	2:12

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.5	29.0	30.5
8		29.75	30.25
Flap		27.25	30.25
Time:	1:44	1:58	2:14

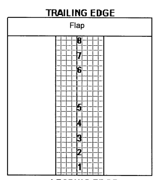
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	119	158	1
3			
4			
5	158	200	5
6			
7			
8	158	158	8
Flap	55	55	6
Time:	1:45	1:58	2:14

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

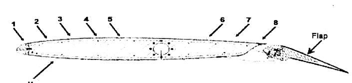


Comments: ___________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

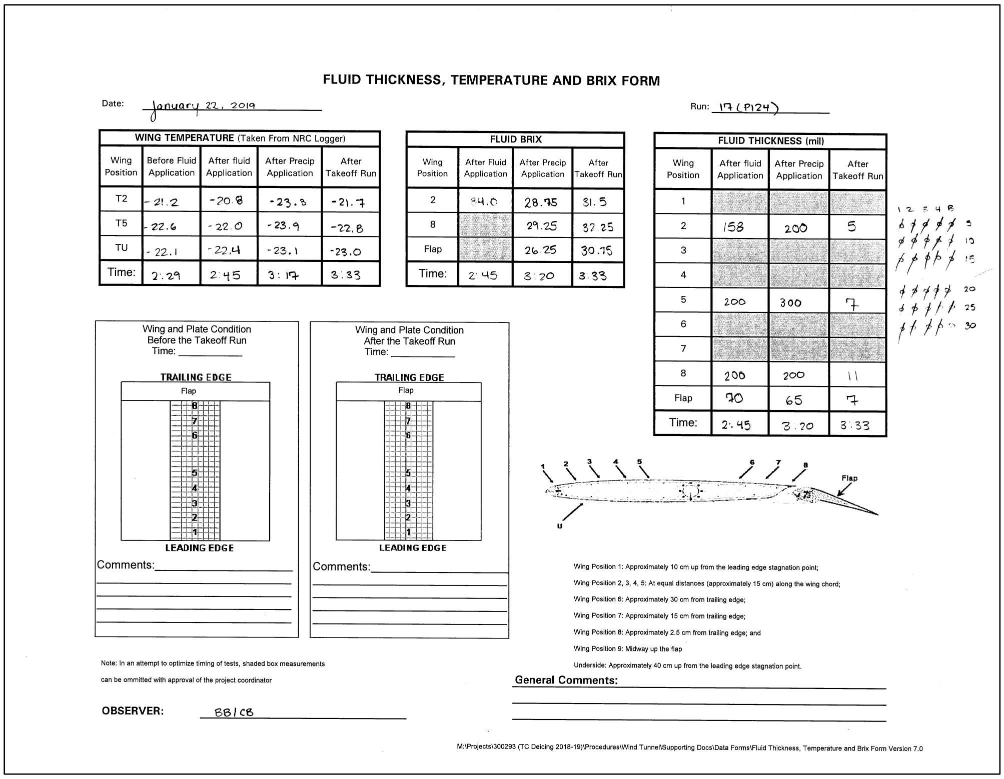
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F14: Run # 16



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

Run: 17 (P124)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-21.2	-20.8	-23.3	-21.7
T5	-22.6	-22.0	-23.9	-22.8
TU	-22.1	-22.4	-23.1	-23.0
Time:	2:29	2:45	3:17	3:33

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.0	28.75	31.5
8		29.25	32.25
Flap		26.25	30.75
Time:	2:45	3:20	3:33

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	158	200	5
3			
4			
5	200	300	7
6			
7			
8	200	200	11
Flap	70	65	7
Time:	2:45	3:20	3:33

1 2 3 4 8
5
10
15
20
25
30

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

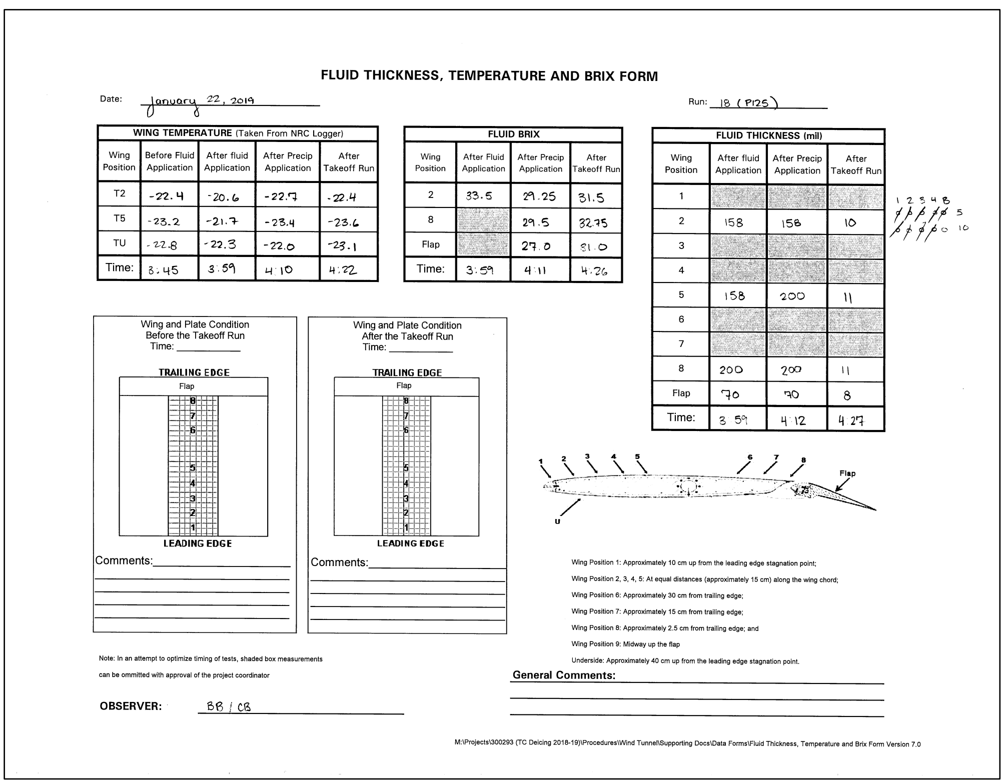
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F15: Run #17



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

Run: 18 (P125)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-22.4	-20.6	-22.7	-22.4
T5	-23.2	-21.7	-23.4	-23.6
TU	-22.8	-22.3	-22.0	-23.1
Time:	3:45	3:59	4:10	4:22

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.5	29.25	31.5
8		29.5	32.75
Flap		27.0	31.0
Time:	3:59	4:11	4:26

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	158	158	10
3			
4			
5	158	200	11
6			
7			
8	200	200	11
Flap	70	70	8
Time:	3:59	4:12	4:27

1 2 3 4 8
5
10

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE

Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F16: Run # 18

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

Run: 19 (P001) / 20 (E3) 21 (P002)

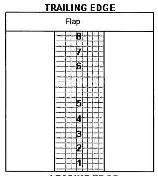
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-12.8			-14.6
T5	-12.2			-15.1
TU	-12.8			-14.5
Time:	20:59			21:13

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE

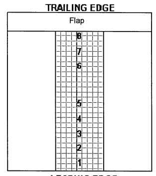


LEADING EDGE

Comments:

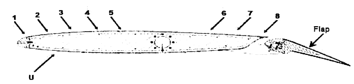
Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F17: Runs # 19 to 21

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

Run: 22 (P045)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-14.5	-14.0	-17.9	-14.4
T5	-14.6	-15.1	-18.4	-14.8
TU	-14.5	-14.8	-15.2	-15.4
Time:	21:21	21:35	21:46	22:05

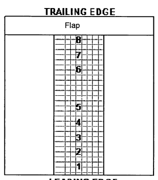
FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.25	26.0	29.0
8		28.5	29.25
Flap		24.25	28.0
Time:	21:35	21:47	22:05

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	55	112	6
3			
4			
5	80	134	5
6			
7			
8	55	104	6
Flap	18	7	6
Time:	21:35	21:48	22:05

1 2 3 4 5
5
10

Wing and Plate Condition Before the Takeoff Run
Time: ___________

TRAILING EDGE

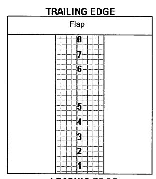


LEADING EDGE

Comments:

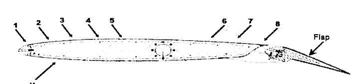
Wing and Plate Condition After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB, CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F18: Run # 22

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

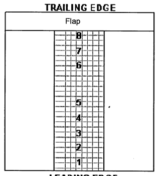
Run: 23 (P097)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-14.0	-14.5	-17.0	-14.8
T5	-14.0	-15.6	-17.7	-15.3
TU	-14.8	-14.8	-15.4	-15.5
Time:	22:16	22:28	22:40	22:56

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.5	29.75	30.75
8		30.5	30.5
Flap		25.25	31.0
Time:	22:28	22:41	22:59

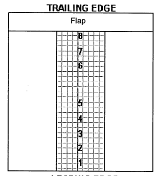
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	112	6
3			
4			
5	119	158	10
6			
7			
8	80	127	9
Flap	28	12	4
Time:	22:28	22:42	22:59

Wing and Plate Condition Before the Takeoff Run
Time: ___________

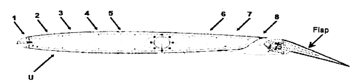


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F19: Run # 23

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 22, 2019

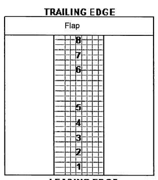
Run: 24 (P104)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.0	-15.8		-14.6
T5	-15.4	-17.0		-15.2
TU	-15.6	-15.7		-15.2
Time:	23:05	23:16		23:32

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.0	n/a	37.25
8		n/a	36.5
Flap		n/a	36.75
Time:	23:17	-	23:33

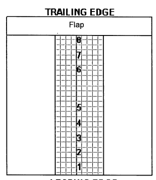
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	n/a	7
3			
4			
5	112	n/a	10
6			
7			
8	80	n/a	12
Flap	30	n/a	5
Time:	23:18	–	23:34

Wing and Plate Condition Before the Takeoff Run
Time: ___________

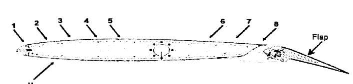


Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F20: Run # 24

No Data Available

Figure F21: Run # 25

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019

Run: 26 (P090)

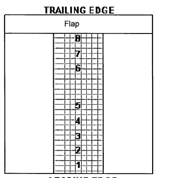
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-12.5	-14.0	-15.0	-13.2
T5	-13.2	-15.3	-15.1	-13.7
TU	-12.7	-13.3	-12.6	-13.9
Time:	1:36	1:49	2:09	2:25

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.25	25.0	22.0
8		27.25	29.0
Flap		20.50	26.0
Time:	1:49	2:10	2:30

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	70	112	5
3			
4			
5	112	150	3
6			
7			
8	80	119	10
Flap	28	7	7
Time:	1:49	2:11	2:30

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE

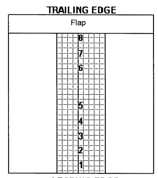


LEADING EDGE

Comments:

