TP 15427E

AIRCRAFT GROUND ICING GENERAL RESEARCH ACTIVITIES DURING THE 2018-19 WINTER

Prepared for:

Transport Canada
Innovation Centre

In cooperation with:

Federal Aviation Administration
William J. Hughes Technical Center

Transport Canada
Civil Aviation

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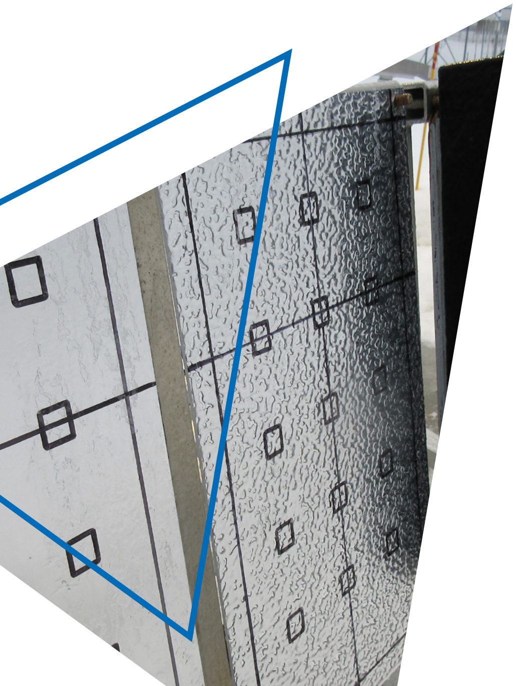
Flight Standards – Air Carrier Operations



APS Aviation Inc.

FINAL VERSION 1.0
NOVEMBER 2019

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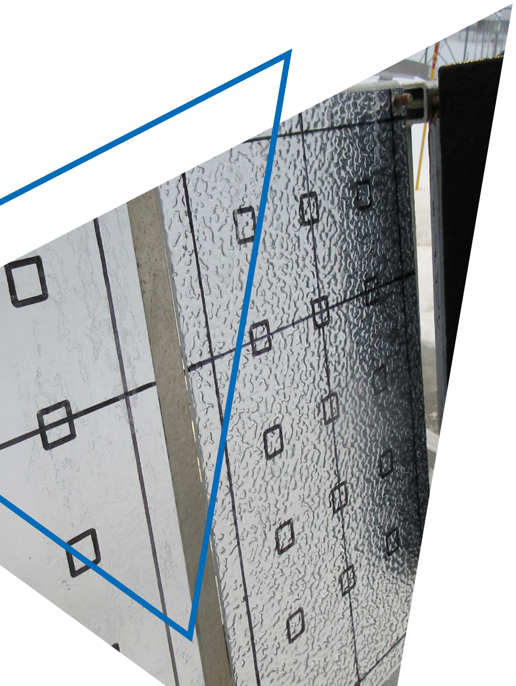

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Un sommaire français se trouve avant la table des matières.

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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 15427E, has the following objective:

- To document the exploratory research and general activities carried out during the winter of 2018-19.

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.

REPORT ACKNOWLEDGEMENTS

APS Aviation Inc. would like to acknowledge the following people for their significant contribution to this report: Marco Ruggi for *Evaluation of Fluid Effectiveness and Characterization of Contamination on High Angle Surfaces: Vertical Stabilizer*; Stephanie Bendickson for *Temperature-Specific Snow Holdover Times*; David Youssef for *Evaluation of New Snow Machine*; Saba Tariq for *Technical Review, Approval, and Publication of Historical Reports* and for *Presentations, Fluid Manufacturer Reports, and Test Procedures for 2018-19*; and Chloë Bernier for *Publication of Holdover Time Guidance Materials*.

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

Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada (TC). These reports 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

This report documents the general activities completed by APS Aviation Inc. related to aircraft ground deicing research in the winter of 2018-19. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2018-19, which are documented in separate reports. The six activities described in this report are listed below:

1) Evaluation of Fluid Effectiveness and Characterization of Contamination on High Angle Surfaces: Vertical Stabilizer;
2) Temperature-Specific Snow Holdover Times;
3) Evaluation of New Snow Machine;
4) Technical Review, Approval, and Publication of Historical Reports;
5) Publication of Holdover Time Guidance Materials; and
6) Presentations, Fluid Manufacturer Reports, and Test Procedures for 2018-19.

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

Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). Ils sont disponibles au 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

Le présent rapport documente les activités d'ordre général réalisées par APS Aviation Inc. en matière de recherche sur le dégivrage d'aéronefs au sol au cours de l'hiver 2018-2019. Les activités dont fait état ce rapport ont été effectuées en plus des projets de la recherche principale menés pendant l'hiver 2018-2019, qui sont documentés dans des rapports distincts. Les six activités qui font l'objet du présent rapport sont énumérées ci-dessous :

1) Évaluation de l'efficacité des liquides et caractérisation de la contamination sur des surfaces à angle élevé : stabilisateur vertical ;
2) Durées d'efficacité spécifiques à la température dans des conditions de neige ;
3) Évaluation du nouvel appareil de fabrication de neige ;
4) Examen technique, approbation et publication de rapports historiques ;
5) Publication de documents d'orientation sur les durées d'efficacité ; et
6) Présentations, rapports aux fabricants de liquides et procédures d'essais pour 2018-2019.

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EXECUTIVE SUMMARY

This report documents the exploratory research and general activities completed in the winter of 2018-19 by APS Aviation Inc. (APS) on behalf of Transport Canada (TC) and the Federal Aviation Administration (FAA). This work is part of the TC/FAA aircraft ground deicing research project. The major activities of the research project are documented in separate reports; this report documents six activities that were carried out in addition to the main research projects in the winter of 2018-19.

Evaluation of Fluid Effectiveness and Characterization of Contamination on High Angle Surfaces: Vertical Stabilizer (Section 2)

The research conducted to date has demonstrated the variability in the fluid protection times and characteristics of contamination that can be present on vertical surfaces. Additional research would provide a better understating of the influence of the different variables including the rate and type of precipitation, along with wind conditions and other meteorological conditions. The overall aerodynamic impact of contamination on vertical surfaces has yet to be fully understood, and should be an area of focus moving forward.

Temperature-Specific Snow Holdover Times (Section 3)

In the winter of 2018-19, APS carried out work to support the development of temperature-specific snow holdover times (HOTs). The primary elements of this work were analysis and meetings. The work is expected to be completed in the winter of 2019-20.

Evaluation of New Snow Machine (Section 4)

Recently, APS had the opportunity to conduct parallel testing with both the current snow machine and the new 2018-19 snow machine. Both machines were produced by the National Center for Atmospheric Research (NCAR). Some parts of the new snow machine (built 20 years later) were constructed with newer, state-of-the-art, components. The primary objective of this testing was to evaluate whether endurance times obtained from the new snow machine yield results similar to the current snow machine.

Technical Review, Approval, and Publication of Historical Reports (Section 5)

APS has conducted research related to ground icing, which involved writing and publishing over 202 reports on behalf of TC and the FAA since 1992. At the request of TC and the FAA, APS undertook the task to process and publish the draft reports backlogged in the system. At the beginning of this project, in 2016-17, 124 reports were identified as non-published. APS performed technical and editorial reviews on 16 reports at the Final Draft 1.0 stage and published them as Final Version 1.0 in October 2017. APS further published and delivered 22 reports in October 2018 and 20 reports in October 2019 to TC and the FAA as Final Version 1.0.

Publication of Holdover Time Guidance Materials (Section 6)

The development and use of HOT guidelines represents an important contribution to the enhancement of flight safety in winter aircraft operations. In the years since their introduction, the HOT guidelines and related guidance materials have become a standard and essential part of winter operations. APS has assisted both TC and the FAA with the development of their guidance documents as well as with updating their websites annually to reflect changes made to the guidelines.

Presentations, Fluid Manufacturer Reports, and Test Procedures for 2018-19 (Section 7)

APS produced a number of presentations, fluid manufacturer reports, and test procedures for the winter 2018-19 test program.

SOMMAIRE

Le présent rapport documente la recherche exploratoire et les activités d'ordre général effectuées au cours de l'hiver 2018-2019 par APS Aviation Inc. (APS), pour le compte de Transports Canada (TC) et de la Federal Aviation Administration (FAA). Ce travail a été effectué dans le cadre du projet de recherche de TC et de la FAA sur le dégivrage d'aéronefs au sol. Les principales activités du projet de recherche sont documentées dans des rapports distincts ; le présent rapport documente les six activités effectuées en plus des principaux projets de recherche de l'hiver 2018-2019.

Évaluation de l'efficacité des liquides et caractérisation de la contamination sur des surfaces à angle élevé : stabilisateur vertical (Section 2)

Les recherches effectuées à ce jour ont révélé la variabilité des durées de protection des liquides et des caractéristiques de la contamination qui peut être présente sur les surfaces verticales. Des études supplémentaires devraient permettre de mieux comprendre l'influence des différentes variables concernées, parmi lesquelles le taux et le type de précipitations, de même que la vitesse du vent et les autres conditions météorologiques. L'effet aérodynamique global de la contamination des surfaces verticales n'est pas encore pleinement compris, et devrait constituer un champ d'intérêt privilégié dans l'avenir.

Durées d'efficacité spécifiques à la température dans des conditions de neige (Section 3)

Au cours de l'hiver 2018-2019, APS a mené des travaux visant à appuyer l'établissement de durées d'efficacité spécifiques à la température dans des conditions de neige. Ces travaux, qui ont principalement pris la forme d'analyses et de réunions, devraient être achevés durant l'hiver 2019-2020.

Évaluation du nouvel appareil de fabrication de neige (Section 4)

APS a récemment eu l'occasion d'effectuer des essais en parallèle sur l'appareil de fabrication de neige courant, de même que sur le nouvel appareil de fabrication de neige pour 2018-2019. Ces deux appareils ont été fabriqués par le National Center for Atmospheric Research (NCAR). Certaines parties du nouvel appareil de fabrication de neige (fabriqué 20 ans plus tard) ont été construites avec de nouveaux composants de pointe. L'objectif principal de ces essais était d'évaluer si les durées d'endurance obtenues à l'aide du nouvel appareil de fabrication de neige étaient comparables à celles de l'appareil courant.

Examen technique, approbation et publication de rapports historiques (Section 5)

Depuis 1992, APS a effectué des études sur le givrage au sol qui ont supposé la rédaction et la publication de plus de 202 rapports pour le compte de TC et de la FAA. À la demande de TC et de la FAA, APS a entrepris le traitement et la publication des rapports préliminaires accumulés dans le système. Au début de ce projet, en 2016-2017, 124 rapports ont été identifiés comme non publiés. APS a effectué des examens techniques et éditoriaux de 16 rapports à l'étape de l'ébauche finale 1.0 et a publié leur version finale 1.0 en octobre 2017. APS a également publié et remis, dans leur version finale 1.0, 22 rapports en octobre 2018 et 20 rapports en octobre 2019 à TC et à la FAA.

Publication de documents d'orientation sur les durées d'efficacité (Section 6)

L'établissement et l'utilisation de lignes directrices relatives aux durées d'efficacité contribuent grandement à l'amélioration de la sécurité des vols lors d'opérations aériennes hivernales. Depuis leur adoption, les lignes directrices relatives aux durées d'efficacité et les documents d'orientation connexes sont devenus la norme, et un élément essentiel des opérations hivernales. Pour refléter les changements apportés à ces lignes directrices, APS a assisté TC et la FAA dans l'élaboration de leurs documents d'orientation, de même que dans la mise à jour annuelle de leurs sites Web.

Présentations, rapports aux fabricants de liquides et procédures d'essais pour 2018-2019 (Section 7)

APS a produit un certain nombre de présentations, de rapports aux fabricants de liquides et de procédures d'essais pour le programme d'essais de l'hiver 2018-2019.

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GLOSSARY

A4A	Airlines for America
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
EFB	Electronic Flight Bag
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LWE	Liquid Water Equivalent
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
SAE	SAE International
TC	Transport Canada

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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 remaining general activities and smaller research projects.

1.1 Activities Completed in 2018-19

The general activities and smaller research projects completed in 2018-19 are documented in this report. Each activity is detailed in a separate section as follows (section number in brackets):

a) Evaluation of Fluid Effectiveness and Characterization of Contamination on High Angle Surfaces: Vertical Stabilizer (Section 2);

b) Temperature-Specific Snow Holdover Times (Section 3);

c) Evaluation of New Snow Machine (Section 4);

d) Technical Review, Approval, and Publication of Historical Reports (Section 5);
e) Publication of Holdover Time Guidance Materials (Section 6); and
f) Presentations, Fluid Manufacturer Reports, and Test Procedures for 2018-19 (Section 7).

The sections of the TC statement of work relevant to these projects can be found in Appendix A.

1.2 Activities Completed with Limited Scope

In addition to the activities described in Subsection 1.1, three activities with limited scope were completed during the winter of 2018-19. These activities are described in the subsections below.

The sections of the TC statement of work relevant to these activities can also be found in Appendix A.

1.2.1 Development of SAE Aircraft Ground Deicing Standards

APS provides support to the SAE International (SAE) G-12 Aircraft Ground Deicing industry group in its development of aerospace standards. In 2018-19, this support consisted of reviewing most SAE standards that were balloted to the SAE G-12 committees, providing comments to document sponsors to improve the documents and/or to harmonize them with other documents, and providing feedback to TC and the FAA on possible implications of changes to SAE standards on TC/FAA regulatory guidance documents.

1.2.2 Support to the SAE G-12 Fluid Requalification Working Group

APS provides support to the SAE G-12 Fluid Requalification Working Group. This includes participation in all meetings and, when required, collecting/reviewing historical data, completing data analysis, reviewing changes to SAE standards drafted by the group, and providing expert opinion on specific topics. In the winter of 2018-19, APS attended two in-person meetings and teleconferences held by this working group.

1.2.3 Support to the SAE G-12 Aerodynamics Working Group

APS provides support to the SAE G-12 Aerodynamics Working Group. This includes participation in all meetings and, when required, collecting data, completing data analysis, and providing expert opinion on specific topics. In the winter of 2018-19, APS attended two in-person meetings, as well as a teleconference.

2. EVALUATION OF FLUID EFFECTIVENESS AND CHARACTERIZATION OF CONTAMINATION ON HIGH ANGLE SURFACES: VERTICAL STABILIZER

This section describes the 2018-19 activities related to the evaluation of fluid effectiveness and the characterization of contamination on high angle surfaces that include the vertical stabilizer. The section of the statement of work pertaining to this activity is provided in Appendix A.

2.1 Background

There is a lack of standardization in the treatment of vertical surfaces. Some operators in the United States and Canada exclude the treatment of vertical surfaces, including the tail fin, while others only consider treatment in ongoing freezing precipitation. Some reports have also indicated that treatment of the tail fin may worsen takeoff performance, as the anti-icing fluid on the tail fin may lead to increased accumulation of contamination in active precipitation conditions.

Current Transport Canada (TC) and Federal Aviation Administration (FAA) rules and regulations require that critical surfaces be free of contamination prior to takeoff. The vertical stabilizer is defined as a critical surface by both TC and the FAA. However, from a regulatory implementation and enforcement standpoint, there is currently no standardized guidance that offers inspectors a means to determine if an air operator is complying with operational rules. If current operational rules aim to achieve the clean aircraft concept – which requires the tail to have zero adhering frozen contamination – the question remains: How can this be adequately achieved, or appropriately mitigated by operators, to ensure a satisfactory level of safety?

2.2 Previous Work

Based on consultations held in 2015-16 with TC, the FAA, and National Aeronautics and Space Administration (NASA), the following research objectives were identified:

a) Verify if contamination is present on the vertical tail pre-deicing and, if so, under what conditions, and characterize (size, surface extent) that level of contamination;

b) Verify if contamination is present on the vertical tail post-deicing and, if so, under what conditions, and characterize (size, surface extent) that level of contamination; and

c) Identify optimal deicing procedures and mitigation plans and evaluate their effectiveness.

The research objectives were intended to span over two research years or more. At the request of TC and the FAA, APS Aviation Inc. (APS) undertook a research plan to evaluate de/anti-icing fluid effectiveness and characterize contamination on high angle surfaces. Only research objectives a) and b) were attempted in 2015-16. The details of this research are included in the TC report, TP 15340E, *Aircraft Ground Icing General Research Activities During the 2015-16 Winter* (1).

Due to other priorities and limited funds, the research was discontinued in 2016-17 and 2017-18. However, in 2017-18, at the request of TC and the FAA, APS prepared a presentation of the research previously conducted in 2015-16 for formal dissemination of the information to industry at the SAE International (SAE) G-12 Holdover Time Committee meeting held in May 2018 in Austin, Texas.

A follow-up meeting was held on September 13, 2018, and attended by TC, FAA, NASA, and APS. The intent was to identify research objectives related to fluid protection times on vertical surfaces for the research year 2018-19. At the meeting, the group recommended that limited additional testing be conducted during the winter of 2018-19 in outdoor conditions only, with best efforts made to target wet snow, dry snow, freezing precipitation, and mixed precipitation conditions.

2.3 Objective

The objective of this research was to carry out plate testing to verify if contamination was present on the vertical tail post de/anti-icing and, if so, under what conditions, and to characterize (size, surface extent) that level of contamination. The results of these tests would help identify optimal deicing procedures and mitigation plans and evaluate their effectiveness.

2.4 Procedure

Testing was conducted with de/anti-iced and untreated test plates in various configurations under natural precipitation conditions. The test protocol was an abbreviated version of the 2015-16 setup focusing on fixed plates, and it excluded the rotating test plates and the Piper Seneca II tail model. Greater focus was given to documenting characteristics of the contamination, including thickness and adherence, and supporting these observations with photography. The intent was to target wet snow, dry snow, freezing precipitation, and mixed precipitation conditions. The details of the outdoor testing procedure can be found in Appendix B.

2.5 Data Collected

A total of three test runs were conducted on two occasions during the winter of 2018-19 in outdoor natural snow conditions. Table 2.1 provides details on the tests that were conducted.

Note that during natural snow conditions, the precipitation rate would fluctuate over the course of a test. When conducting comparative tests, it was necessary to adjust the measured endurance times to compensate for variations in precipitation rates. This was done by adjusting the measured endurance time for each test by a linear ratio determined by the average rate of precipitation measured over the course of each individual test compared to the average rate during the baseline test. The endurance times were adjusted based on a linear relationship through the following formula:

$$\text{Adjusted Endurance Time} = \text{Actual Endurance Time} \times \frac{\text{Rate of Precip}}{\text{Avg Rate of Precip of Baseline Test(s)}}$$

Table 2.1: 2018-19 Log of Tests – Vertical Surfaces

Run #	Date	Condition	Fluid Type	Dilution	Surface	Endurance Time (min)	Adjusted Endurance Time (min)	Baseline Endurance Time (min)	Ratio of Endurance Time to Baseline (%)	Precip Rate ($g/dm^2/h$)	Wind Speed (km/h)	OAT (°C)	Thickness @ 5 min (mm)	Brix @ Fail (°)	Thickness @ Baseline End (mm)	Brix @ Baseline End (°)	Comments
23	24-Feb-19	ZR / IP	IV	100%	Baseline 10° Plate	141.8	141.8	141.8	100%	20.7	21.8	-0.3	1.6	0.50	n/a	0.50	DNF @ 8:14
	24-Feb-19	ZR / IP	N/A	n/a	10° Dry Plate	12.2	1.5	141.8	1%	2.6	21.8	-0.3	-	-	1.6-4.8	-	Thick ice with roughness due to pellets
	24-Feb-19	ZR / IP	I	B=20.0	10° Box	35.5	7.2	141.8	5%	4.2	22.7	-0.5	0.0	3.25	0.4-3.2	0.00	Ice with roughness due to pellets
	24-Feb-19	ZR / IP	IV	100%	80° Plate	117.4	78.9	141.8	56%	13.9	22.0	-0.4	0.5	3.00	0.4	0.00	Smoother ice
	24-Feb-19	ZR / IP	N/A	n/a	80° Dry Plate	13.1	1.7	141.8	1%	2.7	22.0	-0.4	-	-	1.2	-	Smoother ice
	24-Feb-19	ZR / IP	I	B=20.0	80° Box	31.6	6.0	141.8	4%	3.9	22.7	-0.5	0.0	3.00	0.8-1.3	0.00	Smoother ice
24	10-Mar-19	Snow	IV	100%	Baseline 10° Plate	68.3	68.3	68.3	100%	43.4	22.5	-1.7	1.7	10.00	4.5-5.7	10.00	Thick slush
	10-Mar-19	Snow	N/A	n/a	10° Box	0.5	0.4	68.3	1%	39.0	24.0	-1.8	-	-	8.9	-	Thick snow
	10-Mar-19	Snow	I	B=21.5	80° Plate	4.2	3.7	68.3	5%	38.3	24.0	-1.8	0.2	1.50	5.7	-	Thick snow, almost adhered
	10-Mar-19	Snow	IV	100%	80° Plate	14.0	12.8	68.3	19%	39.7	24.0	-1.8	0.6	7.50	0.4-5.7	-	Blotchy slush
	10-Mar-19	Snow	N/A	n/a	80° Dry Plate	65.1	65.4	68.3	96%	43.6	22.4	-1.7	-	-	0-0.1	-	DNF @ 11:05. Thin snow layer
	10-Mar-19	Snow	I	B=21.5	80° Box	8.3	7.3	68.3	11%	38.0	24.0	-1.8	0.1	1.00	0-4.5	-	Blotchy snow and adhered snow
25	10-Mar-19	Snow	IV	100%	Baseline 10° Plate	57.5	57.5	57.5	100%	37.4	22.1	-0.9	1.9	8.50	4.5	8.50	Thick slush
	10-Mar-19	Snow	N/A	n/a	10° Box	4.3	2.1	57.5	4%	18.8	19.0	-1.3	-	-	18.0	0.00	Thick snow
	10-Mar-19	Snow	I	B=21.5	80° Plate	13.2	6.7	57.5	12%	19.0	19.0	-1.3	0.2	0.00	15.0	0.00	Thick snow
	10-Mar-19	Snow	IV	100%	80° Plate	23.8	18.1	57.5	32%	28.5	19.0	-1.3	0.6	4.50	0-7.0	2.00	Blotchy snow
	10-Mar-19	Snow	N/A	n/a	80° Dry Plate	55.1	56.1	57.5	98%	38.1	22.3	-0.9	-	-	0-1.6	0.00	DNF @ 12:48. Thin snow layer
	10-Mar-19	Snow	I	B=21.5	80° Box	16.5	9.9	57.5	17%	22.4	19.0	-1.3	0.1	0.00	0-5.7	0.00	Blotchy ice/snow, not adhered

2.6 Summary of Test Results

The data collected was reviewed and analysed. Summary tables of the test results are included in Figure 2.1, Figure 2.2, and Figure 2.3.

It should be noted that the data collected was exploratory, and additional testing would be required to further substantiate these observations.

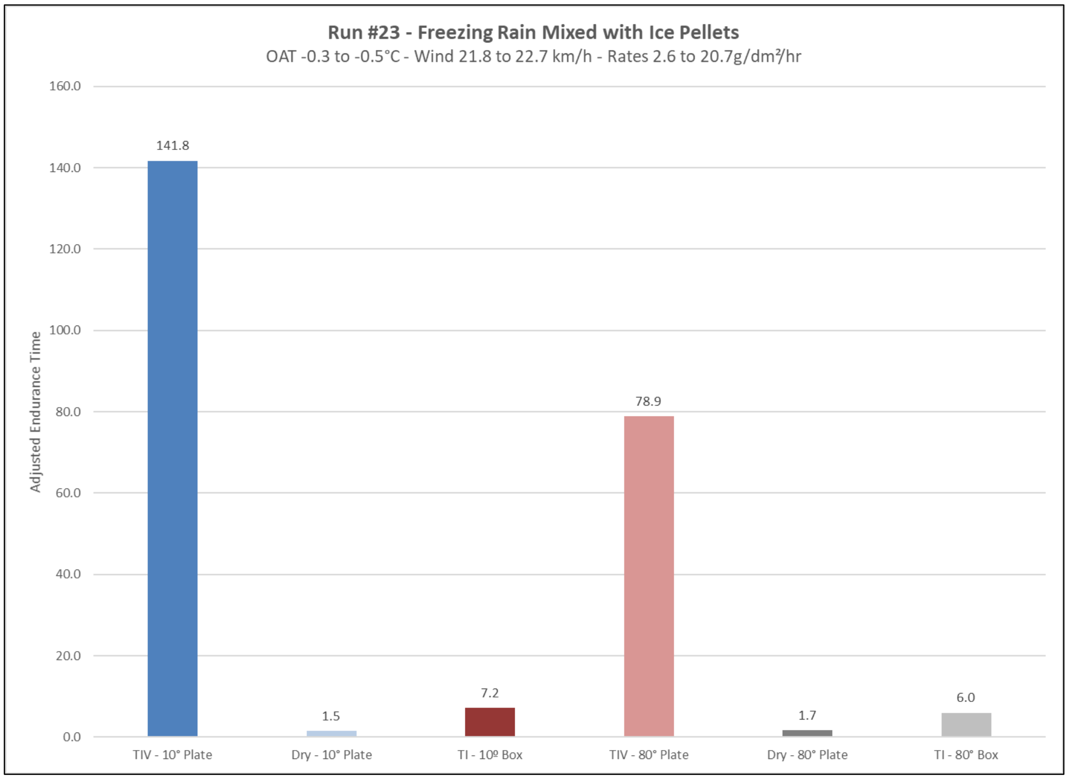


Figure 2.1: Run #23 – Summary of Results

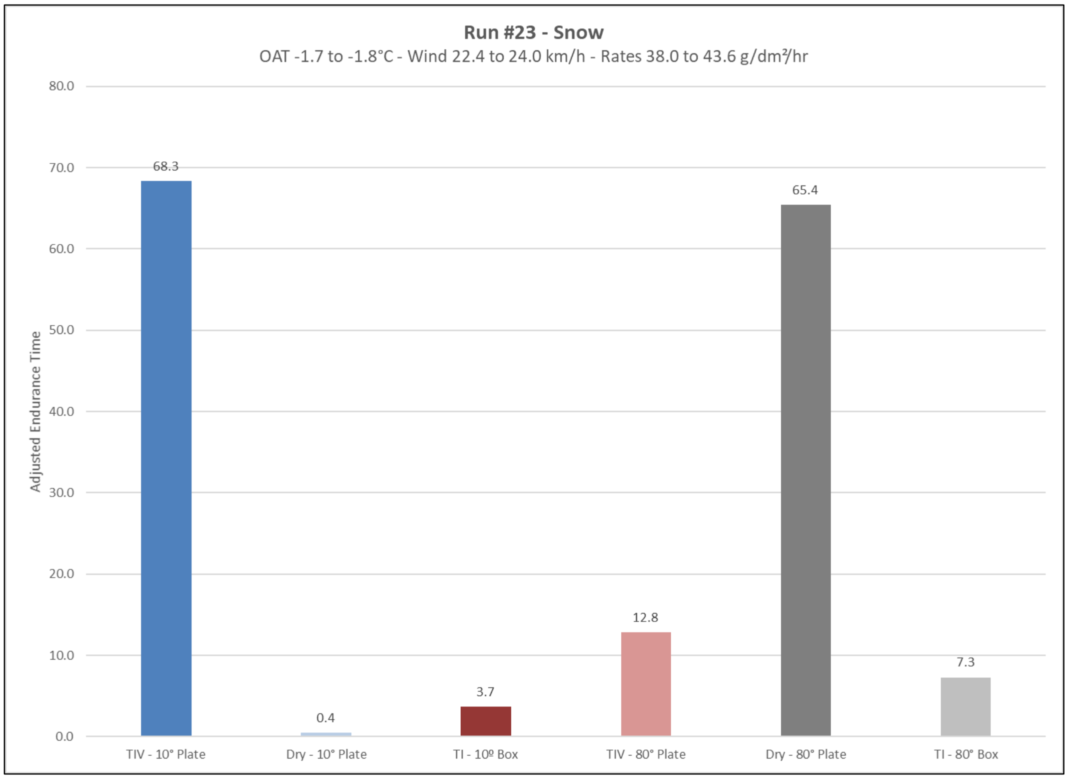


Figure 2.2: Run #24 – Summary of Results

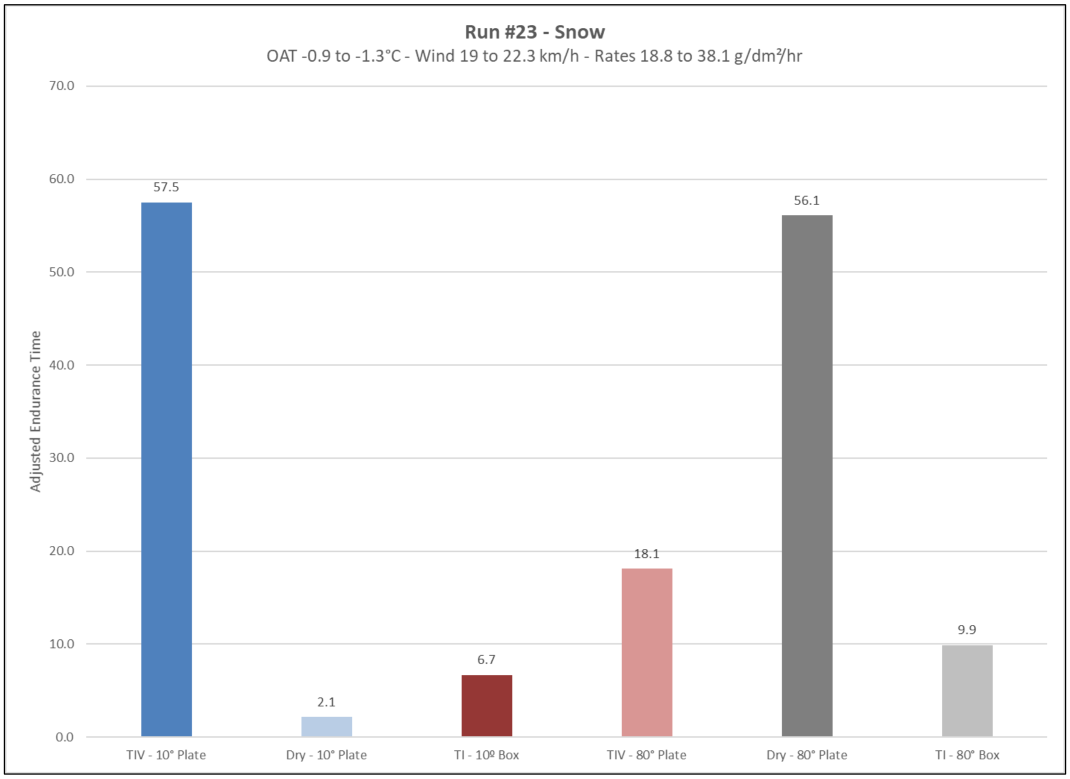


Figure 2.3: Run #25 – Summary of Results

2.6.1 Run #23

The test was conducted in conditions of freezing rain and ice pellets. The Type IV protected surfaces (both 10º and 80º) demonstrated significantly longer protection times compared to the dry untreated and Type I treated surfaces. At the time of the baseline 10º Type IV standard plate failure, the contamination was inspected on all surfaces. There was a notable difference in the type of contamination present on the 80º surfaces than on the 10º: the 80º surfaces had a smoother ice contamination, as the ice pellets likely “bounced off” the surfaces and only the freezing rain adhered, whereas the 10º surfaces had a much rougher ice contamination as a result of the ice pellets remaining on the surface and adhering and fusing with the freezing rain. The overall amount of ice present was greater on the 10º surfaces compared to the vertical surfaces; being close to 0ºC, both the ice pellets and some of the freezing rain would roll off the 80º surfaces, but would remain and freeze on the 10º surfaces. Photo 2.1 shows the condition of the test surfaces at the time of failure of the 80º Type IV plate.

2.6.2 Run #24

Dry snow conditions were experienced, and as a result, the dry untreated 80º surface was relatively clean for almost as long as the baseline 10º Type IV plate. Similar levels of contamination were present on the 80º Type I and Type IV plates; however, the Type I surface had adhered contamination at the end of the test, whereas the Type IV surface did not. The adherence on the Type I 80º surface was likely due to the high rate of precipitation, which diluted the fluid to water before the surface cooled below 0ºC. The contamination on the 10º plates was much thicker and slushier compared to that of the 80º plates.

Photo 2.2 shows the condition of the test surfaces at the approximate time of failure of the 10º Type IV plate.

In an attempt to quantify the remaining contamination present, an “air duster” was used to displace the contamination. When measured using a regular weight scale, the “air duster” created approximately 40 g of pressure when perpendicular to the scale surface at a distance of 5 cm. Each surface was sprayed from 5 cm away perpendicular to the surface, and the circular size of the displaced fluid/contamination was measured (see Photo 2.3). The methodology demonstrated merit in that the amount of fluid and/or contamination displaced varied in size, and in some cases did not move (when adhered). If a device could be developed to replicate the shear forces experienced during takeoff, a methodology could be developed to help determine the pass/fail criteria of the contaminated fluid observed. A full video of the “air duster” test was recorded, which provides additional information and observations.

2.6.3 Run #25

Similar conditions were observed in Run #25 as in Run #24 (tests were conducted back-to-back). The only difference was the rate of precipitation in Run #25, which was lower, and as a result adherence was not observed on the Type I 80º surface. Photo 2.4 shows the condition of the test surfaces at the approximate time of failure of the 80º Type IV Plate.

2.7 General Observations

The results obtained were in line with previous research findings indicating that, in general, the fluid protection was reduced on vertical surfaces. However, these tests maintained the observation that the rate and type of precipitation, along with wind and other meteorological conditions, greatly influenced the duration of protection time, and the overall amount of contamination collected on these surfaces over time. Further research is required to quantify those impacts on fluid protection time and the overall aerodynamic impact for aircraft.

The use of the “air duster” also demonstrated technical merit in quantifying the shear resistance of the contamination on the surfaces; with further development, the “air duster” could be calibrated to simulate shear forces experienced during takeoff.

2.8 Recommendations

The research conducted to date has demonstrated the variability of the fluid protection times and the characteristics of contamination on vertical surfaces. Additional research would provide a better understating of the influence of different variables, including the rate and type of precipitation and wind and other meteorological conditions.

The overall aerodynamic impact of contamination on vertical surfaces has yet to be fully understood. A working group was started in June 2019, which included FAA, TC, NASA, Boeing, and APS, with the objective to determine the best plan forward for testing in 2019-20 to quantify the aerodynamic impacts of contamination on vertical surfaces. A preliminary plan has been developed to use the TC owned Piper Seneca II tail model and conduct testing at the National Research Council Canada (NRC) Propulsion Icing Tunnel in Ottawa to qualify the contaminated fluid flow-off characteristics. This data will then be used by aircraft manufacturers to better understand the expected impacts on their specific aircraft types. Testing is expected to be conducted in January 2020.