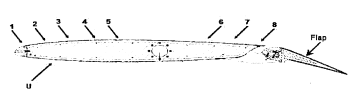
Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments:



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB | CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F22: Run # 26

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019

Run: 27 (P03B)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-12.2	-12.5	-14.7	-12.5
T5	-12.5	-13.5	-15.2	-12.8
TU	-13.1	-13.3	-12.5	-13.5
Time:	2:43	2:58	3:17	3:36

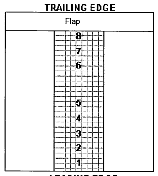
FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.5	24.5	24.25
8		26.25	22.25
Flap		21.5	21.75
Time:	2:58	3:18	3:36

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	50	96	3
3			
4			
5	80	112	10
6			
7			
8	60	80	8
Flap	18	9	8
Time:	2:58	3:19	3:26

1 2 3 4 B

Wing and Plate Condition Before the Takeoff Run
Time: ______

TRAILING EDGE

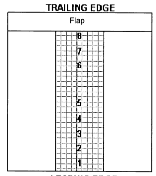


LEADING EDGE

Comments: ______

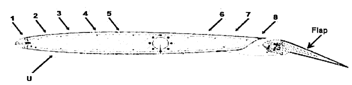
Wing and Plate Condition After the Takeoff Run
Time: ______

TRAILING EDGE



LEADING EDGE

Comments: ______



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ______

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F23: Run # 27

12L

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019

Run: 28 (P

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-12.1	-13.3	-14.6	-12.0
T5	-12.5	-14.6	-15.2	-12.3
TU	-12.7	-12.9	-12.5	-12.9
Time:	3:54	4:02	4:23	4:43

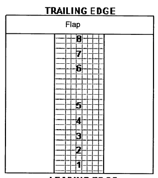
FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.25	21.5	26.25
8		25.25	26.75
Flap		19.75	24.75
Time:	4:03	4:24	4:44

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	60	119	4
3			
4			
5	80	127	8
6			
7			
8	60	96	8
Flap	22	9	8
Time:	4:03	4:25	4:44

1 2 3 4 B
5
10
15

Wing and Plate Condition Before the Takeoff Run
Time: ______

TRAILING EDGE

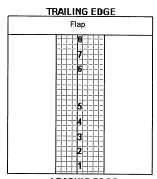


LEADING EDGE

Comments: ______

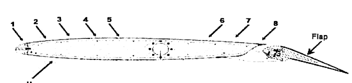
Wing and Plate Condition After the Takeoff Run
Time: ______

TRAILING EDGE



LEADING EDGE

Comments: ______



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

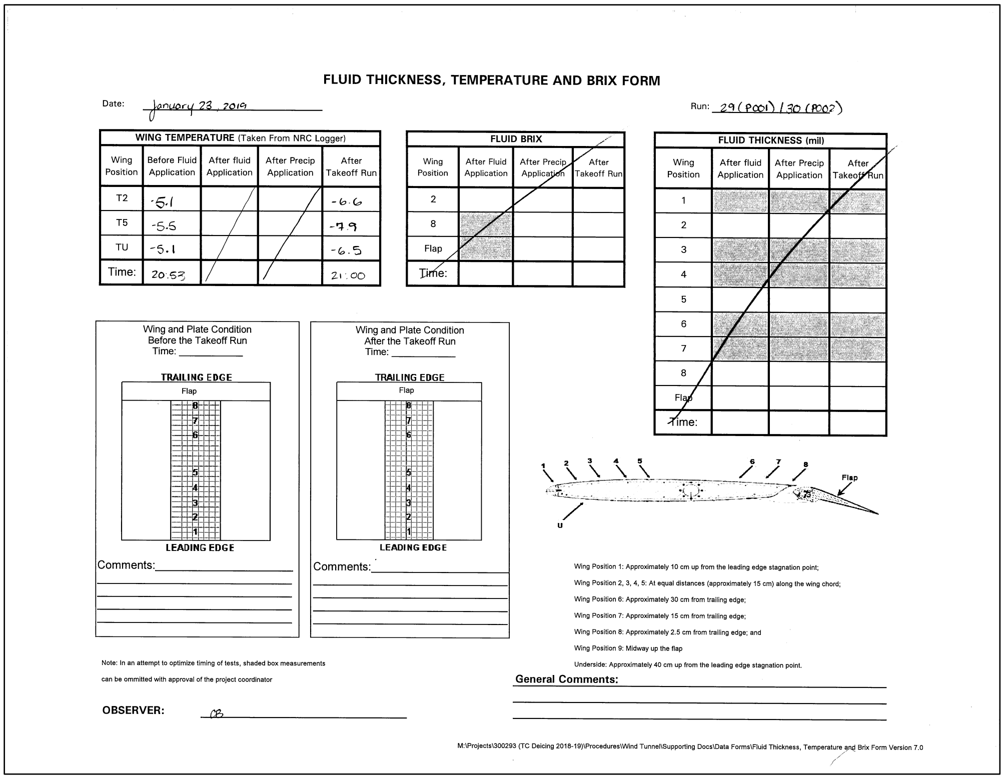
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ______

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F24: Run # 28



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019 Run: 29 (P001) / 30 (P002)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.1			-6.6
T5	-5.5			-7.9
TU	-5.1			-6.5
Time:	20:53			21:00

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition Before the Takeoff Run Time: ____
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ____

Wing and Plate Condition After the Takeoff Run Time: ____
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ____

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

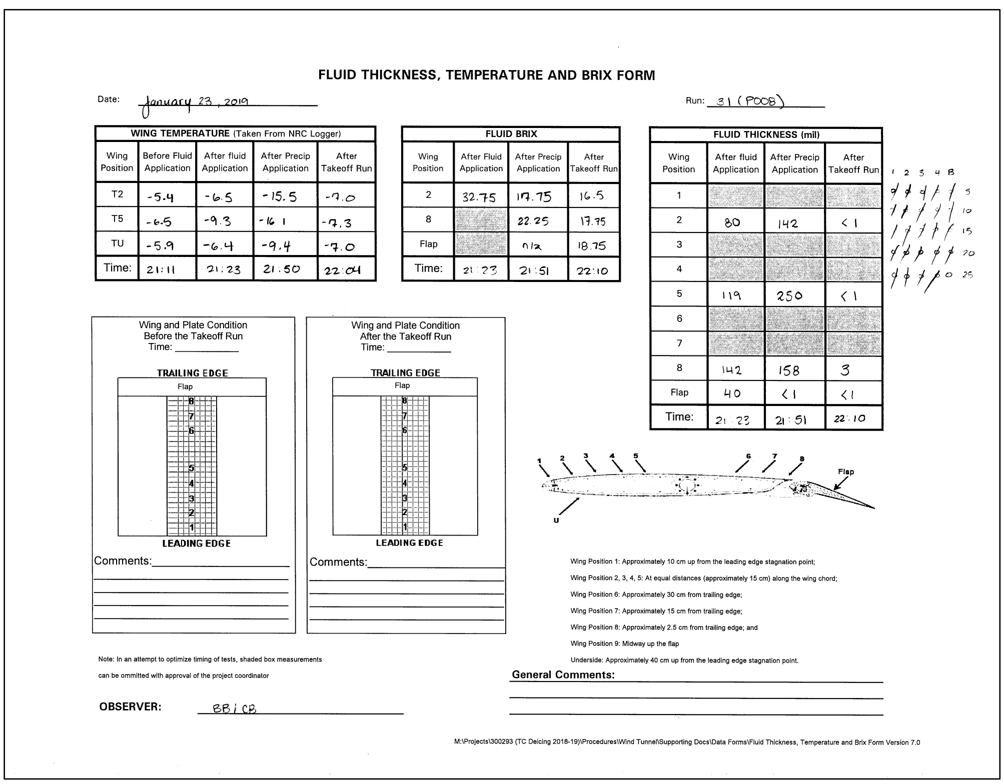
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F25: Runs # 29 to 30



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019 Run: 31 (P008)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.4	-6.5	-15.5	-7.0
T5	-6.5	-9.3	-16.1	-7.3
TU	-5.9	-6.4	-9.4	-7.0
Time:	21:11	21:23	21:50	22:04

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	32.75	17.75	16.5
8		22.25	17.75
Flap		n/a	18.75
Time:	21:23	21:51	22:10

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	142	<1
3			
4			
5	119	250	<1
6			
7			
8	142	158	3
Flap	40	<1	<1
Time:	21:23	21:51	22:10

1 2 3 4 B
5 10 15 20 25

Wing and Plate Condition Before the Takeoff Run Time: ____
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ____

Wing and Plate Condition After the Takeoff Run Time: ____
TRAILING EDGE / Flap / 8 7 6 5 4 3 2 1 / LEADING EDGE
Comments: ____

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____

OBSERVER: BB; CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F26: Run # 31

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 23, 2019

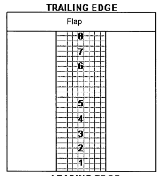
Run: 32 (P112)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.6	-7.5	-16.2	-6.0
T5	-6.0	-8.5	-15.9	-5.9
TU	-5.9	-6.5	-9.1	-6.1
Time:	22:20	22:34	23:00	23:19

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.0	18.75	18.0
8		19.0	21.5
Flap		n/a	21.0
Time:	22:22	23:01	23:19

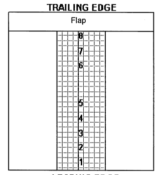
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	134	150	1
3			
4			
5	158	300	3
6			
7			
8	158	158	2
Flap	55	3	5
Time:	22:22	23:02	23:19

Wing and Plate Condition Before the Takeoff Run
Time: ___________

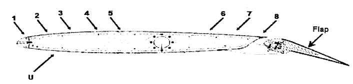


Comments:___________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:___________

OBSERVER: BB/CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F27: Run # 32

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 24 2019

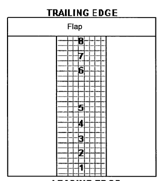
Run: 33 (P086)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-5.4	-6.5	-12.6	-5.5
T5	-5.2	-8.0	-13.2	-5.9
TU	-5.2	-5.8	-7.3	-5.6
Time:	23:35	23:48	00:08	00:18

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	20.0	19.75
8		24.5	23.25
Flap		16.5	22.75
Time:	23:48	00:08	00:24

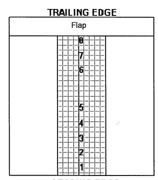
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	119	1
3			
4			
5	119	200	9
6			
7			
8	80	142	10
Flap	28	6	10
Time:	23:48	00:08	00:24

Wing and Plate Condition Before the Takeoff Run
Time: ___________

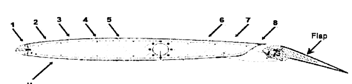


Comments:___________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

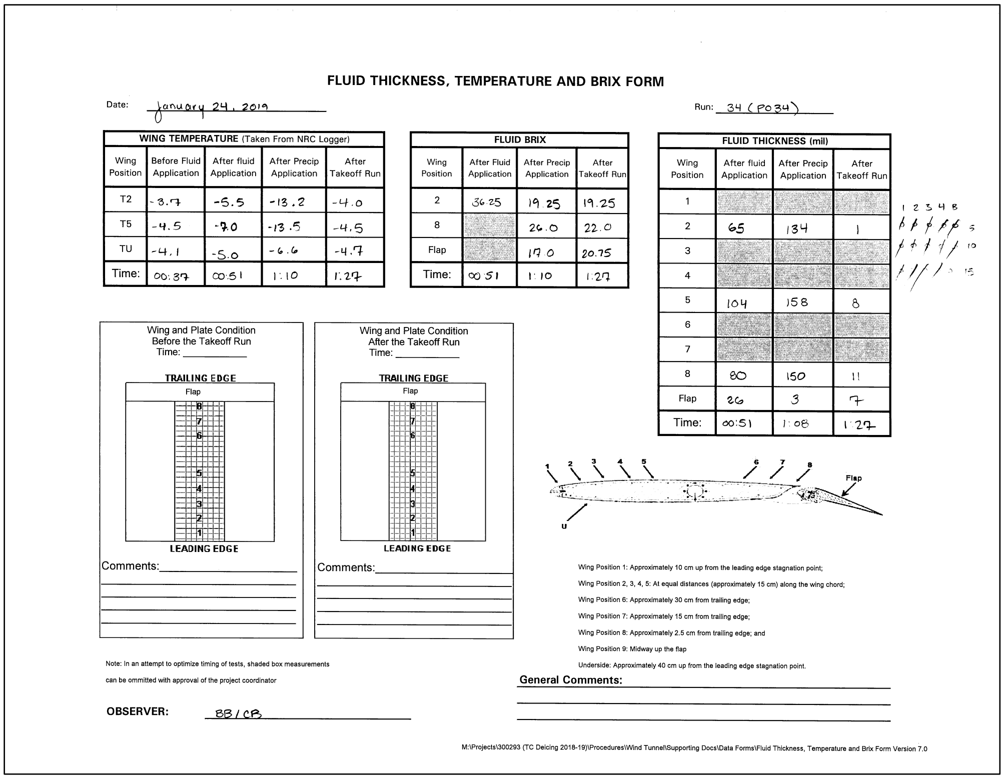
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:___________

OBSERVER: BB/CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F28: Run # 33



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 24, 2019 Run: 34 (P034)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-3.7	-5.5	-13.2	-4.0
T5	-4.5	-7.0	-13.5	-4.5
TU	-4.1	-5.0	-6.6	-4.7
Time:	00:37	00:51	1:10	1:27

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.25	19.25	19.25
8		26.0	22.0
Flap		17.0	20.75
Time:	00:51	1:10	1:27

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	65	134	1
3			
4			
5	104	158	8
6			
7			
8	80	150	11
Flap	26	3	7
Time:	00:51	1:08	1:27

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE
Comments: ___

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE
Comments: ___

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

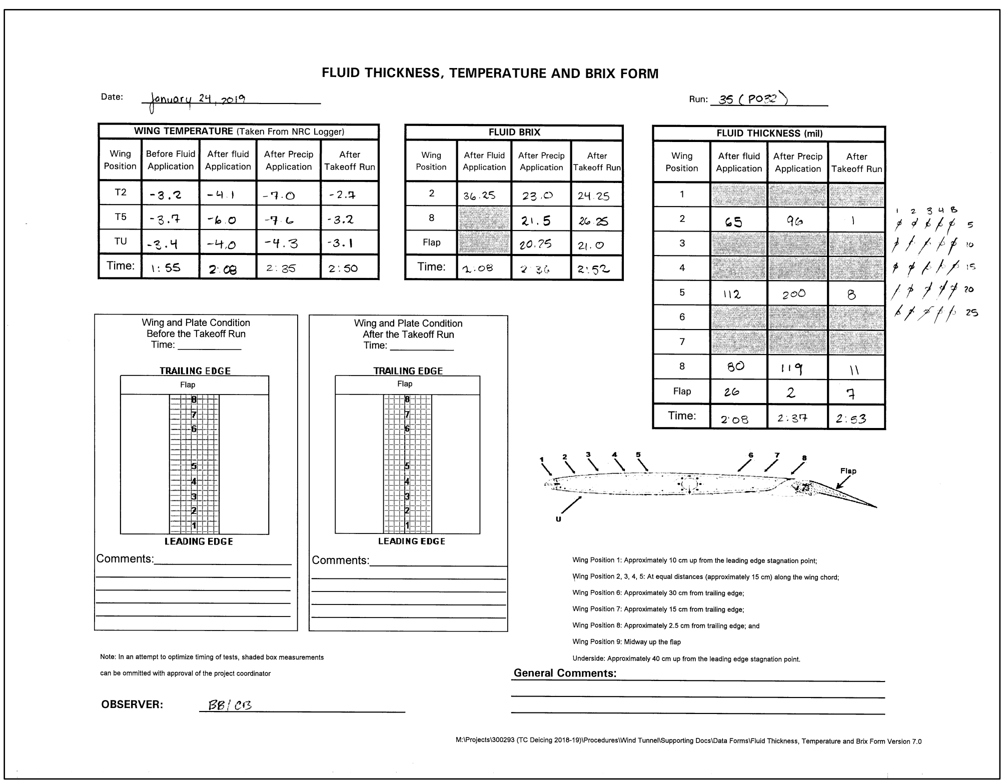
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___

OBSERVER: BB/CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F29: Run # 34



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 24, 2019 Run: 35 (P032)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-3.2	-4.1	-7.0	-2.7
T5	-3.7	-6.0	-7.6	-3.2
TU	-3.4	-4.0	-4.3	-3.1
Time:	1:55	2:08	2:35	2:50

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.25	23.0	24.25
8		21.5	26.25
Flap		20.75	21.0
Time:	2:08	2:36	2:52

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	65	96	1
3			
4			
5	112	200	8
6			
7			
8	80	119	11
Flap	26	2	7
Time:	2:08	2:37	2:53

Wing and Plate Condition Before the Takeoff Run Time: ___
TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE
Comments: ___

Wing and Plate Condition After the Takeoff Run Time: ___
TRAILING EDGE Flap 8 7 6 5 4 3 2 1 LEADING EDGE
Comments: ___

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___

OBSERVER: BB/CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F30: Run # 35

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 24, 2019

Run: 36 (P111)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-1.6	-4.2	-7.8	-1.0
T5	-2.2	-5.7	-8.6	-1.4
TU	-1.9	-3.0	-3.4	-1.2
Time:	3:07	3:23	3:55	4:09

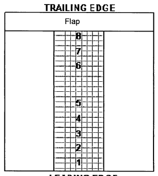
FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.0	15.25	21.25
8		21.5	25.25
Flap		12.0	22.0
Time:	3:23	3:55	4:10

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	119	184	1
3			
4			
5	158	200	3
6			
7			
8	142	150	8
Flap	55	5	3
Time:	3:23	3:55	4:11

1 2 3 4 5
5
10
15
20
25

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE

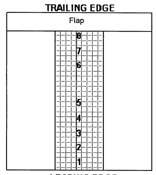


LEADING EDGE

Comments: ___________

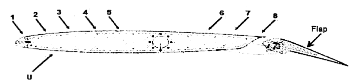
Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F31: Run # 36

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 24, 2019

Run: 37 (P685)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-0.6	-3.6	-7.0	-2.1
T5	-1.8	-5.7	-7.2	-2.6
TU	-1.2	-2.7	-3.4	-2.0
Time:	4:24	4:35	5:05	5:15

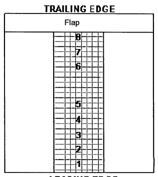
FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.0	19.25	/
8		21.5	/
Flap		21.25	/
Time:	4:35	5:06	/

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	50	/
3			/
4			/
5	119	158	/
6			/
7			/
8	80	80	/
Flap	30	1	/
Time:	4:35	5:07	

1 2 3 4 5
5
10
15
20
25

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

TRAILING EDGE

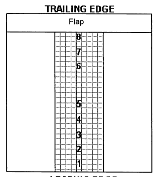


LEADING EDGE

Comments: ___________

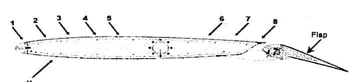
Wing and Plate Condition
After the Takeoff Run
Time: ___________

TRAILING EDGE



LEADING EDGE

Comments: ___________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F32: Run # 37

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2019

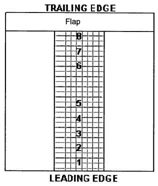
Run: 38 (P001) / 39 (P002)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.2			-17.0
T5	-13.1			-18.6
TU	-13.0			-17.1
Time:	7:58			8.05

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

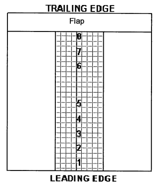
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

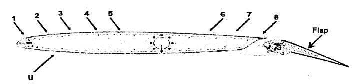


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F33: Runs # 38 to 39

-15.8
33.5

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29 2019

Run: 40 (P096)

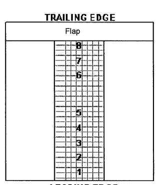
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-16.2	-16.2	-17.5	-16.2
T5	-16.6	-17.1	-18.0	-17.0
TU	-16.8	-17.0	-16.5	-16.6
Time:	8:19	8:30	8:51	9:06

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	35.5	25.5	29.0
8		30.75	29.25
Flap		24.25	29.5
Time:	8:30	8:51	9:06

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	96	1
3			
4			
5	127	158	3
6			
7			
8	80	104	11
Flap	26	10	6
Time:	8 30	8:51	9 06

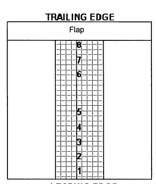
1 2 3 4 8
ϕ ϕ ϕ ϕ ϕ 5
ϕ ϕ ϕ ϕ ϕ 10
ϕ ϕ ϕ ϕ 0 15

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

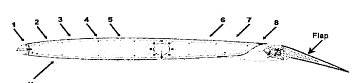


Comments:___________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ___________________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F34: Run # 40

-16.1 -17.4
34.0

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2019

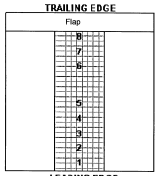
Run: 41 (2018)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.9	-15.2	-18.2	-15.2
T5	-16.3	-16.2	-19.1	-16.0
TU	-16.3	-16.0	-15.9	-15.6
Time:	9:19	9:31	9:48	10:02

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	34.0	23.25	30.5
8		25.75	29.0
Flap		21.0	28.5
Time:	9:32	9:49	10:05

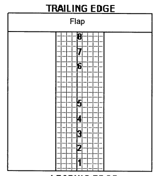
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96	127	4
3			
4			
5	150	158	7
6			
7			
8	142	134	11
Flap	55	14	2
Time:	9:33	9:50	10:05

Wing and Plate Condition
Before the Takeoff Run
Time: ____________

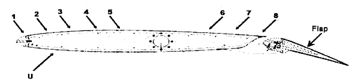


Comments:____________________

Wing and Plate Condition
After the Takeoff Run
Time: ____________



Comments:____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:____________________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F35: Run # 41