Photo 2.1: Run #24 Test Surfaces at Time of Failure of 80º Type IV Plate

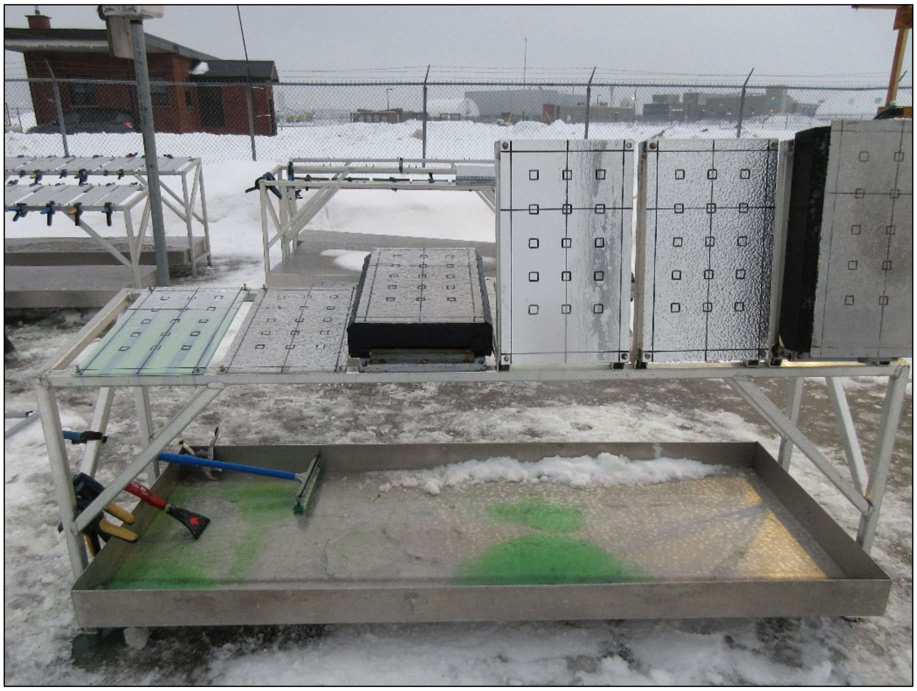


Photo 2.2: Run #24 Test Surfaces at Time of Failure of 10º Type IV Plate

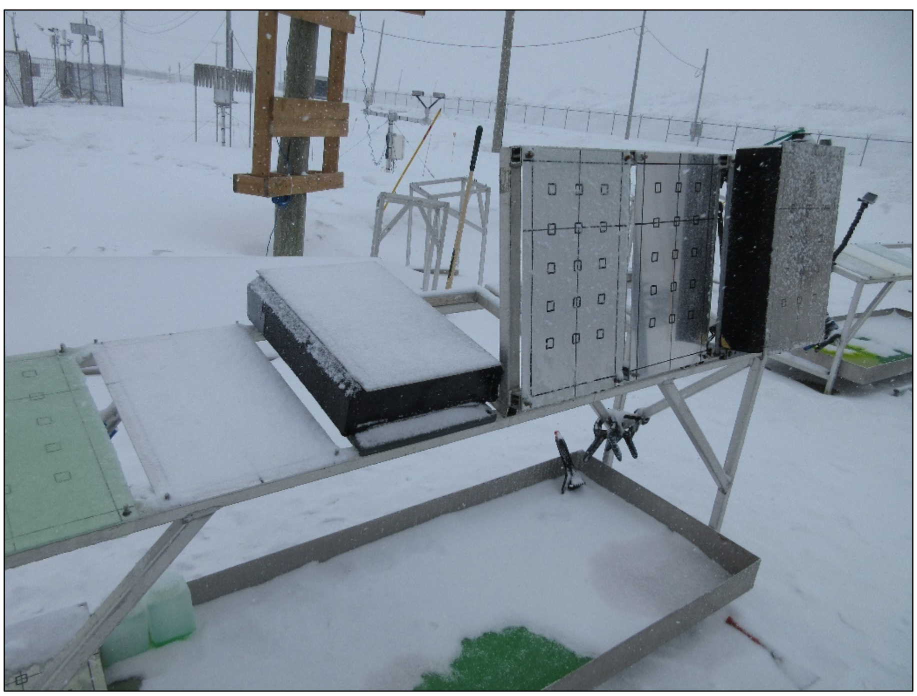


Photo 2.3: Run #24 "Air Duster" Displacement of Fluid/Contamination

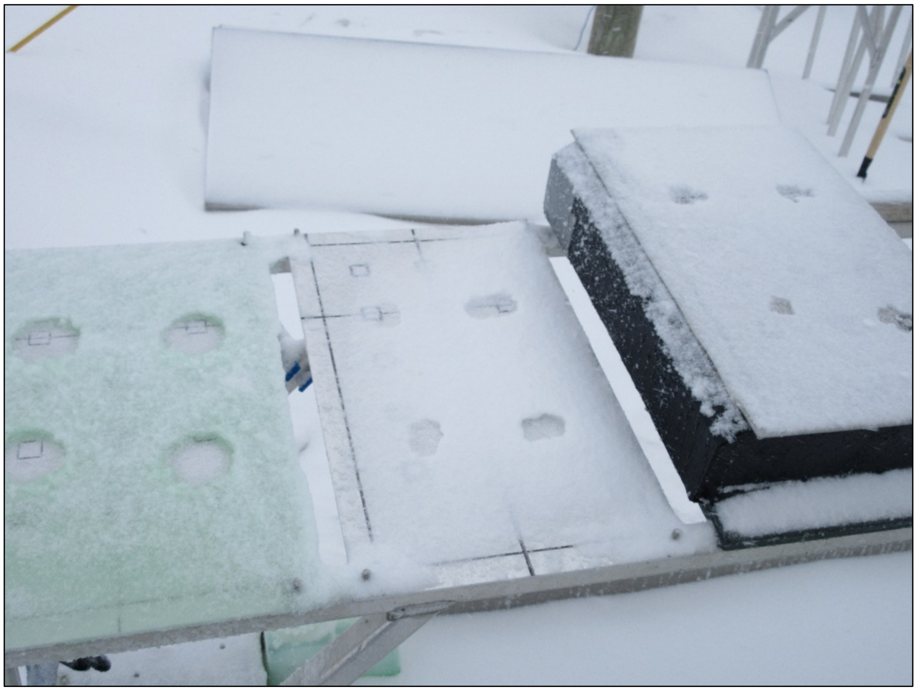
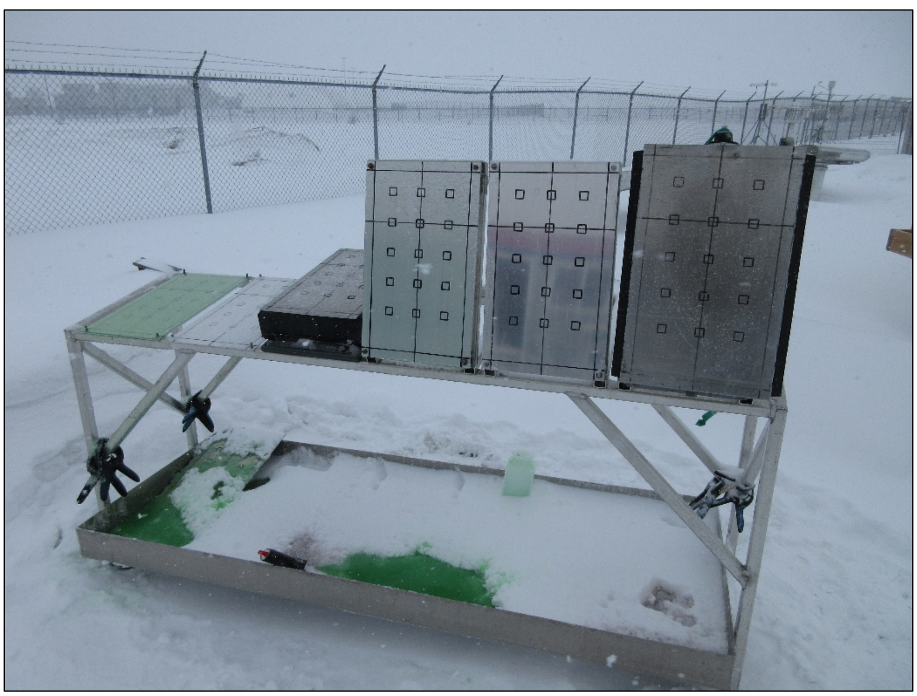


Photo 2.4: Run #25 Test Surfaces at Time of Failure of 80º Type IV Plate



3. TEMPERATURE-SPECIFIC SNOW HOLDOVER TIMES

This section documents the work carried out by APS Aviation Inc. (APS) in support of the development of temperature-specific snow holdover times (HOTs). This work was initiated in the winter of 2018-19 and is expected to be completed in the winter of 2019-20.

3.1 Background

Snow HOTs are derived from data collected at various temperatures. Multi-variable regression analysis is applied to this data to derive HOTs for specific temperatures; specifically, HOTs are calculated for the coldest temperature in each temperature band in the HOT tables. These HOTs are then used for all temperatures in the temperature band.

Although the data supports them, snow HOTs are not published for every temperature because it is neither practical nor user friendly to include this amount of data in the HOT tables published by Transport Canada (TC) and the Federal Aviation Administration (FAA). However, as HOTs almost always increase as temperature increases, there is an operational advantage to be gained by providing this data to operators (see example in Figure 3.1).

The adoption of electronic flight bags (EFBs) and the advent of apps that provide HOTs electronically have made it possible to provide HOTs for every temperature in a user-friendly format. However, in order to do this, TC and the FAA need to publish temperature-specific HOT values.

HOT Table Approach

Temp.	Moderate Snow HOT
-3°C and above	1:05 - 1:55
below -3 to -8°C	0:50 - 1:25

Temperature-Specific HOTs Approach

Temp.	Moderate Snow HOT
-3°C	1:05 - 1:55
-4°C	1:00 - 1:45
-5°C	0:57 - 1:37
-6°C	0:52 - 1:32
-7°C	0:51 - 1:27
-8°C	0:50 - 1:25

Figure 3.1: Example of HOT Table vs. Temperature-Specific HOTs Approaches

At the request of industry, TC and the FAA undertook a project in the winter of 2018-19 to develop and publish temperature-specific HOTs for snow. It should be noted that the project was limited to snow – other precipitation types were not included because HOT test data does not exist for all temperatures for other precipitation types.

3.2 Objectives

The objective of the temperature-specific snow HOTs project is to enable operators to use temperature-specific snow HOTs. At the request of TC and the FAA, the project was split into a research project and an operational implementation project. This division was made to obtain funding from appropriate sources for the research and operational aspects of the project. The tasks involved in each project were discussed by APS, TC, and the FAA in the fall of 2018 and are included in the TC statement of work. An excerpt from this document is provided in Appendix A. Table 3.1 provides the more detailed list of tasks that was created when the project began.

Table 3.1: Detailed Project Tasks

Task	Sub-Project
1. Prepare project plan	Both
2. Analytical work: mine existing data to determine how much temperatures change within one hour	Research
3. Analytical work: review endurance time data of existing fluids to determine how HOTs change with a 1, 2, and 3°C change in temperature	Research
4. Identify decisions regarding data production. Create summary document*	Research
5. Hold meetings with TC/FAA to inform them of issues and make decisions (three meetings expected)*	Research
6. Hold discussions to determine the exact format of data output*	Research
7. Hold discussions to determine the appropriate regulatory process to enable data use (guidance in TP 14052E/N 8900 or an Advisory Circular, Principal Inspector approval, or TC/FAA approval of data generators)	Operational
8. Create data output*	Operational
9. Conduct detailed verification of data output*	Operational
10. Assist TC/FAA to make regulatory changes as required	Operational
11. Support publication of data	Operational
12. Prepare presentation for SAE G-12	Both
13. Publish report	Both

** Task required if TC/FAA decide to publish data; task is not required if they elect to allow app developers to perform the calculations. Previous tasks may also render this task unnecessary.*

3.3 Meetings

Meetings between APS, TC, and the FAA were an important part of this project. The purpose of these meetings was to communicate the details of analyses completed to date and discuss decisions that impact the contents of the final temperature-specific HOTs data output.

Four meetings were held during the 2018-19 project year. Representatives from APS, TC, and the FAA attended all meetings.

1. Meeting #1: February 11, 2019 (Teleconference)
2. Meeting #2: March 15, 2019 (Teleconference)
3. Meeting #3: April 11, 2019 (In-person in Ottawa, Ontario)
4. Meeting #4: June 13, 2019 (In-person in Washington, DC)

The primary focus of these meetings was to discuss questions related to the data output (see Subsection 3.4). However, additional discussions took place at the meetings that impacted the work carried out in 2018-19 and will likely also impact work carried out in the future.

Key points from these discussions are listed below for reference.

- Temperature-specific HOTs will be published for Winter 2020-21 (not for Winter 2019-20).
- Air operators should be able to use temperature-specific HOTs without having to purchase an app. For example, an operator could make a HOT table with double the number of temperature bands than in the existing HOT tables.
- Regulators will likely need to publish additional guidance that governs how the temperature-specific HOTs database can be used (in related advisory circulars, standalone advisory circulars, or elsewhere). This will assist users in implementing them appropriately and will also ensure that inspectors know how to assess their implementation.
- Guidance materials should state the appropriate sources for accessing temperature data. These are the same as those used with the HOT tables.
- Guidance materials should specify that users must have a verification process in place to ensure that any conversion of the database into other materials (printed or electronic) has been done accurately.
- Guidance materials should include an explanation of the temperature buffer. The explanation should detail that the buffer is not in place for HOT table boundary temperatures.

- HOT values obtained from the HOT tables and from the temperature-specific HOTs database will both be considered valid TC/FAA sources of data. Users will be able to elect which source to use. It may be possible to combine the data sources.
- If user feedback shows confusion about why precipitation conditions other than snow are not included in the temperature-specific HOTs database, consideration should be given to adding them in the future (values for other precipitation conditions will not be temperature-specific).
- The end product will likely have three components: database, notes, and verification process or requirements.
- Regulators should communicate to known app developers in the spring prior to publication. Providing a data excerpt to the developers would enable them to program their apps to accept data from the database before it is published.

3.4 Analysis: Data Questions and Decisions

A significant part of this project was to identify, research, discuss, and resolve questions related to the publication of temperature-specific HOT data. Preliminary analysis was carried out by APS, and the results were brought forward to TC and the FAA. Decisions by TC and the FAA were facilitated by APS through a series of meetings (see Subsection 3.3).

Table 3.2 provides a list of the data questions and the corresponding decisions made for each question. It should be noted that final decisions have not been made for several of the questions.

Table 3.2: Data Questions and Decisions

Question	Decision
1. Do users do their own calculations for temperature-specific HOTs or do TC/FAA do the calculations and publish a database?	• Decision (Feb 11): TC/FAA to do calculations.
2. Are HOT table capping rules retained (2 hours TC, 3 hours FAA)?	• Decision (Feb 11): Yes.
3. Can data be provided in a complex table format or does it need to be in a proper database format with one entry per HOT value?	• Decision (Feb 11): Needs to be a universal database; therefore, needs to be one entry per value.
4. Should HOTs be provided for the actual reported temperature or should a conservative factor be added?	• Decision (Mar 7): Add conservative factor. • Decision (Mar 15): Conservative factor will be 1°C. • Decision (Apr 11): It's okay to calculate at 1°C colder than the LOUT because HOT regression curves are not dependent on LOUT. Therefore, this will be done. • Decision (Apr 11): Populate database at boundary conditions with boundary temperature values (no 1°C buffer) to avoid lack of harmonization between HOT tables and database.
5. Should the user have to apply the temperature conservatism, or should it be embedded in the database?	• Decision (Mar 7): Embed conservatism in database.
6. Will temperature-specific HOTs be provided for diluted fluids?	• Decision (Mar 15): Do not include dilutions. Consider doing in future if requested by industry.
7. Are HOT table rounding rules retained?	• Decision (Mar 15): No. Values will be rounded to the nearest minute. HOTs below 10 minutes will be rounded down to the nearest whole minute.
8. In what format will the data be published?	• Decision (Mar 15): Data will be published in Excel. This decision was driven by the need for average users (airlines) to be able to use the data. XML requires a program be created to decode/process data.
9. Should data be published only to the lowest operational use temperature (LOUT) or to a very cold temperature with a caution to respect the LOUT?	• Decision (Feb 11): Publish data only to LOUT.

Table 3.2: Data Questions and Decisions (cont'd)

Question	Decision
10. Will temperature-specific HOTs be provided for very cold snow (temperatures below -14°C)?	• Decision (Apr 11): Fluids with fluid-specific HOTs for very cold snow will be populated with temperature-specific values. Fluids with generic very cold snow HOTs will be populated with boundary temperature values (no regression for generics).
11. Will temperature-specific HOTs be provided below -25°C?	• Decision (Apr 11): Yes, HOTs will be provided to LOUT.
12. Should there be a limitation for short HOTs? (TC restricts pre-takeoff contamination inspections with Type I fluids and with Type II/III/IV fluids with HOTs below 20 minutes.)	• Decision (Apr 11): No.
13. Will temperature-specific HOTs be provided for all fluids?	• Decision (June 13): Will be provided for Type II, Type III, and Type IV fluids but not for Type I fluids.
14. Do notes/cautions need to be provided with temperature-specific HOTs? If yes, are these provided in the database or by the data provider (i.e. with the app)?	• Further discussion required.
15. What is the impact of temperature-specific HOTs on liquid water equivalent (LWE) systems? Some harmonization/thought required to ensure equivalency between HOT tables, temp-specific HOTs, and LWE HOTs. Notably, restrictions regarding changing temperatures and inclusion of notes/cautions. Need to have similar restrictions.	• Further discussion required.

3.5 Analysis: Impact of Hourly Temperature Reporting on Holdover Times

A concern was brought forward that temperature-specific HOTs calculated for METAR-reported temperatures could be inaccurate. This is due to METAR typically reporting temperature on an hourly basis (not more frequently). If temperature has decreased since the last METAR report, the actual HOT could be shorter than the HOT provided for the reported temperature. An in-depth analysis was carried out to assess this possible safety risk.

The analysis was conducted in two parts: first, hourly variance in air temperatures was evaluated (see Subsection 3.5.1) and second, change in HOTs based on a 1°C decrease in temperature was evaluated (see Subsection 3.5.2). Based on the results of these analyses, options for mitigating this risk were proposed (see Subsection 3.5.3).

3.5.1 Hourly Variance in Air Temperatures During Snow Events

The initial analysis examined hourly variance in air temperatures during snow events.

- Data Collection: Data that had previously been collected as part of a long-term weather analysis project was used. The data included weather data collected during active snow events at six weather stations in Quebec. The weather data included air temperatures. Data from five years was collected. (Additional data was available, but it was deemed unnecessary as little variance was seen year-to-year in the five years of data.)
- Data Processing: The data was processed to collect hourly temperatures. Temperatures were compared to the temperature collected the previous hour to determine the change in temperature in one hour (in one-degree increments). Data points without a measurement the previous hour were declared invalid and removed. The result was approximately 4,400 data points.
- Outliers: Data points with a greater than 3°C change in hourly temperature were identified as outliers and were further examined. They were compared to current Environment Canada historical weather records. Data points with temperatures inconsistent with the currently available Environment Canada historical data were removed. All other data points were retained. It should be noted that Environment Canada has stated there may be errors in the historical data (e.g. sensor malfunction). This type of error could not be checked. This likely indicates some of the outliers in the database are in fact not valid points (i.e. the analysis is more conservative than reality).

- Results: The data showed that temperature changed by 1°C or less in an hour 97 percent of the time, and it changed by 2°C or less 99 percent of the time (see Table 3.3). As increasing temperatures do not pose a safety risk, the occurrence of decreases only was examined. The data showed that temperature stayed the same or increased 87 percent of the time, and temperature did not decrease by more than 1°C 98 percent of the time (see Table 3.4).
- Conclusion: Temperature very rarely decreases by more than 1°C per hour during an active snow event.

Table 3.3: Hourly Changes in Temperature During Active Snow – Increases and Decreases

Change in Temperature (°C)	Data Points						Percentage of Data	Cumulative Percentage
	2002-03	2003-04	2004-05	2005-06	2006-07	ALL		
No Change	594	467	554	783	564	**2962**	**67%**	**67%**
Change by ±1	254	195	247	348	269	**1313**	**30%**	**97%**
Change by ±2	20	14	25	38	21	**118**	**3%**	**99.3%**
Change by ±3	1	4	7	8	5	**25**	**0.6%**	**99.8%**
Change by > ±3	3	0	1	0	3	**7**	**0.2%**	**100.0%**
Total	**872**	**680**	**834**	**1177**	**862**	**4425**	**100%**	**100.0%**

Table 3.4: Hourly Changes in Temperature During Active Snow – Decreases Only

Change in Temperature (°C)	Data Points						Percentage of Data	Cumulative Percentage
	2002-03	2003-04	2004-05	2005-06	2006-07	ALL		
Temp Increase	169	131	184	201	192	**877**	**20%**	**20%**
No Change	594	467	554	783	564	**2962**	**67%**	**87%**
Decrease by 1	93	73	79	170	94	**509**	**12%**	**98%**
Decrease by 2	13	7	10	18	8	**56**	**1.3%**	**99.5%**
Decrease by 3	0	2	6	5	2	**15**	**0.3%**	**99.9%**
Decrease by >3	3	0	1	0	2	**6**	**0.1%**	**100.0%**
Total	**872**	**680**	**834**	**1177**	**862**	**4425**	**100%**	**100.0%**

3.5.2 Impact on Holdover Time of a 1°C Change in Temperature

The second analysis examined the impact of a 1°C change in temperature on HOT.

- Data Collection: All Type II and Type IV 100/0 fluids in the TC/FAA HOT Guidelines were included in the analysis. For warm snow (-14°C and above), this included 30 fluids; for cold snow (below -14°C), it included only six fluids (only select fluids have cold snow data available).
- Data Processing: Regression coefficients were used to calculate HOTs for each data set for rates of 4 and 25 g/dm²/h for five temperature pairs separated by 1°C (warm snow: -2/-3°C, -8/-9°C, -13/-14°C; cold snow: -16/-17°C, -24/-25°C). The difference in HOT caused by a 1°C decrease in temperature was calculated for each data set for each precipitation rate and temperature pair combination.
- Results: See summary in Table 3.5. In many cases, a 1°C decrease in temperature did not have a significant impact on HOT. However, in other cases, there could be a significant impact (decrease of greater than 10 percent). The key factors that influence the degree of change are:
  - Fluid brand: Some fluids are more temperature dependent, and therefore changes in temperature have a bigger impact on HOT;
  - Temperature (top or bottom of the temperature range used in the regression): The shape of the regression curve used for HOTs (power law) leads to larger differences in HOTs for similar temperature changes at warmer relative to colder temperatures; and
  - Temperature (warm snow vs. cold snow): Changes in HOTs due to temperature changes are more significant in cold snow relative to warm snow.
- Conclusion: A 1°C decrease in air temperature can, in some cases, lead to a significant change in HOT performance.

Table 3.5: Summary – Percent Changes in HOTs with 1°C Decrease in Temperature

Warm Snow (≥-14°C)			Cold Snow (<-14°C)		
Decrease in HOT	**Data Points (#)**	**Data Points (%)**	**Decrease in HOT**	**Data Points (#)**	**Data Points (%)**
0 to 5%	133	74%	0 to 5%	4	17%
5 to 10%	39	22%	5 to 10%	5	21%
> 10%	8	4%	> 10%	15	63%
All	**180**	**100%**	**All**	**24**	**100%**

3.5.3 Risk Mitigation Options

The analyses determined that there is some risk to using hourly data to determine temperature-specific HOTs. Three possible risk mitigation options were identified.

1. Stop Project: Do not allow temperature-specific HOTs to be used.
2. Real-time Temperature Observation Required: Allow temperature-specific HOTs to be used only if accurate, real-time temperature is available.
3. Introduce Conservatism: Require that temperature-specific HOTs provide HOT for 1°C colder than the METAR-reported temperature. This will mean that 98 percent of the time, the temperature-specific HOTs will be less than or equal to the true HOT for the reported current temperature.

These analyses and risk mitigation options were presented to TC and the FAA at the first project meeting. TC and the FAA elected to incorporate a conservatism of 1°C into the temperature-specific HOTs database (see also Subsection 3.3).

3.6 Presentation Material

APS drafted presentation material on temperature-specific HOTs for the SAE International (SAE) G-12 annual meeting held in Dubrovnik, Croatia in May 2019. Ultimately, this material was incorporated into a larger presentation prepared and given by TC.

3.7 Conclusions and Recommendations

Significant progress was made on the development of temperature-specific snow HOTs in the winter of 2018-19. Many of the questions related to the publication of the data were resolved. However, several regulatory issues remain outstanding, and the database needs to be created. It is recommended that this project be continued in the winter of 2019-20 and that the outstanding tasks be completed.

4. EVALUATION OF NEW SNOW MACHINE

This section documents the work carried out by APS Aviation Inc. (APS) to conduct parallel testing of the current APS snow machine and the new snow machine to evaluate whether endurance times obtained from the new snow machine were similar to the current snow machine.

4.1 Background

Transport Canada (TC) and the Federal Aviation Administration (FAA) have provided ongoing funding to the National Center for Atmospheric Research (NCAR) for the development of and subsequent continued improvements to an artificial snowmaking system (“the Snow Machine”). The primary goal of this research is to improve aviation safety by providing accurate information on aircraft holdover times (HOTs), which in turn improve safety for aircraft on takeoff and increase the efficiency of aircraft ground operations in winter conditions.

The snow machine can be used to perform indoor snow testing of aircraft de/anti-icing fluids in a cold room laboratory environment to determine HOTs. Prior to the winter of 2018-19, two machines were built; one is currently used by NCAR, and the other is currently used by APS.

In 2016-17, it was recommended that a new snow machine be built to increase the testing capacity of APS and to provide a backup in the event of system failure. To have continuity with a large dataset of historical research, it is necessary for this new snow machine to provide consistent results with the current snow machine.

4.2 Objective

The objective of this work is to provide a brief summary of testing that was completed to compare the performance of the current APS snow machine with that of the new snow machine. All testing was conducted in accordance with the SAE International (SAE) Aerospace Recommended Practice (ARP) 5485B, *Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids* (2). This standard contains a detailed description of the test equipment, test parameters, snow measurement methods, snow test conditions, and a snow test procedure for conducting endurance time tests for SAE Type II, III, and IV de/anti-icing fluids.

The primary goal of this testing was to evaluate whether endurance times obtained from the new snow machine were similar to those from the current snow machine.

A supplementary objective was to test and validate the functionality of the new snow machine, including all its individual components, in sub-zero temperatures.

4.3 Variances in the Snow Machines

Slight variances exist between the new snow machine and its predecessor. Although the method through which these two machines generate artificial snow is identical, certain variances in the components of the two machines exist. While the current snow machine is still fitted with some of its original components (drill press, translator, et cetera), the new snow machine has been outfitted with modern components.

The following component changes/enhancements in the new snow machine were noted:

- Drill blade is sharper in the new snow machine;
- Absence of drill whiskers in the new snow machine;
- Absence of drill protector (half-moon assembly) in the new snow machine;
- Drill press type is larger in the new snow machine;
- Fan placement and type capacity of fan is different in the new snow machine;
- Core support distance from blade is less on the new snow machine; and
- Resolution of stepper motor is finer in the new snow machine.

4.3.1 Drill Blade Sharpness

It is generally understood that the sharpness of the drill blades can change the snow characterization and/or snowflake size. Differences in snowflake size can alter the visual perception of a failed plate. During this testing, differences in snowflake size were observed and could possibly generate a bias.

4.3.2 Drill Whiskers and Drill Protector

The drill whiskers are installed directly onto the blade assembly to prevent snow from building up onto the upper parts of the drill protector (half-moon assembly). The purpose of these two components is to prevent snow from building up on the upper portions of the snow dispensing system, so as to not let excess quantities of snowfall onto the plate. A design change in the new machine eliminated the need for drill whiskers and a drill protector.

4.3.3 Drill Press Type

The new snow machine is fitted with a larger drill press than the current APS snow machine. A new drill press may have a more stable consistent rpm than that of an older, worn-down drill press. An unstable rpm may potentially produce different snow characterization and hence alter the results.

4.3.4 Distribution Fans

Both systems use fans to improve distribution of snow across the test plate. However, NCAR has changed the location of these fans to a higher position. This small variation could result in a different distribution of snow on the test plate.

4.3.5 Stepper Motor

The stepper motor is a component that powers the translator to feed the ice core into the system. The step resolution of the new snow machine is finer than that of the current machine, which results in a smoother feed rate.

4.4 Test Methodology

This section describes the test site, equipment, test surface, fluids, personnel requirements, and test procedure used to carry out the testing.

4.4.1 Test Site

Indoor tests were conducted in a temperature-controlled test chamber at PMG Technologies in Blainville, Quebec.

4.4.2 Equipment

Two snow machines were used in this testing. As described previously, both the new snow machine and current snow machine were built by NCAR. The current snow machine has been in use for many years to measure all endurance times in artificial snow.

4.4.3 Test Surface

Both machines utilise a standard aluminum endurance time test plate (500 mm by 300 mm), which is fixed to the fluid collection bucket of the snow machine assembly. The plate and collection bucket assembly were positioned to maintain the test surface at a 10° incline.

4.4.4 Fluids

All of the fluids that underwent endurance time testing in the winter of 2018-19 were used as representative fluids for this comparative testing. This fluid list was comprised of one Type II and four Type IV fluids.

4.4.5 Personnel

As two snow machines were used simultaneously, two senior employees and one junior employee were required. The senior employees conducting these tests had advanced knowledge in the operation of the snow machines, and a junior employee was on-hand to provide support.

During a portion of this testing, a lead engineer was on-hand to investigate any anomalies between the two machines and provide insight into possible variances.

4.4.6 Test Procedure

Endurance time tests were conducted using the test protocols outlined in the procedure titled *Endurance Time Testing in Simulated Snow with SAE Type I, II, III, and IV De/Anti-icing Fluids*. This procedure is included in the TC report, TP 15425E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2018-19 Winter* (3).

The two snow machines were run simultaneously at identical times in identical conditions to best eliminate any bias.

4.5 Data Collection and Analysis

This section provides a log and analysis of the comparative tests that were conducted.

4.5.1 Complete Log of Tests (18 Tests)

Eighteen runs were conducted comparing the new snow machine to the current snow machine. Tests were conducted with five representative HOT fluids at both -18°C and -25°C and at rates of 3, 4, 10, and 25 g/dm^2/h. For direct comparison, the normalized rate was used. The selection of the tests was based upon the procedure developed for endurance time testing, which is included in TP 15425E (3).

The results of the entire data set indicate that the new machine yielded endurance times eight percent longer (on average) than that of the current machine.

Table 4.1 and Figure 4.1 provide a summary of the data collected.

Table 4.1: Log of Comparative Tests (Whole Data Set)

#	Fluid Code	Temperature (°C)	Normalized Rate ($g/dm^2/h$)	New Machine Endurance Time (min)	Current Machine Endurance Time (min)	Difference New Machine to Current Machine (%)
1	018A	-18	3.1	66.0	62.0	6%
2	018A	-25	4.1	60.3	58.7	3%
3	018A	-25	25.7	15.9	13.1	22%
4	018A	-18	4.1	51.7	53.3	-3%
5	014A	-25	4.1	26.7	27.3	-2%
6	014A	-25	3.9	28.7	23.4	23%
7	014A	-25	9.9	16.2	11.3	43%
8	014A	-18	3.1	54	51.0	6%
9	014A	-18	25.3	8.9	7.0	27%
10	011A	-25	3.1	70.8	69.1	2%
11	011A	-25	4.1	51.0	56.0	-9%
12	011A	-25	25.2	15.0	14.0	8%
13	011A	-18	10.3	32.7	30.3	8%
14	017A	-25	4.1	135.7	133.3	2%
15	017A	-25	25.0	22.1	19.9	11%
16	020A	-25	4.1	159.0	156.9	1%
17	020A	-25	25.5	24.8	22.2	12%
18	020A	-18	3.2	182.9	197.9	-8%
					Average	**8%**

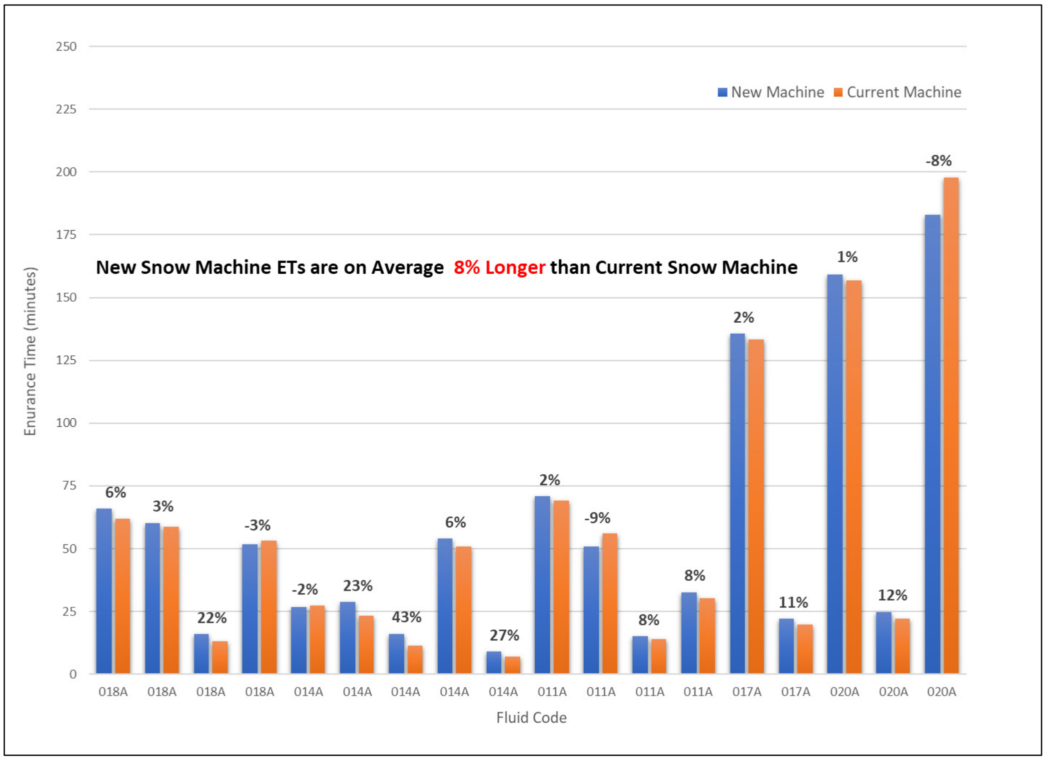


Figure 4.1: New Snow Machine vs. Current Snow Machine (Whole Data Set)

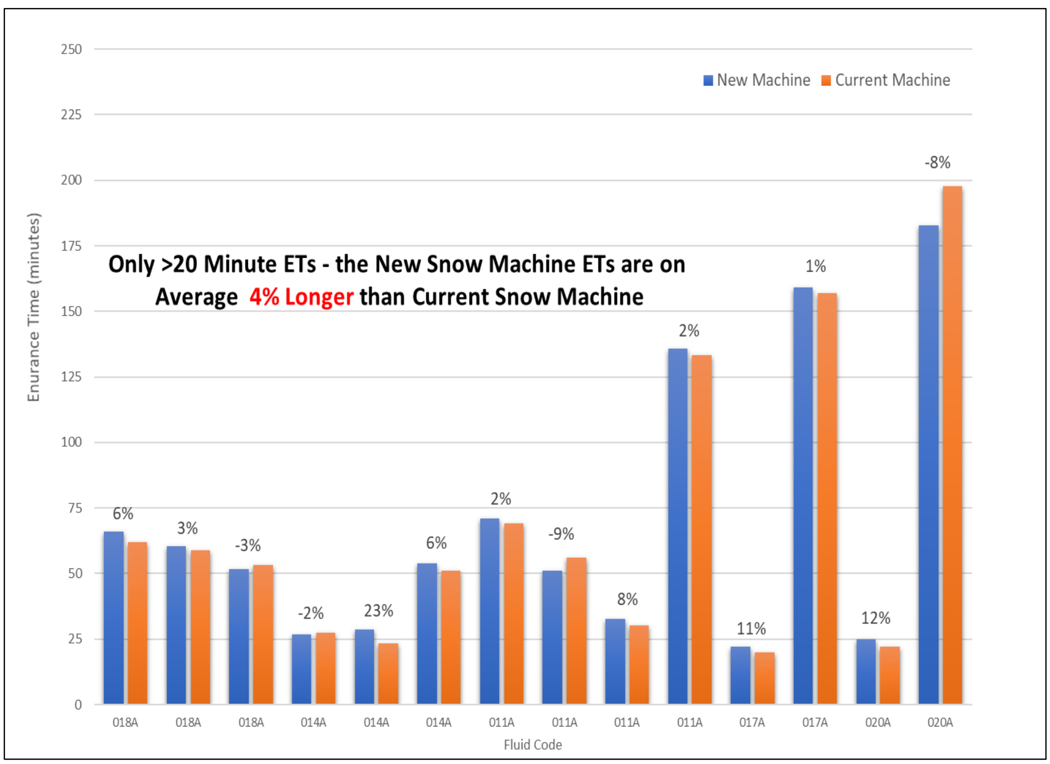


Figure 4.2: New Snow Machine vs. Current Snow Machine – Greater than 20 Minutes Endurance Times

4.5.2 Data with Endurance Times Greater than 20 Minutes (14 Tests)

The data set was segmented to include only those tests with endurance times greater than 20 minutes. Endurance times were on average four percent longer for the new snow machine than the current snow machine in 14 out of 18 tests. Table 4.2 and Figure 4.2 provide a summary of the data collected.

Table 4.2: Log of Comparative Tests (Greater than 20 Minutes)

#	Fluid Code	Temperature (°C)	Normalized Rate ($g/dm^2/h$)	New Machine Endurance Time (min)	Current Machine Endurance Time (min)	Ratio of New Machine to Current Machine (%)
1	018A	-18	3.1	66.0	62.0	6%
2	018A	-25	4.1	60.3	58.7	3%
4	018A	-18	4.1	51.7	53.3	-3%
5	014A	-25	4.1	26.7	27.3	-2%
6	014A	-25	3.9	28.7	23.4	23%
8	014A	-18	3.1	54	51.0	6%
10	011A	-25	3.1	70.8	69.1	2%
11	011A	-25	4.1	51.0	56.0	-9%
13	011A	-18	10.3	32.7	30.3	8%
14	017A	-25	4.1	135.7	133.3	2%
15	017A	-25	25.0	22.1	19.9	11%
16	020A	-25	4.1	159.0	156.9	1%
17	020A	-25	25.5	24.8	22.2	12%
18	020A	-18	3.2	182.9	197.9	-8%
					Average	**4%**

4.5.3 Data with Endurance Times Less than 20 Minutes (4 Tests)

The dataset was segmented to include only those tests with endurance times less than 20 minutes. Endurance times were 25 percent longer for the new snow machine than the current snow machine in 4 out of 18 tests. Table 4.3 and Figure 4.3 provide a summary of the data collected.

Table 4.3: Log of Comparative Tests (Less than 20 Minutes)

#	Fluid Code	Temperature (°C)	Normalized Rate (g/dm^2/h)	New Machine Endurance Time (min)	Current Machine Endurance Time (min)	Ratio of New Machine to Current Machine (%)
3	018A	-25	25.7	15.9	13.1	22%
7	014A	-25	9.9	16.2	11.3	43%
9	014A	-18	25.3	8.9	7.0	27%
12	011A	-25	25.2	15.0	14.0	8%
					Average	**25%**

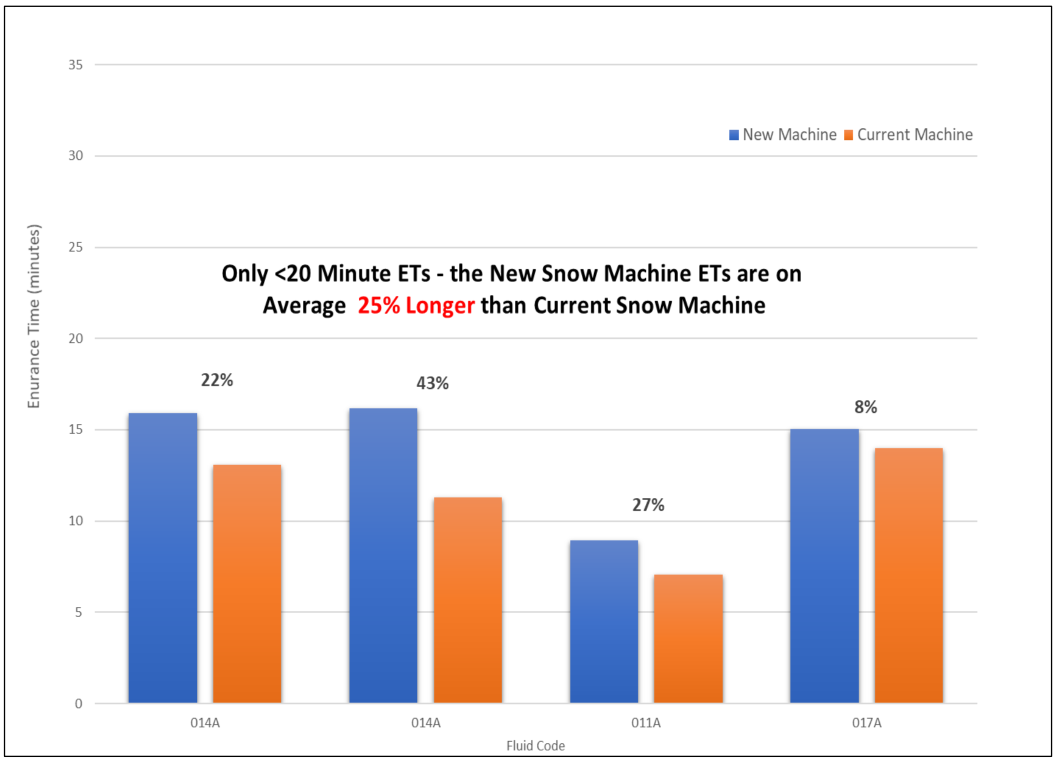


Figure 4.3: New Snow Machine vs. Current Snow Machine – Less than 20 Minutes Endurance Times

4.6 Conclusions and Recommendations

The new snow machine functioned in accordance with its design. Testing identified no significant issues with the functionality or control of the new snow machine.

The analysis indicated that there was variance in the results between the new machine and the current machine. In the TC report, TP15399E, *Artificial Snow Research Activities for the 2017-18 Winter* (4), it was determined that the primary factor for discrepancies in snow machine repeatability was machine influence. This report indicates that issues with repeatability have been identified not only when comparing multiple machines but also when comparing the individual results of a single machine.

As part of the five-year plan that commenced in 2018-19, plans are in place to develop a new generation snow machine that will minimize variances, which will allow it to be used as a surrogate for natural conditions testing. As part of these plans, both the current snow machine and the new snow machine will be replaced by this new generation snow machine. Therefore, it can be concluded that the new snow machine can be used for the current annual endurance time testing and research. If endurance times are expected to be less than 20 minutes, it is recommended that tests be conducted using the current machine.

5. TECHNICAL REVIEW, APPROVAL, AND PUBLICATION OF HISTORICAL REPORTS

This section describes the process used by APS Aviation Inc. (APS) to publish reports for the de/anti-icing research program on behalf of Transport Canada (TC) and the Federal Aviation Administration (FAA). It also details the status of the technical review of historical reports in the publication process and provides guidance for handling such reports subsequently.

5.1 Background

As of October 31, 2016, APS had prepared over 187 reports on aircraft ground icing research and development on behalf of TC and the FAA. Out of these 187 reports, 124 reports were not published. This backlog is attributed to limited resources and shifting priorities within TC and the FAA. To remedy the backlog, APS was tasked to develop a prioritized list of unpublished reports, accelerate these reports through the publication process, and deliver them as Final Version 1.0.

5.2 Objective

The objective of this project for the 2018-19 year was to publish 20 reports (targets for subsequent years will be determined at the completion of each year).

This objective was achieved through the following measures:

- Coordinating and outsourcing technical and editorial reviews of reports with technical and editorial experts;
- Performing technical and editorial reviews (to be done by technical and editorial experts) and making necessary updates to prepare reports for final editing and publishing; and
- Providing a status of progress within the monthly progress reports.

5.3 Publication Process and Delivery of Technical Reports

APS produces reports annually for the de/anti-icing research program on behalf of TC and the FAA through a detailed reports management process that it has developed and continually updates. Figure 5.1 displays the updated reports management process, offering a global view of the progression of reports from "Draft" to "Final" stage of publication. It includes all the phases with their respective milestones and detailed tasks from initiation to publication.

The Reports Management Process comprises eight phases. The first four phases are internal to APS and labelled Phase 1, 2, 3, and 4, respectively. The following four phases are related to the publication of a report and are labelled Phase 5, 6, 7, and 8, respectively. Reports typically undergo these phases prior to delivery of Final Version 1.0.

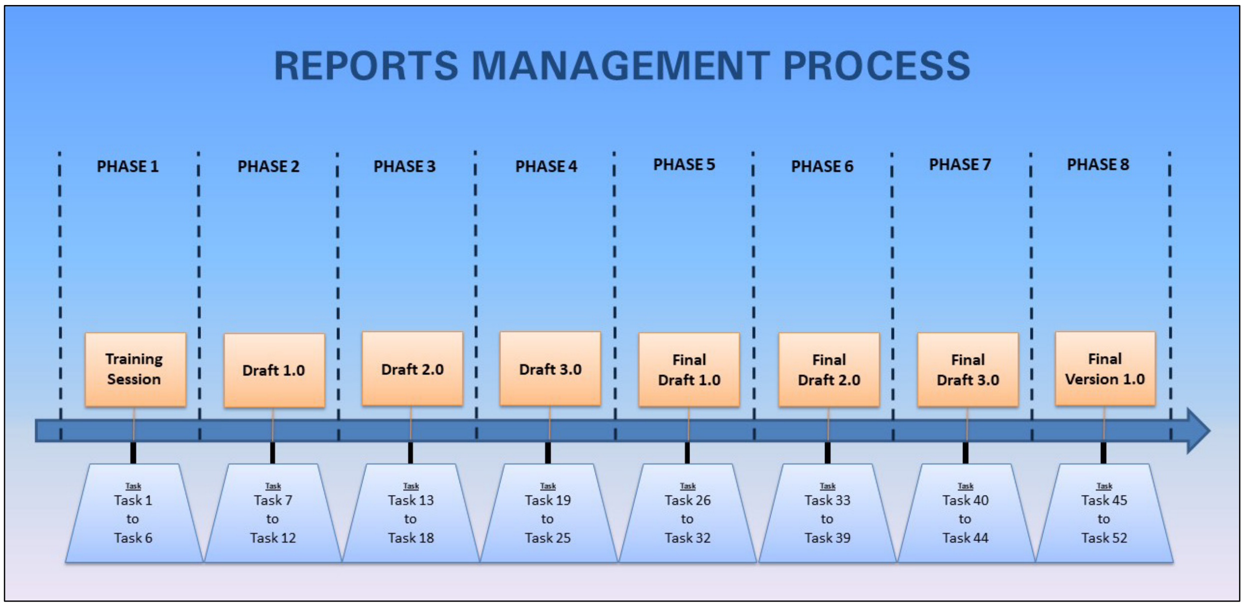


Figure 5.1: Reports Management Process

For the year 2016-17, APS surpassed the goal of 12 reports and published 16 reports in total. These reports were published and delivered to TC and the FAA as Final Version 1.0 via "WeTransfer." The details of the reports published in 2016-17 are provided in TC report, TP 15374E, *Aircraft Ground Icing General Research Activities During the 2016-17 Winter* (5).

For the year 2017-18, APS surpassed the goal of 20 reports and published 22 reports in total. The details of the reports published in 2017-18 are provided in TC report, TP 15398E, *Aircraft Ground Icing General Research Activities During the 2017-18 Winter* (6). These reports were published and delivered to TC and the FAA as Final Version 1.0 via "WeTransfer" and USB drives.

For the year 2018-19, APS published 20 reports, as shown in Table 5.1 These reports were published and delivered to TC and the FAA as Final Version 1.0 via "WeTransfer" and USB drives.

Table 5.1: List of Published Technical Reports (2018-19)

No.	TP Number	Year	Report Title	Category	Latest Version	Publication Date
1	TP 15397E	2017-18	Regression Coefficients and Equations Used to Develop the Winter 2018-19 Aircraft Ground Deicing Holdover Time Tables	Regression	Final Version 1.0	May 13, 2019
2	TP 15200E	2011-12	Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing	Sensors	Final Version 1.0	June 27, 2019
3	TP 15231E	2012-13	Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)	Sensors	Final Version 1.0	June 27, 2019
4	TP 15272E	2013-14	Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 3 of 3)	Sensors	Final Version 1.0	June 27, 2019
5	TP 15398E	2017-18	Aircraft Ground Icing General Research Activities During the 2017-18 Winter	General & Exploratory	Final Version 1.0	June 28, 2019
6	TP 15399E	2017-18	Artificial Snow Research Activities for the 2017-18 Winter	Artificial Snow	Final Version 1.0	July 31, 2019
7	TP 14374E	2003-04	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2003-04 Winter	Holdover Time	Final Version 1.0	October 11, 2019
8	TP 14443E	2004-05	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2004-05 Winter	Holdover Time	Final Version 1.0	October 11, 2019
9	TP 14712E	2005-06	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2005-06 Winter	Holdover Time	Final Version 1.0	October 11, 2019
10	TP 14776E	2006-07	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2006-07 Winter	Holdover Time	Final Version 1.0	October 11, 2019
11	TP 14869E	2007-08	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2007-08 Winter	Holdover Time	Final Version 1.0	October 11, 2019
12	TP 14933E	2008-09	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2008-09 Winter	Holdover Time	Final Version 1.0	October 11, 2019
13	TP 15050E	2009-10	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2009-10 Winter	Holdover Time	Final Version 1.0	October 11, 2019
14	TP 15156E	2010-11	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2010-11 Winter	Holdover Time	Final Version 1.0	October 11, 2019
15	TP15203E	2011-12	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter	Holdover Time	Final Version 1.0	October 11, 2019
16	TP 15228E	2012-13	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter	Holdover Time	Final Version 1.0	October 11, 2019
17	TP 15271E	2013-14	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter	Holdover Time	Final Version 1.0	October 11, 2019
18	TP 15321E	2014-15	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2014-15 Winter	Holdover Time	Final Version 1.0	October 11, 2019
19	TP 15338E	2015-16	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2015-16 Winter	Holdover Time	Final Version 1.0	October 11, 2019
20	TP 15396E	2017-18	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2017-18 Winter	Holdover Time	Final Version 1.0	October 11, 2019

5.3.1 Overall Publication Status of Technical Reports

The overall status of the reports as of October 31, 2018, was as follows:

- Published reports: 103;
- Non-published reports: 95; and
- Total reports: 198.

Detailed in Table 5.1, the following 20 reports from past years were delivered to TC and the FAA as Final Version 1.0 during the 2018-19 year:

- One report from 2003-04;
- One report from 2004-05;
- One report from 2005-06;
- One report from 2006-07;
- One report from 2007-08;
- One report from 2008-09;
- One report from 2009-10;
- One report from 2010-11;
- Two reports from 2011-12;
- Two reports from 2012-13;
- Two reports from 2013-14;
- One report from 2014-15;
- One report from 2015-16; and
- Four reports from 2017-18.

In 2017-18, a detailed analysis of all past APS reports was conducted, and they were consequently re-categorized in 2017-18. The overall status and progression of report publication with the new categorization from October 31, 2018, to October 31, 2019, is presented in Table 5.2.

Table 5.2: Overall Status of Reports from 2017-18 to 2018-19

Category	Description	2017-18 (# of reports as of Oct. 31, 2018)	2018-19 (# of reports as of Oct. 31, 2019)
Published Reports	TP reports that are published as Final Version 1.0.	103	123
Interim Reports Incorporated into a TP Report	Reports initially produced as interim reports and subsequently incorporated into TP reports.	21	22
Interim Reports not to be Published	Reports that have not been assigned TP numbers and will not be published; however, some information contained in these reports has been included in a subsequent TP report.	2	2
Protected Reports	Reports that are not for distribution; two reports for the Department of National Defence and one Ops Survey report for TC.	3	3
Non-published Reports	TP reports that are still in Draft stages.	64	48
Interim Reports to be Published	Reports that have not been assigned TP numbers and may be published.	5	4
Total Reports Produced	Total number of reports produced by APS.	**198**	**202**

In addition, APS is currently working on five reports for the Winter 2018-19 research activities; these are not included in the totals as of October 31, 2019.

As of October 31, 2019, estimating that APS will publish 20 reports per year, it will take approximately three-and-a-half years to clear the backlog. As of October 31, 2019, the number of published reports, including the reports that are expected to be published, totals to 175.

5.4 Conclusions

APS has been involved in writing and publishing technical reports on behalf of TC and the FAA since 1992 and has prepared over 202 reports. Due to TC's and the FAA's limited resources, 124 reports were still outstanding in 2016-17, and APS was tasked with developing a prioritized list of unpublished reports that needed to be reviewed and published. By October 2017, APS published 16 reports that were delivered to TC and the FAA as Final Version 1.0. By October 2018, APS published 22 reports that were delivered to TC and the FAA as Final Version 1.0. By October 2019, APS published 20 reports that were delivered to TC and the FAA as Final Version 1.0.

5.5 Recommendations

Since APS has taken a more active role in completing this project, it is recommended that proper resources be dedicated to publishing these reports on a yearly basis.

6. PUBLICATION OF HOLDOVER TIME GUIDANCE MATERIALS

This section describes the work APS Aviation Inc. (APS) completed in the winter of 2018-19 in support of Transport Canada (TC) and the Federal Aviation Administration (FAA) holdover time (HOT) guidance materials.

6.1 Background

The development and use of HOT Guidelines represent an important contribution to the enhancement of flight safety in winter aircraft operations. In the years since their introduction, the HOT Guidelines and related guidance materials have become a standard and essential part of winter operations. APS plays a significant role in the preparation and management of these documents.

6.2 APS Contribution to Holdover Time Guidance Materials

Over the years, APS has supported TC and the FAA in the development and management of the HOT Guidelines documents. APS completes the following tasks in support of the HOT guidance materials on an annual basis:

a) Develops fluid-specific HOT and regression tables for new Type II, III, and IV anti-icing fluids that undergo endurance time testing;

b) Requests, collects, and reviews information provided by fluid manufacturers related to fluid qualification dates and lowest operational use temperatures (LOUTs) – this results in updates being made to the list of fluids in the HOT Guidelines;

c) Recommends changes to the HOT guidance materials as a result of new research findings;

d) Maintains an ongoing list of potential future changes to the HOT guidance materials, schedules and runs meetings to review and discuss these changes with TC/FAA, and implements changes as required;

e) Drafts HOT Guidelines and HOT regression information documents on an annual basis, including TC English, TC French, and FAA versions;

f) Provides support for the update of the FAA N 8900 series document;

g) Restructures guidance material to make it accessible for people with disabilities; and

h) Provides the latest HOT Guidelines and regression information to the TC publications department for them to update their website on an annual basis (or more frequently if updates to the HOT Guidelines are necessary).

6.3 Winter 2019-20 Holdover Time Guidance Materials

In August 2019, the 2019-20 HOT Guidelines and Regression Information documents were finalized. The changes made to the documents are summarized in the documents themselves and are described in detail in two TC reports:

1. **Holdover Time Guidelines:** TP 15425E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2018-19 Winter* (3); and
2. **Holdover Time Regression Information:** TP 15426E, *Regression Coefficients and Equations Used to Develop the Winter 2019-20 Aircraft Ground Deicing Holdover Time Tables* (7).

The titles of the 2019-20 documents are listed in Table 6.1. Final drafts of TC and FAA documents were provided to the TC and the FAA publications departments, respectively, for publication on August 6, 2019.

A Revision to the FAA HOT Guidelines was published on August 19, 2019 to amend references and numbering on select table notes in the document. No update was required for the TC HOT Guidelines.

As intended, the FAA finalized and published its N 8900 series notice, along with the other HOT guidance materials, on August 6, 2019. An updated N 8900 series notice was published on October 7, 2019.

Table 6.1: 2019-20 HOT Guidance Documents

HOT Guidelines	1. Transport Canada Holdover Time (HOT) Guidelines Winter 2019-2020, Original Issue, August 6, 2019
	2. Guide de Transports Canada sur les durées d'efficacité Hiver 2019-2020, version originale, 6 août 2019
	3. FAA Holdover Time Guidelines Winter 2019-2020, Original Issue, August 6, 2019
	4. FAA Holdover Time Guidelines Winter 2019-2020, Revision 1.0, August 19, 2019
Regression Information	5. Transport Canada HOT Guidelines Regression Information Winter 2019-2020, Original Issue, August 6, 2019
	6. Transports Canada Guide des durées d'efficacité Information de régression Hiver 2019-2020, version originale, 6 août 2019
	7. FAA Holdover Time Regression Information Winter 2019-2020, Original Issue, August 6, 2019

6.4 Future Responsibilities

APS will continue contributing to the development of the TC and the FAA HOT guidance materials in the winter of 2019-20. Specifically, APS will continue carrying out the tasks listed in Subsection 6.2.

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7. PRESENTATIONS, FLUID MANUFACTURER REPORTS, AND TEST PROCEDURES FOR 2018-19

This section contains an account of the test procedures, presentations, and fluid manufacturer reports prepared by APS Aviation Inc. (APS) in the winter of 2018-19.

7.1 Presentations

SAE International (SAE) G-12 Committees hold several meetings on an annual basis. During these and other meetings, APS presents the findings of work completed during the year. Most of the research presented at these meetings is eventually documented in various reports.

In 2018-19, APS gave presentations at the following meetings:

1) SAE G-12 Holdover Time (HOT) Committee, Montreal, Canada, November 2018;
2) SAE G-12 HOT Committee, Dubrovnik, Croatia, May 2019;
3) Airlines for America (A4A) Ground Deicing Forum, Washington, USA, June 2019; and
4) SAE International Icing Conference, Minneapolis, USA, June 2019.

The presentations given by APS at each of these meetings are listed in the following subsections. A copy of each presentation listed is contained in Appendix C.

7.1.1 SAE G-12 Holdover Time Committee Meeting, Montreal, Canada, November 2018

The following three presentations were prepared for the SAE G-12 HOT Committee meeting held in Montreal, Canada, in November 2018:

1) SAE G-12 HOT Committee: Document Updates;
2) Changes to HOT Guidance for Winter 2018-19 [prepared by APS and presented by Transport Canada (TC) and the Federal Aviation Administration (FAA)]; and
3) 2018-19 Endurance Time Testing Program.

7.1.2 SAE G-12 Holdover Time Committee, Dubrovnik, Croatia, May 2019

The following six presentations were prepared for the SAE G-12 HOT Committee meeting held in Dubrovnik, Croatia, in May 2019:

1) Winter 2018-19 Endurance Time Testing Results;
2) SAE G-12 HOT Committee: Documents Status;
3) Changes to HOT Guidelines for Winter 2019-20 (prepared by APS and presented by TC and the FAA);
4) Natural Snow Characterization Testing;
5) Artificial Snow: A Historical Review (prepared by APS and presented by TC and the FAA); and
6) Updates on Guidance for METAR Codes GS, GR, PL, SHGS, SG (prepared by APS and presented by the FAA).

7.1.3 Airlines for America Ground Deicing Forum, Washington, USA, June 2019

The following two presentations were prepared for the A4A Ground Deicing Forum held in Washington, USA, in June 2019:

1) Changes to HOT Guidelines Winter 2019-20; and
2) Updates on Guidance for METAR Codes GS, GR, PL, SHGS, SG (prepared and presented by APS on behalf of the FAA).

7.1.4 SAE International Icing Conference, Minneapolis, USA, June 2019

The following presentation was prepared for the SAE Icing Conference held in Minneapolis, USA in June 2019:

1) Ground Icing Research Program (prepared and presented by TC and APS).

7.2 Fluid Manufacturer Reports

As part of the HOT research program, several fluids are tested for holdover performance each year. The data from commercialized fluids is published in the related TC report, TP 15425E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2018-19 Winter* (3), while the non-commercialized fluid reports are maintained by the respective fluid manufacturers for internal research purposes.

7.2.1 Holdover Time Testing Reports

Seven reports were prepared to document HOT testing conducted in the winter of 2018-19. Copies of these reports were provided to the fluid manufacturers and to TC and FAA project managers.

Four of the reports were for commercialized fluids; these reports can be found in the appendices of TP 15425E (3). Three reports were for experimental fluids.

The seven reports were:

1) Type II: ROMCHIM ADD-PROTECT TYPE II;
2) Type IV: AllClear ClearWing EG;
3) Type IV: Cryotech Polar Guard Xtend;
4) Type IV: LNT E450 (supplemental testing to support LOUT change); and
5) Three non-commercialized experimental fluids.

A companion document outlining the methodologies used in endurance time testing of Type II, III, and IV fluids was also prepared and provided to the manufacturers.

7.3 Test Procedures

Several procedures were developed to guide and support the research team in conducting tests in the winter of 2018-19. Table 7.1 provides the list of the procedures. The procedures have been included as appendices to the winter 2018-19 reports; the specific reports are listed in the last column of Table 7.1.

Table 7.1: List of Procedures 2018-19

Program Element #	ID #	Contract Program Element	Name of Procedure	Latest Version Details	Report
1	1.1	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Procedure: Endurance Time Testing in Simulated Freezing Precipitation with SAE Type I, II, III, and IV De/Anti-Icing Fluids	Final Version 1.0, November 2018	HOT
1	1.2	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Procedure: Endurance Time Testing in Natural Snow with SAE Type I, II, III, and IV De/Anti-Icing Fluids	Final Version 1.0, November 2018	HOT
1	1.3	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Procedure: Endurance Time Testing in Simulated Snow with SAE Type I, II, III, and IV Fluids	Final Version 1.0, November 2018	HOT
1	1.4	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Procedure: Endurance Time Testing in Active Frost with SAE Type I, II, III, and IV De/Anti-Icing Fluids	Final Version 1.0, November 2018	HOT
1	1.5	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Overall Program of Tests at NRC, April 2019	Final Version 1.0, March 27, 2019	HOT
1	1.6	Endurance Time Testing for Maintenance and Publication of HOT Guidance Material	Overall Program of Tests at PMG, March 2019	Final Version 1.0, March 28, 2019	HOT
2	2.1	Snow Machine R&D Project: Support NCAR with Snow Machine Repeatability and Outdoor Testing Characterization	Procedure: Natural Snow Characterization Endurance Time Testing	Final Version 1.0, January 17, 2019	G&E
4	4.1	Exploratory Research and Standards (V-Stab, SAE Standards, AWG, FRWG, HOT Committee, and Other)	Procedure: Vertical Surfaces Testing	Final Version 1.0, February 7, 2019	G&E
8	8.1	Wind Tunnel Testing - Type IV High Speed Validation of Allowance Times for New Fluids with Thin High Performance Wing	Procedure: Wind Tunnel Tests to Examine Fluid Removed from Aircraft During Takeoff with Mixed Ice Pellet Precipitation Conditions	Final Version 1.2, August 21, 2019	WT

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1. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2015-16 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, January 2017, TP 15340E, XX (to be published).

2. SAE International Aerospace Recommended Practice 5485B, *Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids*, October 2017.

3. Bernier, B., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2018-19 Winter*, APS Aviation Inc., Transport Canada, Montreal, December 2019, TP 15425E, XX (to be published).

4. Bendickson, S., Bernier, B., *Artificial Snow Research Activities for the 2017-18 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2018, TP 15399E, 82.

5. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2016-17 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2017, TP 15374E, 52.

6. 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.

7. Bernier, B., *Regression Coefficients and Equations Used to Develop the Winter 2019-20 Aircraft Ground Deicing Holdover Time Tables*, APS Aviation Inc., Transport Canada, Montreal, October 2019, TP 15426E, XX (to be published).

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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

4. Exploratory Research and Standards (V-Stab, SAE Standards, AWG, FRWG, HOT Committee, and Other)

Note: This program element includes research activities that will be pursued on an exploratory and ad-hoc basis. These activities were selected by representatives from TC and the FAA from a larger set of potential activities. Due to funding constraints, only those activities listed below are planned to be performed (activities may be added at the discretion of TC/FAA).

a) Support activities of SAE G-12 Aerodynamics Working Group.

b) Support activities of the SAE G-12 Fluid Requalification Working Group.

c) Provide support for further development of SAE aircraft ground deicing standards as needed.

d) Provide support to the SAE G-12 Holdover Time Committee, including providing a qualified individual to serve as the committee's secretary.

e) Support activities related to fluid protection times on vertical surfaces, which may include limited testing as required.

f) Provide technical support services and exploratory testing to provide regulators with timely data and documentation to address unexpected operationally driven industry incidents / concerns / questions.

g) Install the new model of NCAR snow machine at the APS snow machine test facility, and conduct some limited testing to evaluate the performance of the new machine relative to the older model.

Note that the following activities were also considered for inclusion, however, were not selected due to funding constraints. If additional funds become available over the course of the program, these activities may be performed at TC/FAA's discretion.

i. Support the rewrite of TP 14052E through attendance of all meeting and consultations, and providing additional technical support, as needed.

ii. Conduct additional analysis relating to rate tolerance in endurance time testing with the goal of further developing ARP5485.

iii. Conduct additional analysis relating to the use of half-plates in endurance time testing with the goal of further developing ARP5485.

iv. Investigate A319 engine icing issues experienced by a commercial operator.

v. Determine scope of work necessary to develop ethylene glycol-specific ice pellet allowance times.

vi. Support the development of an equivalency look up table (to support HOTDS systems) to cross-reference METAR reported weather vs hot table conditions.

vii. Determine rates in mist and freezing mist to support HOT development for snow mixed with mist or fog.

viii. Evaluate the addition of heavy snow hots to HOT tables for 25-50 $g/dm^2/h$.

ix. Documentation of test methods and protocols for hot, ice pellet, snow machine, etc.

x. Evaluate hangar operations with and without fluids.

xi. Investigation of new technologies to support the modernization of the ground icing research program.

10. Development of Temperature-Specific Snow HOT Data: Preliminary Research

a) Prepare project plan and have kickoff meeting with TC/FAA.

b) Conduct analysis to mine existing data (i.e. HOT, EC, READAC, or other) to determine how temperatures change within one hour, and how much do HOTs change with this change.

c) Identify decisions regarding data production and create a summary document.

d) Hold meetings with TC/FAA to inform them of issues and make decisions on path forward (3 meetings expected).

e) Hold discussions to determine exact format of data output (variables included, data format, separate vs. single TC/FAA output, et cetera.).

f) Prepare presentation for SAE G-12.

g) Prepare a report.

11. Development of Temperature-Specific Snow HOT Data: Support for Operational Implementation

It should be noted that this task will be started following the completion of Task 10.

a) Prepare project plan and have a kickoff meeting with TC/FAA.

b) Create the data output.

c) Conduct detailed verification of the data output.

d) Hold discussions to determine the regulatory process which will be employed to enable operators to use data (e.g. TP 14052/N 8900, advisory circular, et cetera.
e) Provide assistance to TC/FAA to make regulatory changes as required.
f) Support the publication of data.
g) Prepare presentation for SAE G-12.
h) Prepare a report.

12. Technical Review, Approval, and Publishing of Technical Reports (20 Reports to Bring from Final Draft 1.0 to Final Publication)

a) Coordinate and manage the master list of reports, the list of references, et cetera.
b) Review, revise, and train publications department and staff on the Reports Training Manual.
c) Develop prioritized list of approximately 20 reports to be published as Final Version 1.0, and create and maintain schedule.
d) Coordinate and schedule editorial reviews, technical reviews, and French translation of each report.
e) Perform editorial review for each report and make changes with author(s) to reports.
f) Perform technical review for each report and make changes with author(s) to reports.
g) Perform French translation for each report and make changes to reports.
h) Format reports for Final TC Approval (including references, signatures, front matter et cetera).
i) Support the TC approval and publishing of each report.
j) Upload reports to the APS website on behalf of TC/FAA.

13. Provision for Project Support Services (Including Progress Reporting and Preparation of Current Year Technical Reports to Final Draft 1.0 Level)

a) Provide support services for program coordination (progress reporting, setup of meetings, coordinate travel, et cetera.).

b) Create task list and provide support services for management of task list.

c) Manage, schedule, and plan current year reports to Final Draft 1.0 level.

d) Develop current year reports from Draft 1.0 to Final Draft 1.0 including report components and appendices.

e) Format and finalize reports for ISO review.

f) Deliver Final Draft 1.0 to TC/FAA.

g) Coordinate, create, and manage the "Exploratory Research and Standards" report.

h) Coordinate and manage the list of reports (costed as part of a separate program element).

14. Update Source Documents for Maintenance and Publication of HOT Guidance Material

The following tasks will be completed (in general) for both phases of this work (Phase 1: New and outstanding changes to be integrated prior to March 31st; and Phase 2: Annual updates to be integrated prior to the publication expected in early August):

a) Prepare project plan and have kickoff meeting with TC/FAA;

b) Maintain a log of proposed changes to the HOT guidelines. Provide project coordination, follow-ups, and training;

c) Coordinate, plan, and lead discussions between TC, FAA and EASA to address and approve new changes to the HOT guidance material;

d) Coordinate, plan, and lead discussions between TC, FAA and EASA to approve annual updates to the HOT guidance material;

e) Update regression coefficients document (detailed activity costed as part of a separate program element including discussions and implementation); and

f) Provide support for publication of documents.

16. Infrastructure for TC/FAA Guideline Development

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

Fluid Management:

a) Receive and catalogue fluids;

b) Verify viscosity of newly received fluids at time of receipt and prior to simulated precipitation testing;

c) At the request of TC/FAA, verify viscosity of fluids in inventory intended for testing use; and

d) Maintain log of fluid inventory and viscosity information.

Preparation and Setup for Natural, Artificial Snow, and Frost Testing:

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

b) Upgrade test site infrastructure (i.e.: trailer, shed, snow machine) to ensure personnel safety, adhere to environmental guidelines, maintain equipment inventory, and ensure equipment is calibrated;

c) Prepare an updated procedure for testing fluids in natural snow;

d) Prepare an updated procedure for testing fluids in frost;

e) Prepare an updated procedure for testing fluids with the snow machine;

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

g) Develop improved, more efficient methods to measure snowfall intensity or holdover times, if appropriate; and

h) Update and maintain iPad based HOT testing data form.

Preparation and Setup for Simulated Precipitation Testing at NRC:

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

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

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

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

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

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

f) Update and maintain the NRC Rate Calculation software.

General Activities:

a) Management and operational coordination;

b) Purchase equipment and modify test facility equipment as required;

c) Monitor weather, provide support to projects, and provide training to staff on operations;

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

e) Prepare reports.

17. Infrastructure for TC/FAA Research and Development

This program element does not include the actual research and development testing. The description of these program elements has been included in other sections of this document and has been budgeted separately.

Fluid Management:

a) Receive and catalogue fluids;

b) Verify viscosity of newly received fluids at time of receipt and prior to simulated precipitation testing;

c) At the request of TC/FAA, verify viscosity of fluids in inventory intended for testing use; and

d) Maintain log of fluid inventory and viscosity information.

Preparation and Setup for Natural, Artificial Snow, and Frost Testing:

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

b) Upgrade test site infrastructure (i.e.: trailer, shed, snow machine) to ensure personnel safety, adhere to environmental guidelines, maintain equipment inventory, and ensure equipment is calibrated;

c) Prepare an updated procedure for testing fluids in natural snow;

d) Prepare an updated procedure for testing fluids in frost;

e) Prepare an updated procedure for testing fluids with the snow machine;

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

g) Develop improved, more efficient methods to measure snowfall intensity or holdover times, if appropriate; and

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General Activities:

a) Management and operational coordination;

b) Purchase equipment and modify test facility equipment as required;

c) Monitor weather, provide support to projects, and provide training to staff on operations;

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

e) Prepare reports.

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APPENDIX B

PROCEDURE:
VERTICAL SURFACES TESTING
WINTER 2018-19

300293

PROCEDURE:

VERTICAL SURFACES TESTING

Winter 2018-19

Prepared for

Innovation Centre
Transport Canada

And the

Federal Aviation Administration

Prepared by: David Youssef

Reviewed by: Marco Ruggi

February 7, 2019
Final Version 1.0

PROCEDURE: VERTICAL SURFACES TESTING

Winter 2018-19

1. BACKGROUND

There is a lack of standardization in the treatment of vertical surfaces. Notwithstanding, some air operators in the United States and Canada currently practice varying de/anti-icing procedures that excludes the treatment of the vertical surfaces, namely the tail. There is a significant amount of operational history that supports this practice; however, there has been no research carried out that has quantitatively demonstrated or determined if the exclusion of treating the tail offers the equivalent level of safety of a contaminant free critical surface.

The belief of some operators is that it is worthwhile to treat vertical surfaces when there is ongoing freezing precipitation (e.g. light freezing rain) whereas there is little to no benefit of anti-icing with ongoing frozen contamination (e.g. snow, ice pellets) given that these forms of precipitation do not typically adhere at colder temperatures.

Conversely, in some operational situations there is the potential that the treatment of vertical surfaces may in fact be detrimental to the takeoff performance of an aircraft (i.e. anti-icing fluid on the tail may lead to increased accumulation of contamination).

From a regulatory implementation and enforcement standpoint there is currently no standardized guidance that offers inspectors a means by which to determine if an air operator is complying with the operational rules. Therefore, if the current operational rules aim to achieve the clean aircraft concept, and thus require the tail to have zero adhering frozen contamination, how can this be adequately achieved or appropriately mitigated by operators to ensure a satisfactory level of safety?

Based on meetings attended by Transport Canada (TC), Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), and APS Aviation Inc. (APS), an initial research testing plan was developed and dated October 8, 2015. This test plan became the basis for testing conducted during the winter of 2015-16. The objective of this testing was to document contamination found on the vertical stabilizer both pre and post deicing, and to evaluate optimal deicing procedures and mitigation plans. Additional limited research with the same mandate was performed for the winter of 2016-17. For the winter of 2017-18, effort was given towards re-analysing the data collected and disseminating the information to the industry.

A follow-up meeting was held on September 13, 2018 and attended by TC, FAA, NASA, and APS. The intent was to identify research objectives related to fluid protection times on vertical surfaces for the research year 2018-19. At the meeting, the group recommended that limited additional testing be conducted in natural snow conditions only. The test protocol will be an abbreviated version of the 2015-16 setup focusing on fixed plates and excluding the rotating test plates and model. More focus will be given to documenting characteristics of the contamination including thickness and adherence, and supporting these observations with photography. Best efforts will be made to target wet snow, dry snow, freezing precipitation, and mixed precipitation conditions.

2. OBJECTIVE

The objectives of this research are the following:

1. Verify if contamination is present on the vertical tail post de/anti-icing, and if so, under what conditions, and characterize (size, surface extent) that level of contamination; and
2. Identify and evaluate optimal deicing procedures and mitigation plans and identify effectiveness of these methods or means.

Emphasis will be placed upon documenting characteristics of the contamination including thickness and adherence, and supporting these observations with photography.

3. TESTING PROCEDURE

Endurance time tests will be conducted with both a Type I and Type IV Ethylene Glycol (EG) fluid and a Type I and Type IV Propylene Glycol (PG) fluid; for a total of four fluids. These fluids will be described in Section 4.

3.1 Test Surfaces

A six position test stand comprised of four test plates and two cold-soak boxes will be used for this testing with the following parameters:

- Position 1: 10° Test Plate treated with Type IV Fluid;
- Position 2: 10° Dry Plate left untreated;
- Position 3: 10° Cold-Soak Box treated with Type I Fluid;

- Position 4: 80° Test Plate treated with Type IV Fluid;
- Position 5: 80° Dry Plate left untreated; and
- Position 6: 80° Cold-Soak Box treated with Type I Fluid.

Figure 3.1 depicts the intended setup.

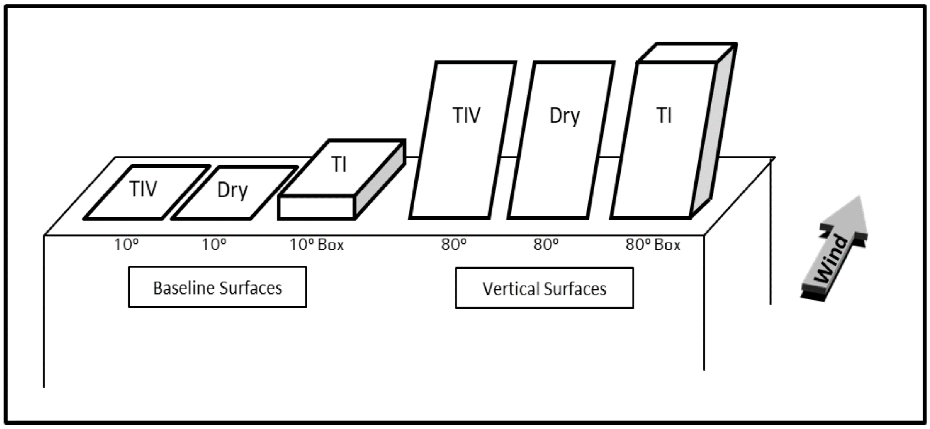


Figure 3.1: Outdoor Testing Setup

3.2 General Procedure

- Standard endurance time testing procedures will be used for this testing.
  - For the Type I fluids, 0.5L of fluid should be applied on a box at 60°C with a warm-soaked 12-hole spreader.
  - For the Type IV Fluid, 1L of fluid should be applied to a test plate at OAT using a pour container.
- Fluid protection times should be recorded for the fluid applied to each of the surfaces.

3.3 Fluid Film Thickness and Refractive Index (Brix) Measurements

Fluid film thickness for all surfaces will be measured five minutes after application. The Brix will be measured for all surfaces at the time of failure.

After the 10° baseline Type IV plate has failed with 1/3 of the test plate contaminated, re-measure Brix, thickness (a ruler may be required if very thick), and characterize the type of contamination present on all surfaces.

3.4 Photographic Documentation of Fluid Failure

An additional objective of this research will be to improve the photo documentation of fluid failure. In order to get better definition in the photos, the following should be considered:

- Use of a DSLR digital camera with more control of light, shutter speed, and exposure error;
- The use of a professional photographer for three to five outdoor test events;
- Post-testing photo processing and analysis; and
- Focus on documenting fluid failure type, thickness, and identifying characteristics.

3.5 Documentation of Adherence

A specially calibrated adherence probe is used to measure for the presence of ice adherence to the test surface. Attachment 1 provides a detailed description of the analysis supporting the use of this adherence probe. A positive detection of adherence will be indicated by a checkmark on the data form at the time of plate failure. Consideration should be given to developing a new air based adherence device.

3.6 Precipitation Rate

The precipitation rate collection (not shown in Figure 3.1) will be conducted on an adjacent test stand. Rate measurements should be conducted before fluid application, after each plate failure, and every five to ten minutes during the test.

4. FLUIDS

Testing will be performed with the following surplus fluids in the APS inventory. Table 4.1 indicates the fluids that will be used for this testing.