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2019

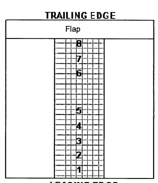
Run: 42 (P122)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-15.0	-15.4	-17.4	-14.1
T5	-15.7	-16.1	-18.3	-14.7
TU	-15.1	-15.5	-15.2	-14.6
Time:	10:13	10:29	10:48	11:03

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.25	29.25	28.25
8		28.25	31.75
Flap		21.75	28.75
Time:	10:29	10:49	11:04

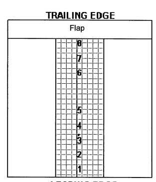
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	142	158	7
3			
4			
5	158	200	12
6			
7			
8	158	158	12
Flap	65	14	7
Time:	10:29	10:50	11:05

Wing and Plate Condition
Before the Takeoff Run
Time: ____________

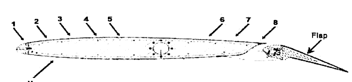


Comments:____________________

Wing and Plate Condition
After the Takeoff Run
Time: ____________



Comments:____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

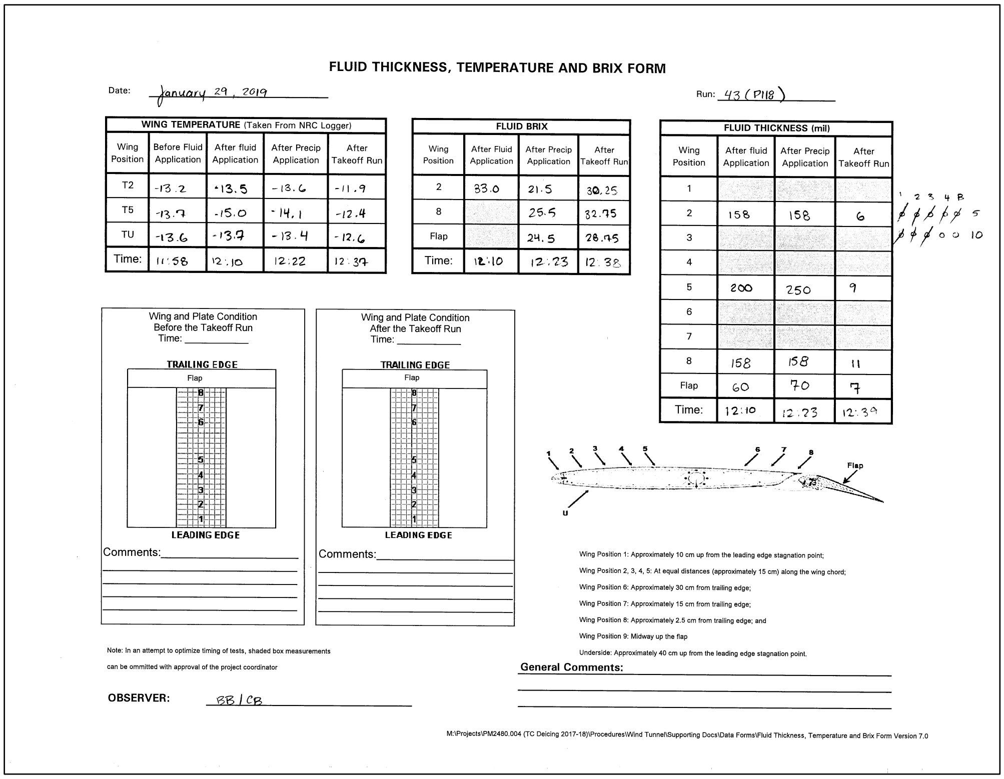
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:____________________

OBSERVER: BB / CB

M:\Projects\300293 (TC Deicing 2018-19)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F36: Run # 42



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 29, 2019

Run: 43 (P118)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.2	-13.5	-13.6	-11.9
T5	-13.7	-15.0	-14.1	-12.4
TU	-13.6	-13.7	-13.4	-12.6
Time:	11:58	12:10	12:22	12:37

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.0	21.5	30.25
8		25.5	32.75
Flap		24.5	28.75
Time:	12:10	12:23	12:38

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	158	158	6
3			
4			
5	200	250	9
6			
7			
8	158	158	11
Flap	60	70	7
Time:	12:10	12:23	12:39

1 2 3 4 8 ϕ ϕ ϕ ϕ ϕ 5
ϕ ϕ ϕ 0 0 10

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

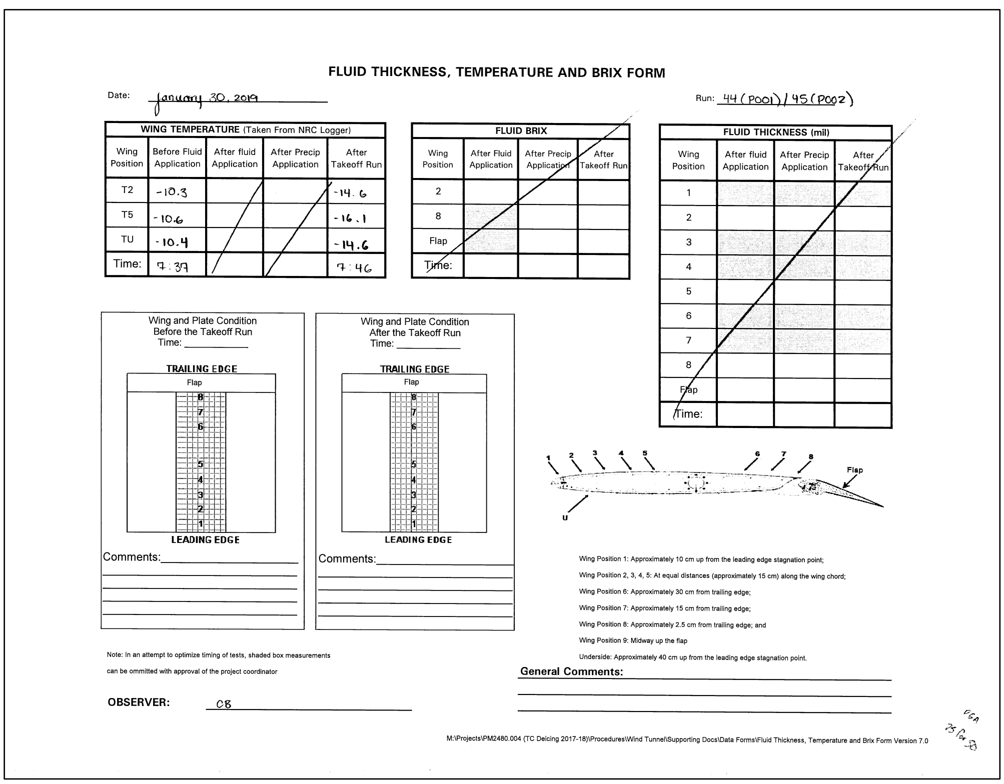
Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F37: Run # 43



FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2019

Run: 44 (P001) / 45 (P002)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-10.3			-14.6
T5	-10.6			-16.1
TU	-10.4			-14.6
Time:	7:37			7:46

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2			
8			
Flap			
Time:			

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2			
3			
4			
5			
6			
7			
8			
Flap			
Time:			

Wing and Plate Condition Before the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

Wing and Plate Condition After the Takeoff Run
Time: ___________
TRAILING EDGE
Flap
8 7 6 5 4 3 2 1
LEADING EDGE
Comments:

1 2 3 4 5 6 7 8 Flap U

Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:

OBSERVER: CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F38: Runs # 44 to 45

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

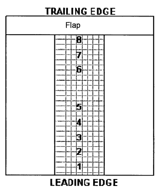
Date: January 30, 2019 Run: 46 (P014)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.8	-12.9	-14.3	-12.8
T5	-14.9	-14.1	-14.3	-14.0
TU	-14.2	-13.5	-13.1	-13.9
Time:	9:34	9:49	10:05	10:19

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	33.0	24.5	not possible
8		23.5	32.0
Flap		21.5	34.0
Time:	9:50	10:05	10:24

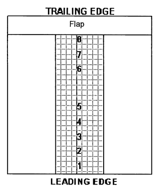
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	96	127	<1
3			
4			
5	134	158	9
6			
7			
8	150	134	9
Flap	60	40	3
Time:	9:50	10:05	10:24

Wing and Plate Condition Before the Takeoff Run
Time: ___________

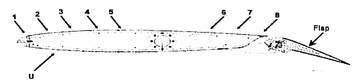


Comments:___________________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:___________________

OBSERVER: BB/CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F39: Run # 46

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

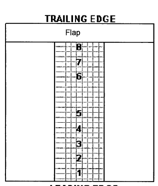
Date: January 30, 2019 Run: 47 (P040)

WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-12.9	-13.1	-13.2	-13.4
T5	-14.5	-14.5	-13.2	-14.6
TU	-13.8	-14.0	-13.7	-14.2
Time:	10:35	10:47	11:02	11:18

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	37.25	28.0	29.0
8		28.25	30.5
Flap		24.25	28.75
Time:	10:46	11:01	11:18

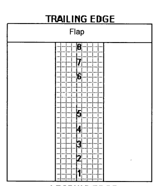
FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	60	96	10
3			
4			
5	80	112	9
6			
7			
8	65	80	18
Flap	24	18	10
Time:	10:45	11:00	11:18

Wing and Plate Condition Before the Takeoff Run
Time: ___________

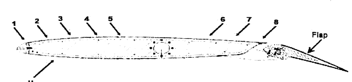


Comments:___________________

Wing and Plate Condition After the Takeoff Run
Time: ___________



Comments:___________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;
Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;
Wing Position 6: Approximately 30 cm from trailing edge;
Wing Position 7: Approximately 15 cm from trailing edge;
Wing Position 8: Approximately 2.5 cm from trailing edge; and
Wing Position 9: Midway up the flap
Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments:___________________

OBSERVER: CB/BB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F40: Run # 47

FLUID THICKNESS, TEMPERATURE AND BRIX FORM

Date: January 30, 2019

Run: 48 (P092)

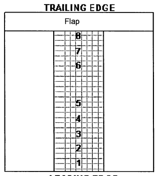
WING TEMPERATURE (Taken From NRC Logger)				
Wing Position	Before Fluid Application	After fluid Application	After Precip Application	After Takeoff Run
T2	-13.8	-13.9	-12.3	-13.0
T5	-15.0	-15.1	-12.3	-14.1
TU	-14.3	-14.4	-14.0	-13.8
Time:	11:31	11:42	11:55	12:10

FLUID BRIX			
Wing Position	After Fluid Application	After Precip Application	After Takeoff Run
2	36.0	28.5	oops
8		32.75	34.0
Flap		23.5	31.75
Time:	11:42	11:55	12:10

FLUID THICKNESS (mil)			
Wing Position	After fluid Application	After Precip Application	After Takeoff Run
1			
2	80	80	5
3			
4			
5	127	150	10
6			
7			
8	80	119	16
Flap	26	7	8
Time:	11:42	11:55	12:10

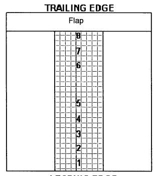
1 2 3 4 B
ø ø ø ø ø 5
ø ø ø 0 0 10

Wing and Plate Condition
Before the Takeoff Run
Time: ___________

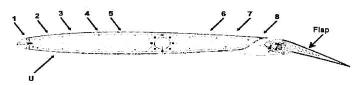


Comments: ____________________

Wing and Plate Condition
After the Takeoff Run
Time: ___________



Comments: ____________________



Wing Position 1: Approximately 10 cm up from the leading edge stagnation point;

Wing Position 2, 3, 4, 5: At equal distances (approximately 15 cm) along the wing chord;

Wing Position 6: Approximately 30 cm from trailing edge;

Wing Position 7: Approximately 15 cm from trailing edge;

Wing Position 8: Approximately 2.5 cm from trailing edge; and

Wing Position 9: Midway up the flap

Underside: Approximately 40 cm up from the leading edge stagnation point.