Table 4.1: Fluids

Fluid Type	Name	Glycol Type	Dilution	Batch #	Quantity Available
Type I	Clariant Octaflo EF Concentrate	PG	10° Buff.	U7LE000857	60 Litres
Type IV	Cryotech Polar Guard Advance	PG	100/0	PGA161216PA 2nd	120 Litres
	Dow UCAR Endurance EG 106	EG	100/0	D268GAC000 1st and 2nd Shipment	20-30 Litres

5. TEST PLAN

Testing is to be conducted in natural snow conditions. Test runs are not subject to a specific precipitation rate or temperature, however varying natural conditions should be targeted as follows:

- Dry snow;
- Wet snow;
- Mixed precipitation with snow;
- Freezing precipitation; and
- Any natural snow condition.

A test plan is included in Table 5.1. Additional tests or repeat tests may be considered. The limited testing will be conducted on three natural precipitation events and could expect one to three test runs per event based on the conditions present.

Table 5.1: Test Plan

Test #	10° TIV Plate	10° Dry Plate	10° TI Box	80° TIV Plate	80° Dry Plate	80° TI Box	Targeted Condition
1	PGA	Dry	Octaflo	PGA	Dry	Octaflo	Dry Snow
2	PGA	Dry	Octaflo	PGA	Dry	Octaflo	Wet Snow
3	PGA	Dry	Octaflo	PGA	Dry	Octaflo	Mixed Precipitation
4	PGA	Dry	Octaflo	PGA	Dry	Octaflo	Freezing Precipitation
5	PGA	Dry	Octaflo	PGA	Dry	Octaflo	Any Natural Snow Condition
6	EG 106	Dry	Octaflo	EG 106	Dry	E-188	Dry Snow
7	EG 106	Dry	Octaflo	EG 106	Dry	E-188	Wet Snow
8	EG 106	Dry	Octaflo	EG 106	Dry	E-188	Mixed Precipitation
9	EG 106	Dry	Octaflo	EG 106	Dry	E-188	Freezing Precipitation
10	EG 106	Dry	Octaflo	EG 106	Dry	E-188	Any Natural Snow Condition

6. EQUIPMENT

Standard equipment used for endurance tests outdoors will be used, with the exception of the stands required to position the test plates at 80° from the horizontal.

7. PERSONNEL

A minimum of two persons will be required for the conduct of these tests. A third assistant would be beneficial for dedicated photography.

8. DATA FORMS AND SOFTWARE

The following data forms and software programs will be used for this testing.

1) End Condition Data Form for Surfaces (Attachment 2).

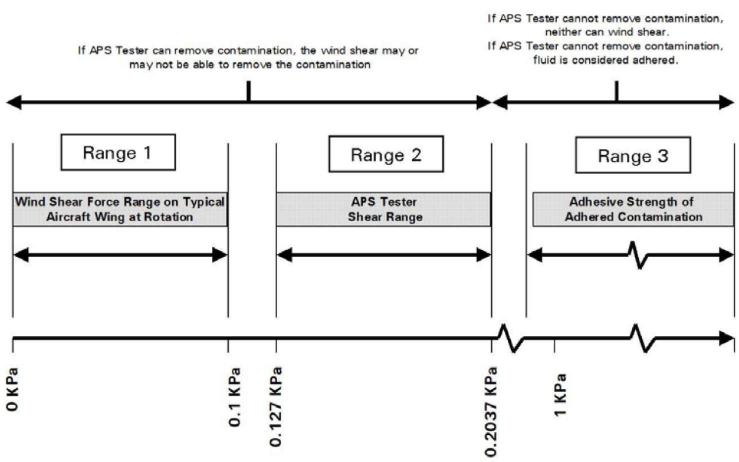
Attachment 1: Analysis of Adherence Tester

ANALYSIS OF ADHERENCE TESTER

The adherence tester exerts a shearing force in the range 1.274×10^{-4} to 2.037×10^{-4} MPa. Under contract to the Transportation Development Centre of Transport Canada, Optima Specialty Chemicals and Technology Inc. undertook in 1995-96 a study to investigate the adhesion of freezing precipitates to de/anti-iced and non-deiced aircraft surfaces. According to this study, the maximum wind shearing force acting on the wing is equal to 1×10^{-4} MPa, and the adhesive strength of ice and failed de/anti-icing fluids is of the order 10^{-3} to 10^{-1} MPa. Therefore, the tester shearing force is almost equal to the wind shearing force when compared to the failed fluid adhesive strength. In the Figure below, APS tester agrees with Optima results in the first range because both the tester and the wind will shear off the failed de/anti-icing fluid. Also in range 3, the tester and the wind cannot shear off the failed fluid. Range number 2 is an indeterminate region where the tester may shear off the failed fluid but the wind will not.

APS TESTER, WIND SHEAR, AND CONTAMINATED FLUID

ADHESIVE STRENGTH RANGES



Attachment 1: Analysis of Adherence Tester (cont'd)

Adherence Tester Force Analysis

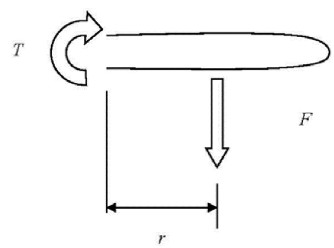
The Adherence Tester exerts a force on the ice particle through the filament. This force can be calculated from the tester motor ratings; namely, the output power, P_{out}, and the shaft rotational speed, ω,

$$P_{out} = T.\omega$$

The above equation gives the shaft torque, T, which can be used to find the adherence force, F, used to shear off the ice particle,

$$F = \frac{T}{r}$$

where r is the torque arm. The figure below illustrates the torque and force on the filament.



The shearing stress is equal to the force divided by the area over which the filament operates

$$\tau = \frac{F}{A} = \frac{F}{\pi(2r)^2}$$

The output power and rotational speed provided by the tester manufacturer are:

P_{out} = 1 Watt and ω = 6500 Hz

Therefore, the torque is

Attachment 1: Analysis of Adherence Tester (cont'd)

$$T = \frac{1\ W}{6500\ \ Hz * \frac{2\pi\ \ rad}{1\ \ revolution}} = 2.45 * 10^{-5}\,N.m$$

The load on the filament is a uniform load. This load can be considered as a concentrated force acting at the average filament radius, $r = 2.5$ mm. Therefore, the shearing force is

$$F = \frac{2.45 * 10^{-5}\,N.m}{2.5 * 10^{-3}\,m} = 0.0098\ \ N$$

and the shearing stress is

$$\tau = \frac{0.0098\ \ N}{\pi * (2 * 2.5 * 10^{-3})^2\,m^2} = 124.8\ \ Pa = 1.248\ \ KPa$$

The above is the theoretical value. If the same analysis was done using the forces obtained from the electric balance, the shearing stress would be in the range 1.274×10^{-4} to 2.037×10^{-4} KPa.

Notes:

(1) It should be noted that the elasticity of the filament is a source of error in the force measurement using the electric balance.
(2) An electric balance of 0.2 g accuracy was used to verify the calculations.

Attachment 2: End Condition Data Form for Surfaces

V-STAB END CONDITION DATA FORM

DATE ____________

TEST MGR ____________

Type I Fluid Information

Fluid Name: ____________

Fluid Dilution: ____________

Batch #: ____________

Initial Brix: ____________

Initial Temp: ____________

Type IV Fluid Information

Fluid Name: ____________

Fluid Dilution: ____________

Batch #: ____________

Initial Brix: ____________

Initial Temp: ____________

EC Hourly Data

RECORDED AT END OF POUR TIME

Temperature °C : ____________

Wind Speed km/h: ____________

Wind Direction: ____________

	10° Baseline Surfaces			80° Vertical Surfaces		
Time of Fluid Application:	____	____	____	____	____	____
Time of 1/3 Cont. (Failure):	____	____	____	____	____	____
	10° TIV	10° Dry	10° TI	80° TIV	80° Dry	80° TI
Description of Contamination @ Baseline End (Draw)	☐	☐	☐	☐	☐	☐
TH @ 5 MINS	/	/	/	/	/	/
BRIX @ FAILURE	/	/	/	/	/	/
TH @BASELINE END		/	/	/	/	/
BRIX @ BASELINE END		/	/	/	/	/
Adherence Present (Check if Yes)	☐	☐	☐	☐	☐	☐

Comments ____

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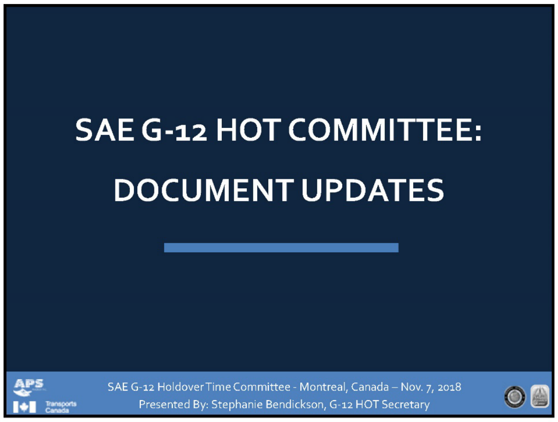
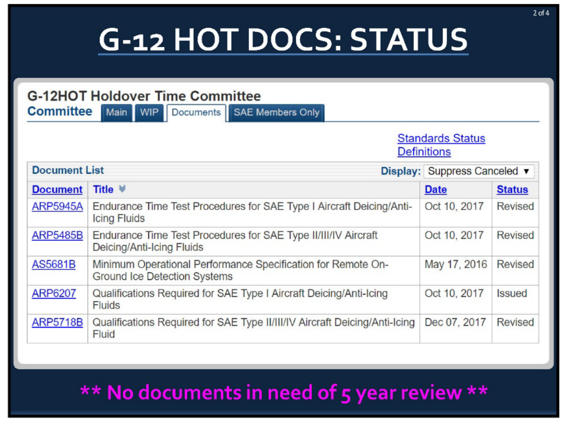
APPENDIX C

PRESENTATIONS, FLUID MANUFACTURER REPORTS, AND TEST PROCEDURES FOR 2018-19

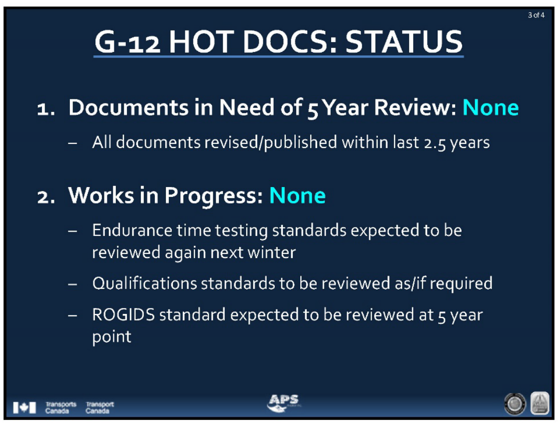
SAE G-12 HOLDOVER TIME COMMITTEE, MONTREAL, CANADA, NOVEMBER 2018

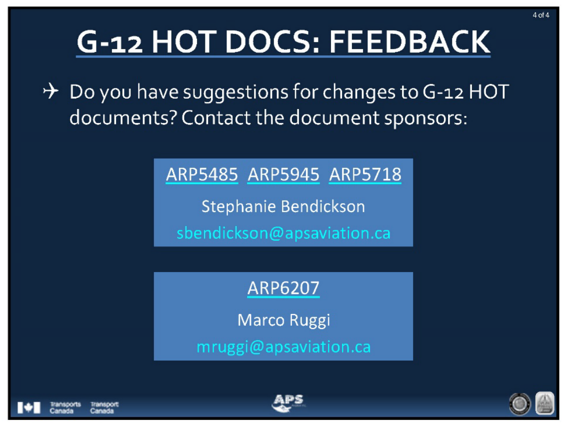
PRESENTATION:
SAE G-12 HOT COMMITTEE: DOCUMENT UPDATES





Document	Title	Date	Status
ARP5945A	Endurance Time Test Procedures for SAE Type I Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Revised
ARP5485B	Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Revised
AS5681B	Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems	May 17, 2016	Revised
ARP6207	Qualifications Required for SAE Type I Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Issued
ARP5718B	Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluid	Dec 07, 2017	Revised





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SAE G-12 HOLDOVER TIME COMMITTEE, MONTREAL, CANADA, NOVEMBER 2018

PRESENTATION:
CHANGES TO HOT GUIDANCE FOR WINTER 2018-19

CHANGES TO HOT GUIDANCE FOR WINTER 2018-19

Presented By: Yvan Chabot and Chuck Enders

SAE G-12 HOT Committee, Montreal, Canada – November 7, 2018

Transport Canada Transports Canada

2018-19 HOT PUBLICATIONS
ORIGINAL ISSUE

- **Published August 7, 2018**
- **Four Documents:**
  1. 2018-19 Holdover Time Guidelines, Original Issue (English)
  2. 2018-19 Holdover Time Guidelines, Original Issue (French)
  3. 2018-19 Regression Information, Original Issue (English)
  4. 2018-19 Regression Information, Original Issue (French)
- **Available Online:**
  - www.tc.gc.ca/en/services/aviation/general-operating-flight-rules/de-icing-aircraft/hold-over-guidelines.html
  - www.tc.gc.ca/fr/services/aviation/regles-generales-utilisation-vol/degivrage-aeronef/tableaux-durees-efficacite.html

2018-19 HOT PUBLICATIONS
ORIGINAL ISSUE

- **Published August 7, 2018**
- **Three Documents:**
  1. 2018-19 Holdover Time Guidelines, Original Issue
  2. 2018-19 Regression Information, Original Issue
  3. Revised FAA-Approved Deicing Program Updates, Winter 2018-2019 (N8900.478)
- **Available Online:**
  - www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/
  - www.faa.gov/documentLibrary/media/Notice/N_8900.478.pdf

2018-19 HOT PUBLICATIONS
FUN FACTS

7 Documents

CHANGES TO GENERIC HOTS

Active Frost	NO CHANGES	
Type I Generic	NO CHANGES	
Type II Generic	CHANGES	- New/removed fluids
Type IV Generic	CHANGES	- Removed fluids

Transports Canada Transport Canada

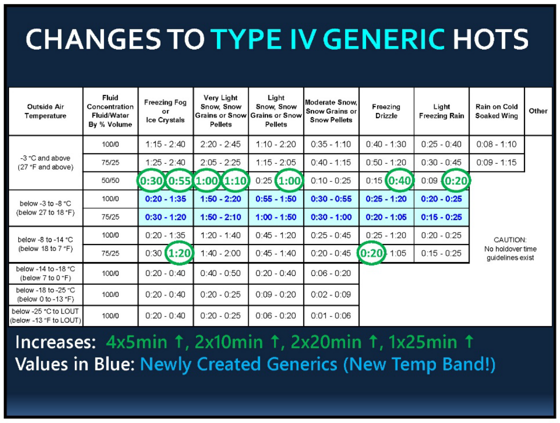
CHANGES TO TYPE II GENERIC HOTS

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	0:55 - 1:50	0:25 - 0:50	0:30 - 1:00	0:20 - 0:35	0:08 - 0:45	
	75/25	0:25 - 0:55	0:15 - 0:25	0:15 - 0:40	0:10 - 0:20	0:04 - 0:25	
	50/50	0:15 - 0:25	0:05 - 0:10	0:08 - 0:15	0:06 - 0:09	CAUTION: No holdover time guidelines exist	
below -3 to -8 °C (below 27 to 18 °F)	100/0	**0:30 - 1:05**	**0:20 - 0:35**	**0:20 - 0:45**	**0:15 - 0:20**		
	75/25	**0:25 - 0:50**	**0:10 - 0:20**	**0:15 - 0:25**	**0:08 - 0:15**		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:30 - 1:05	0:15 - 0:30	0:20 - 0:45	0:15 - 0:20		
	75/25	0:25 - 0:50	0:08 - 0:20	0:15 - 0:25	0:08 - 0:15		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:15 - 0:35	0:06 - 0:20				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:15 - 0:35	0:02 - 0:09				
below -25 °C to LOUT (below -13 °F to LOUT)	100/0	0:15 - 0:35	0:01 - 0:06				

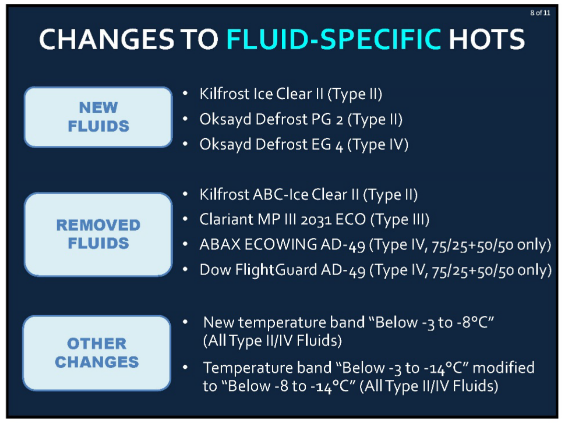
Increases: 1x ≤5min ↑, 1x 5 min ↑

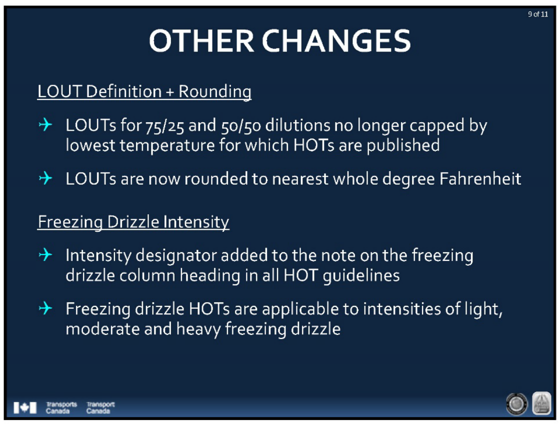
Decreases: 3x 5mins ↓

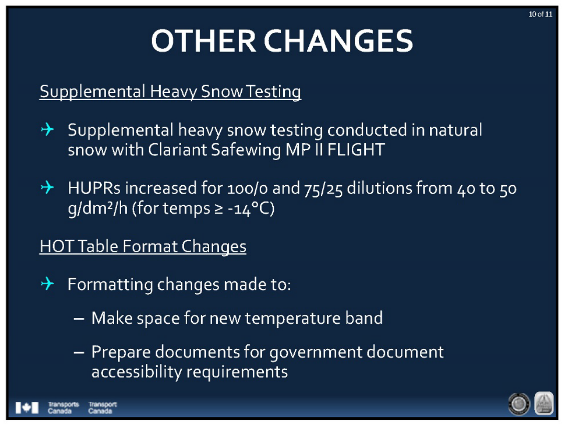
Values in Blue: Newly Created Generics (New Temp Band!)

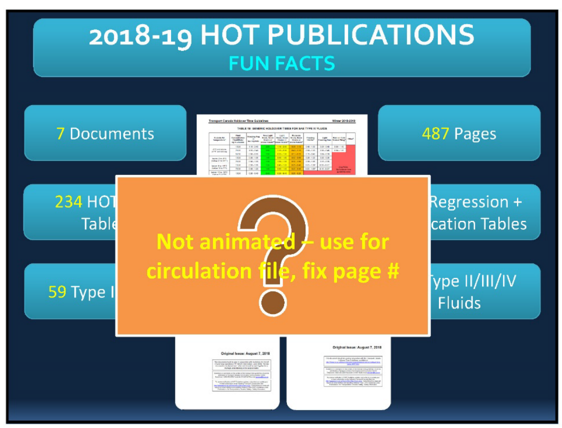


Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:15 - 2:40	2:20 - 2:45	1:10 - 2:20	0:35 - 1:10	0:40 - 1:30	0:25 - 0:40	0:08 - 1:10	
	75/25	1:25 - 2:40	2:05 - 2:25	1:15 - 2:05	0:40 - 1:15	0:50 - 1:20	0:30 - 0:45	0:09 - 1:15	
	50/50	0:30 0:55	1:00 1:10	0:25 1:00	0:10 - 0:25	0:15 0:40	0:09 0:20		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:20 - 1:35	1:50 - 2:20	0:55 - 1:50	0:30 - 0:55	0:25 - 1:20	0:20 - 0:25		
	75/25	0:30 - 1:20	1:50 - 2:10	1:00 - 1:50	0:30 - 1:00	0:20 - 1:05	0:15 - 0:25		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:20 - 1:35	1:20 - 1:40	0:45 - 1:20	0:25 - 0:45	0:25 - 1:20	0:20 - 0:25	CAUTION: No holdover time guidelines exist	
	75/25	0:30 1:20	1:40 - 2:00	0:45 - 1:40	0:20 - 0:45	0:20 1:05	0:15 - 0:25		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:20 - 0:40	0:40 - 0:50	0:20 - 0:40	0:06 - 0:20				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:20 - 0:40	0:20 - 0:25	0:09 - 0:20	0:02 - 0:09				
below -25 °C to LOUT (below -13 °F to LOUT)	100/0	0:20 - 0:40	0:20 - 0:25	0:06 - 0:20	0:01 - 0:06				









SAE G-12 HOLDOVER TIME COMMITTEE, MONTREAL, CANADA, NOVEMBER 2018

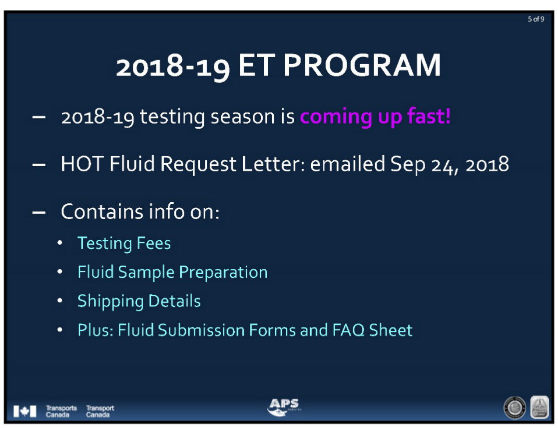
PRESENTATION: ENDURANCE TIME TESTING PROGRAM WINTER 2018-19

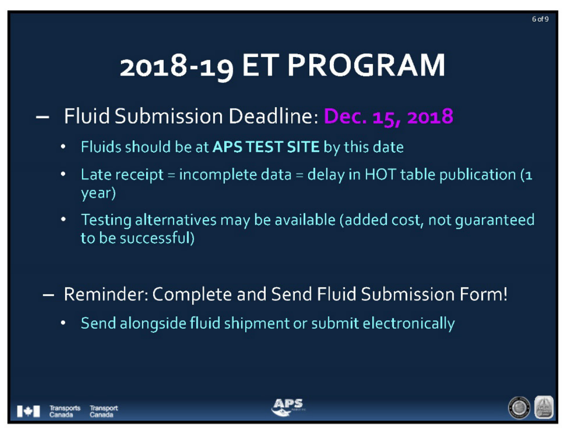

ENDURANCE TIME TESTING PROGRAM
Winter 2018-19
SAE G-12 Holdover Time Committee - Montreal, Canada – November 7, 2018
Presented By: Benjamin Bernier, Junior Project Leader
Prepared by:
APS
Presented on behalf of:
Transports Canada
Transport Canada

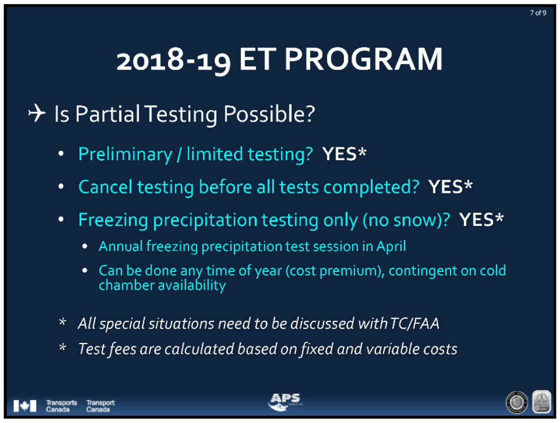

2 of 9
ENDURANCE TIME PROGRAM
APS Aviation is contracted to conduct
HOT Testing on behalf of TC/FAA
APS


3 of 9
ENDURANCE TIME PROGRAM
Natural Snow and Natural Frost Testing
APS Test Site (Montreal, Canada)
Natural Snow
Natural Frost
APS


4 of 9
ENDURANCE TIME PROGRAM
Simulated Freezing Precipitation Testing
NRC-CEF (Ottawa, Canada)
Simulated Freezing Precipitation
APS


5 of 9
2018-19 ET PROGRAM
– 2018-19 testing season is coming up fast!
– HOT Fluid Request Letter: emailed Sep 24, 2018
– Contains info on:
• Testing Fees
• Fluid Sample Preparation
• Shipping Details
• Plus: Fluid Submission Forms and FAQ Sheet
APS


6 of 9
2018-19 ET PROGRAM
– Fluid Submission Deadline: Dec. 15, 2018
• Fluids should be at APS TEST SITE by this date
• Late receipt = incomplete data = delay in HOT table publication (1 year)
• Testing alternatives may be available (added cost, not guaranteed to be successful)
– Reminder: Complete and Send Fluid Submission Form!
• Send alongside fluid shipment or submit electronically
APS


7 of 9
2018-19 ET PROGRAM
Is Partial Testing Possible?
Preliminary / limited testing? YES*
Cancel testing before all tests completed? YES*
Freezing precipitation testing only (no snow)? YES*
Annual freezing precipitation test session in April
Can be done any time of year (cost premium), contingent on cold chamber availability
* All special situations need to be discussed with TC/FAA
* Test fees are calculated based on fixed and variable costs
Transports Canada Transport Canada
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8 of 9
VERY COLD SNOW PROGRAM
– 2018-19 Very Cold Snow Testing
Optional testing for new or existing Type II/III/IV fluids
Participating fluids will receive fluid-specific snow HOTs for temperatures below -14°C down to fluid LOUT
Fluid-specific very cold snow HOTs are generally longer than the generic HOTs
Testing only conducted every second winter, and only if at least two fluids participate
– Confirmation Deadline: Dec. 1, 2018
Written confirmation of participation needed by this date.
– Fluid Submission Deadline: Dec. 15, 2018
Fluids should be at APS TEST SITE by this date
Transports Canada Transport Canada
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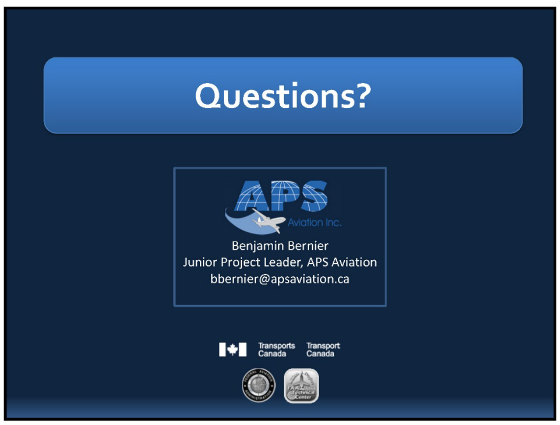
Questions?
APS Aviation Inc.
Benjamin Bernier
Junior Project Leader, APS Aviation
bbernier@apsaviation.ca
Transports Canada Transport Canada

SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
WINTER 2018-19 ENDURANCE TIME TESTING RESULTS

PURPOSE

- To provide an overview of the new fluids tested for inclusion in the HOT guidelines
- Notes:
  - HOTs are not official until published by TC/FAA
  - All data/charts included in an Appendix for brevity. Appendix slides will be available on the SAE website, but not shown at meeting unless requested.

OUTLINE

1. 2018-19 Testing Overview
2. Methodology
3. Test Results Summary: 3 Fluids
4. Supplemental Testing: LNT E450 LOUT Change
5. Supplemental Analysis: Very Very Cold Snow
6. Summary
7. Appendix: Detailed Test Results

2018-19 TESTING OVERVIEW

- Several fluids submitted, **614** individual ET tests conducted
- Of the fluids submitted, three expected to be incorporated into the HOT guidelines

Rhodia/Solvay	Type II	ADD-PROTECT Type II
ALLCLEAR	Type IV	ClearWing EG
CRYOTECH	Type IV	Polar Guard Xtend

2018-19 TESTS CONDUCTED

Fluid Type	Fluid Dilution	Natural Snow	Artificial Snow	Freezing Fog	Freezing Drizzle	Light Freezing Rain	Cold-Soak Surface	Frost	Total
Type I	Alum.	-	-	-	-	-	-	-	0
	Comp.	-	-	-	-	-	-	-	0
Type II	100/0	33	16	12	8	8	4	10	91
	75/25	36	-	8	8	8	4	10	74
	50/50	15	-	4	4	4	n/a	2	29
Type III	100/0	-	-	-	-	-	-		0
	75/25	-	-	-	-	-	-		0
	50/50	-	-	-	-	-	n/a		0
Type IV	100/0	125	49	54	32	33	16	15	324
	75/25	31	-	8	8	8	4	5	64
	50/50	17	-	4	4	6	n/a	1	32
Total		257	65	90	64	67	28	43	614

OUTLINE

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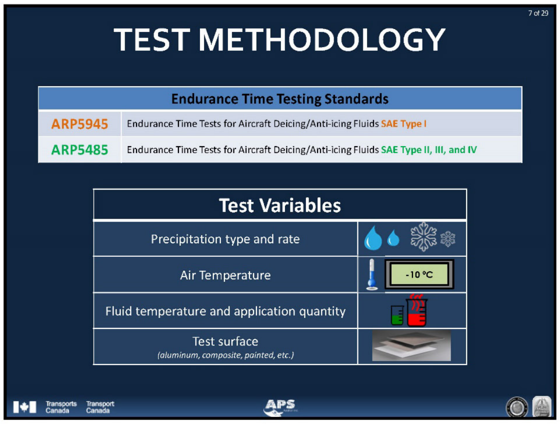
7 of 29
TEST METHODOLOGY
Endurance Time Testing Standards
ARP5945
Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type I
ARP5485
Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type II, III, and IV
Test Variables
Precipitation type and rate
Air Temperature
-10 °C
Fluid temperature and application quantity
Test surface
(aluminum, composite, painted, etc.)
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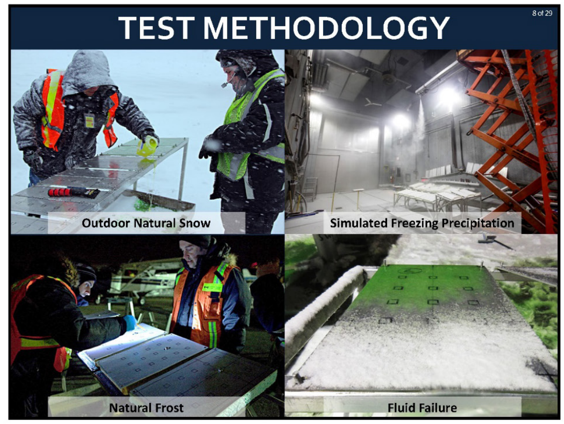
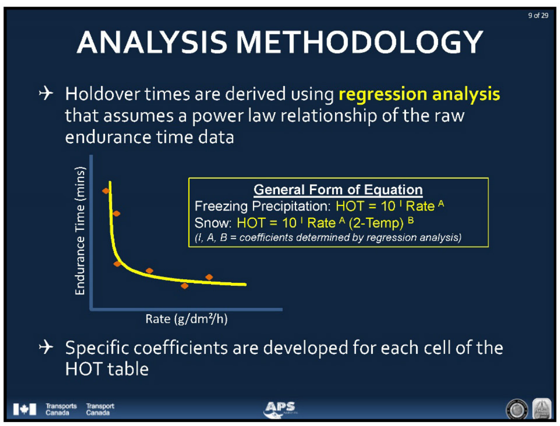
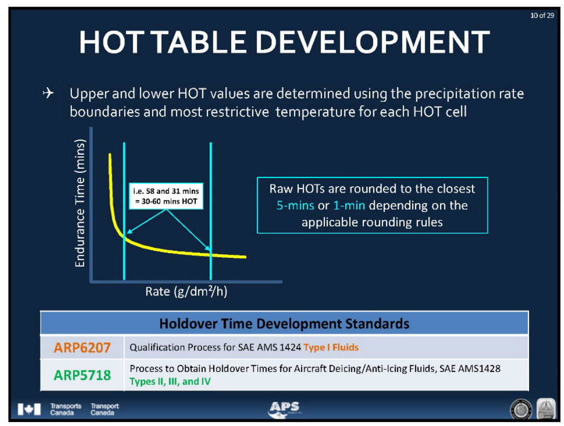

8 of 29
TEST METHODOLOGY
Outdoor Natural Snow
Simulated Freezing Precipitation
Natural Frost
Fluid Failure
APS


9 of 29
ANALYSIS METHODOLOGY
Holdover times are derived using regression analysis that assumes a power law relationship of the raw endurance time data
Endurance Time (mins)
Rate (g/dm²/h)
General Form of Equation
Freezing Precipitation: HOT = 10 I Rate A
Snow: HOT = 10 I Rate A (2-Temp) B
(I, A, B = coefficients determined by regression analysis)
Specific coefficients are developed for each cell of the HOT table
APS


10 of 29
HOT TABLE DEVELOPMENT
Upper and lower HOT values are determined using the precipitation rate boundaries and most restrictive temperature for each HOT cell
Endurance Time (mins)
i.e. 58 and 31 mins = 30-60 mins HOT
Raw HOTs are rounded to the closest 5-mins or 1-min depending on the applicable rounding rules
Rate (g/dm²/h)
Holdover Time Development Standards
ARP6207
Qualification Process for SAE AMS 1424 Type I Fluids
ARP5718
Process to Obtain Holdover Times for Aircraft Deicing/Anti-Icing Fluids, SAE AMS1428 Types II, III, and IV
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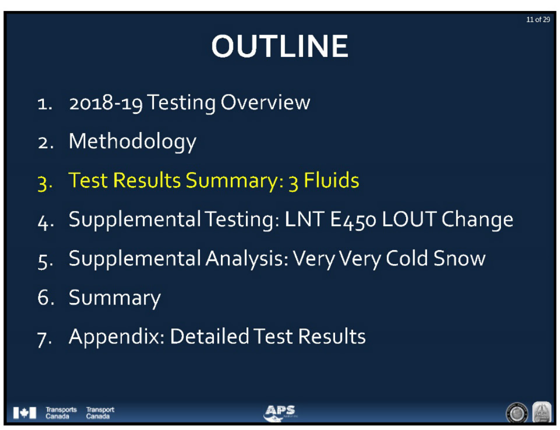
11 of 29
OUTLINE
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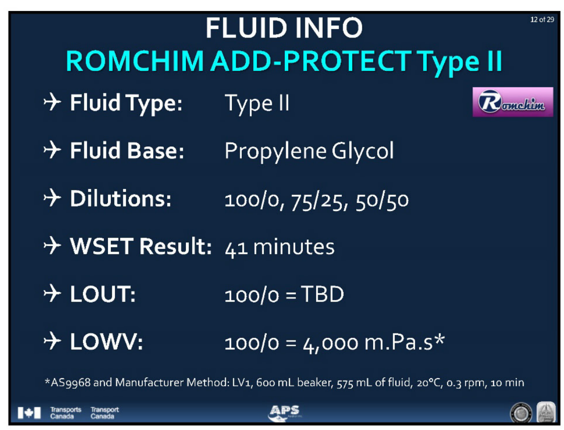
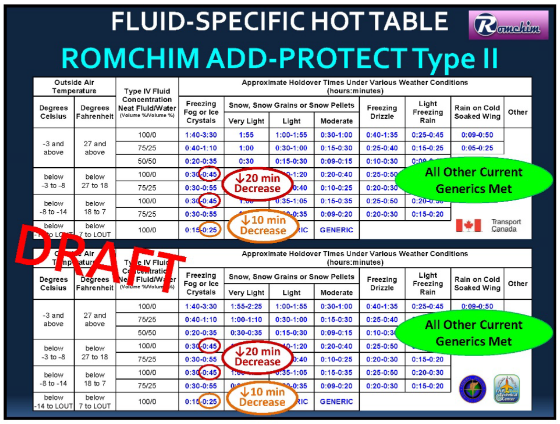
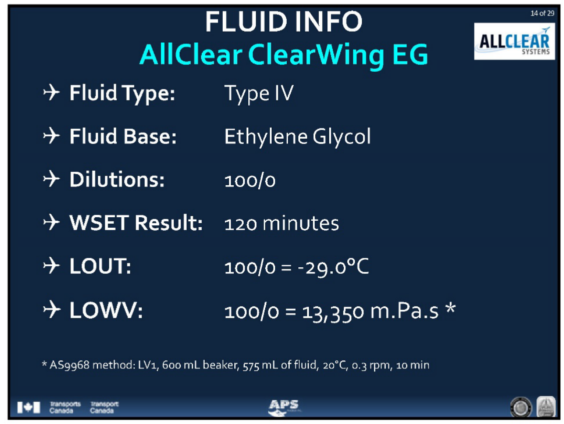
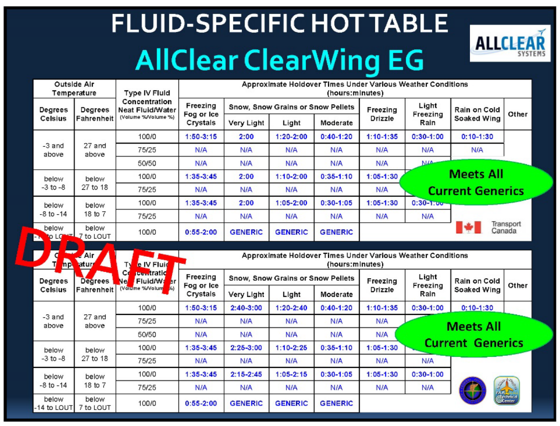

12 of 29
FLUID INFO
ROMCHIM ADD-PROTECT Type II
Fluid Type: Type II
Fluid Base: Propylene Glycol
Dilutions: 100/0, 75/25, 50/50
WSET Result: 41 minutes
LOUT: 100/0 = TBD
LOWV: 100/0 = 4,000 m.Pa.s*
*AS9968 and Manufacturer Method: LV1, 600 mL beaker, 575 mL of fluid, 20°C, 0.3 rpm, 10 min
APS



Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:40-3:30	1:55	1:00-1:55	0:30-1:00	0:40-1:35	0:25-0:45	0:09-0:50	
		75/25	0:40-1:10	1:00	0:30-1:00	0:15-0:30	0:25-0:40	0:15-0:25	0:05-0:25	
		50/50	0:20-0:35	0:30	0:15-0:30	0:09-0:15	0:10-0:30	[illegible]		
below -3 to -8	below 27 to 18	100/0	0:30-0:45	[illegible]	[illegible]	0:20-0:40	0:25-0:50	[illegible]		
		75/25	0:30-0:55	[illegible]	[illegible]	0:10-0:25	0:20-0:30	[illegible]		
below -8 to -14	below 18 to 7	100/0	0:30-0:45	[illegible]	0:35-1:05	0:15-0:35	0:25-0:50	[illegible]		
		75/25	0:30-0:55	[illegible]	[illegible]	0:09-0:20	0:20-0:30	0:15-0:20		
below [illegible] to LOUT	below 7 to LOUT	100/0	0:15-0:25	[illegible]	[illegible]	GENERIC				

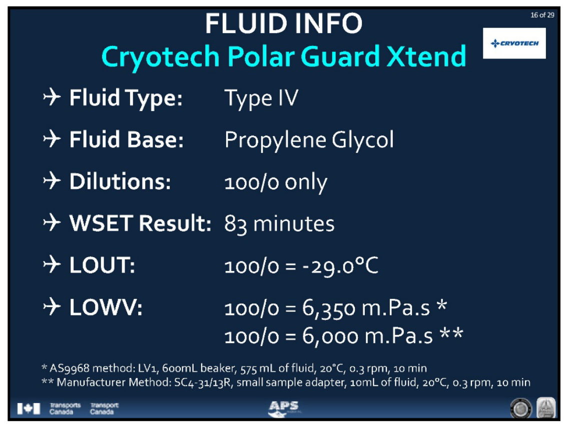
Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:40-3:30	1:55-2:25	1:00-1:55	0:30-1:00	0:40-1:35	0:25-0:45	0:09-0:50	
		75/25	0:40-1:10	1:00-1:10	0:30-1:00	0:15-0:30	0:25-0:40	[illegible]	[illegible]	
		50/50	0:20-0:35	0:30-0:35	0:15-0:30	0:09-0:15	[illegible]	[illegible]		
below -3 to -8	below 27 to 18	100/0	0:30-0:45	[illegible]	[illegible]	0:20-0:40	0:25-0:50	[illegible]		
		75/25	0:30-0:55	[illegible]	[illegible]	0:10-0:25	0:20-0:30	0:15-0:20		
below -8 to -14	below 18 to 7	100/0	0:30-0:45	[illegible]	0:35-1:05	0:15-0:35	0:25-0:50	0:20-0:30		
		75/25	0:30-0:55	[illegible]	[illegible]	0:09-0:20	0:20-0:30	0:15-0:20		
below -14 to LOUT	below 7 to LOUT	100/0	0:15-0:25	[illegible]	[illegible]	GENERIC				

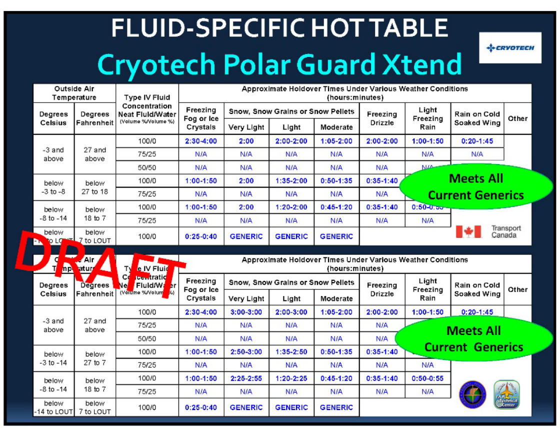




Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:50-3:15	2:00	1:20-2:00	0:40-1:20	1:10-1:35	0:30-1:00	0:10-1:30	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -3 to -8	below 27 to 18	100/0	1:35-3:45	2:00	1:10-2:00	0:35-1:10	1:05-1:30	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -8 to -14	below 18 to 7	100/0	1:35-3:45	2:00	1:05-2:00	0:30-1:05	1:05-1:30	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below [illegible] to LOUT	below 7 to LOUT	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				

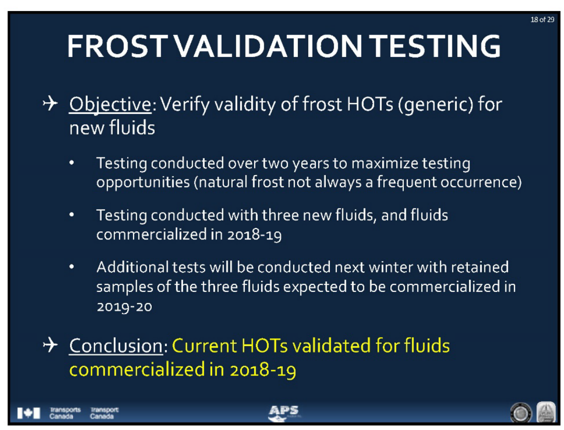
Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	1:50-3:15	2:40-3:00	1:20-2:40	0:40-1:20	1:10-1:35	0:30-1:00	0:10-1:30	
		75/25	N/A	N/A	N/A	N/A	N/A	[illegible]	[illegible]	
		50/50	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -3 to -8	below 27 to 18	100/0	1:35-3:45	2:25-3:00	1:10-2:25	0:35-1:10	1:05-1:30	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14	below 18 to 7	100/0	1:35-3:45	2:15-2:45	1:05-2:15	0:30-1:05	1:05-1:30	0:30-1:00		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to LOUT	below 7 to LOUT	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				

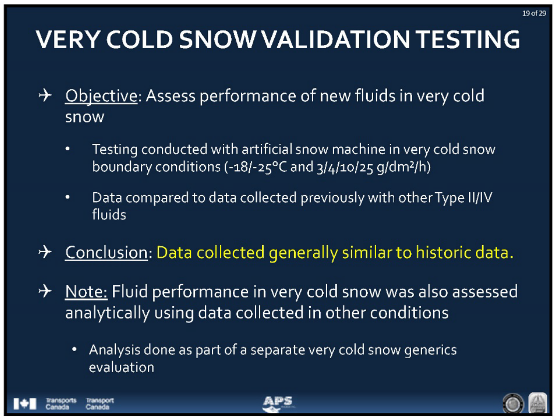


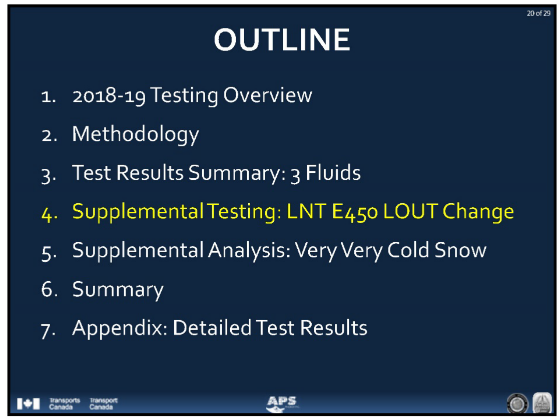


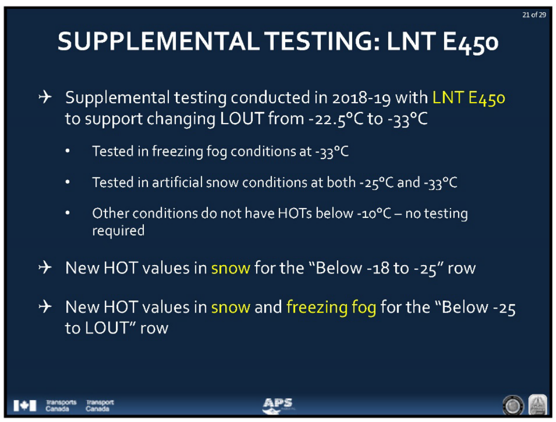
Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	2:30-4:00	2:00	2:00-2:00	1:05-2:00	2:00-2:00	1:00-1:50	0:20-1:45	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -3 to -8	below 27 to 18	100/0	1:00-1:50	2:00	1:35-2:00	0:50-1:35	0:35-1:40	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -8 to -14	below 18 to 7	100/0	1:00-1:50	2:00	1:20-2:00	0:45-1:20	0:35-1:40	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below [illegible] to LOUT	below 7 to LOUT	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				

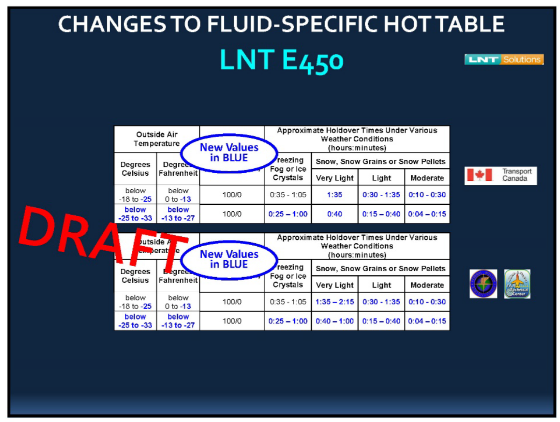
Outside Air Temperature: Degrees Celsius	Outside Air Temperature: Degrees Fahrenheit	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 and above	27 and above	100/0	2:30-4:00	3:00-3:00	2:00-3:00	1:05-2:00	2:00-2:00	1:00-1:50	0:20-1:45	
		75/25	N/A	N/A	N/A	N/A	N/A	[illegible]	[illegible]	
		50/50	N/A	N/A	N/A	N/A	N/A	[illegible]		
below -3 to -14	below 27 to 7	100/0	1:00-1:50	2:50-3:00	1:35-2:50	0:50-1:35	0:35-1:40	[illegible]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14	below 18 to 7	100/0	1:00-1:50	2:25-2:55	1:20-2:25	0:45-1:20	0:35-1:40	0:50-0:55		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to LOUT	below 7 to LOUT	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				





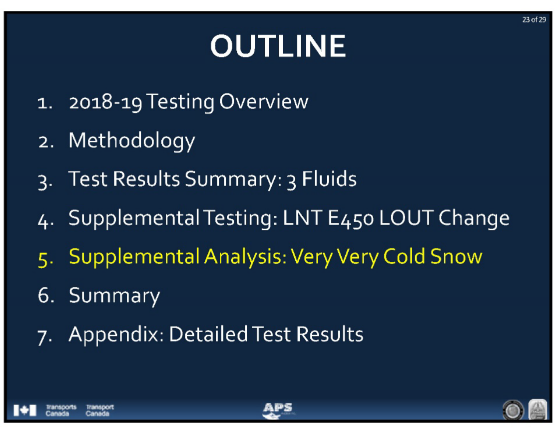


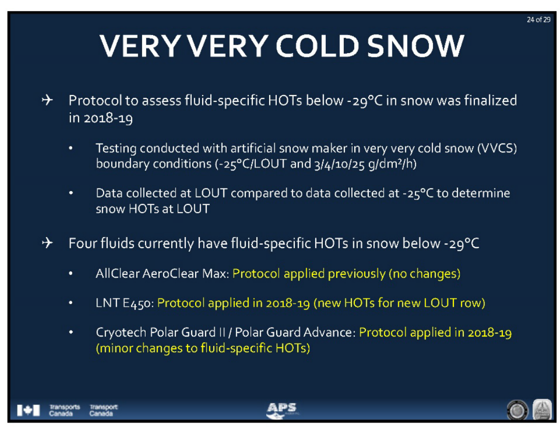


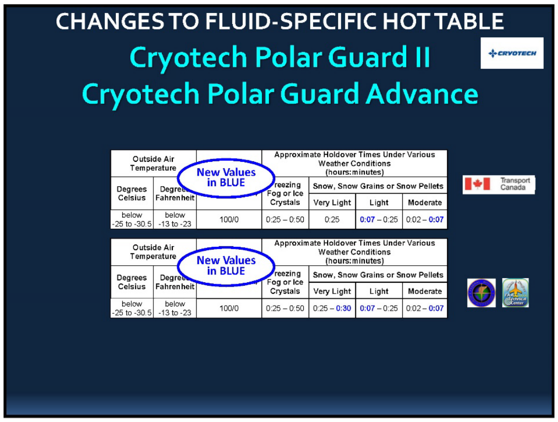


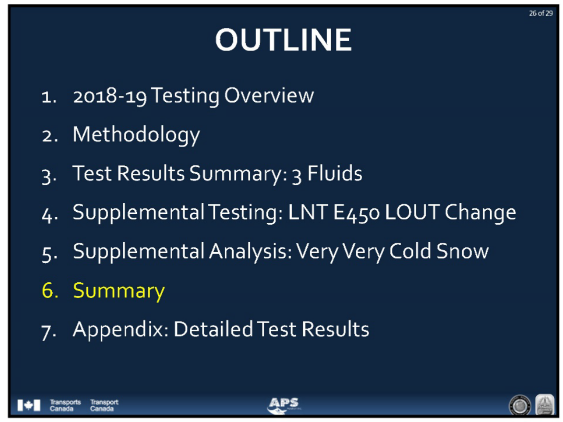
Outside Air Temperature			Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Light	Moderate
below -18 to -25	below 0 to -13	100/0	0:35 - 1:05	1:35	0:30 - 1:35	0:10 - 0:30
below -25 to -33	below -13 to -27	100/0	0:25 – 1:00	0:40	0:15 – 0:40	0:04 – 0:15

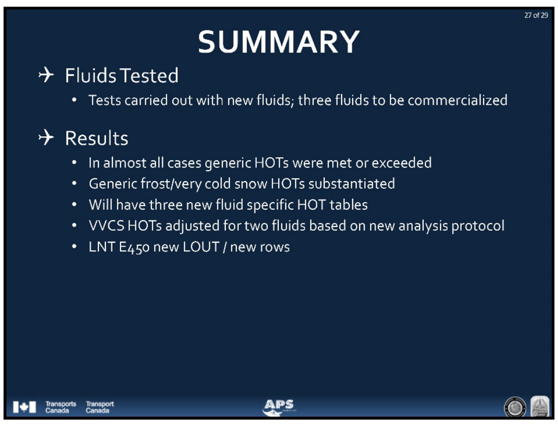
Outside Air Temperature			Approximate Holdover Times Under Various Weather Conditions (hours:minutes)			
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light	Light	Moderate
below -18 to -25	below 0 to -13	100/0	0:35 - 1:05	1:35 – 2:15	0:30 - 1:35	0:10 - 0:30
below -25 to -33	below -13 to -27	100/0	0:25 – 1:00	0:40 – 1:00	0:15 – 0:40	0:04 – 0:15

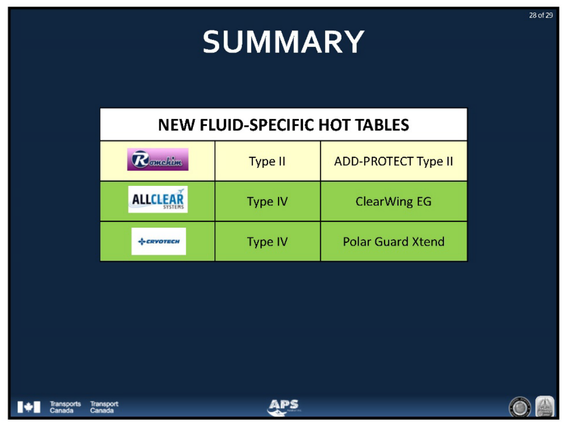




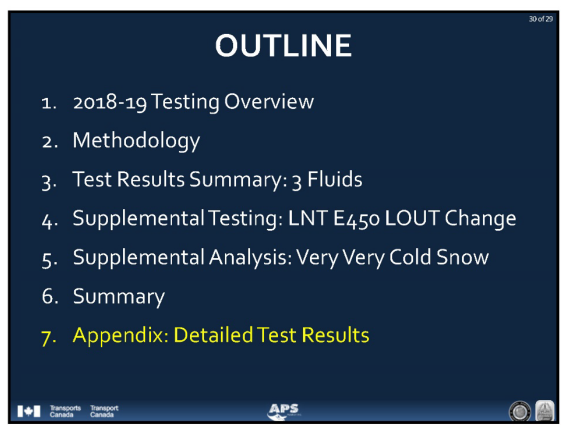

CHANGES TO FLUID-SPECIFIC HOT TABLE
Cryotech Polar Guard II
Cryotech Polar Guard Advance
CRYOTECH
Outside Air Temperature
Degrees Celsius
Degrees Fahrenheit
New Values in BLUE
Approximate Holdover Times Under Various Weather Conditions (hours:minutes)
Freezing Fog or Ice Crystals
Snow, Snow Grains or Snow Pellets
Very Light
Light
Moderate
below -25 to -30.5 | below -13 to -23 | 100/0 | 0:25 – 0:50 | 0:25 | 0:07 – 0:25 | 0:02 – 0:07
Transport Canada
Outside Air Temperature
Degrees Celsius
Degrees Fahrenheit
New Values in BLUE
Approximate Holdover Times Under Various Weather Conditions (hours:minutes)
Freezing Fog or Ice Crystals
Snow, Snow Grains or Snow Pellets
Very Light
Light
Moderate
below -25 to -30.5 | below -13 to -23 | 100/0 | 0:25 – 0:50 | 0:25 – 0:30 | 0:07 – 0:25 | 0:02 – 0:07


26 of 29
OUTLINE
1. 2018-19 Testing Overview
2. Methodology
3. Test Results Summary: 3 Fluids
4. Supplemental Testing: LNT E450 LOUT Change
5. Supplemental Analysis: Very Very Cold Snow
6. Summary
7. Appendix: Detailed Test Results
APS


27 of 29
SUMMARY
Fluids Tested
• Tests carried out with new fluids; three fluids to be commercialized
Results
• In almost all cases generic HOTs were met or exceeded
• Generic frost/very cold snow HOTs substantiated
• Will have three new fluid specific HOT tables
• VVCS HOTs adjusted for two fluids based on new analysis protocol
• LNT E450 new LOUT / new rows
APS


28 of 29
SUMMARY
NEW FLUID-SPECIFIC HOT TABLES
Type II | ADD-PROTECT Type II
ALLCLEAR | Type IV | ClearWing EG
CRYOTECH | Type IV | Polar Guard Xtend
APS


APS
Aviation Inc.
?
Benjamin Bernier
email: bbernier@apsaviation.ca


30 of 29
OUTLINE
1. 2018-19 Testing Overview
2. Methodology
3. Test Results Summary: 3 Fluids
4. Supplemental Testing: LNT E450 LOUT Change
5. Supplemental Analysis: Very Very Cold Snow
6. Summary
7. Appendix: Detailed Test Results
APS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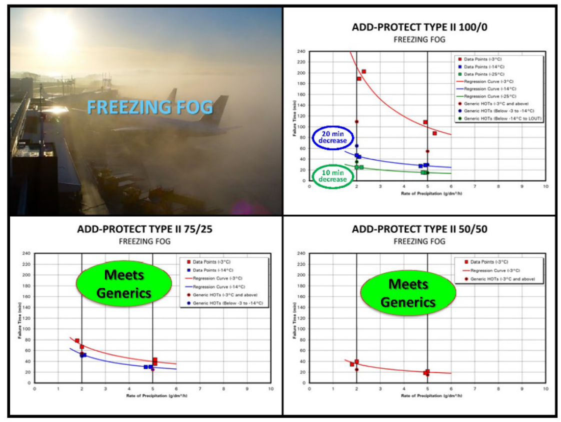
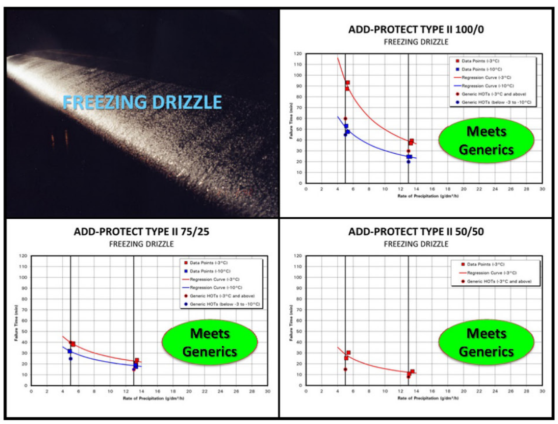
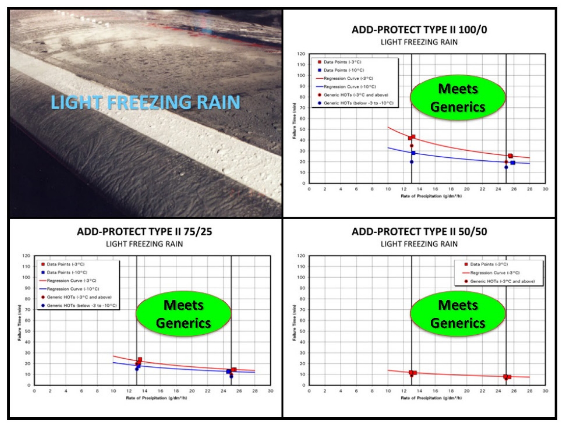
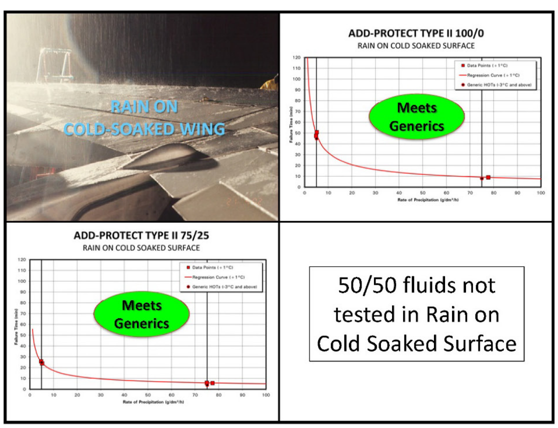
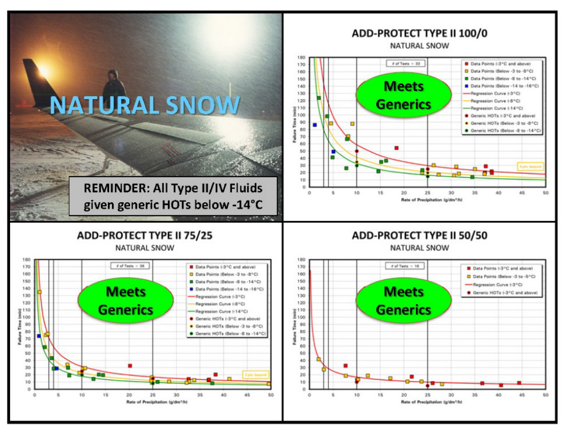
ROMCHIM
ADD-PROTECT Type II
Transports Canada
Transport Canada
APS

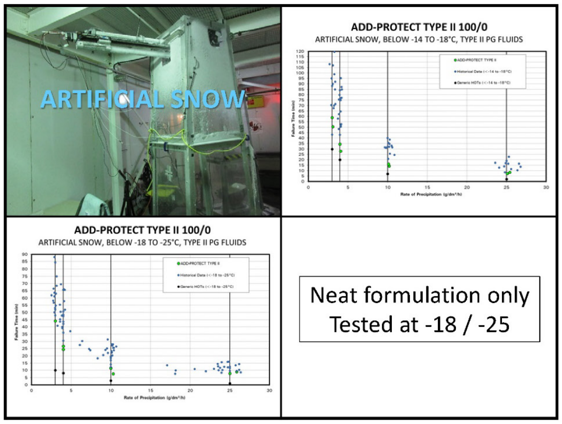

FREEZING FOG
ADD-PROTECT TYPE II 100/0
FREEZING FOG
20 min decrease
10 min decrease
ADD-PROTECT TYPE II 75/25
FREEZING FOG
Meets Generics
ADD-PROTECT TYPE II 50/50
FREEZING FOG
Meets Generics


FREEZING DRIZZLE
ADD-PROTECT TYPE II 100/0
FREEZING DRIZZLE
Meets Generics
ADD-PROTECT TYPE II 75/25
FREEZING DRIZZLE
Meets Generics
ADD-PROTECT TYPE II 50/50
FREEZING DRIZZLE
Meets Generics


LIGHT FREEZING RAIN
ADD-PROTECT TYPE II 100/0
LIGHT FREEZING RAIN
Meets Generics
ADD-PROTECT TYPE II 75/25
LIGHT FREEZING RAIN
Meets Generics
ADD-PROTECT TYPE II 50/50
LIGHT FREEZING RAIN
Meets Generics


RAIN ON COLD-SOAKED WING
ADD-PROTECT TYPE II 100/0
RAIN ON COLD SOAKED SURFACE
Meets Generics
ADD-PROTECT TYPE II 75/25
RAIN ON COLD SOAKED SURFACE
Meets Generics
50/50 fluids not tested in Rain on Cold Soaked Surface


NATURAL SNOW
REMINDER: All Type II/IV Fluids given generic HOTs below -14°C
ADD-PROTECT TYPE II 100/0
NATURAL SNOW
Meets Generics
ADD-PROTECT TYPE II 75/25
NATURAL SNOW
Meets Generics
ADD-PROTECT TYPE II 50/50
NATURAL SNOW
Meets Generics


ARTIFICIAL SNOW
ADD-PROTECT TYPE II 100/0
ARTIFICIAL SNOW, BELOW -14 TO -18°C, TYPE II PG FLUIDS
ADD-PROTECT TYPE II 100/0
ARTIFICIAL SNOW, BELOW -18 TO -25°C, TYPE II PG FLUIDS
Neat formulation only
Tested at -18 / -25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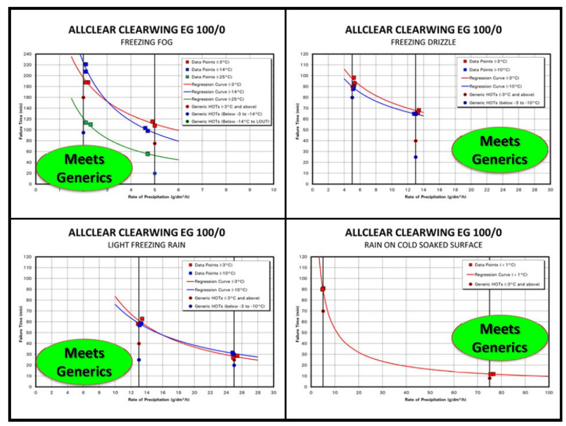
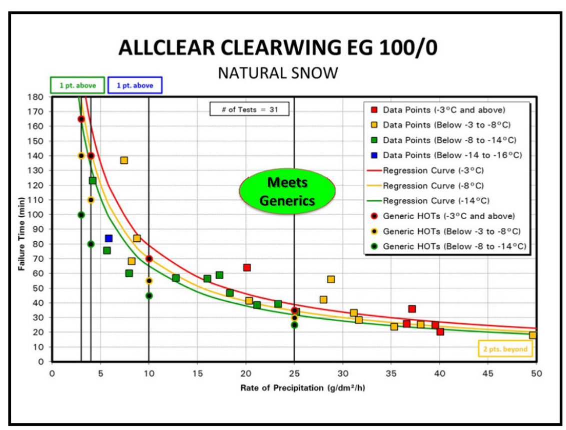
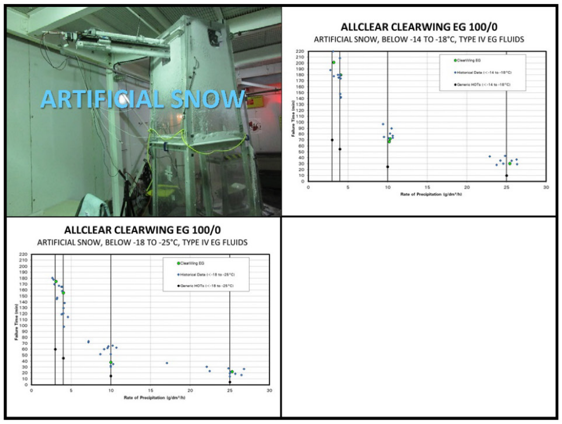
ALLCLEAR
CLEARWING EG
APS


FREEZING FOG
FREEZING DRIZZLE
LIGHT FREEZING RAIN
RAIN ON
COLD-SOAKED WING


ALLCLEAR CLEARWING EG 100/0
FREEZING FOG
Meets
Generics
ALLCLEAR CLEARWING EG 100/0
FREEZING DRIZZLE
Meets
Generics
ALLCLEAR CLEARWING EG 100/0
LIGHT FREEZING RAIN
Meets
Generics
ALLCLEAR CLEARWING EG 100/0
RAIN ON COLD SOAKED SURFACE
Meets
Generics


NATURAL SNOW


ALLCLEAR CLEARWING EG 100/0
NATURAL SNOW
1 pt. above
1 pt. above
# of Tests = 31
Meets
Generics
Data Points (-3°C and above)
Data Points (Below -3 to -8°C)
Data Points (Below -8 to -14°C)
Data Points (Below -14 to -16°C)
Regression Curve (-3°C)
Regression Curve (-8°C)
Regression Curve (-14°C)
Generic HOTs (-3°C and above)
Generic HOTs (Below -3 to -8°C)
Generic HOTs (Below -8 to -14°C)
2 pts. beyond
Failure Time (min)
Rate of Precipitation (g/dm²/h)


ARTIFICIAL SNOW
ALLCLEAR CLEARWING EG 100/0
ARTIFICIAL SNOW, BELOW -14 TO -18°C, TYPE IV EG FLUIDS
ALLCLEAR CLEARWING EG 100/0
ARTIFICIAL SNOW, BELOW -18 TO -25°C, TYPE IV EG FLUIDS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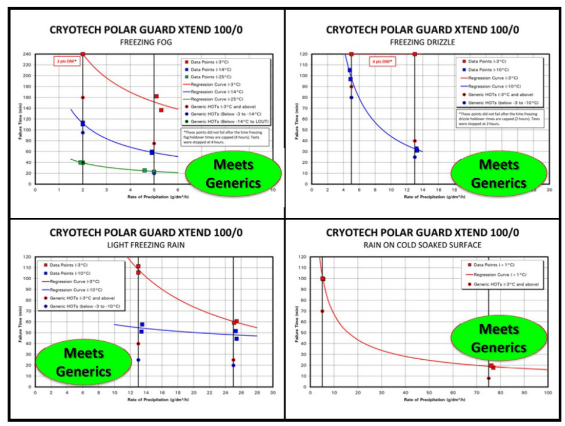
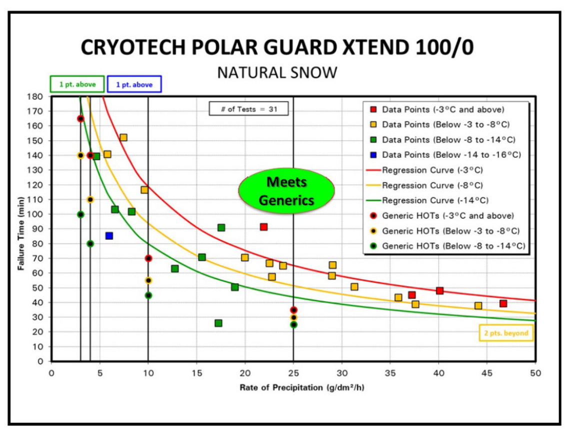
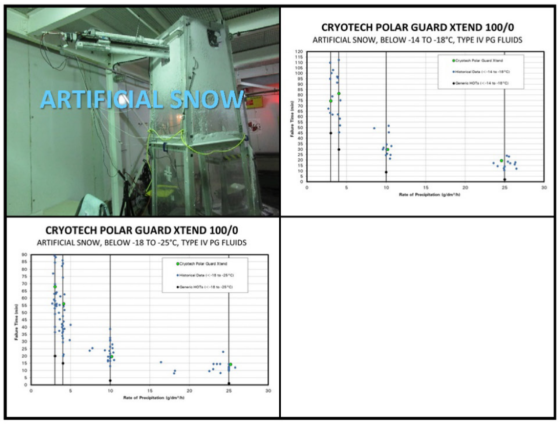
CRYOTECH
POLAR GUARD XTEND
Transports Canada
Transport Canada
APS


FREEZING FOG
FREEZING DRIZZLE
LIGHT FREEZING RAIN
RAIN ON
COLD-SOAKED WING


CRYOTECH POLAR GUARD XTEND 100/0
FREEZING FOG
Meets
Generics
CRYOTECH POLAR GUARD XTEND 100/0
FREEZING DRIZZLE
Meets
Generics
CRYOTECH POLAR GUARD XTEND 100/0
LIGHT FREEZING RAIN
Meets
Generics
CRYOTECH POLAR GUARD XTEND 100/0
RAIN ON COLD SOAKED SURFACE
Meets
Generics


NATURAL SNOW


CRYOTECH POLAR GUARD XTEND 100/0
NATURAL SNOW
1 pt. above
1 pt. above
# of Tests = 31
Data Points (-3°C and above)
Data Points (Below -3 to -8°C)
Data Points (Below -8 to -14°C)
Data Points (Below -14 to -16°C)
Regression Curve (-3°C)
Regression Curve (-8°C)
Regression Curve (-14°C)
Generic HOTs (-3°C and above)
Generic HOTs (Below -3 to -8°C)
Generic HOTs (Below -8 to -14°C)
Meets
Generics
2 pts. beyond
Failure Time (min)
Rate of Precipitation (g/dm²/h)


ARTIFICIAL SNOW
CRYOTECH POLAR GUARD XTEND 100/0
ARTIFICIAL SNOW, BELOW -14 TO -18°C, TYPE IV PG FLUIDS
CRYOTECH POLAR GUARD XTEND 100/0
ARTIFICIAL SNOW, BELOW -18 TO -25°C, TYPE IV PG FLUIDS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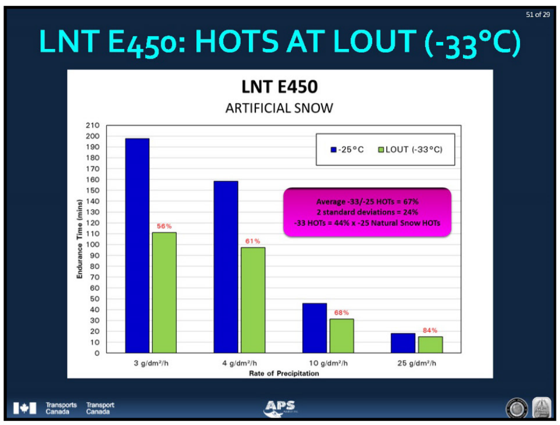
LNT
E450
Transports Canada Transport Canada
APS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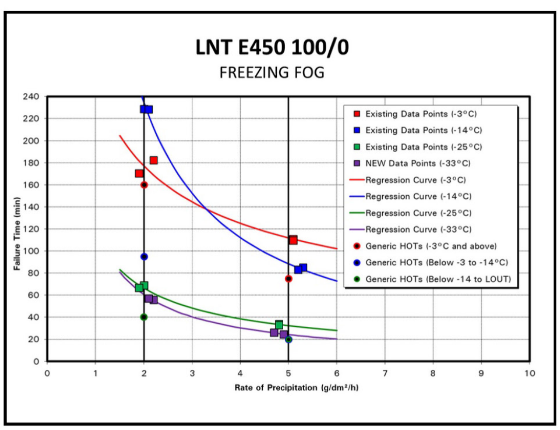
LNT E450: HOTS AT LOUT (-33°C)
LNT E450
ARTIFICIAL SNOW
-25°C
LOUT (-33°C)
Average -33/-25 HOTs = 67%
2 standard deviations = 24%
-33 HOTs = 44% x -25 Natural Snow HOTs
56%
61%
68%
84%
Endurance Time (mins)
3 g/dm²/h
4 g/dm²/h
10 g/dm²/h
25 g/dm²/h
Rate of Precipitation
Transports Canada Transport Canada
APS


FREEZING FOG


LNT E450 100/0
FREEZING FOG
Existing Data Points (-3°C)
Existing Data Points (-14°C)
Existing Data Points (-25°C)
NEW Data Points (-33°C)
Regression Curve (-3°C)
Regression Curve (-14°C)
Regression Curve (-25°C)
Regression Curve (-33°C)
Generic HOTs (-3°C and above)
Generic HOTs (Below -3 to -14°C)
Generic HOTs (Below -14 to LOUT)
Failure Time (min)
Rate of Precipitation (g/dm²/h)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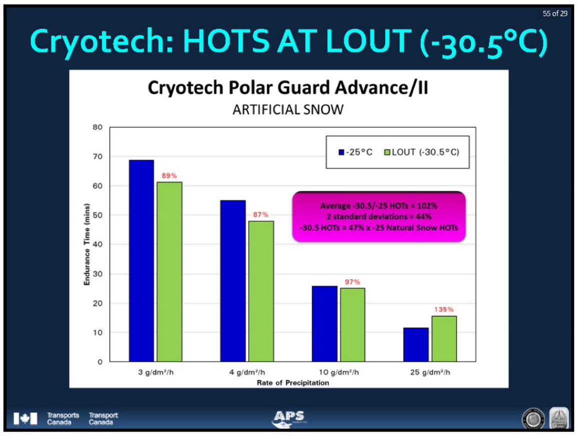
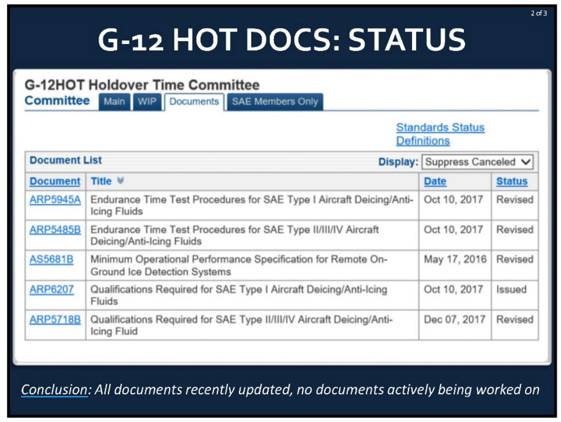
CRYOTECH
POLAR GUARD II
POLAR GUARD ADVANCE
Transports Canada Transport Canada
APS

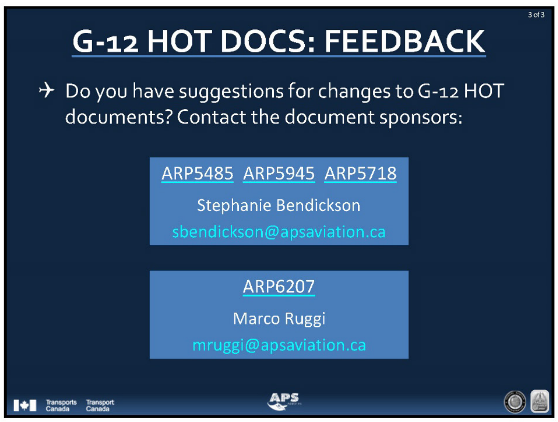

55 of 29
Cryotech: HOTS AT LOUT (-30.5°C)
Cryotech Polar Guard Advance/II
ARTIFICIAL SNOW
-25°C
LOUT (-30.5°C)
Average -30.5/-25 HOTs = 102%
2 standard deviations = 44%
-30.5 HOTs = 47% x -25 Natural Snow HOTs
89%
87%
97%
135%
Endurance Time (mins)
0
10
20
30
40
50
60
70
80
3 g/dm²/h
4 g/dm²/h
10 g/dm²/h
25 g/dm²/h
Rate of Precipitation
Transports Canada
Transport Canada
APS

SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
SAE G-12 HOT COMMITTEE: DOCUMENT STATUS



Document	Title	Date	Status
ARP5945A	Endurance Time Test Procedures for SAE Type I Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Revised
ARP5485B	Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Revised
AS5681B	Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems	May 17, 2016	Revised
ARP6207	Qualifications Required for SAE Type I Aircraft Deicing/Anti-Icing Fluids	Oct 10, 2017	Issued
ARP5718B	Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluid	Dec 07, 2017	Revised



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SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
CHANGES TO HOT GUIDELINES FOR WINTER 2019-20

CHANGES TO HOT GUIDELINES FOR WINTER 2019-20

Presented By: Yvan Chabot and Chuck Enders

SAE G-12 HOT Committee, Dubrovnik, Croatia – May 21, 2019

Transport Canada Transports Canada

OBJECTIVE / OUTLINE

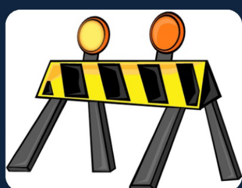
- Objective:

  Present changes FAA/TC will be making to HOT Guidance materials for 2019-20

- Changes are Resulting From:

  1. 2018-19 Endurance Time Testing Program
  2. Annual HOT Guidelines Maintenance
  3. Further Very Very Cold Snow Analysis
  4. Supplemental Testing with LNT Solutions E450

! CAUTION !



HOTs provided in this presentation are preliminary and subject to change – final data verification is required

HOTs are not official until published in the TC/FAA HOT Guidelines documents in Summer 2019

Changes resulting from…

2018-19 ENDURANCE TIME TESTING PROGRAM

2018-19 ENDURANCE TIME TESTING PROGRAM

- Three new fluids will be added to the HOT Guidelines
  1. Romchim ADD-PROTECT Type II (Type II - PG)
  2. AllClear ClearWing EG (Type IV - EG)
  3. Cryotech Polar Guard Xtend (Type IV - PG)

FLUID-SPECIFIC HOT TABLE (TC)
ROMCHIM ADD-PROTECT TYPE II

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:40-3:30	1:55	1:00-1:55	0:30-1:00	0:40-1:35	0:25-0:45	0:09-0:50	
	75/25	0:40-1:10	1:00	0:30-1:00	0:15-0:30	0:25-0:40	0:15-0:25	0:05-0:25	
	50/50	0:20-0:35	0:30	0:15-0:30	0:09-0:15	0:10-0:30	0:08-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:30-0:45	1:20	0:40-1:20	0:20-0:40	0:25-0:50	0:20-0:30		
	75/25	0:30-0:55	0:40	0:25-0:40	0:10-0:25	0:20-0:30	0:15-0:20		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:30-0:45	1:05	0:35-1:05	0:15-0:35	0:25-0:50	0:20-0:30		
	75/25	0:30-0:55	0:35	0:20-0:35	0:09-0:20	0:20-0:30	0:15-0:20		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -25 to LOUT (below -13 to LOUT)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				

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FLUID-SPECIFIC HOT TABLE (FAA)
ROMCHIM ADD-PROTECT TYPE II

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:40-3:30	1:55-2:25	1:00-1:55	0:30-1:00	0:40-1:35	0:25-0:45	0:09-0:50	
	75/25	0:40-1:10	1:00-1:10	0:30-1:00	0:15-0:30	0:25-0:40	0:15-0:25	0:05-0:25	
	50/50	0:20-0:35	0:30-0:35	0:15-0:30	0:09-0:15	0:10-0:30	0:08-0:10		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:30-0:45	1:20-1:40	0:40-1:20	0:20-0:40	0:25-0:50	0:20-0:30	CAUTION: No holdover time guidelines exist	
	75/25	0:30-0:55	0:40-0:50	0:25-0:40	0:10-0:25	0:20-0:30	0:15-0:20		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:30-0:45	1:05-1:20	0:35-1:05	0:15-0:35	0:25-0:50	0:20-0:30		
	75/25	0:30-0:55	0:35-0:40	0:20-0:35	0:09-0:20	0:20-0:30	0:15-0:20		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -25 to LOUT (below -13 to LOUT)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				

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Transports Canada Transport Canada

FLUID-SPECIFIC HOT TABLE (TC)
ALLCLEAR CLEARWING EG

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50-3:15	2:00	1:20-2:00	0:40-1:20	1:10-1:35	0:30-1:00	0:10-1:30	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:35-3:45	2:00	1:10-2:00	0:35-1:10	1:05-1:30	0:30-1:00	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:35-3:45	2:00	1:05-2:00	0:30-1:05	1:05-1:30	0:30-1:00		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				

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Transport Canada

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FLUID-SPECIFIC HOT TABLE (FAA)
ALLCLEAR CLEARWING EG

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50-3:15	2:40-3:00	1:20-2:40	0:40-1:20	1:10-1:35	0:30-1:00	0:10-1:30	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:35-3:45	2:25-3:00	1:10-2:25	0:35-1:10	1:05-1:30	0:30-1:00	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:35-3:45	2:15-2:45	1:05-2:15	0:30-1:05	1:05-1:30	0:30-1:00		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				

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FLUID-SPECIFIC HOT TABLE (TC)
CRYOTECH POLAR GUARD XTEND

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:30-4:00	2:00	2:00-2:00	1:05-2:00	2:00-2:00	1:00-1:50	0:20-1:45	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:00-1:50	2:00	1:35-2:00	0:50-1:35	0:35-1:40	0:50-0:55	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:00-1:50	2:00	1:20-2:00	0:45-1:20	0:35-1:40	0:50-0:55		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				

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Transport Canada

Transports Canada Transport Canada

FLUID-SPECIFIC HOT TABLE (FAA)
CRYOTECH POLAR GUARD XTEND

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:30-4:00	3:00-3:00	2:00-3:00	1:05-2:00	2:00-2:00	1:00-1:50	0:20-1:45	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:00-1:50	2:50-3:00	1:35-2:50	0:50-1:35	0:35-1:40	0:50-0:55	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:00-1:50	2:25-2:55	1:20-2:25	0:45-1:20	0:35-1:40	0:50-0:55		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				

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Changes resulting from…

2019-20
ANNUAL HOT GUIDELINES MAINTENANCE

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Annual Maintenance: REMOVED FLUIDS

- No Type II, Type III, or Type IV fluids became obsolete -> no fluids removed for 2019-20

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TC/FAA TYPE II FLUID-SPECIFIC HOT GUIDELINES 2019-20

1) ABAX ECOWING 26
2) ABAX ECOWING AD-2
3) Aviation Shaanxi Cleanwing II
4) Beijing Yadilite YD-102
5) Clariant Safewing MP II FLIGHT
6) Clariant Safewing MP II FLIGHT PLUS
7) Cryotech Polar Guard II
8) Kilfrost ABC-K PLUS
9) Kilfrost Ice Clear II
10) Newave Aerochemical FCY-2 Bio+
11) Oksayd Defrost PG 2
12) **ROMCHIM ADD-PROTECT Type II (new)**

REMOVED:
No Type II fluids being removed this year.

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TC/FAA TYPE III FLUID-SPECIFIC HOT GUIDELINES 2019-20

1) AllClear AeroClear MAX (High Speed)
2) AllClear AeroClear MAX (Low Speed)

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TC/FAA TYPE IV FLUID-SPECIFIC HOT GUIDELINES 2019-20

1) ABAX ECOWING AD-49
2) **AllClear ClearWing EG (new)**
3) CHEMCO ChemR EG IV
4) Clariant Max Flight 04
5) Clariant Max Flight AVIA
6) Clariant Max Flight SNEG
7) Clariant Safewing EG IV NORTH
8) Clariant Safewing MP IV LAUNCH
9) Clariant Safewing MP IV LAUNCH PLUS
10) Cryotech Polar Guard Advance
11) **Cryotech Polar Guard Xtend (new)**
12) Inland Technologies ECO-SHIELD
13) Dow UCAR Endurance EG106
14) Dow UCAR FlightGuard AD-49
15) Kilfrost ABC-S PLUS
16) LNT Solutions E450
17) Newave Aerochemical FCY 9311
18) Oksayd Defrost ECO 4
19) Oksayd Defrost EG 4
20) Shaanxi Cleanway Cleansurface IV

REMOVED:
No Type IV fluids being removed this year.

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Annual Maintenance: RECALCULATION OF GENERIC HOTS

Type II

- Added: ROMCHIM ADD-PROTECT Type II

Type IV

- Added: AllClear ClearWing EG
- Added: Cryotech Polar Guard Xtend

Very Cold Snow Generics Analysis

- In 2018-19 the analysis to determine the generic HOTs for VCS was finalized
- This affects all Type II/IV fluids/HOT tables without fluid specific HOTs in VCS

Transports Canada Transport Canada

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Annual Maintenance: NEW GENERIC VCS HOTS

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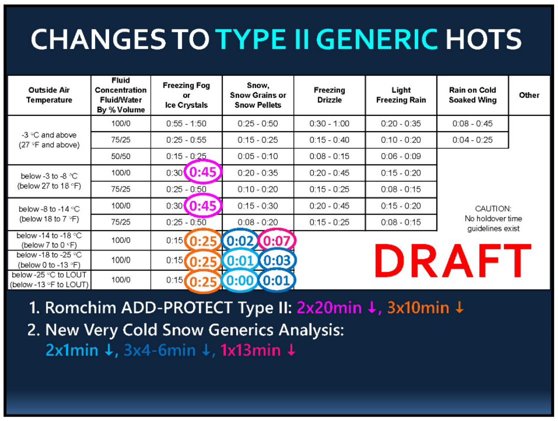
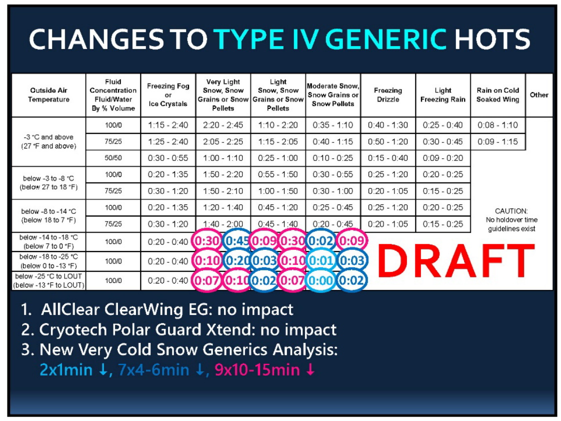
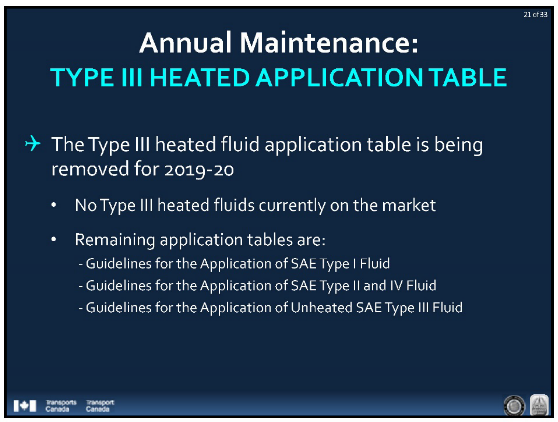
Outside Air Temperature	Dilution	Very Light Snow	Light Snow	Moderate Snow
TYPE II PG FLUIDS				
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:20 - 0:30*	0:07 - 0:20	0:02 - 0:07
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:09 - 0:15*	0:03 - 0:09	0:01 - 0:03
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:05 - 0:07*	0:01 - 0:05	0:00 - 0:01
TYPE IV PG FLUIDS				
below -1[illegible] -18 °C (below [illegible] to 0 °F)	100/0	0:30 - 0:45*	0:09 - 0:30	0:02 – 0:09
[illegible] -18 [illegible] -25 °C ([illegible] 0 to -13 °F)	100/0	0:10 - 0:20*	0:03 - 0:10	0:01 - 0:03
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:07 - 0:10*	0:02 - 0:07	0:00 - 0:02
TYPE IV EG FLUIDS				
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:50 - 1:05*	0:25 - 0:50	0:10 - 0:25
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:40 - 0:55*	0:15 - 0:40	0:05 - 0:15
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:25 - 0:35*	0:08 - 0:25	0:02 - 0:08

*Upper HOT in very light snow included in FAA tables only (not Transport Canada tables)

Transports Canada Transport Canada


CHANGES TO TYPE II GENERIC HOTS
Outside Air Temperature | Fluid Concentration Fluid/Water By % Volume | Freezing Fog or Ice Crystals | Snow, Snow Grains or Snow Pellets | Freezing Drizzle | Light Freezing Rain | Rain on Cold Soaked Wing | Other
-3 °C and above (27 °F and above) | 100/0 | 0:55 - 1:50 | 0:25 - 0:50 | 0:30 - 1:00 | 0:20 - 0:35 | 0:08 - 0:45
75/25 | 0:25 - 0:55 | 0:15 - 0:25 | 0:15 - 0:40 | 0:10 - 0:20 | 0:04 - 0:25
50/50 | 0:15 - 0:25 | 0:05 - 0:10 | 0:08 - 0:15 | 0:06 - 0:09
below -3 to -8 °C (below 27 to 18 °F) | 100/0 | 0:30 0:45 | 0:20 - 0:35 | 0:20 - 0:45 | 0:15 - 0:20
75/25 | 0:25 - 0:50 | 0:10 - 0:20 | 0:15 - 0:25 | 0:08 - 0:15
below -8 to -14 °C (below 18 to 7 °F) | 100/0 | 0:30 0:45 | 0:15 - 0:30 | 0:20 - 0:45 | 0:15 - 0:20
75/25 | 0:25 - 0:50 | 0:08 - 0:20 | 0:15 - 0:25 | 0:08 - 0:15
below -14 to -18 °C (below 7 to 0 °F) | 100/0 | 0:15 0:25 | 0:02 0:07
below -18 to -25 °C (below 0 to -13 °F) | 100/0 | 0:15 0:25 | 0:01 0:03
below -25 °C to LOUT (below -13 °F to LOUT) | 100/0 | 0:15 0:25 | 0:00 0:01
CAUTION: No holdover time guidelines exist
DRAFT
1. Romchim ADD-PROTECT Type II: 2x20min ↓, 3x10min ↓
2. New Very Cold Snow Generics Analysis:
2x1min ↓, 3x4-6min ↓, 1x13min ↓


CHANGES TO TYPE IV GENERIC HOTS
Outside Air Temperature | Fluid Concentration Fluid/Water By % Volume | Freezing Fog or Ice Crystals | Very Light Snow, Snow Grains or Snow Pellets | Light Snow, Snow Grains or Snow Pellets | Moderate Snow, Snow Grains or Snow Pellets | Freezing Drizzle | Light Freezing Rain | Rain on Cold Soaked Wing | Other
-3 °C and above (27 °F and above) | 100/0 | 1:15 - 2:40 | 2:20 - 2:45 | 1:10 - 2:20 | 0:35 - 1:10 | 0:40 - 1:30 | 0:25 - 0:40 | 0:08 - 1:10
75/25 | 1:25 - 2:40 | 2:05 - 2:25 | 1:15 - 2:05 | 0:40 - 1:15 | 0:50 - 1:20 | 0:30 - 0:45 | 0:09 - 1:15
50/50 | 0:30 - 0:55 | 1:00 - 1:10 | 0:25 - 1:00 | 0:10 - 0:25 | 0:15 - 0:40 | 0:09 - 0:20
below -3 to -8 °C (below 27 to 18 °F) | 100/0 | 0:20 - 1:35 | 1:50 - 2:20 | 0:55 - 1:50 | 0:30 - 0:55 | 0:25 - 1:20 | 0:20 - 0:25
75/25 | 0:30 - 1:20 | 1:50 - 2:10 | 1:00 - 1:50 | 0:30 - 1:00 | 0:20 - 1:05 | 0:15 - 0:25
below -8 to -14 °C (below 18 to 7 °F) | 100/0 | 0:20 - 1:35 | 1:20 - 1:40 | 0:45 - 1:20 | 0:25 - 0:45 | 0:25 - 1:20 | 0:20 - 0:25
75/25 | 0:30 - 1:20 | 1:40 - 2:00 | 0:45 - 1:40 | 0:20 - 0:45 | 0:20 - 1:05 | 0:15 - 0:25
below -14 to -18 °C (below 7 to 0 °F) | 100/0 | 0:20 - 0:40 | 0:30 0:45 | 0:09 0:30 | 0:02 0:09
below -18 to -25 °C (below 0 to -13 °F) | 100/0 | 0:20 - 0:40 | 0:10 0:20 | 0:03 0:10 | 0:01 0:03
below -25 °C to LOUT (below -13 °F to LOUT) | 100/0 | 0:20 - 0:40 | 0:07 0:10 | 0:02 0:07 | 0:00 0:02
CAUTION: No holdover time guidelines exist
DRAFT
1. AllClear ClearWing EG: no impact
2. Cryotech Polar Guard Xtend: no impact
3. New Very Cold Snow Generics Analysis:
2x1min ↓, 7x4-6min ↓, 9x10-15min ↓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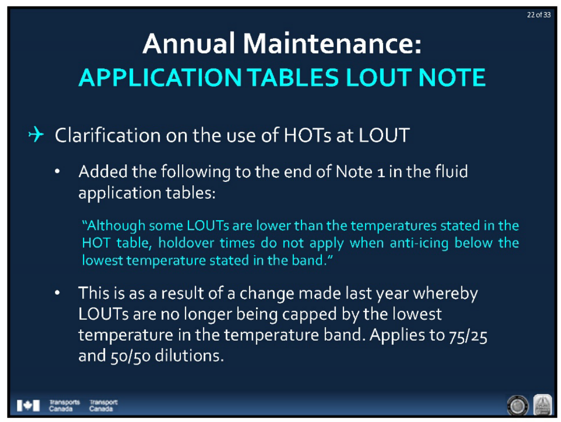
Annual Maintenance:
TYPE III HEATED APPLICATION TABLE
The Type III heated fluid application table is being removed for 2019-20
No Type III heated fluids currently on the market
Remaining application tables are:
- Guidelines for the Application of SAE Type I Fluid
- Guidelines for the Application of SAE Type II and IV Fluid
- Guidelines for the Application of Unheated SAE Type III Fluid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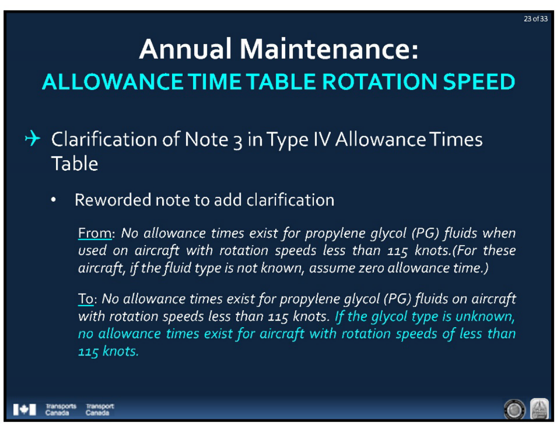
Annual Maintenance:
APPLICATION TABLES LOUT NOTE
Clarification on the use of HOTs at LOUT
Added the following to the end of Note 1 in the fluid application tables:
"Although some LOUTs are lower than the temperatures stated in the HOT table, holdover times do not apply when anti-icing below the lowest temperature stated in the band."
This is as a result of a change made last year whereby LOUTs are no longer being capped by the lowest temperature in the temperature band. Applies to 75/25 and 50/50 dilutions.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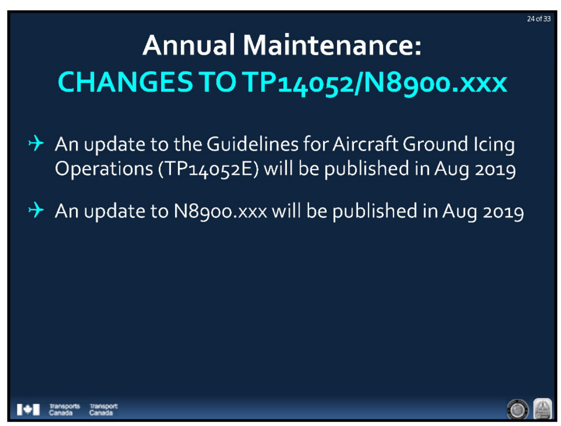
Annual Maintenance:
ALLOWANCE TIME TABLE ROTATION SPEED
Clarification of Note 3 in Type IV Allowance Times Table
Reworded note to add clarification
From: No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots.(For these aircraft, if the fluid type is not known, assume zero allowance time.)
To: No allowance times exist for propylene glycol (PG) fluids on aircraft with rotation speeds less than 115 knots. If the glycol type is unknown, no allowance times exist for aircraft with rotation speeds of less than 115 knots.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Annual Maintenance:
CHANGES TO TP14052/N8900.xxx
An update to the Guidelines for Aircraft Ground Icing Operations (TP14052E) will be published in Aug 2019
An update to N8900.xxx will be published in Aug 2019

Changes resulting from…

SUPPLEMENTAL ANALYSIS IN VERY VERY COLD SNOW

SUPPLEMENTAL ANALYSIS IN VERY VERY COLD SNOW

- In 2018-19 the analysis to determine snow HOTs in the temperature band "below -25°C to LOUT" for fluids whose LOUTs are <-29°C was finalized. This resulted in changes to the following fluids:
  - Cryotech Polar Guard II
  - Cryotech Polar Guard Advance
  - LNT Solutions E450

CHANGES TO CRYOTECH POLAR GUARD II/ADVANCE

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:50 - 4:00	2:00	1:55 - 2:00	1:05 - 1:55	1:35 - 2:00	1:15 - 1:30	0:15 - 2:00	CAUTION: No holdover time guidelines exist
	75/25	2:30 - 4:00	2:00	1:25 - 2:00	0:40 - 1:25	1:40 - 2:00	0:40 - 1:10	0:09 - 1:40	
	50/50	0:50 - 1:25	1:10	0:25 - 1:10	0:10 - 0:25	0:20 - 0:45	0:09 - 0:20		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:55 - 2:30	2:00	1:25 - 2:00	0:50 - 1:25	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:00	1:05 - 2:00	0:30 - 1:05	0:25 - 1:05	0:35 - 0:45		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:55 - 2:30	2:00	1:10 - 2:00	0:40 - 1:10	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:00	0:55 - 2:00	0:25 - 0:55	0:25 - 1:05	0:35 - 0:45		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25 - 0:50	1:35	0:35 - 1:35	0:10 - 0:35				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25 - 0:50	0:40	0:15 - 0:40	0:04 - 0:15				
below -25 to -30.5°C (below -13 to -23°F)	100/0	0:25 - 0:50	0:25	**0:07** - 0:25	0:02 - **0:07**				

DRAFT

Transport Canada

CHANGES TO CRYOTECH POLAR GUARD II/ADVANCE

Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:50 - 4:00	3:00 - 3:00	1:55 - 3:00	1:05 - 1:55	1:35 - 2:00	1:15 - 1:30	0:15 - 2:00	CAUTION: No holdover time guidelines exist
	75/25	2:30 - 4:00	3:00 - 3:00	1:25 - 3:00	0:40 - 1:25	1:40 - 2:00	0:40 - 1:10	0:09 - 1:40	
	50/50	0:50 - 1:25	1:10 - 1:35	0:25 - 1:10	0:10 - 0:25	0:20 - 0:45	0:09 - 0:20		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:55 - 2:30	2:25 - 2:50	1:25 - 2:25	0:50 - 1:25	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:20 - 3:00	1:05 - 2:20	0:30 - 1:05	0:25 - 1:05	0:35 - 0:45		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:55 - 2:30	2:00 - 2:20	1:10 - 2:00	0:40 - 1:10	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:00 - 2:30	0:55 - 2:00	0:25 - 0:55	0:25 - 1:05	0:35 - 0:45		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25 - 0:50	1:35 - 2:15	0:35 - 1:35	0:10 - 0:35				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25 - 0:50	0:40 - 0:55	0:15 - 0:40	0:04 - 0:15				
below -25 to -30.5°C (below -13 to -23°F)	100/0	0:25 - 0:50	0:25 - **0:30**	**0:07** - 0:25	0:02 - **0:07**				

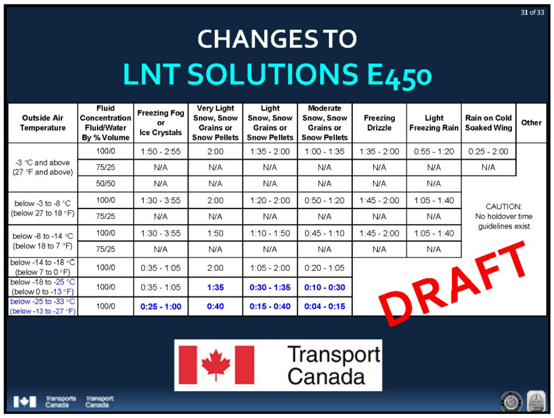
DRAFT

Changes resulting from…

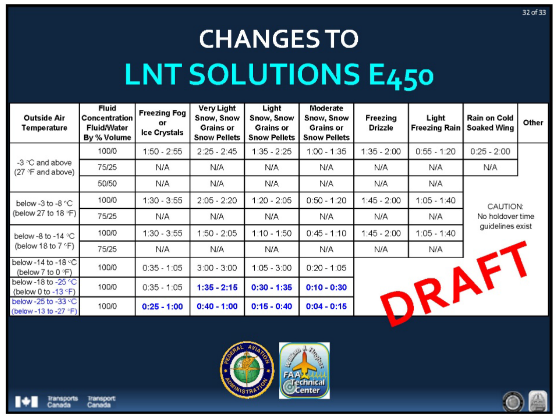
SUPPLEMENTAL TESTING WITH LNT SOLUTIONS E450

SUPPLEMENTAL TESTING WITH LNT SOLUTIONS E450

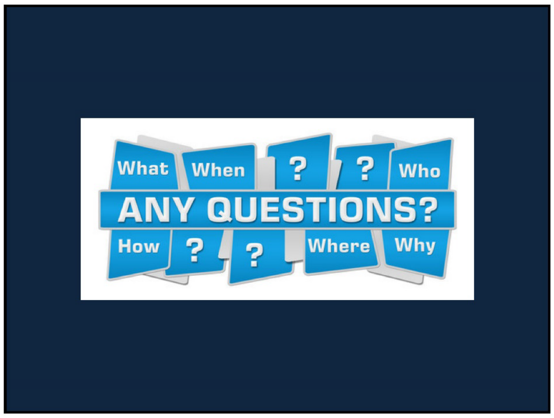
- In 2018-19 additional testing was conducted with LNT E450 to support a lower LOUT
  - New temperature band "below -25 to LOUT" was added
  - New HOTs for freezing fog and snow down to the LOUT were calculated
- This, along with the supplemental analysis in very very cold snow resulted in the following changes to the fluid specific HOT table



Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50 - 2:55	2:00	1:35 - 2:00	1:00 - 1:35	1:35 - 2:00	0:55 - 1:20	0:25 - 2:00	CAUTION: No holdover time guidelines exist
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:30 - 3:55	2:00	1:20 - 2:00	0:50 - 1:20	1:45 - 2:00	1:05 - 1:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:30 - 3:55	1:50	1:10 - 1:50	0:45 - 1:10	1:45 - 2:00	1:05 - 1:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:35 - 1:05	2:00	1:05 - 2:00	0:20 - 1:05				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:35 - 1:05	**1:35**	**0:30 - 1:35**	**0:10 - 0:30**				
below -25 to -33 °C (below -13 to -27 °F)	100/0	**0:25 - 1:00**	**0:40**	**0:15 - 0:40**	**0:04 - 0:15**				



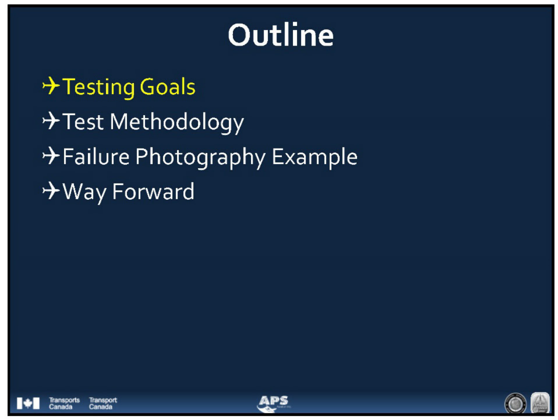
Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50 - 2:55	2:25 - 2:45	1:35 - 2:25	1:00 - 1:35	1:35 - 2:00	0:55 - 1:20	0:25 - 2:00	CAUTION: No holdover time guidelines exist
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:30 - 3:55	2:05 - 2:20	1:20 - 2:05	0:50 - 1:20	1:45 - 2:00	1:05 - 1:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:30 - 3:55	1:50 - 2:05	1:10 - 1:50	0:45 - 1:10	1:45 - 2:00	1:05 - 1:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:35 - 1:05	3:00 - 3:00	1:05 - 3:00	0:20 - 1:05				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:35 - 1:05	**1:35 - 2:15**	**0:30 - 1:35**	**0:10 - 0:30**				
below -25 to -33 °C (below -13 to -27 °F)	100/0	**0:25 - 1:00**	**0:40 - 1:00**	**0:15 - 0:40**	**0:04 - 0:15**				

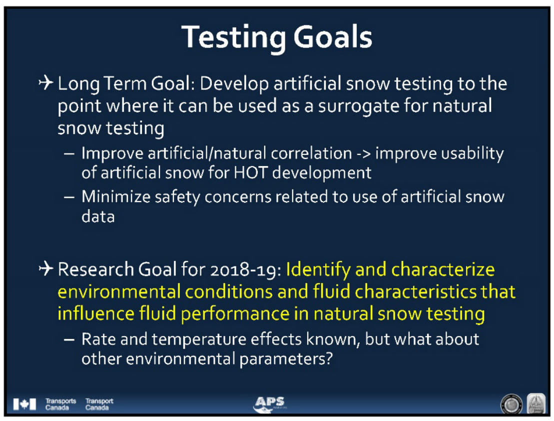


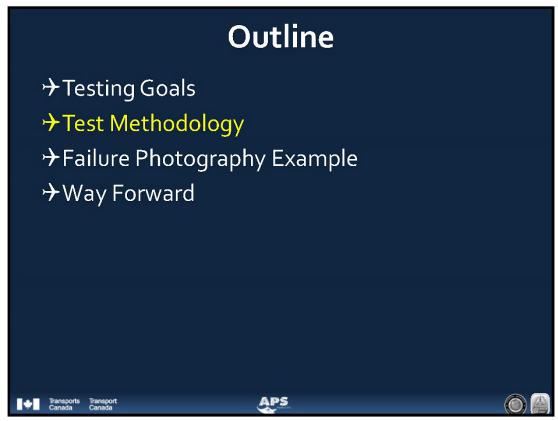
SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
NATURAL SNOW CHARACTERIZATION TESTING


Joint research led by:
Transport Canada
Transports Canada
Conducted by:
APS Aviation Inc.
NATURAL SNOW CHARACTERIZATION TESTING
SAE G-12 HOT Committee, Dubrovnik, May 21, 2019
Prepared and Presented by: Benjamin Bernier


Outline
Testing Goals
Test Methodology
Failure Photography Example
Way Forward


Testing Goals
Long Term Goal: Develop artificial snow testing to the point where it can be used as a surrogate for natural snow testing
– Improve artificial/natural correlation -> improve usability of artificial snow for HOT development
– Minimize safety concerns related to use of artificial snow data
Research Goal for 2018-19: Identify and characterize environmental conditions and fluid characteristics that influence fluid performance in natural snow testing
– Rate and temperature effects known, but what about other environmental parameters?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Testing Goals
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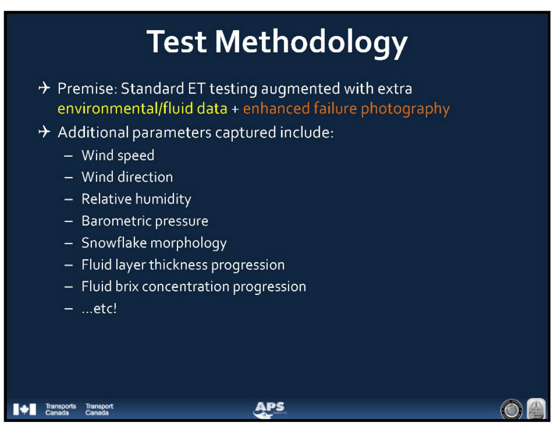
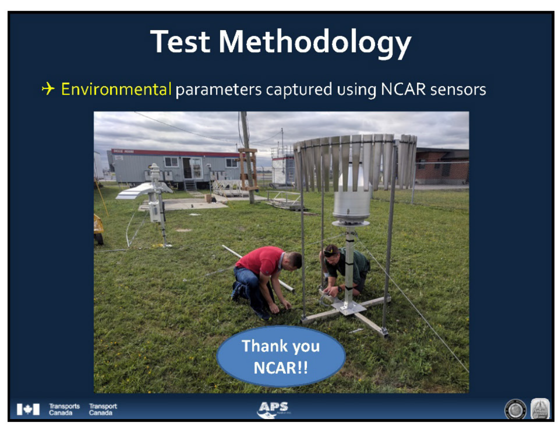
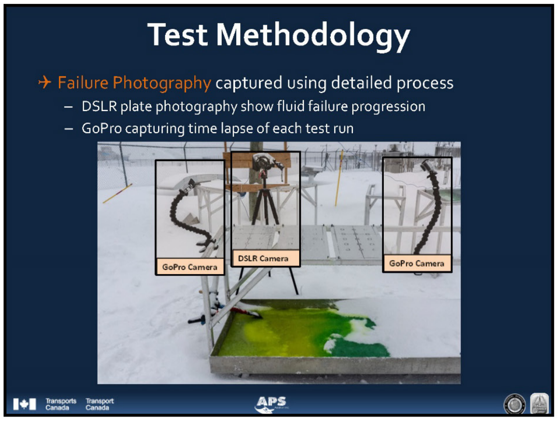
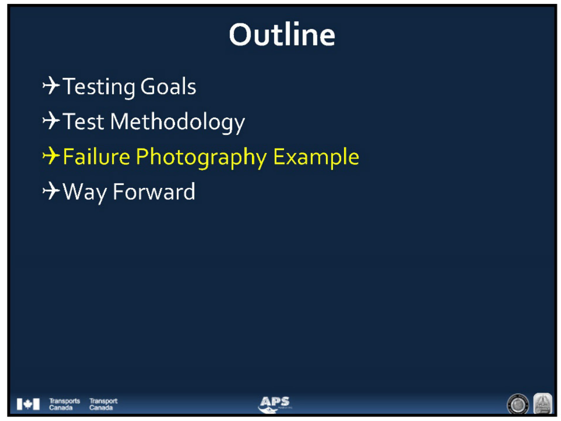
Way Forward


Test Methodology
Premise: Standard ET testing augmented with extra environmental/fluid data + enhanced failure photography
Additional parameters captured include:
– Wind speed
– Wind direction
– Relative humidity
– Barometric pressure
– Snowflake morphology
– Fluid layer thickness progression
– Fluid brix concentration progression
– ...etc!


Test Methodology
Environmental parameters captured using NCAR sensors
Thank you NCAR!!