Note: In an attempt to optimize timing of tests, shaded box measurements can be ommitted with approval of the project coordinator

General Comments: ____________________

OBSERVER: BB / CB

M:\Projects\PM2480.004 (TC Deicing 2017-18)\Procedures\Wind Tunnel\Supporting Docs\Data Forms\Fluid Thickness, Temperature and Brix Form Version 7.0

Figure F41: Run # 48

This page intentionally left blank.

APPENDIX G

2017-18 LOG OF TESTS CONDUCTED WITH THIN HIGH PERFORMANCE WING SECTION – RJ WING

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
1	28-Jan-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.466	-0.32%	18.64	98.56	any	1.1	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	28-Jan-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.459	0.15%	51.08	86.61	any	-4.2	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	29-Jan-18	P080	Type IV Validation and New Fluids	IP Mod	ECO-SHIELD	WT.17.18.IES	8	100	20	1.380	5.59%	19.34	97.84	>-5	-7.3	16	-9.9	-4.6	-4.2	75	-	-	-	15	2.0	2.0	3.7	1.0	1.7	2.2	1.0	1.0	1.0
4	29-Jan-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.465	-0.26%	18.61	98.34	any	-4.4	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5	29-Jan-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.465	-0.27%	50.8	82.3	any	-8.4	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6	29-Jan-18	P083	Type IV Validation and New Fluids	IP-	ECO-SHIELD	WT.17.18.IES	8	100	20	1.391	4.82%	18.5	98.44	-5 to -10	-7.4	16	-9.6	-6.8	-10.1	25	-	-	-	30	1.7	1.7	3.0	1.0	1.5	1.8	1.0	1.0	1.0
7	29-Jan-18	P086	Type IV Validation and New Fluids	IP- / ZR-	ECO-SHIELD	WT.17.18.IES	8	100	20	1.391	4.85%	18.75	98.59	-5 to -10	-8.1	16	-9.7	-8.0	-7.4	25	-	25	-	10	1.3	1.7	2.5	1.0	1.1	1.8	1.0	1.0	1.0
8	30-Jan-18	P014	Type IV Validation and New Fluids	IP- / ZR-	ChemR EG IV	WT.17.18.CHEM	8	100	20	1.415	3.21%	18.99	99.11	-5 to -10	-8.2	15	-9.6	-7.9	-8.5	25	-	25	-	10	1.3	1.5	2.2	1.0	1.0	1.5	1.0	1.0	1.2
9	30-Jan-18	P016	Type IV Validation and New Fluids	IP Mod/ ZD	ChemR EG IV	WT.17.18.CHEM	8	100	20	1.427	2.36%	18.9	99.62	-5 to -10	-7.9	15	-9.4	-8.4	-11.3	75	-	13	-	7	1.5	1.7	2.3	1.0	1.2	1.5	1.0	1.0	1.2
10	30-Jan-18	P088	Type IV Validation and New Fluids	IP Mod/ ZD	ECO-SHIELD	WT.17.18.IES	8	100	20	1.377	5.79%	18.8	99.15	-5 to -10	-7.1	16	-9.8	-8.3	-10.1	75	-	13	-	7	2.0	2.0	2.7	1.0	1.7	2.0	1.0	1.0	1.0
11	30-Jan-18	P084	Type IV Validation and New Fluids	IP- / SN-	ECO-SHIELD	WT.17.18.IES	8	100	20	1.389	4.96%	18.83	98.98	-5 to -10	-5.5	16	-10.1	-8.7	-10.2	25	10	-	-	15	1.8	1.8	2.8	1.1	1.7	2.3	1.0	1.0	1.0
12	30-Jan-18	P012	Type IV Validation and New Fluids	IP- / SN-	ChemR EG IV	WT.17.18.CHEM	8	100	20	1.425	2.48%	18.73	98.8	-5 to -10	-7.8	15	-10.4	-7.8	-11.6	25	10	-	-	15	1.8	1.7	3.3	1.0	1.2	1.5	1.0	1.0	1.0
13	30-Jan-18	P015	Type IV Validation and New Fluids	IP Mod	ChemR EG IV	WT.17.18.CHEM	8	100	20	1.434	1.86%	18.81	101.47	-5 to -10	-10.0	15	-11	-9.0	-13.1	75	-	-	-	10	1.8	2.0	2.3	1.0	1.3	1.5	1.0	1.0	1.2
14	30-Jan-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.462	-0.06%	19.11	98.14	any	-11.9	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15	30-Jan-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.464	-0.19%	65.76	81.23	any	-12.6	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16	30-Jan-18	P017	Type IV Validation and New Fluids	IP-	ChemR EG IV	WT.17.18.CHEM	8	100	20	1.423	2.60%	18.57	99	-10 to -16	-13.3	15	-14.2	-12.0	-15.1	25	-	-	-	30	2.0	2.0	2.8	1.0	1.2	1.4	1.0	1.0	1.2

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate ($g/dm^2/h$)	SN Rate ($g/dm^2/h$)	ZR Rate ($g/dm^2/h$)	R Rate ($g/dm^2/h$)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
17	30-Jan-18	P018	Type IV Validation and New Fluids	IP- / SN-	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.412	3.36%	18.86	99.93	-10 to -16	-12.5	15	-15.2	-13.4	-15.2	25	10	-	-	15	2.0	2.0	2.8	1.0	1.3	1.5	1.0	1.0	1.2
18	31-Jan-18	P019	Type IV Validation and New Fluids	IP Mod	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.422	2.71%	18.77	99.62	-10 to -16	-14.8	15	-15.7	-13.8	-16.6	75	-	-	-	10	2.0	1.8	2.8	1.0	1.2	1.6	1.0	1.0	1.2
19	31-Jan-18	P025	Type IV Validation and New Fluids	Fluid Only	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.383	5.38%	18.91	99.53	-16 to -22	-14.5	15	-16.2	-14.5	-12.6	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20	31-Jan-18	P089	Type IV Validation and New Fluids	IP-	ECO-SHIELD	WT.17.18. IES	8	115	20	1.366	6.54%	26	112.78	-10 to -16	-15.8	16	-16.8	-14.0	-15.4	25	-	-	-	30	2.5	2.3	3.3	1.0	1.8	2.3	1.0	1.0	1.1
21	31-Jan-18	P090	Type IV Validation and New Fluids	IP- / SN-	ECO-SHIELD	WT.17.18. IES	8	115	20	1.369	6.36%	24.87	114.01	-10 to -16	-13.6	16	-17.3	-15.4	-15.1	25	10	-	-	15	2.2	2.0	3.2	1.0	1.5	1.9	1.0	1.0	1.1
22	31-Jan-18	P091	Type IV Validation and New Fluids	IP Mod	ECO-SHIELD	WT.17.18. IES	8	115	20	1.333	8.79%	21.42	116	-10 to -16	-17.0	16	-17.7	-15.7	-16.7	75	-	-	-	10	2.2	2.0	3.7	1.0	1.7	2.3	1.0	1.0	1.2
23	31-Jan-18	P097	Type IV Validation and New Fluids	Fluid Only	ECO-SHIELD	WT.17.18. IES	8	100	20	1.373	6.05%	19.57	98.69	-16 to -22	-16.7	16	-17.7	-16.2	-14.3	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24	31-Jan-18	P235	Type III HS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	8	100	20	1.414	3.27%	18.5	99.43	-16 to -22	-17.1	15	-18	-15.6	-14.8	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	31-Jan-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.453	0.60%	18.66	98.57	any	-9.1	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26	31-Jan-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.451	0.71%	2.04	84.82	any	n/a	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27	31-Jan-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.461	0.03%	18.51	99.83	any	-9.8	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28	31-Jan-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.458	0.26%	17.06	80.88	any	n/a	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29	31-Jan-18	P096	Type IV Validation and New Fluids	Fluid Only	ECO-SHIELD	WT.17.18. IES	8	100	20	1.376	5.81%	18.51	100.52	-5 to -10	-9.6	16	-11.8	-9.1	-9.5	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30	31-Jan-18	P024	Type IV Validation and New Fluids	Fluid Only	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.389	4.97%	18.69	99.69	-5 to -10	-8.6	15	-11.5	-8.5	-9.3	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31	31-Jan-18	P177	EG Type IV Expansion	IP-	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.435	1.80%	18.77	98.91	-5 to -10	-8.7	15	-10.8	-8.7	-12.3	25	-	-	-	50	2.3	2.7	3.9	1.0	1.2	1.6	1.0	1.0	1.0
32	1-Feb-18	P179	EG Type IV Expansion	IP- / ZD	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.382	5.43%	18.48	98.94	-5 to -10	-6.4	15	-10.2	-8.2	-10.0	25	-	13	-	30	2.5	2.5	4.0	1.0	1.0	5.0	1.0	1.0	1.5

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
33	1-Feb-18	P178	EG Type IV Expansion	IP- / SN-	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.408	3.68%	18.98	99.74	-5 to -10	-5.2	15	-9.7	-7.1	-10.3	25	10	-	-	50	2.9	2.5	4.3	1.0	1.6	4.0	1.0	1.0	3.8
34	1-Feb-18	P087	Type IV Validation and New Fluids	IP Mod	ECO-SHIELD	WT.17.18. IES	8	100	20	1.361	6.89%	18.83	99.74	-5 to -10	-7.6	16	-9.4	-7.3	-11.2	75	-	-	-	10	2.3	2.3	3.0	1.0	1.6	2.0	1.0	1.0	1.1
35	1-Feb-18	P234	Type III HS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	8	100	20	1.423	2.65%	18.59	100.12	-5 to -10	-7.3	13	-9.2	-7.5	-8.5	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36	1-Feb-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.457	0.29%	18.75	99.58	any	-0.1	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37	1-Feb-18	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.463	-0.11%	1.97	82.77	any	n/a	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38	1-Feb-18	P082	Type IV Validation and New Fluids	IP Mod / R	ECO-SHIELD	WT.17.18. IES	8	100	20	1.394	4.65%	18.37	100.27	>0	-1.6	16	-1.6	-0.6	-4.8	75	-	-	75	10	2.2	2.5	4.0	1.0	1.1	2.7	1.0	1.0	1.7
39	1-Feb-18	P010	Type IV Validation and New Fluids	IP Mod / R	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.356	7.21%	18.65	100.38	>0	-3.5	15	-4.2	-3.3	-7.0	75	-	-	75	10	2.2	2.2	4.7	1.0	1.0	5.0	1.0	1.0	5.0
40	1-Feb-18	P003	Type IV Validation and New Fluids	IP-	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.443	1.28%	18.47	99.42	>-5	-6.8	15	-7.4	-4.7	-10.5	25	-	-	-	50	2.5	2.5	3.5	1.0	1.1	1.3	1.0	1.0	1.2
41	1-Feb-18	P075	Type IV Validation and New Fluids	IP-	ECO-SHIELD	WT.17.18. IES	8	100	20	1.366	6.50%	18.65	99.24	>-5	-8.2	16	-9.1	-7.6	-10.3	25	-	-	-	50	2.3	2.5	4.0	1.0	1.8	2.2	1.0	1.0	1.0
42	2-Feb-18	P181	EG Type IV Expansion	IP Mod	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.428	2.29%	18.63	98.82	-5 to -10	-10.5	15	-11	-8.8	-14.2	75	-	-	-	25	2.6	2.8	4.0	1.0	1.1	1.7	1.0	1.0	1.1
43	2-Feb-18	P180	EG Type IV Expansion	IP- / ZR-	ChemR EG IV	WT.17.18. CHEM	8	100	20	1.377	5.76%	18.65	100.04	-5 to -10	-12.2	15	-13.3	-10.9	-10.7	25	-	25	-	30	3.3	2.8	5.0	1.8	1.1	5.0	1.0	1.0	5.0

This page intentionally left blank.

APPENDIX H

2017-18 LOG OF TESTS CONDUCTED WITH LS-0417 WING SECTION

Log of Tests Conducted with LS-0417 Wing Section

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot.(kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp. Before Fluid Appl. (°C)	AVG Wing Temp. Before Test (°C)	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rot. LE	Rating At Rot. TE	Rating At Rot. Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
1	5-Feb-18	P246	Clean Wing	None	none	n/a	8	100	20	1.517	0.59%	n/a	n/a	any	-13.4	n/a	-9.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	05-Feb-18	P248	Clean Wing	None	none	n/a	8	80	20	1.522	0.25%	n/a	n/a	any	-13.4	n/a	-9.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	05-Feb-18	P250	Clean Wing	None	none	n/a	8, then stall	80	20	1.527	-0.10%	n/a	n/a	any	-13.4	n/a	-9.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4	05-Feb-18	P252	Clean Wing	None	none	n/a	stall	80	20	1.528	-0.13%	n/a	n/a	any	-13.4	n/a	-9.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5	05-Feb-18	P254	Clean Wing	None	none	n/a	Stall -4 to stall +23 PP@1	80	20	1.527	-0.07%	n/a	n/a	any	-13.4	n/a	-9.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6	05-Feb-18	P247	Clean Wing	None	none	n/a	8	100	20	1.511	0.99%	n/a	n/a	any	-12.05	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7	05-Feb-18	P249	Clean Wing	None	none	n/a	8	80	20	1.528	-0.11%	n/a	n/a	any	-12.05	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8	05-Feb-18	P251	Clean Wing	None	none	n/a	8, then stall	80	20	1.526	-0.04%	n/a	n/a	any	-12.05	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9	05-Feb-18	P253	Clean Wing	None	none	n/a	stall	80	20	1.525	0.03%	n/a	n/a	any	-12.05	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10	05-Feb-18	P255	Clean Wing	None	none	n/a	Stall -4 to stall +23 PP@1	80	20	1.530	-0.25%	n/a	n/a	any	-12.05	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11	05-Feb-18	P263	Roughness (Trips)	40-grit	none	n/a	stall	80	20	1.503	1.52%	17.68	79.28	any	-5.31	n/a	-9.6	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12	05-Feb-18	P264	Roughness (Trips)	40-grit	none	n/a	Stall -4 to stall +23 PP@1	80	20	1.509	1.11%	n/a	n/a	any	-5.31	n/a	-9.6	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13	05-Feb-18	P265	Roughness (Trips)	150-grit	none	n/a	stall	80	20	1.519	0.44%	n/a	n/a	any	-5.15	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14	05-Feb-18	P266	Roughness (Trips)	150-grit	none	n/a	stall -4 to stall +23 PP@1	80	20	1.518	0.48%	17.52	86.17	any	-5.15	n/a	-9.0	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15	05-Feb-18	P267	Roughness (Trips)	80-grit	none	n/a	stall	80	20	1.516	0.64%	n/a	n/a	any	-2.49	n/a	-7.7	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Log of Tests Conducted with LS-0417 Wing Section (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot.(kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp. Before Fluid Appl. (°C)	AVG Wing Temp. Before Test (°C)	IP Rate ($g/dm^2/h$)	SN Rate ($g/dm^2/h$)	ZR Rate ($g/dm^2/h$)	R Rate ($g/dm^2/h$)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rot. LE	Rating At Rot. TE	Rating At Rot. Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
16	05-Feb-18	P268	Roughness (Trips)	80-grit	none	n/a	stall -4 to stall +23 PP@1	80	20	1.516	0.62%	17.55	84.41	any	-2.49	n/a	-7.7	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17	06-Feb-18	P269	Roughness (Trips)	Full Wing Grit (80)	none	n/a	stall	80	20	1.475	3.35%	n/a	n/a	any	3.24	n/a	-6.4	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18	06-Feb-18	P270	Roughness (Trips)	Full Wing Grit (80)	none	n/a	stall -4 to stall +23 PP@1	80	20	n/a	n/a	n/a	n/a	any	n/a	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19	06-Feb-18	P270	Roughness (Trips)	Full Wing Grit (80)	none	n/a	stall -4 to stall +23 PP@1	80	20	1.478	3.14%	n/a	n/a	any	3.24	n/a	-4.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20	06-Feb-18	P271	Roughness (Trips)	Grit (-30% grit on LE)	none	n/a	stall	80	20	1.491	2.31%	n/a	n/a	any	-2.75	n/a	-3.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21	06-Feb-18	P272	Roughness (Trips)	Grit (-30% grit on LE)	none	n/a	stall -4 to stall +23 PP@1	80	20	1.489	2.44%	n/a	n/a	any	-2.75	n/a	-3.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22	06-Feb-18	P273	Roughness (Trips)	Grit (-60% grit on LE)	none	n/a	stall	80	20	1.499	1.78%	n/a	n/a	any	-0.77	n/a	-3.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23	06-Feb-18	P274	Roughness (Trips)	Grit (-60% grit on LE)	none	n/a	stall -4 to stall +23 PP@1	80	20	1.497	1.87%	n/a	n/a	any	-0.77	n/a	-3.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24	06-Feb-18	P275	Roughness (Trips)	Grit (Flap Only)	none	n/a	stall	80	20	1.509	1.13%	n/a	n/a	any	-2.25	n/a	-4.4	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	06-Feb-18	P276	Roughness (Trips)	Grit (Flap Only)	none	n/a	stall -4 to stall +23 PP@1	80	20	1.504	1.45%	n/a	n/a	any	-2.25	n/a	-4.4	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26	06-Feb-18	P279	Boundary-layer Rake Measurements	BL Rake TE Center	none	n/a	stall -4 to stall +23 PP@1	80	20	1.478	3.10%	n/a	n/a	TBD	-3.62	n/a	-4.5	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
27	06-Feb-18	P280	Boundary-layer Rake Measurements	BL Rake TE Center -3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.492	2.20%	n/a	n/a	TBD	-4.12	n/a	-4.7	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28	06-Feb-18	P281	Boundary-layer Rake Measurements	BL Rake TE Center +3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.475	3.34%	n/a	n/a	TBD	-3.51	n/a	-4.7	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
29	07-Feb-18	P284	Boundary-layer Rake Measurements	BL Rake Flap Center +3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.500	1.66%	n/a	n/a	TBD	0.55	n/a	-15.1	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30	07-Feb-18	P282	Boundary-layer Rake Measurements	BL Rake Flap Center	none	n/a	stall -4 to stall +23 PP@1	80	20	1.489	2.44%	n/a	n/a	TBD	-4.85	n/a	-14.6	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31	07-Feb-18	P283	Boundary-layer Rake Measurements	BL Rake Flap Center -3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.498	1.80%	n/a	n/a	TBD	-3.87	n/a	-13.7	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Log of Tests Conducted with LS-0417 Wing Section (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot.(kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp. Before Fluid Appl. (°C)	AVG Wing Temp. Before Test (°C)	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rot. LE	Rating At Rot. TE	Rating At Rot. Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
32	07-Feb-18	P278	Roughness (Trips)	Diff. Grit (Flap Only)	none	n/a	stall -4 to stall +23 PP@1	80	20	1.478	3.16%	n/a	n/a	any	-1.7	n/a	-11.8	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33	07-Feb-18	P277	Roughness (Trips)	Diff. Grit (Flap Only)	none	n/a	stall	80	20	1.470	3.68%	n/a	n/a	any	-1.7	n/a	-11.8	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34	07-Feb-18	P263	Roughness (Trips)	40-grit	none	n/a	stall	80	20	1.488	2.51%	17.12	80.02	any	3.42	n/a	-10.6	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
35	07-Feb-18	P264	Roughness (Trips)	40-grit	none	n/a	stall -4 to stall +23 PP@1	80	20	1.498	1.80%	n/a	n/a	any	3.42	n/a	-10.6	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
36	07-Feb-18	P264	Roughness (Trips)	40-grit	none	n/a	stall -4 to stall +23 PP@1	80	20	-1.761	215.44%	n/a	n/a	any	0.0	n/a	-9.8	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
37	07-Feb-18	P279	Boundary-layer Rake Measurements	BL Rake TE Center	none	n/a	stall -4 to stall +23 PP@1	80	20	1.454	4.70%	n/a	n/a	TBD	1.13	n/a	-9.5	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
38	07-Feb-18	P279	Boundary-layer Rake Measurements	BL Rake TE Center	none	n/a	stall -4 to stall +23 PP@1	80	20	1.455	4.62%	n/a	n/a	TBD	-1.55	n/a	-9.4	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39	07-Feb-18	P281	Boundary-layer Rake Measurements	BL Rake TE Center +3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.398	8.39%	n/a	n/a	TBD	-3.94	n/a	-9.1	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40	07-Feb-18	P280	Boundary-layer Rake Measurements	BL Rake TE Center -3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.514	0.77%	n/a	n/a	TBD	-3.23	n/a	-9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41	07-Feb-18	P280	Boundary-layer Rake Measurements	BL Rake TE Center -3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.514	0.77%	n/a	n/a	TBD	-3.99	n/a	-8.8	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
42	07-Feb-18	P281	Boundary-layer Rake Measurements	BL Rake TE Center +3ft	none	n/a	stall -4 to stall +23 PP@1	80	20	1.406	7.85%	n/a	n/a	TBD	1.89	n/a	-8.4	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
43	08-Feb-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.517	0.54%	18.22	99.18	any	-12.72	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
44	08-Feb-18	P002	Baseline	Dry Wing	none	n/a	23	80	20	1.528	-0.12%	n/a	n/a	any	-12.72	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45	08-Feb-18	P163	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.469	3.71%	17.11	79.75	-16 to -22	-12.37	15	-13.6	-10.2	-9.8	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46	08-Feb-18	P163	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.466	3.90%	17.31	80.22	-16 to -22	-12.33	14	-12	-9.7	-9.0	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
47	08-Feb-18	P163	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.489	2.43%	n/a	84.54	-16 to -22	-9.9	14	-7	-8.6	-7.9	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Log of Tests Conducted with LS-0417 Wing Section (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot.(kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp. Before Fluid Appl. (°C)	AVG Wing Temp. Before Test (°C)	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rot. LE	Rating At Rot. TE	Rating At Rot. Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
48	08-Feb-18	P163	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.476	3.26%	17.08	78.92	-16 to -22	-8.89	14	-5.9	-7.8	-7.1	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
49	08-Feb-18	P149	Type III LS Allowance Times	IP- / ZR-	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.490	2.32%	17.27	78.28	>-5	-7.88	14	-5.4	-6.1	-8.0	25	-	25	-	15	1.5	1.6	2.1	1.0	1.1	1.0	1.0	1.0	1.0
50	08-Feb-18	P168	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	8	100	20	1.477	3.19%	18.79	99.91	-16 to -22	-7.27	14	-5.8	-6.7	-6.6	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
51	08-Feb-18	P025	Type IV Validation and New Fluids	Fluid Only	ChemR EG IV	IV 35317-1	8	100	20	1.463	4.08%	19.71	99.33	-16 to -22	-7.01	18	-5.7	-5.6	-6.4	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
52	08-Feb-18	P025	Type IV Validation and New Fluids	Fluid Only	ChemR EG IV	IV 35317-1	23	80	20	1.440	5.64%	17.2	78.96	-16 to -22	-6.54	18	-6	-5.0	-6.2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
53	08-Feb-18	P147	Type III LS Allowance Times	IP-	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.491	2.31%	17.42	78.9	>-5	-6.01	14	-5.5	-4.8	-8.6	25	-	-	-	30	1.7	1.7	1.9	1.0	1.1	1.0	1.0	1.0	1.0
54	08-Feb-18	P151	Type III LS Allowance Times	IP Mod	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.502	1.58%	17.31	79.8	>-5	-6.52	14	-6.1	-5.6	-11.1	75	-	-	-	20	2.0	2.0	2.0	1.0	1.7	1.0	1.0	1.1	1.0
55	09-Feb-18	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.519	0.47%	20	98.7	any	-9.83	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
56	09-Feb-18	P002	Baseline	Dry Wing	none	n/a	23	80	20	1.524	0.14%	2	82.34	any	-9.83	n/a	n/a	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
57	09-Feb-18	P163	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.469	3.71%	18.2	78.56	-16 to -22	-10.94	15	-11.5	-6.9	-6.9	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
58	09-Feb-18	P168	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	8	100	20	1.479	3.07%	20.47	99	-16 to -22	-10.81	13	-11	-8.0	-7.9	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
59	09-Feb-18	P153	Type III LS Allowance Times	IP- / SN-	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.473	3.44%	17.55	78.67	-5 to -10	-9.99	14	-9.6	-7.8	-12.5	25	10	-	-	20	1.8	1.8	2.0	1.0	1.7	1.0	1.0	1.2	1.0
60	09-Feb-18	P154	Type III LS Allowance Times	IP- / ZR-	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.478	3.13%	18.52	78.23	-5 to -10	-8.58	13	-7.3	-8.7	-8.3	25	-	25	-	20	1.7	1.7	2.9	1.0	1.1	1.0	1.0	1.1	1.0
61	09-Feb-18	P155	Type III LS Allowance Times	IP Mod	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.481	2.95%	17.37	79.21	-5 to -10	-7.99	14	-5.6	-6.8	-11.9	75	-	-	-	20	2.0	2.3	2.8	1.0	1.5	1.2	1.0	1.0	1.1
62	09-Feb-18	P152	Type III LS Allowance Times	IP-	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.496	1.94%	17.5	78.43	-5 to -10	-6.74	14	-5.4	-7.1	-10.1	25	-	-	-	40	1.3	1.5	1.8	1.0	1.3	1.0	1.0	1.0	1.0
63	09-Feb-18	P240	R&D	Heavy Cont	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.474	3.38%	17.64	79.06	TBD	-5.99	14	-5.6	-6.5	-7.0	220	-	25	-	25	5	5	5	1	1.5	1.166667	1	1	1
64	09-Feb-18	P162	Type III LS Allowance Times	Fluid Only	AeroClear MAX - Cold	TAB17-1023	23	80	20	1.471	3.62%	17.08	79.07	-5 to -10	-5.58	14	-5.4	-5.6	-5.0	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