Test Methodology
Failure Photography captured using detailed process
– DSLR plate photography show fluid failure progression
– GoPro capturing time lapse of each test run
GoPro Camera
DSLR Camera
GoPro Camera
APS


Outline
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Failure Photography Example
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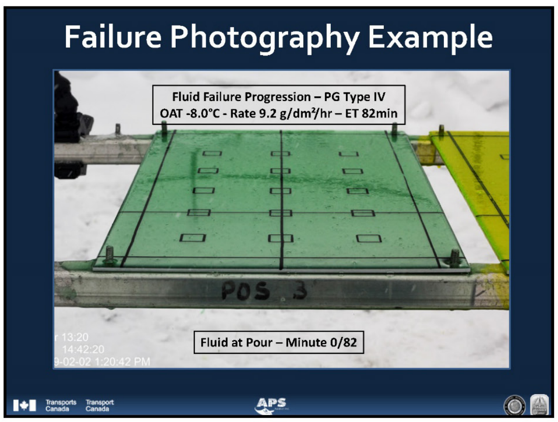
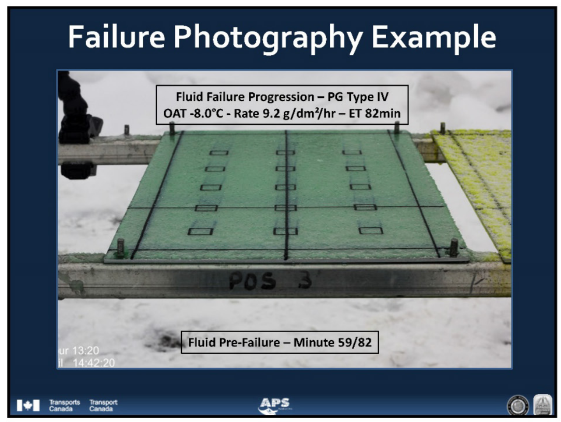
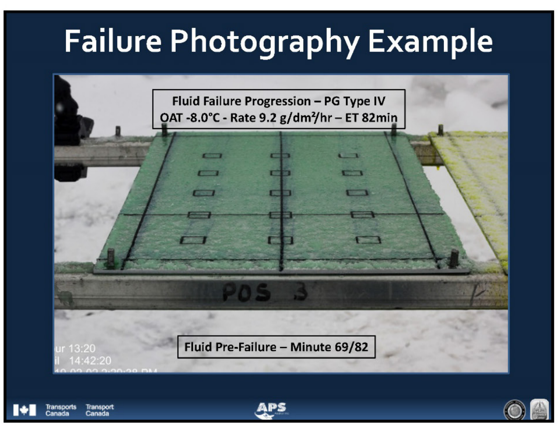
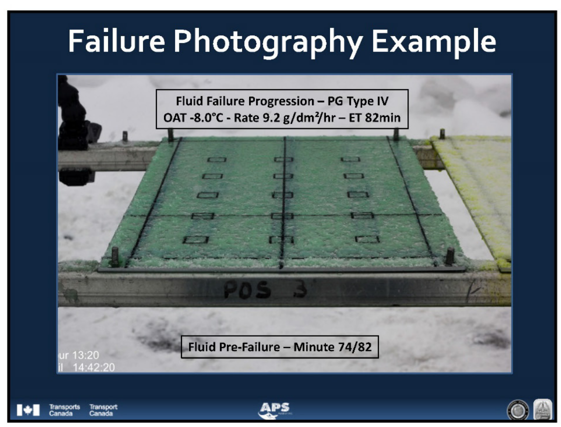
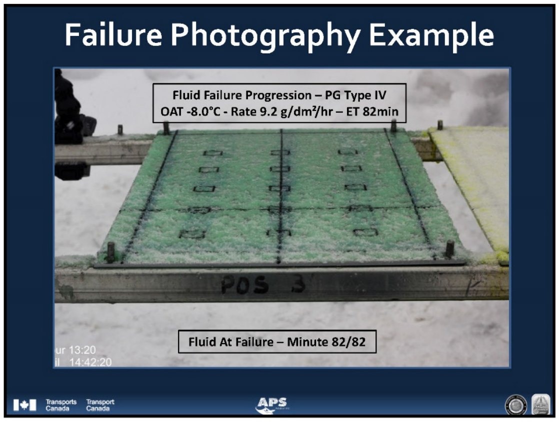
APS

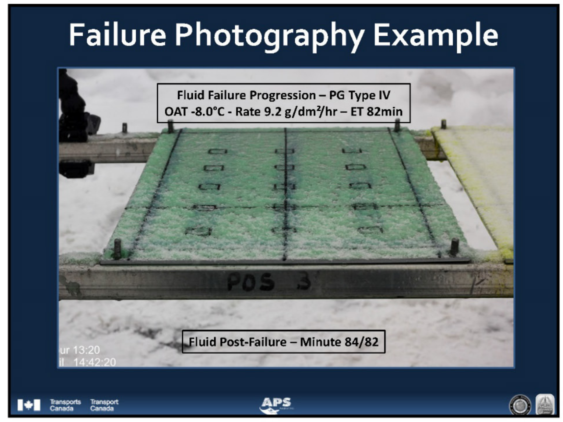

Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
POS 3
Fluid at Pour – Minute 0/82
APS

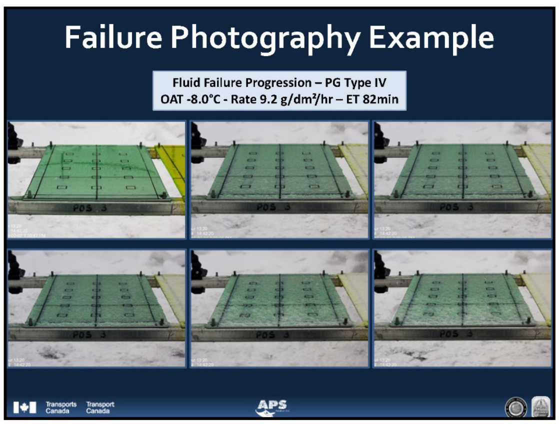

Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
POS 3
Fluid Pre-Failure – Minute 59/82
APS


Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
POS 3
Fluid Pre-Failure – Minute 69/82
APS


Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
POS 3
Fluid Pre-Failure – Minute 74/82
APS


Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
Fluid At Failure – Minute 82/82
APS


Failure Photography Example
Fluid Failure Progression – PG Type IV
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
Fluid Post-Failure – Minute 84/82
APS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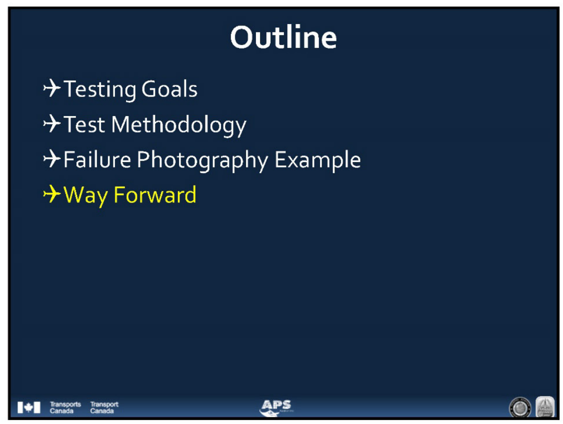
OAT -8.0°C - Rate 9.2 g/dm²/hr – ET 82min
APS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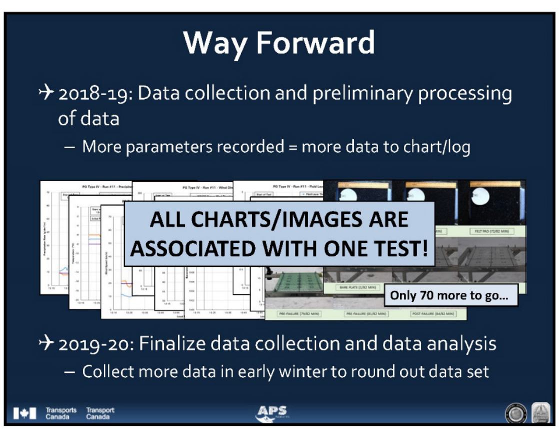
Way Forward
2018-19: Data collection and preliminary processing of data
– More parameters recorded = more data to chart/log
ALL CHARTS/IMAGES ARE ASSOCIATED WITH ONE TEST!
Only 70 more to go…
2019-20: Finalize data collection and data analysis
– Collect more data in early winter to round out data set
APS


?
APS
Benjamin Bernier
bbernier@apsaviation.ca

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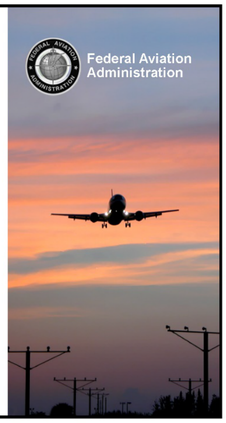
SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
ARTIFICIAL SNOW: A HISTORICAL REVIEW

Artificial Snow: A Historical Review



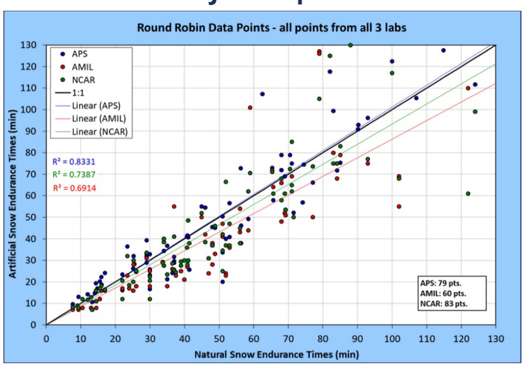
Presented to: SAE G-12 HOT Committee
By: Warren Underwood
On Behalf of: FAA and Transport Canada
Date: May 21, 2019

Initial Research

- 1998-99 to 2003-04: Many years of research attempting to correlate natural and artificial snow endurance time performance
  - Tweaks made to snow machines, i.e. heating blanket, etc.
  - Comparative / round robin inter-lab testing promising, but did show scatter

Federal Aviation Administration 2 / 9

Inter-Laboratory Comparison: 2003-04



Standard Development

- 2004-05: Artificial snow test procedure developed for SAE Endurance Time testing standard for Type II/III/IV fluids
  - 2007: Standard published (publication took several years)
  - Ballotted and approved by the SAE G-12 HOT Committee
  - Note: Artificial snow test procedures added to AS5485A despite scatter relative to natural snow

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Dual Testing

- 2005-06, 2006-07, 2007-08: Fluids submitted for HOT testing tested in both artificial and natural snow – to confirm artificial snow gives similar HOTs as natural snow
  - 11 Fluids Tested
  - Observations: Significant differences between HOTs generated using artificial and natural snow data

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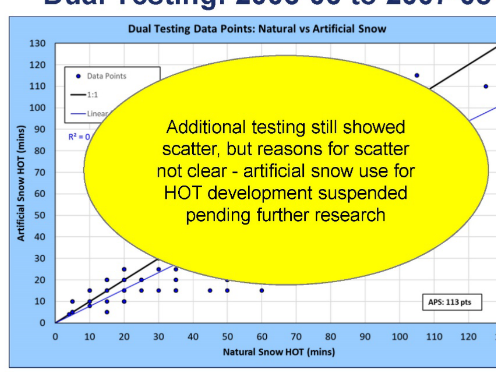
Dual Testing: 2005-06 to 2007-08



Recent Developments

- 2016-17: ARP5485 updated
  - TC/FAA decision to not use artificial snow for HOT development added to standard (test procedures remain in standard)
- 2016-17: Natural and artificial testing completed in very cold snow for the first time
  - Very cold snow testing completed as a result of preliminary very cold natural snow data collected in 2014-15 showing potential reductions to HOTs
  - Data showed previous assumption of artificial snow producing shorter HOTs than natural snow at very cold temperatures not necessarily valid

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Advantages of Artificial Snow

- Why is Ability to use Artificial Snow to derive HOTs Valuable?
  - Can test at any time of year
  - Can get HOTs from fewer tests (boundary conditions) / faster
  - Can get HOTs for very specific conditions (controlled conditions)
  - Can get HOTs for conditions which are hard to get outside
  - Should be more efficient than natural snow testing
- Conclusion: Viable artificial snow machine is advantageous; research efforts are ongoing

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Future Research Objectives

1. Continue investigating previously identified sources of discrepancy between natural and artificial snow data
2. Address metrics that will improve accuracy and expediency for acceptable calibration methods
3. Identify and characterize environmental conditions and fluid characteristics that influence natural snow testing
4. Determine if changes are required for artificial snow to provide results accurately correlated to natural snow results
5. Evaluate performance of snow machines with comparative natural conditions testing
6. At the completion of the above exercises – update the calibration and test procedures for artificial snow testing in the SAE G-12 endurance time testing standards

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Additional Analysis Techniques to Address Scatter

- Alternate analysis techniques examined 2009-10 to 2014-15 to address artificial-natural scatter
  1. Regression Approach: Collect data at various temperatures and rates rather than at worst-case boundary conditions
     - Conclusion: no, same result (shorter HOTs)
  2. Multiplier Approach: Apply multipliers for specific rates / temps to AS results improve correlation with NS data
     - Conclusion: Multipliers can be used to improve average correlation, but scatter remains (still significant # points well above / below NS)

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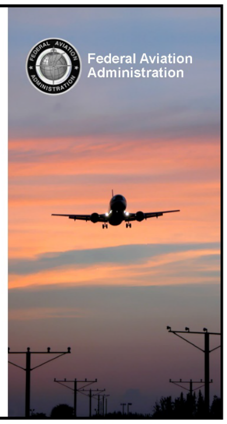
SAE G-12 HOLDOVER TIME COMMITTEE, DUBROVNIK, CROATIA, MAY 2019

PRESENTATION:
UPDATES ON GUIDANCE FOR METAR CODES GS, GR, PL, SHGS, SG

Updates on Guidance for METAR Codes
GS, GR, PL, SHGS, SG



Presented to: SAE G-12 HOT Committee
By: Charles J. Enders
On Behalf of: FAA and Transport Canada
Date: May 21, 2019

METAR Code Guidance

- Guidance on METAR codes related to Hail, Small Hail, Ice Pellets, Snow Grains and Snow Pellets was updated in FAA/TC HOT guidance documents following changes to METAR reporting in both US and Canada
  - Changes led to increased complexity as same reports in different countries = different weather conditions

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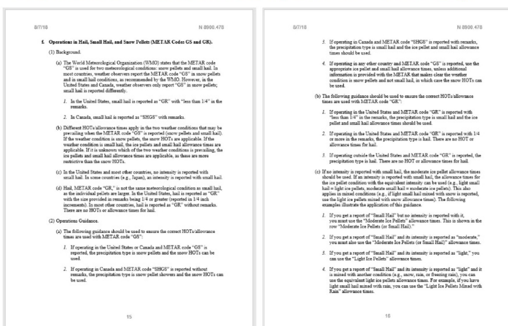
Current Guidance (FAA Format)

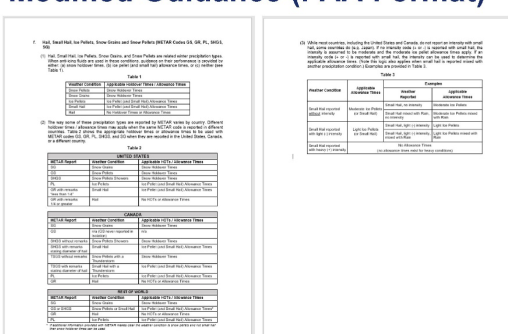


Feedback from Industry

- Guidance is detailed and complex
- Is there a clearer way to communicate the information?

Federal Aviation Administration 4 / 11

Modified Guidance (FAA Format)



Modified Guidance

- Putting information in tables reduces complexity
- Three sections
  - Background
  - Guidance by country
  - Guidance for intensity reporting

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Background

f. Hail, Small Hail, Ice Pellets, Snow Grains and Snow Pellets (METAR Codes GS, GR, PL, SHGS, SG)

(1) Hail, Small Hail, Ice Pellets, Snow Grains, and Snow Pellets are related winter precipitation types. When anti-icing fluids are used in these conditions, guidance on their performance is provided by either: (a) snow holdover times, (b) ice pellet (and small hail) allowance times, or (c) neither (see Table 1).

Table 1

Weather Condition	Applicable Holdover Times / Allowance Times
Snow Pellets	Snow Holdover Times
Snow Grains	Snow Holdover Times
Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
Small Hail	Ice Pellet (and Small Hail) Allowance Times
Hail	No Holdover Times or Allowance Times

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Guidance by Country

(2) The way some of these precipitation types are reported by METAR varies by country. Different holdover times / allowance times may apply when the same METAR code is reported in different countries. Table 2 shows the appropriate holdover times or allowance times to be used with METAR codes GS, GR, PL, SHGS, and SG when they are reported in the United States, Canada, or a different country.

Table 2

UNITED STATES		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS	Snow Pellets	Snow Holdover Times
SHGS	Snow Pellets Showers	Snow Holdover Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
GR with remarks "less than 1/4"	Small Hail	Ice Pellet (and Small Hail) Allowance Times
GR with remarks 1/4 or greater	Hail	No HOTs or Allowance Times

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CANADA		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS	n/a (GS never reported in isolation)	n/a
SHGS without remarks	Snow Pellets Showers	Snow Holdover Times
SHGS with remarks stating diameter of hail	Small Hail	Ice Pellet (and Small Hail) Allowance Times
TSGS without remarks	Snow Pellets with a Thunderstorm	Snow Holdover Times
TSGS with remarks stating diameter of hail	Small Hail with a Thunderstorm	Ice Pellet (and Small Hail) Allowance Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
GR	Hail	No HOTs or Allowance Times

REST OF WORLD		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS or SHGS	Snow Pellets or Small Hail	Ice Pellet (and Small Hail) Allowance Times*
GR	Hail	No HOTs or Allowance Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times

** If additional information provided with METAR makes clear the weather condition is snow pellets and not small hail then snow holdover times can be used*

Intensity Guidance

(3) While most countries, including the United States and Canada, do not report an intensity with small hail, some countries do (e.g. Japan). If no intensity code (+ or -) is reported with small hail, the intensity is assumed to be moderate and the moderate ice pellet allowance times apply. If an intensity code (+ or -) is reported with small hail, the intensity can be used to determine the applicable allowance times. (Note this logic also applies when small hail is reported mixed with another precipitation condition.) Examples are provided in Table 3.

Table 3

Weather Condition	Applicable Allowance Times	Examples	
		Weather Reported	**Applicable Allowance Times**
Small Hail reported <u>without</u> intensity	Moderate Ice Pellets (or Small Hail)	Small Hail, no intensity	Moderate Ice Pellets
		Small Hail mixed with Rain, no intensity	Moderate Ice Pellets mixed with Rain
Small Hail reported with light (-) intensity	Light Ice Pellets (or Small Hail)	Small Hail, light (-) intensity	Light Ice Pellets
		Small Hail, light (-) intensity, mixed with Rain	Light Ice Pellets mixed with Rain
Small Hail reported with heavy (+) intensity	No Allowance Times (no allowance times exist for heavy conditions)		

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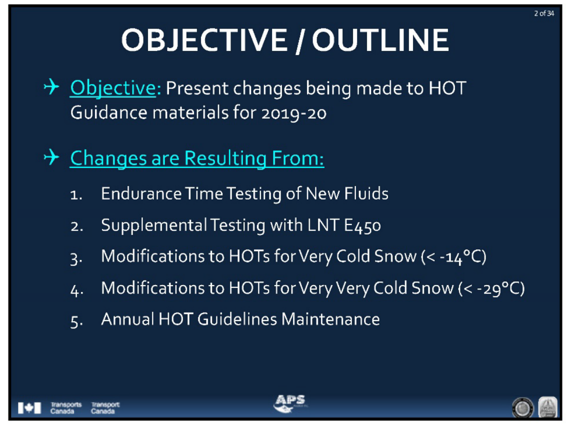
Conclusions

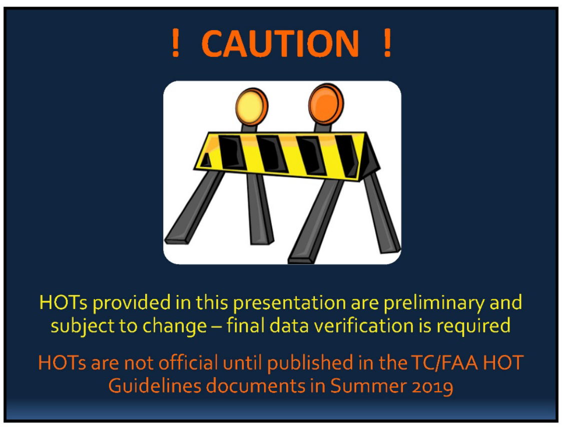
- Changes pending final input from FAA and TC meteorology specialists
- Changes expected to be implemented in winter 2019-20 guidance documents

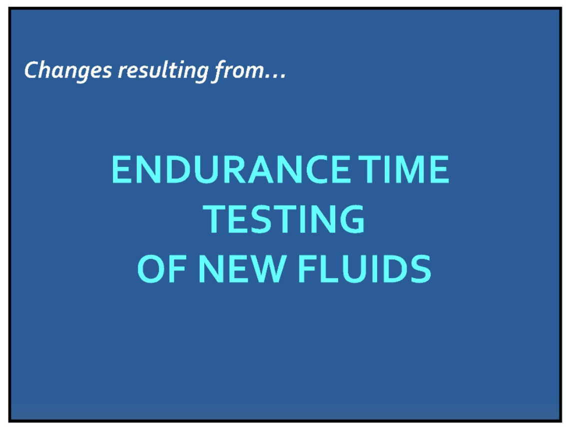
Federal Aviation Administration 11 / 11

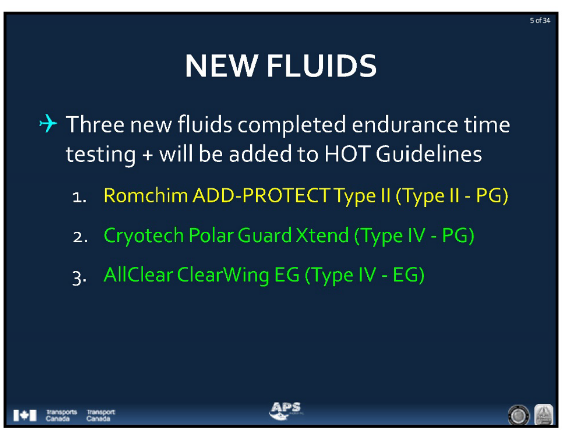
AIRLINES FOR AMERICA (A4A) GROUND DEICING FORUM, WASHINGTON, USA, JUNE 2019

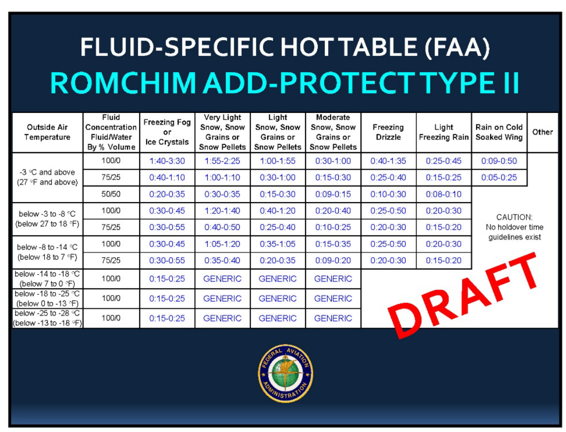
PRESENTATION:
CHANGES TO HOT GUIDELINES FOR WINTER 2019-20



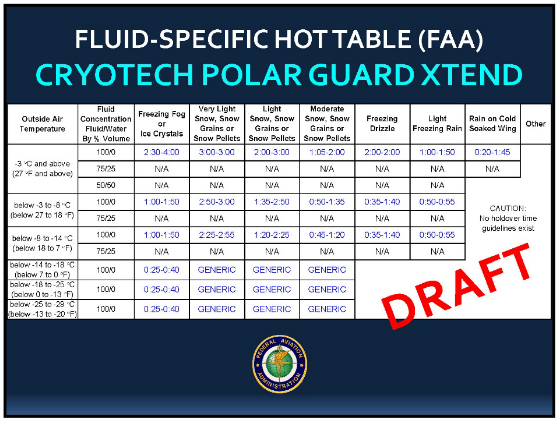




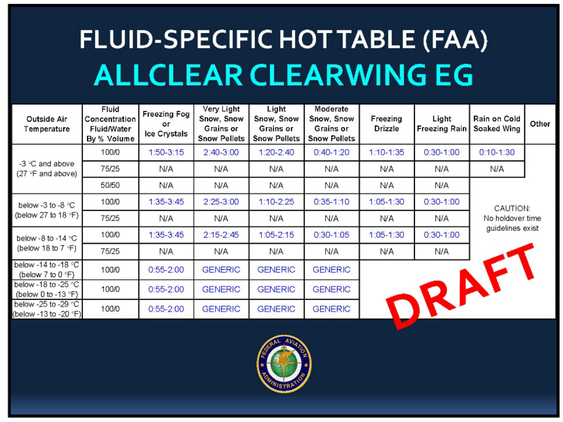




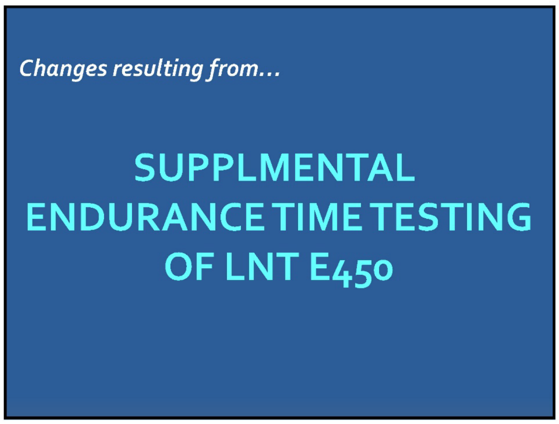
Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:40-3:30	1:55-2:25	1:00-1:55	0:30-1:00	0:40-1:35	0:25-0:45	0:09-0:50	
	75/25	0:40-1:10	1:00-1:10	0:30-1:00	0:15-0:30	0:25-0:40	0:15-0:25	0:05-0:25	
	50/50	0:20-0:35	0:30-0:35	0:15-0:30	0:09-0:15	0:10-0:30	0:08-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:30-0:45	1:20-1:40	0:40-1:20	0:20-0:40	0:25-0:50	0:20-0:30		
	75/25	0:30-0:55	0:40-0:50	0:25-0:40	0:10-0:25	0:20-0:30	0:15-0:20		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:30-0:45	1:05-1:20	0:35-1:05	0:15-0:35	0:25-0:50	0:20-0:30		
	75/25	0:30-0:55	0:35-0:40	0:20-0:35	0:09-0:20	0:20-0:30	0:15-0:20		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				
below -25 to -28 °C (below -13 to -18 °F)	100/0	0:15-0:25	GENERIC	GENERIC	GENERIC				

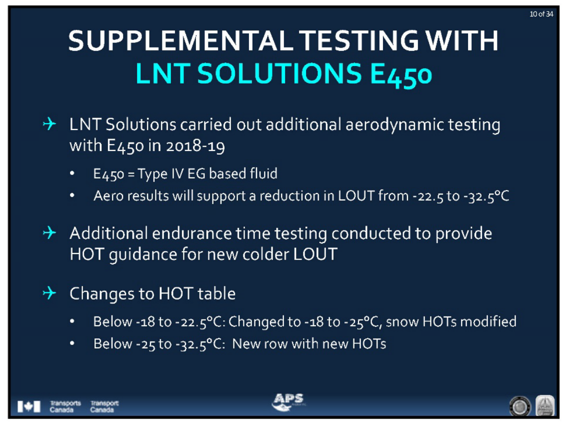


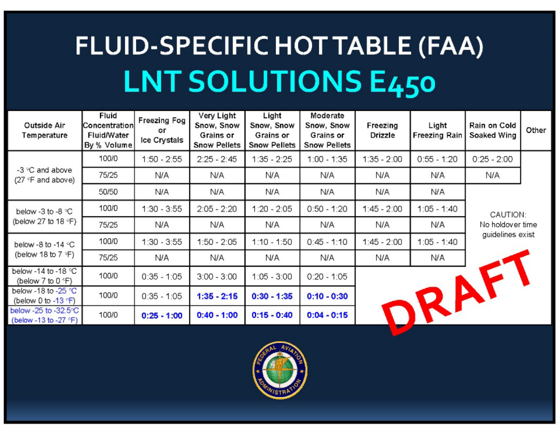
Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:30-4:00	3:00-3:00	2:00-3:00	1:05-2:00	2:00-2:00	1:00-1:50	0:20-1:45	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:00-1:50	2:50-3:00	1:35-2:50	0:50-1:35	0:35-1:40	0:50-0:55	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:00-1:50	2:25-2:55	1:20-2:25	0:45-1:20	0:35-1:40	0:50-0:55		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:25-0:40	GENERIC	GENERIC	GENERIC				



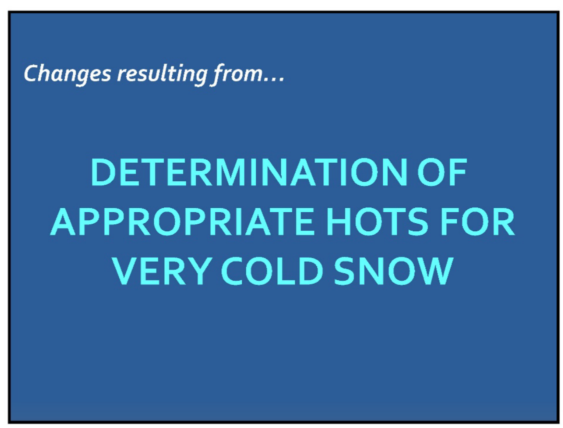
Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50-3:15	2:40-3:00	1:20-2:40	0:40-1:20	1:10-1:35	0:30-1:00	0:10-1:30	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:35-3:45	2:25-3:00	1:10-2:25	0:35-1:10	1:05-1:30	0:30-1:00	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:35-3:45	2:15-2:45	1:05-2:15	0:30-1:05	1:05-1:30	0:30-1:00		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				
below -25 to -29 °C (below -13 to -20 °F)	100/0	0:55-2:00	GENERIC	GENERIC	GENERIC				







Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	1:50 - 2:55	2:25 - 2:45	1:35 - 2:25	1:00 - 1:35	1:35 - 2:00	0:55 - 1:20	0:25 - 2:00	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -8 °C (below 27 to 18 °F)	100/0	1:30 - 3:55	2:05 - 2:20	1:20 - 2:05	0:50 - 1:20	1:45 - 2:00	1:05 - 1:40	CAUTION: No holdover time guidelines exist	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -8 to -14 °C (below 18 to 7 °F)	100/0	1:30 - 3:55	1:50 - 2:05	1:10 - 1:50	0:45 - 1:10	1:45 - 2:00	1:05 - 1:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:35 - 1:05	3:00 - 3:00	1:05 - 3:00	0:20 - 1:05				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:35 - 1:05	**1:35 - 2:15**	**0:30 - 1:35**	**0:10 - 0:30**				
below -25 to -32.5°C (below -13 to -27 °F)	100/0	**0:25 - 1:00**	**0:40 - 1:00**	**0:15 - 0:40**	**0:04 - 0:15**				



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HOTS FOR VERY COLD SNOW

- Very Cold Snow (VCS) = snow at temps below -14°C
- Until recently, the same HOT values were published for all Type II/IV fluids for VCS (values were "generic")
  - Limited testing conducted in VCS conditions
- Optional testing in 2016-17 resulted in some fluids getting fluid-specific HOT values for very cold snow
- Testing and analysis ongoing over last 5 years has indicated "generic" values require reductions

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HOTS FOR VERY COLD SNOW

- Analysis finalized this year; reductions will be made to many "generic" HOT values
- Three sets of "generic" HOTs for VCS:
  - Type II PG-based fluids
  - Type IV PG-based fluids
  - Type IV EG-based fluids
  - Three sets of generics provide longer HOTs when possible (Type IV > Type II, EG > PG)

GENERIC HOTS FOR VERY COLD SNOW

DRAFT

Outside Air Temperature	Dilution	Very Light Snow	Light Snow	Moderate Snow
TYPE II PG FLUIDS				
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:20 - 0:30	0:07 - 0:20	0:02 - 0:07
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:09 - 0:15	0:03 - 0:09	0:01 - 0:03
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:05 - 0:07	0:01 - 0:05	0:00 - 0:01
TYPE IV PG FLUIDS				
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:30 - 0:45	0:09 - 0:30	0:02 - 0:09
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:10 - 0:20	0:03 - 0:10	0:01 - 0:03
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:07 - 0:10	0:02 - 0:07	0:00 - 0:02
TYPE IV EG FLUIDS				
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:50 - 1:05	0:25 - 0:50	0:10 - 0:25
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:40 - 0:55	0:15 - 0:40	0:05 - 0:15
below -18 to LOUT °C (below 0 to LOUT °F)	100/0	0:25 - 0:35	0:08 - 0:25	0:02 - 0:08

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HOTS FOR VERY COLD SNOW

- Note: Fluids with fluid-specific HOTS in very cold snow will not be affected. This includes:

Type II
- Clariant Safewing MP II FLIGHT
- Cryotech Polar Guard II

Type III
- AllClear AeroClear MAX

Type IV
- Clariant Safewing MP IV LAUNCH
- Clariant Safewing MP IV LAUNCH PLUS
- Cryotech Polar Guard Advance
- Dow Endurance EG106
- LNT Solutions E450

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HOTS FOR VERY COLD SNOW

- Generic Type II and Type IV HOT tables will be affected
- Fluid-specific HOT tables for all fluids without fluid-specific VCS HOTs will be affected:

Type II PG VCS HOTs

Type II Generic Table

ABAX ECOWING 26
ABAX ECOWING AD-2
Aviation Shaanxi Cleanwing II
Beijing Yadilite YD-102
Clariant Safewing MP II FLIGHT PLUS
Kilfrost ABC-K PLUS
Kilfrost Ice Clear II
Newave Aerochemical FCY-2
Newave Aerochemical FCY-2 Bio+
Oksayd Defrost PG 2
ROMCHIM ADD-PROTECT Type II

Type IV PG VCS HOTs

Type IV Generic Table

ABAX ECOWING AD-49
Clariant Max Flight 04
Clariant Max Flight SNEG
Cryotech Polar Guard Xtend
Dow UCAR FlightGuard AD-49
Inland Technologies ECO-SHIELD
Kilfrost ABC-S Plus
Newave Aerochemical FCY 9311
Oksayd Defrost ECO 4
Shaanxi Cleanway Cleansurface IV

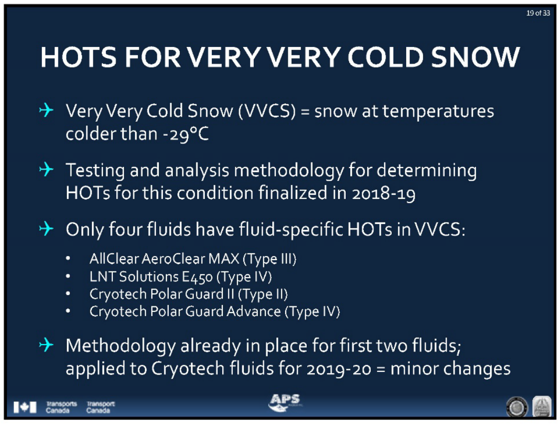
Type IV EG VCS HOTs

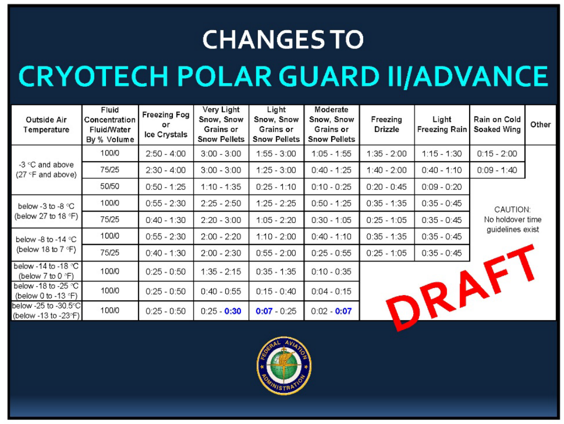
No generic table with Type IV EG VCS HOTs

AllClear ClearWing EG
CHEMCO ChemR EG IV
Clariant Max Flight AVIA
Clariant Safewing EG IV NORTH
Oksayd Defrost EG 4

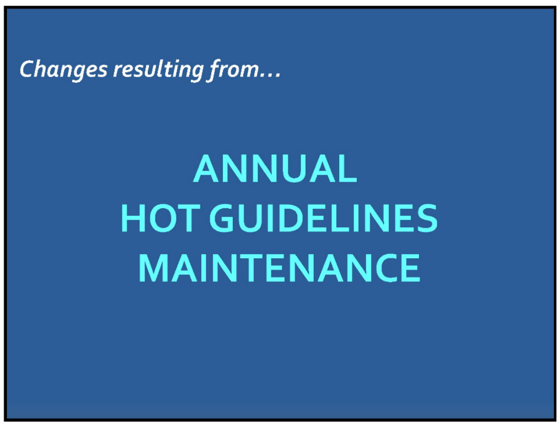
Changes resulting from…

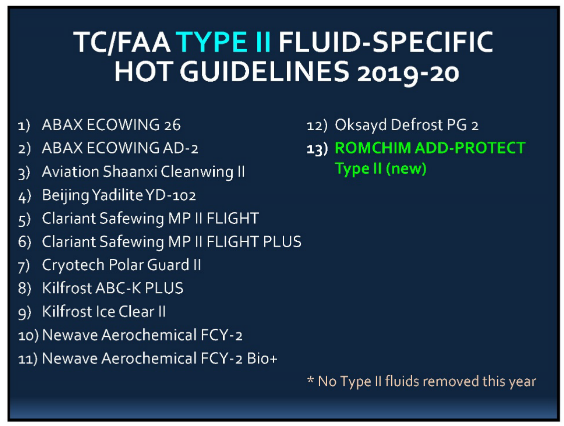
DETERMINATION OF APPROPRIATE HOTS FOR VERY VERY COLD SNOW

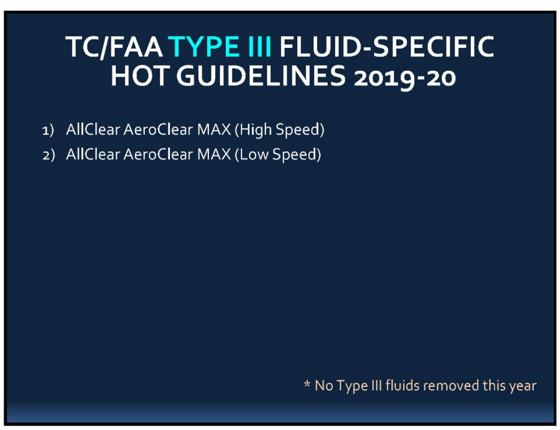


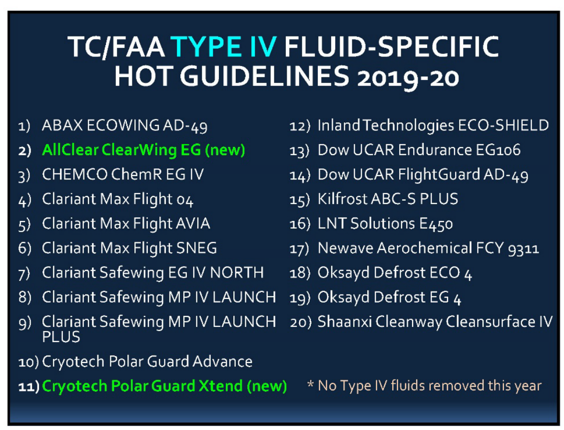


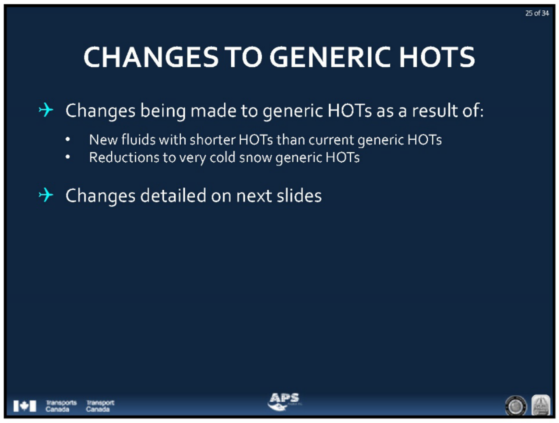
Outside Air Temperature	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets	Light Snow, Snow Grains or Snow Pellets	Moderate Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-3 °C and above (27 °F and above)	100/0	2:50 - 4:00	3:00 - 3:00	1:55 - 3:00	1:05 - 1:55	1:35 - 2:00	1:15 - 1:30	0:15 - 2:00	CAUTION: No holdover time guidelines exist
	75/25	2:30 - 4:00	3:00 - 3:00	1:25 - 3:00	0:40 - 1:25	1:40 - 2:00	0:40 - 1:10	0:09 - 1:40	
	50/50	0:50 - 1:25	1:10 - 1:35	0:25 - 1:10	0:10 - 0:25	0:20 - 0:45	0:09 - 0:20		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:55 - 2:30	2:25 - 2:50	1:25 - 2:25	0:50 - 1:25	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:20 - 3:00	1:05 - 2:20	0:30 - 1:05	0:25 - 1:05	0:35 - 0:45		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:55 - 2:30	2:00 - 2:20	1:10 - 2:00	0:40 - 1:10	0:35 - 1:35	0:35 - 0:45		
	75/25	0:40 - 1:30	2:00 - 2:30	0:55 - 2:00	0:25 - 0:55	0:25 - 1:05	0:35 - 0:45		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:25 - 0:50	1:35 - 2:15	0:35 - 1:35	0:10 - 0:35				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:25 - 0:50	0:40 - 0:55	0:15 - 0:40	0:04 - 0:15				
below -25 to -30.5°C (below -13 to -23°F)	100/0	0:25 - 0:50	0:25 - **0:30**	**0:07** - 0:25	0:02 - **0:07**				