APPENDIX I

2018-19 LOG OF TESTS CONDUCTED WITH THIN HIGH PERFORMANCE WING SECTION – RJ WING

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
1	21-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.473	-0.47%	18.95	98.74	any	-18.1	n/a	-21.9	n/a	-16.9	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	21-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.447	1.30%	1.8	83.84	any	-18.1	n/s	-21.9	n/a	-16.9	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	21-Jan-19	P027	Type IV Validation and New Fluids	Fluid Only	Max Flight AVIA	41	8	100	20	1.394	4.89%	18.65	99.4	-16 to -22	-22.8	18	-22	-22.1	-20.8	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	21-Jan-19	P053	Type IV Validation and New Fluids	Fluid Only	Max Flight SNEG	8	8	100	20	1.364	6.99%	18.91	99.35	-16 to -22	-22.6	14	-22.3	-21.7	-21.1	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	21-Jan-19	P105	Type IV Validation and New Fluids	Fluid Only	Defrost ECO 4	4 (Lot 48)	8	100	20	1.329	9.38%	18.54	98.87	-16 to -22	-22.6	18	-22.2	-22.9	-21.3	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	21-Jan-19	P131	Type IV Validation and New Fluids	Fluid Only	Defrost EG 4	1 (Lot 47)	8	100	20	1.367	6.77%	18.46	98.32	-16 to -22	-22.8	24	-22.4	-22.6	-21.9	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7	21-Jan-19	E1	Type IV Validation and New Fluids	Fluid Only	Polar Gyard Advance	PGA1812 05PA	8	100	20	1.364	6.94%	18.93	99.23	-16 to -22	-22.4	11	-22.3	-22.4	-21.3	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	21-Jan-19	E2	Type IV Validation and New Fluids	Fluid Only	Endurance EG106	D268IB7001	8	100	20	1.396	4.80%	18.72	98.96	-16 to -22	-22.0	20	-22.5	-22.2	-21.4	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9	21-Jan-19	P105	Type IV Validation and New Fluids	Fluid Only	Defrost ECO 4	4 (Lot 48)	8	100	20	1.336	8.90%	18.58	99.9	-16 to -22	-22.3	16	-22.6	-22.1	-21.7	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10	21-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.464	0.12%	18.9	97.97	any	-18.6	n/a	-18.5	n/a	-17.8	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11	21-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.459	0.46%	16.83	79.92	any	-18.6	n/a	-18.5	n/a	-17.8	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12	21-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.462	0.26%	21.7	76.89	any	-19.8	n/a	-18.7	n/a	-19.5	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13	21-Jan-19	P046	Type IV Validation and New Fluids	IP-	Max Flight SNEG	8	8	115	20	1.362	7.07%	28.23	111.4	-16 to -22	-19.8	13	-19.5	-19.5	-20.5	25	-	-	-	30	2.3	2.3	3.8	1.0	1.8	3.3	1.0	1.1	1.3
14	21-Jan-19	P098	Type IV Validation and New Fluids	IP-	Defrost ECO 4	4 (Lot 48)	8	115	20	1.337	8.77%	21.47	115.3	-16 to -22	-20.7	15	-20.2	-20.1	-21.4	25	-	-	-	30	2.0	2.0	3.3	1.0	1.9	3.0	1.0	1.0	1.7
15	22-Jan-19	P020	Type IV Validation and New Fluids	IP-	Max Flight AVIA	41	8	100	20	1.383	5.66%	19.22	98.48	-16 to -22	-21.4	18	-21.2	-21.3	-22.6	25	-	-	-	30	2.0	2.0	3.0	1.0	1.7	2.0	1.0	1.0	1.1
16	22-Jan-19	P021	Type IV Validation and New Fluids	IP Mod	Max Flight AVIA	41	8	100	20	1.385	5.53%	18.96	99.12	-16 to -22	-21.0	18	-21.1	-22.3	-23.1	75	-	-	-	10	2.0	2.0	2.7	1.0	1.5	2.0	1.0	1.0	1.1

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
17	22-Jan-19	P124	Type IV Validation and New Fluids	IP-	Defrost EG 4	1 (Lot 47)	8	100	20	1.367	6.72%	18.83	100.02	-16 to -22	-22.0	25	-22.1	-21.6	-23.4	25	-	-	-	30	2.0	2.0	2.5	1.0	1.5	2.0	1.0	1.0	1.2
18	22-Jan-19	P125	Type IV Validation and New Fluids	IP Mod	Defrost EG 4	1 (Lot 47)	8	100	20	1.369	6.62%	18.57	97.01	-16 to -22	-21.1	25	-21.7	-22.8	-22.7	75	-	-	-	10	2.0	2.0	2.7	1.0	1.4	2.1	1.0	1.0	1.2
19	22-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.475	-0.60%	18.44	98.35	any	-12.2	n/a	-14.9	n/a	-12.6	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20	22-Jan-19	E3	Baseline	Dry Wing	none	n/a	Pitch Pause	100	20	n/a	n/a	n/a	n/a	any	-12.2	n/a	-14.9	n/a	-12.6	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21	22-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.425	2.80%	16.68	79.64	any	-12.2	n/a	-14.9	n/a	-12.6	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22	22-Jan-19	P045	Type IV Validation and New Fluids	IP Mod	Max Flight SNEG	8	8	115	20	1.361	7.18%	21.04	115.19	-10 to -16	-13.5	13	-14.9	-14.5	-17.2	75	-	-	-	10	2.0	2.0	3.3	1.0	1.5	2.2	1.0	1.0	1.3
23	22-Jan-19	P097	Type IV Validation and New Fluids	IP Mod	Defrost ECO 4	4 (Lot 48)	8	115	20	1.374	6.30%	21.41	115.64	-10 to -16	-13.35	16	-15.1	-14.3	-16.7	75	-	-	-	10	2.0	2.0	3.0	1.0	1.5	2.0	1.0	1.0	1.2
24	22-Jan-19	P104	Type IV Validation and New Fluids	Fluid Only	Defrost ECO 4	4 (Lot 48)	8	100	20	1.356	7.53%	18.84	100.47	-10 to -16	-13.65	16	-15.0	-15.3	-16.2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	23-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.464	0.11%	18.63	99.57	any	-7.1	n/a	-13.9	n/a	n/a	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26	23-Jan-19	P090	Type IV Validation and New Fluids	IP- / SN-	Defrost ECO 4	4 (Lot 48)	8	100	20	1.352	7.75%	18.58	99.17	-5 to -10	-8.51	15	-13.9	-12.8	-14.2	25	10	-	-	15	2	2	3	1.1	1.75	2.25	1.2	1	1.3
27	23-Jan-19	P038	Type IV Validation and New Fluids	IP- / SN-	Max Flight SNEG	8	8	100	20	1.321	9.91%	18.77	99.66	-5 to -10	-8.35	12	-13.4	-12.6	-14.1	25	10	-	-	15	2	2	3.25	1.15	1.8	2.25	1.05	1	1.5
28	23-Jan-19	P044	Type IV Validation and New Fluids	IP- / SN-	Max Flight SNEG	8	8	115	20	1.366	6.83%	21.3	115.64	-10 to -16	-8.9	12	-12.8	-12.4	-14.1	25	10	-	-	15	2	2	3	1.1	1.35	1.75	1	1	1.25
29	23-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.463	0.22%	18.39	99.44	any	-3.75	n/a	-5.3	n/a	-5.2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30	23-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.449	1.19%	16.9	81.11	any	-3.75	n/a	-5.3	n/a	-5.2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
31	23-Jan-19	P008	Type IV Validation and New Fluids	IP Mod	Max Flight AVIA	41	8	100	20	1.438	1.92%	18.74	101.69	>-5	-4.12	18	-4.9	-5.9	-13.7	75	-	-	-	25	2.25	2.45	3.5	1	1	1.05	1	1	1
32	23-Jan-19	P112	Type IV Validation and New Fluids	IP Mod	Defrost EG 4	1 (Lot 47)	8	100	20	1.429	2.49%	18.78	100.29	>-5	-3.86	21	-4.5	-5.8	-13.7	75	-	-	-	25	2.25	2.25	3.5	1	1	1.15	1	1	1

Log of Tests Conducted with Thin High Performance Wing Section – RJ Wing (cont'd)

Test #	Date	Test Plan #	Objective	Test Condition	Fluid Name	Fluid Batch #	Rotation Angle	Speed Kts	Flap Angle (0°, 20°)	Corrected for 3D Effects CL At 8°	Corrected for 3D Effects % Lift Loss On 8° Cl vs Dry Cl	Time from 40kts to Rotation (sec)	Max Speed At Approx. Time of Rot. (kts)	Target OAT (°C)	Tunnel Temp. Before Test (°C)	Fluid Amount (L)	OAT Before Test (°C)	AVG Wing Temp Before Fluid Appl. (°C)	AVG Wing Temp Before Test	IP Rate (g/dm²/h)	SN Rate (g/dm²/h)	ZR Rate (g/dm²/h)	R Rate (g/dm²/h)	Exposure Time (min)	Rating Before Take-Off Run LE	Rating Before Take-Off Run TE	Rating Before Take-Off Run Flap	Rating At Rotation LE	Rating At Rotation TE	Rating At Rotation Flap	Rating After Take-Off Run LE	Rating After Take-Off Run TE	Rating After Take-Off Run Flap
33	24-Jan-19	P086	Type IV Validation and New Fluids	IP Mod	Defrost ECO 4	4 (Lot 48)	8	100	20	1.415	3.48%	18.79	101.68	>-5	-2.84	14	-3.7	-5.3	-11.0	75	-	-	-	15	2.25	2.25	3.4	1	1.5	1.9	1	1	1
34	24-Jan-19	P034	Type IV Validation and New Fluids	IP Mod	Max Flight SNEG	8	8	100	20	1.400	4.48%	18.46	101.9	>-5	-2.57	15	-3.2	-4.1	-11.1	75	-	-	-	15	2.25	2.25	3	1	1.25	1.25	1	1	1
35	24-Jan-19	P032	Type IV Validation and New Fluids	IP- / ZR-	Max Flight SNEG	8	8	100	20	1.415	3.47%	18.61	102	>-5	-0.81	11	-2.1	-3.4	-6.3	25	-	25	-	25	2	2	3	1	1	1.25	1	1	1.25
36	24-Jan-19	P111	Type IV Validation and New Fluids	IP- / R-	Defrost EG 4	1 (Lot 47)	8	100	20	1.445	1.44%	18.61	102.49	>0	0.65	21	0.0	-1.9	-6.6	25	-	-	25	25	1.5	1.5	2	1	1	1	1	1	1
37	24-Jan-19	P085	Type IV Validation and New Fluids	IP- / R-	Defrost ECO 4	4 (Lot 48)	8	100	20	1.423	2.93%	18.72	101.86	>0	0.72	15	-0.1	-1.2	-5.9	25	-	-	25	25	1.5	1.75	2.75	1	1	1	1	1	1
38	29-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.466	-0.02%	18.78	99.65	any	-11.65	n/a	-16.6	n/a	-13.1	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39	29-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.444	1.47%	2.37	81.65	any	-11.65	n/a	-16.6	n/a	-13.1	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40	29-Jan-19	P096	Type IV Validation and New Fluids	IP- / SN-	Defrost ECO 4	4 (Lot 48)	8	115	20	1.350	7.89%	21.04	115.72	-10 to -16	-15.54	14	-15.8	-16.5	-17.3	25	10	-	-	15	2.5	2.5	2.75	1.1	1.45	1.75	1	1.05	1.3
41	29-Jan-19	P018	Type IV Validation and New Fluids	IP- / SN-	Max Flight AVIA	41	8	100	20	1.403	4.33%	18.54	100.27	-10 to -16	-13.95	18	-14.9	-16.2	-17.7	25	10	-	-	15	2	2	2.5	1.05	1.15	1.3	1	1	1.05
42	29-Jan-19	P122	Type IV Validation and New Fluids	IP- / SN-	Defrost EG 4	1 (Lot 47)	8	100	20	1.390	5.15%	18.84	101.09	-10 to -16	-13.13	22	-13.7	-15.3	-17.0	25	10	-	-	15	2.5	2.5	2.75	1	1.05	1.3	1	1	1.05
43	29-Jan-19	P118	Type IV Validation and New Fluids	IP- / ZR-	Defrost EG 4	1 (Lot 47)	8	100	20	1.402	4.36%	18.69	100.88	-5 to -10	-10.07	24	-12	-13.5	-13.7	25	-	25	-	10	2	2	2.5	1	1	1.15	1	1	1
44	30-Jan-19	P001	Baseline	Dry Wing	none	n/a	8	100	20	1.451	1.04%	18.81	100.28	any	-7.87	n/a	-14.1	n/a	-10.4	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
45	30-Jan-19	P002	Baseline	Dry Wing	none	n/a	22	80	20	1.445	1.46%	1.71	81.78	any	-7.87	n/a	-14.1	n/a	-10.4	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
46	30-Jan-19	P014	Type IV Validation and New Fluids	IP- / ZR-	Max Flight AVIA	41	8	100	20	1.423	2.95%	18.41	100.83	-5 to -10	-10.31	18	-10.7	-14.3	-13.9	25	-	25	-	10	2.25	2	2.5	1	1	1.1	1	1	1
47	30-Jan-19	P040	Type IV Validation and New Fluids	IP- / ZR-	Max Flight SNEG	8	8	100	20	1.347	8.14%	18.36	100.45	-5 to -10	-13.24	13	-9.9	-13.7	-13.4	25	-	25	-	10	2.5	2.5	3	1.2	1.6	3.8	1	1.1	3.8
48	30-Jan-19	P092	Type IV Validation and New Fluids	IP- / ZR-	Defrost ECO 4	4 (Lot 48)	8	100	20	1.358	7.12%	18.95	101.3	-5 to -10	-13	17	-9.2	-14.367	-12.867	25	-	25	-	10	2.5	2.5	3	1.05	1.35	2.5	1	1	1.2

This page intentionally left blank.

APPENDIX J

EG WIND TUNNEL DATA ANALYSIS WITH THIN HIGH PERFORMANCE WING – 2009-10 TO 2018-19

<u>EG106</u> (Lift losses for this data in the range of **1 to 4%***, with exception of failed IP-/ZR- test at 7%)

Precipitation Type	**Outside Air Temperature**			
	-5°C and above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes 50+ minutes	30 minutes	30 minutes[3] 30+ minutes	30 minutes[3] 30+ minutes
Light Ice Pellets Mixed with Snow	40 minutes 40+ minutes	15 minutes	15 minutes[3] 25+ minutes	15+ minutes
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes same as ↓	10 minutes Same as ↓	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes 25+ minutes, but by default could be 30-35 = or > than →	10 minutes 40 minutes just failed, 30-35 should be ok		
Light Ice Pellets Mixed with Rain	25 minutes[4] same as ↑			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] 25+ minutes	10 minutes	10 minutes[3]	10 minutes[7] 10+ minutes
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[5] Mixed with Rain	10 minutes[8]			

<u>LNT E450</u> (Lift losses for this data in the range of **3 to 6%***)

Precipitation Type	**Outside Air Temperature**			
	-5°C and above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3] 30+ minutes	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes 15+ minutes	15 minutes[3]	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes same as↓	10 minutes same ↓	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes 25+ minutes	10 minutes 10+ minutes		
Light Ice Pellets Mixed with Rain	25 minutes[4] same as ↑			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] 25 minutes ok	10 minutes	10 minutes[3] 10+ minutes	10 minutes[7] 10+ minutes
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance imes currently exist**	

ChemR EG IV (Lift losses for this data in the range of **1 to 6%***)

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes 50+ minutes	30 minutes[3] 30+ minutes	30 minutes[3]
Light Ice Pellets Mixed with Snow	40 minutes 50 minutes ok	15 minutes 15+ minutes	15 minutes[3] 15+ minutes	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes 30 minutes ok	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes 10+ minutes		
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6]	10 minutes 25+ minutes	10 minutes[3] 10+ minutes	10 minutes[7]
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes 10+ minutes	**Caution: No allowance times currently exist**	

Clariant AVIA (Lift losses for this data in the range of **2 to 6%***)

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] 30 minutes ok
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes	15 minutes[3] 15+ minutes	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes 10+ minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes		
Light Ice Pellets Mixed with Rain	25 minutes[4]			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] 25+ minutes	10 minutes	10 minutes[3]	10 minutes[7] 10 minutes ok
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	

<u>Defrost EG 4</u> (Lift losses for this data in the range of **1 to 7%***)

Precipitation Type	Outside Air Temperature			
	-5°C and above	**Below -5 to -10°C**	**Below -10 to -16°C**	**Below -16 to -22°C[2]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3] 30 minutes ok
Light Ice Pellets Mixed with Snow	40 minutes	15 minutes	15 minutes[3] 15+ minutes	
Light Ice Pellets Mixed with Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Freezing Rain	25 minutes	10 minutes 10+ minutes		
Light Ice Pellets Mixed with Rain	25 minutes[4] 25+ minutes			
Moderate Ice Pellets (or Small Hail)[5]	25 minutes[6] 25+ minutes	10 minutes	10 minutes[3]	10 minutes[7] 10 minutes ok
Moderate Ice Pellets (or Small Hail)[5] Mixed with Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	

This page intentionally left blank.