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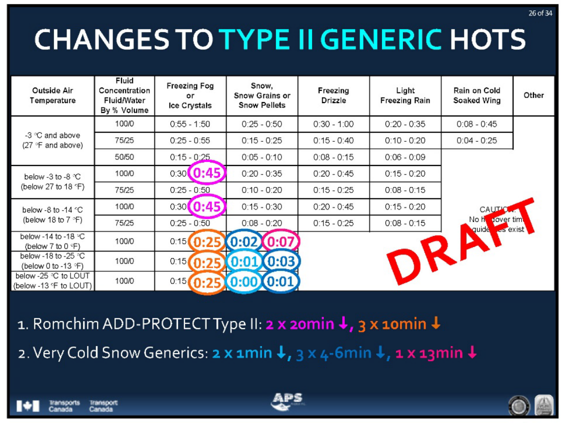
CHANGES TO GENERIC HOTS
Changes being made to generic HOTs as a result of:
New fluids with shorter HOTs than current generic HOTs
Reductions to very cold snow generic HOTs
Changes detailed on next slides
Transports Canada Transport Canada
APS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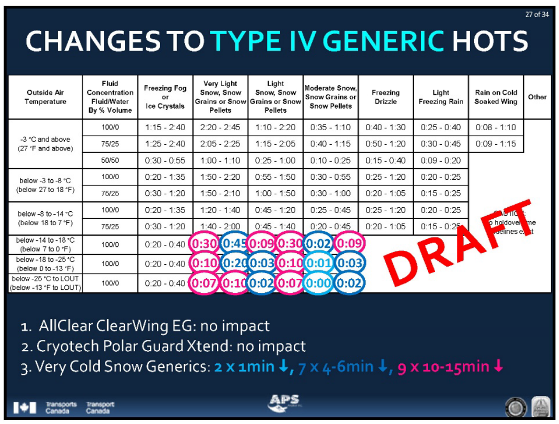
CHANGES TO TYPE II GENERIC HOTS
Outside Air Temperature | Fluid Concentration Fluid/Water By % Volume | Freezing Fog or Ice Crystals | Snow, Snow Grains or Snow Pellets | Freezing Drizzle | Light Freezing Rain | Rain on Cold Soaked Wing | Other
-3 °C and above (27 °F and above) | 100/0 | 0:55 - 1:50 | 0:25 - 0:50 | 0:30 - 1:00 | 0:20 - 0:35 | 0:08 - 0:45
75/25 | 0:25 - 0:55 | 0:15 - 0:25 | 0:15 - 0:40 | 0:10 - 0:20 | 0:04 - 0:25
50/50 | 0:15 - 0:25 | 0:05 - 0:10 | 0:08 - 0:15 | 0:06 - 0:09
below -3 to -8 °C (below 27 to 18 °F) | 100/0 | 0:30 0:45 | 0:20 - 0:35 | 0:20 - 0:45 | 0:15 - 0:20
75/25 | 0:25 - 0:50 | 0:10 - 0:20 | 0:15 - 0:25 | 0:08 - 0:15
below -8 to -14 °C (below 18 to 7 °F) | 100/0 | 0:30 0:45 | 0:15 - 0:30 | 0:20 - 0:45 | 0:15 - 0:20
75/25 | 0:25 - 0:50 | 0:08 - 0:20 | 0:15 - 0:25 | 0:08 - 0:15
below -14 to -18 °C (below 7 to 0 °F) | 100/0 | 0:15 0:25 | 0:02 0:07
below -18 to -25 °C (below 0 to -13 °F) | 100/0 | 0:15 0:25 | 0:01 0:03
below -25 °C to LOUT (below -13 °F to LOUT) | 100/0 | 0:15 0:25 | 0:00 0:01
DRAFT
1. Romchim ADD-PROTECT Type II: 2 x 20min ↓, 3 x 10min ↓
2. Very Cold Snow Generics: 2 x 1min ↓, 3 x 4-6min ↓, 1 x 13min ↓
Transports Canada Transport Canada
APS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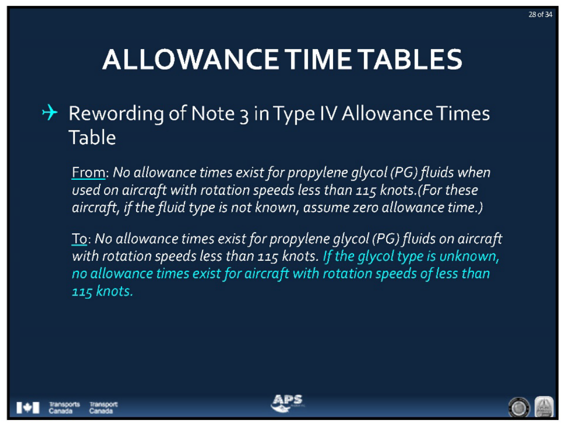
CHANGES TO TYPE IV GENERIC HOTS
Outside Air Temperature | Fluid Concentration Fluid/Water By % Volume | Freezing Fog or Ice Crystals | Very Light Snow, Snow Grains or Snow Pellets | Light Snow, Snow Grains or Snow Pellets | Moderate Snow, Snow Grains or Snow Pellets | Freezing Drizzle | Light Freezing Rain | Rain on Cold Soaked Wing | Other
-3 °C and above (27 °F and above) | 100/0 | 1:15 - 2:40 | 2:20 - 2:45 | 1:10 - 2:20 | 0:35 - 1:10 | 0:40 - 1:30 | 0:25 - 0:40 | 0:08 - 1:10
75/25 | 1:25 - 2:40 | 2:05 - 2:25 | 1:15 - 2:05 | 0:40 - 1:15 | 0:50 - 1:20 | 0:30 - 0:45 | 0:09 - 1:15
50/50 | 0:30 - 0:55 | 1:00 - 1:10 | 0:25 - 1:00 | 0:10 - 0:25 | 0:15 - 0:40 | 0:09 - 0:20
below -3 to -8 °C (below 27 to 18 °F) | 100/0 | 0:20 - 1:35 | 1:50 - 2:20 | 0:55 - 1:50 | 0:30 - 0:55 | 0:25 - 1:20 | 0:20 - 0:25
75/25 | 0:30 - 1:20 | 1:50 - 2:10 | 1:00 - 1:50 | 0:30 - 1:00 | 0:20 - 1:05 | 0:15 - 0:25
below -8 to -14 °C (below 18 to 7 °F) | 100/0 | 0:20 - 1:35 | 1:20 - 1:40 | 0:45 - 1:20 | 0:25 - 0:45 | 0:25 - 1:20 | 0:20 - 0:25
75/25 | 0:30 - 1:20 | 1:40 - 2:00 | 0:45 - 1:40 | 0:20 - 0:45 | 0:20 - 1:05 | 0:15 - 0:25
below -14 to -18 °C (below 7 to 0 °F) | 100/0 | 0:20 - 0:40 | 0:30 0:45 | 0:09 0:30 | 0:02 0:09
below -18 to -25 °C (below 0 to -13 °F) | 100/0 | 0:20 - 0:40 | 0:10 0:20 | 0:03 0:10 | 0:01 0:03
below -25 °C to LOUT (below -13 °F to LOUT) | 100/0 | 0:20 - 0:40 | 0:07 0:10 | 0:02 0:07 | 0:00 0:02
DRAFT
1. AllClear ClearWing EG: no impact
2. Cryotech Polar Guard Xtend: no impact
3. Very Cold Snow Generics: 2 x 1min ↓, 7 x 4-6min ↓, 9 x 10-15min ↓
Transports Canada Transport Canada
APS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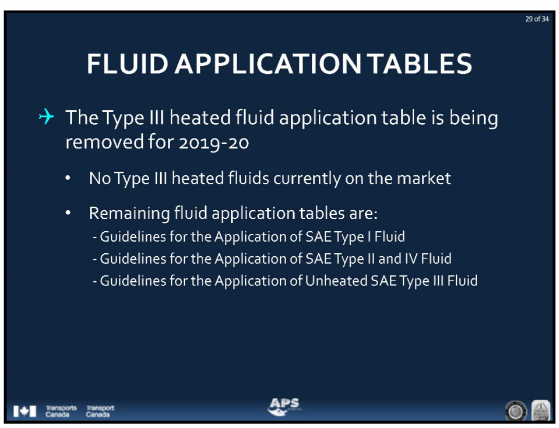
ALLOWANCE TIME TABLES
Rewording of Note 3 in Type IV Allowance Times Table
From: No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots.(For these aircraft, if the fluid type is not known, assume zero allowance time.)
To: No allowance times exist for propylene glycol (PG) fluids on aircraft with rotation speeds less than 115 knots. If the glycol type is unknown, no allowance times exist for aircraft with rotation speeds of less than 115 knots.
Transports Canada Transport Canada
APS


29 of 34
FLUID APPLICATION TABLES
The Type III heated fluid application table is being removed for 2019-20
No Type III heated fluids currently on the market
Remaining fluid application tables are:
- Guidelines for the Application of SAE Type I Fluid
- Guidelines for the Application of SAE Type II and IV Fluid
- Guidelines for the Application of Unheated SAE Type III Fluid
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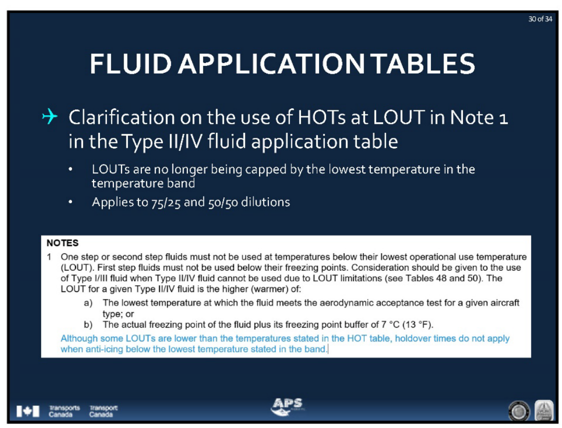
30 of 34
FLUID APPLICATION TABLES
Clarification on the use of HOTs at LOUT in Note 1 in the Type II/IV fluid application table
LOUTs are no longer being capped by the lowest temperature in the temperature band
Applies to 75/25 and 50/50 dilutions
NOTES
1 One step or second step fluids must not be used at temperatures below their lowest operational use temperature (LOUT). First step fluids must not be used below their freezing points. Consideration should be given to the use of Type I/III fluid when Type II/IV fluid cannot be used due to LOUT limitations (see Tables 48 and 50). The LOUT for a given Type II/IV fluid is the higher (warmer) of:
a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
b) The actual freezing point of the fluid plus its freezing point buffer of 7 °C (13 °F).
Although some LOUTs are lower than the temperatures stated in the HOT table, holdover times do not apply when anti-icing below the lowest temperature stated in the band.
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CHANGES TO TP14052 / N8900.xxx

- Updates to the related HOT guidance documents will be published in August 2019
  - TC: Guidelines for Aircraft Ground Icing Operations (TP14052E)
  - FAA: Revised FAA-Approved Deicing Program Updates, Winter 2019-2020 (N8900.xxx)
- Updates will include changes to content on METAR codes related to small hail and ice pellets (see separate presentation for details)

POSSIBLE FUTURE CHANGES

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POTENTIAL FUTURE CHANGES
Feedback from Industry Requested

- Very Light Snow HOTs
  - Change HOT provided in these cells from range (two values) to single value
  - Single value will be current lower (shorter) HOT value
  - Note: Applies to FAA only (TC already has single value)
- Freezing Rain HOTs
  - Considering changing from range (two values) to single value

Questions?

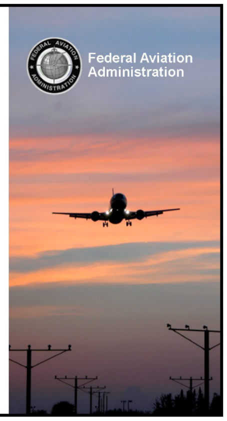
Stephanie Bendickson
Senior Project Leader, APS Aviation
sbendickson@apsaviation.ca

AIRLINES FOR AMERICA (A4A) GROUND DEICING FORUM, WASHINGTON, USA, JUNE 2019

PRESENTATION:
UPDATES ON GUIDANCE FOR METAR CODES GS, GR, PL, SHGS, SG

Updates on Guidance for METAR Codes

GS, GR, PL, SHGS, SG



Presented to: SAE G-12 HOT Committee
By: Charles J. Enders
On Behalf of: FAA and Transport Canada
Date: May 21, 2019

METAR Code Guidance

- Guidance on METAR codes related to Hail, Small Hail, Ice Pellets, Snow Grains and Snow Pellets was updated in FAA/TC HOT guidance documents following changes to METAR reporting in both US and Canada
  - Changes led to increased complexity as same reports in different countries = different weather conditions

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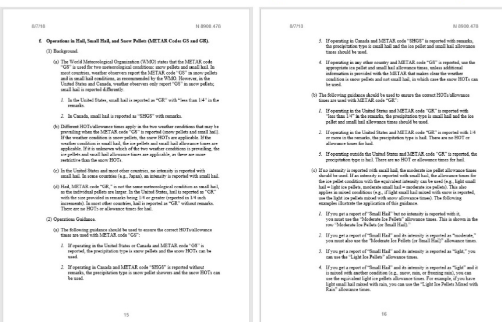
Current Guidance (FAA Format)



Feedback from Industry

- Guidance is detailed and complex
- Is there a clearer way to communicate the information?

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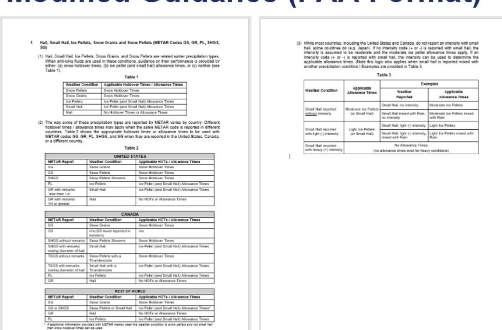
Modified Guidance (FAA Format)



Modified Guidance

- Putting information in tables reduces complexity
- Three sections
  - Background
  - Guidance by country
  - Guidance for intensity reporting

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Background

f. Hail, Small Hail, Ice Pellets, Snow Grains and Snow Pellets (METAR Codes GS, GR, PL, SHGS, SG)

(1) Hail, Small Hail, Ice Pellets, Snow Grains, and Snow Pellets are related winter precipitation types. When anti-icing fluids are used in these conditions, guidance on their performance is provided by either: (a) snow holdover times, (b) ice pellet (and small hail) allowance times, or (c) neither (see Table 1).

Table 1

Weather Condition	Applicable Holdover Times / Allowance Times
Snow Pellets	Snow Holdover Times
Snow Grains	Snow Holdover Times
Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
Small Hail	Ice Pellet (and Small Hail) Allowance Times
Hail	No Holdover Times or Allowance Times

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Guidance by Country

(2) The way some of these precipitation types are reported by METAR varies by country. Different holdover times / allowance times may apply when the same METAR code is reported in different countries. Table 2 shows the appropriate holdover times or allowance times to be used with METAR codes GS, GR, PL, SHGS, and SG when they are reported in the United States, Canada, or a different country.

Table 2

UNITED STATES		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS	Snow Pellets	Snow Holdover Times
SHGS	Snow Pellets Showers	Snow Holdover Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
GR with remarks "less than 1/4"	Small Hail	Ice Pellet (and Small Hail) Allowance Times
GR with remarks 1/4 or greater	Hail	No HOTs or Allowance Times

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CANADA		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS	n/a (GS never reported in isolation)	n/a
SHGS without remarks	Snow Pellets Showers	Snow Holdover Times
SHGS with remarks stating diameter of hail	Small Hail	Ice Pellet (and Small Hail) Allowance Times
TSGS without remarks	Snow Pellets with a Thunderstorm	Snow Holdover Times
TSGS with remarks stating diameter of hail	Small Hail with a Thunderstorm	Ice Pellet (and Small Hail) Allowance Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times
GR	Hail	No HOTs or Allowance Times

REST OF WORLD		
METAR Report	**Weather Condition**	**Applicable HOTs / Allowance Times**
SG	Snow Grains	Snow Holdover Times
GS or SHGS	Snow Pellets or Small Hail	Ice Pellet (and Small Hail) Allowance Times*
GR	Hail	No HOTs or Allowance Times
PL	Ice Pellets	Ice Pellet (and Small Hail) Allowance Times

* *If additional information provided with METAR makes clear the weather condition is snow pellets and not small hail then snow holdover times can be used*

Intensity Guidance

(3) While most countries, including the United States and Canada, do not report an intensity with small hail, some countries do (e.g. Japan). If no intensity code (+ or -) is reported with small hail, the intensity is assumed to be moderate and the moderate ice pellet allowance times apply. If an intensity code (+ or -) is reported with small hail, the intensity can be used to determine the applicable allowance times. (Note this logic also applies when small hail is reported mixed with another precipitation condition.) Examples are provided in Table 3.

Table 3

Weather Condition	Applicable Allowance Times	Examples	
		Weather Reported	**Applicable Allowance Times**
Small Hail reported without intensity	Moderate Ice Pellets (or Small Hail)	Small Hail, no intensity	Moderate Ice Pellets
		Small Hail mixed with Rain, no intensity	Moderate Ice Pellets mixed with Rain
Small Hail reported with light (-) intensity	Light Ice Pellets (or Small Hail)	Small Hail, light (-) intensity	Light Ice Pellets
		Small Hail, light (-) intensity, mixed with Rain	Light Ice Pellets mixed with Rain
Small Hail reported with heavy (+) intensity	No Allowance Times (no allowance times exist for heavy conditions)		

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Conclusions

- Changes pending final input from FAA and TC meteorology specialists
- Changes expected to be implemented in winter 2019-20 guidance documents

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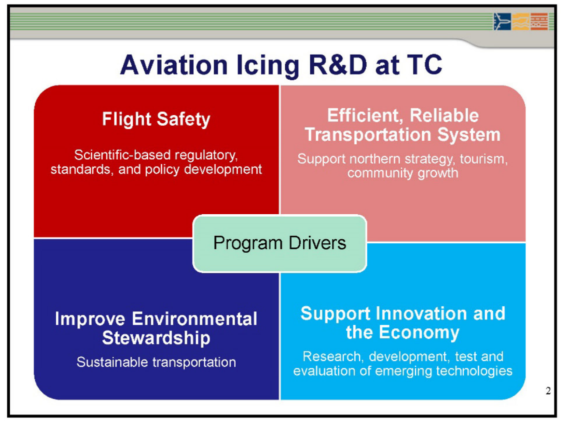
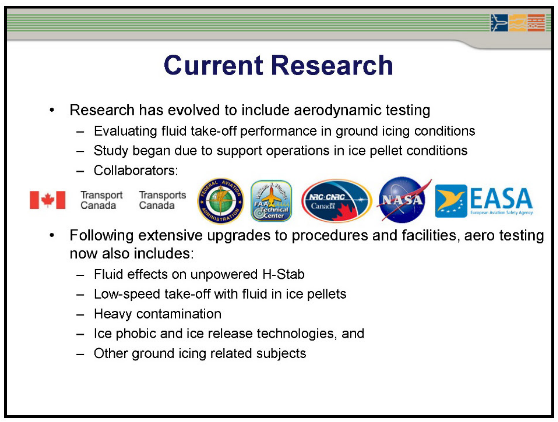
SAE INTERNATIONAL ICING CONFERENCE, MINNEAPOLIS, USA, JUNE 2019

**PRESENTATION:
GROUND ICING RESEARCH PROGRAM**


Ground Icing Research Program
Antoine Lacroix, Research Development Officer
SAE 2019 International Conference on Icing of Aircraft, Engines, and Structures
Minneapolis – June 19, 2019

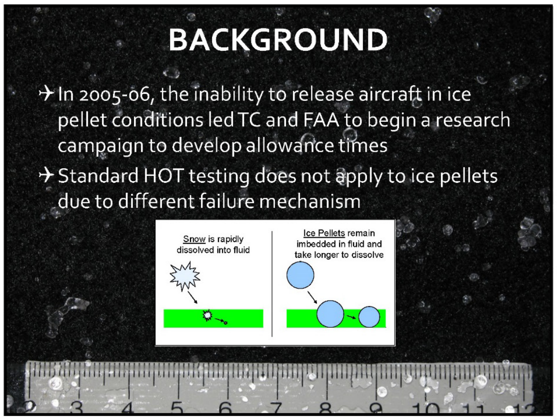

Aviation Icing R&D at TC
Flight Safety
Scientific-based regulatory, standards, and policy development
Efficient, Reliable Transportation System
Support northern strategy, tourism, community growth
Program Drivers
Improve Environmental Stewardship
Sustainable transportation
Support Innovation and the Economy
Research, development, test and evaluation of emerging technologies
2

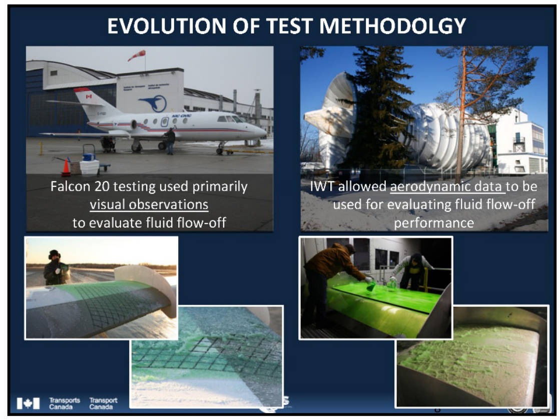

Current Research
• Research has evolved to include aerodynamic testing
– Evaluating fluid take-off performance in ground icing conditions
– Study began due to support operations in ice pellet conditions
– Collaborators:
Transport Canada
Transports Canada
NASA
EASA
• Following extensive upgrades to procedures and facilities, aero testing now also includes:
– Fluid effects on unpowered H-Stab
– Low-speed take-off with fluid in ice pellets
– Heavy contamination
– Ice phobic and ice release technologies, and
– Other ground icing related subjects

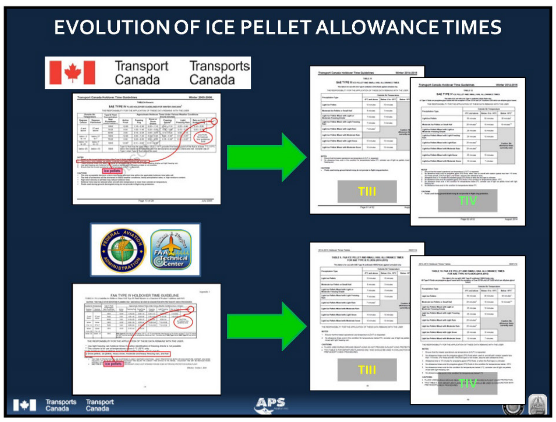

Research Facilities
TC/APS Montreal Airport (YUL) Test Site facility
NRC OTTAWA CLIMATIC ENGINEERING FACILITY
NRC OTTAWA PROPULSION ICING WIND TUNNEL FACILITY (PIWT)

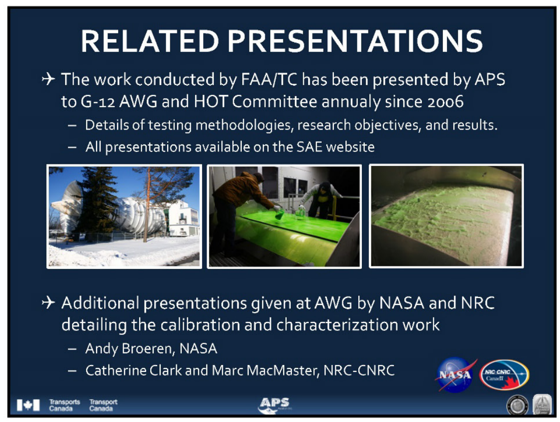

12 Successful Test Campaigns!!!
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2014-15
2015-16
2017-18
2018-19

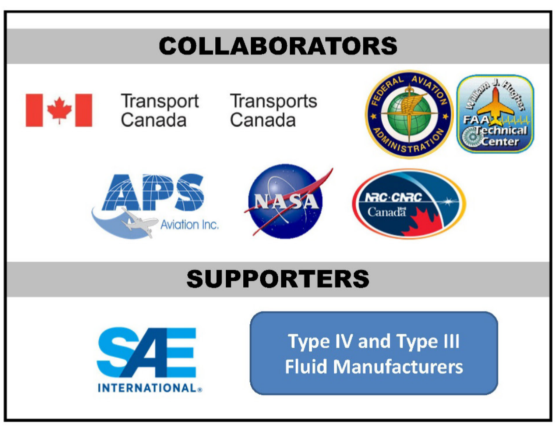

APS Aviation Inc.
PROPULSION ICING WIND TUNNEL RESEARCH SIMULATING ICE PELLET CONDITIONS
SAE International Icing Conference, Minneapolis– June 19, 2019
Presented By: Marco Ruggi, Eng., M.B.A., Senior Project Leader
Prepared and Presented on behalf of:
Transport Canada
Transports Canada

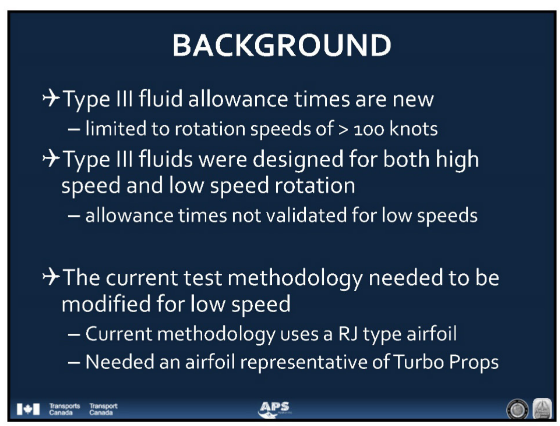

BACKGROUND
In 2005-06, the inability to release aircraft in ice pellet conditions led TC and FAA to begin a research campaign to develop allowance times
Standard HOT testing does not apply to ice pellets due to different failure mechanism
Snow is rapidly dissolved into fluid
Ice Pellets remain imbedded in fluid and take longer to dissolve

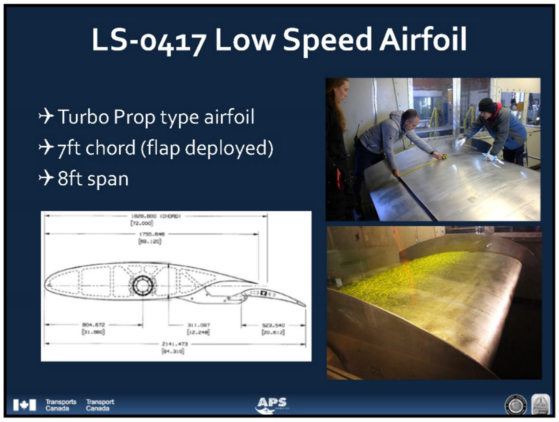

EVOLUTION OF TEST METHODOLGY
Falcon 20 testing used primarily visual observations to evaluate fluid flow-off
IWT allowed aerodynamic data to be used for evaluating fluid flow-off performance

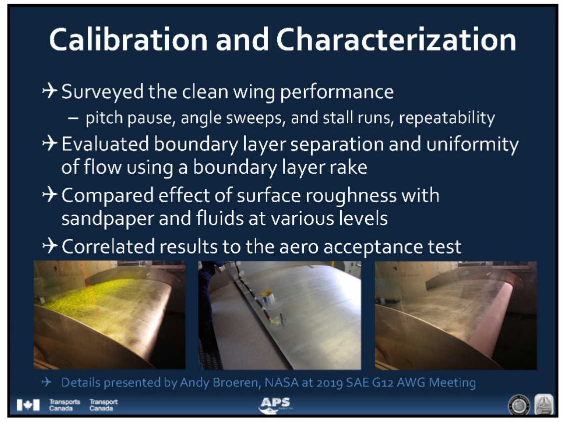

EVOLUTION OF ICE PELLET ALLOWANCE TIMES
Transport Canada
Transports Canada
TIII
TIV


RELATED PRESENTATIONS
The work conducted by FAA/TC has been presented by APS to G-12 AWG and HOT Committee annually since 2006
– Details of testing methodologies, research objectives, and results.
– All presentations available on the SAE website
Additional presentations given at AWG by NASA and NRC detailing the calibration and characterization work
– Andy Broeren, NASA
– Catherine Clark and Marc MacMaster, NRC-CNRC

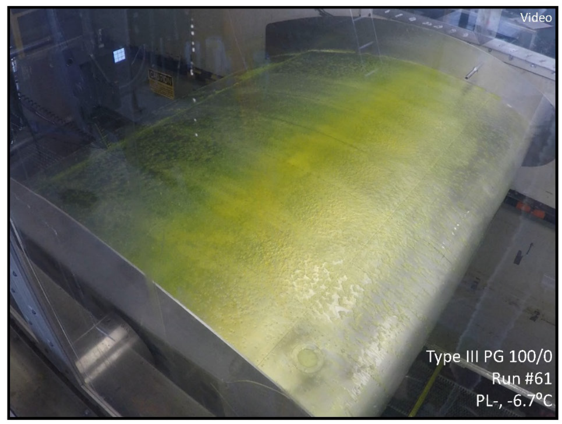

COLLABORATORS
Transport Canada
Transports Canada
APS Aviation Inc.
NASA
NRC-CNRC Canada
SUPPORTERS
SAE INTERNATIONAL
Type IV and Type III Fluid Manufacturers

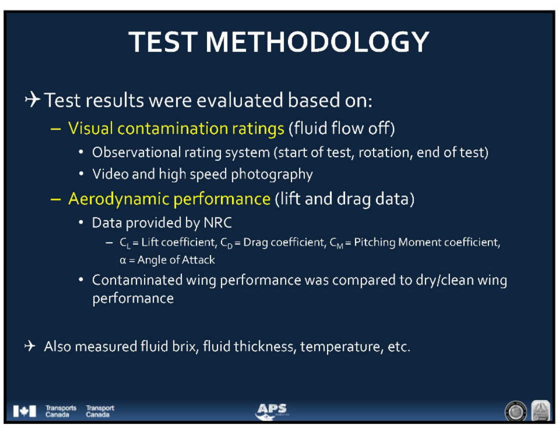

BACKGROUND
Type III fluid allowance times are new
– limited to rotation speeds of > 100 knots
Type III fluids were designed for both high speed and low speed rotation
– allowance times not validated for low speeds
The current test methodology needed to be modified for low speed
– Current methodology uses a RJ type airfoil
– Needed an airfoil representative of Turbo Props

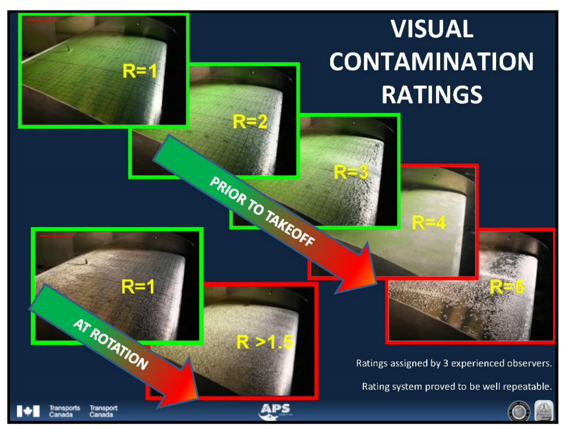

LS-0417 Low Speed Airfoil
Turbo Prop type airfoil
7ft chord (flap deployed)
8ft span

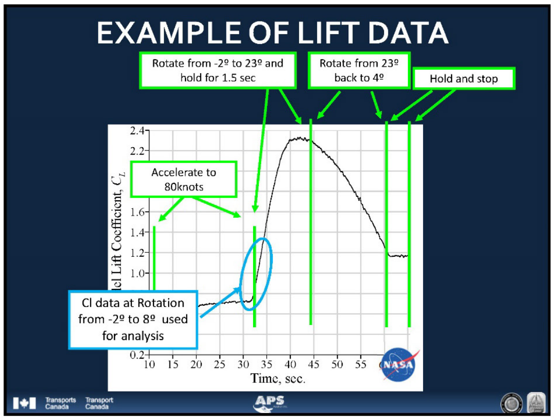

Calibration and Characterization
Surveyed the clean wing performance
– pitch pause, angle sweeps, and stall runs, repeatability
Evaluated boundary layer separation and uniformity of flow using a boundary layer rake
Compared effect of surface roughness with sandpaper and fluids at various levels
Correlated results to the aero acceptance test
Details presented by Andy Broeren, NASA at 2019 SAE G12 AWG Meeting

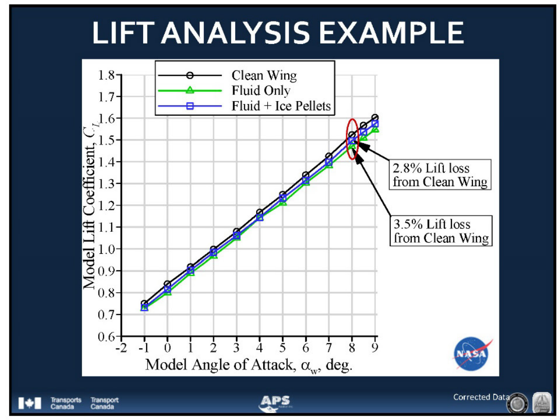

RUN SEQUENCE
Apply Fluid
Inspect Application
Apply Precipitation
Pre-Run Inspection
Test Run
Post-Run Inspection
*Average run time is about 45-minutes, plus the time of precipitation (which can vary).

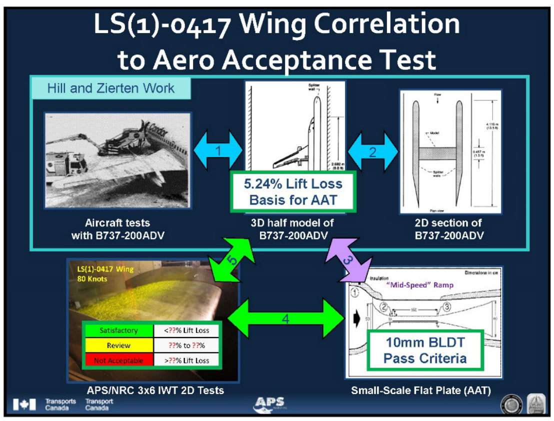

Video
Type III PG 100/0
Run #61
PL-, -6.7°C

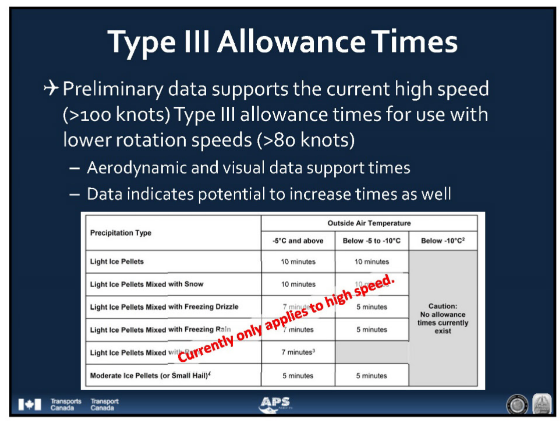

TEST METHODOLOGY
Test results were evaluated based on:
– Visual contamination ratings (fluid flow off)
• Observational rating system (start of test, rotation, end of test)
• Video and high speed photography
– Aerodynamic performance (lift and drag data)
• Data provided by NRC
– C_L = Lift coefficient, C_D = Drag coefficient, C_M = Pitching Moment coefficient, α = Angle of Attack
• Contaminated wing performance was compared to dry/clean wing performance
Also measured fluid brix, fluid thickness, temperature, etc.


VISUAL CONTAMINATION RATINGS
R=1
R=2
R=3
R=4
R=5
PRIOR TO TAKEOFF
R=1
R >1.5
AT ROTATION
Ratings assigned by 3 experienced observers.
Rating system proved to be well repeatable.


EXAMPLE OF LIFT DATA
Rotate from -2º to 23º and hold for 1.5 sec
Rotate from 23º back to 4º
Hold and stop
Accelerate to 80knots
Cl data at Rotation from -2º to 8º used for analysis
Model Lift Coefficient, C_L
Time, sec.
Transports Canada
Transport Canada
APS


LIFT ANALYSIS EXAMPLE
Clean Wing
Fluid Only
Fluid + Ice Pellets
2.8% Lift loss from Clean Wing
3.5% Lift loss from Clean Wing
Model Lift Coefficient, C_L
Model Angle of Attack, α_w, deg.
Corrected Data
Transports Canada
Transport Canada
APS


LS(1)-0417 Wing Correlation
to Aero Acceptance Test
Hill and Zierten Work
5.24% Lift Loss
Basis for AAT
Aircraft tests with B737-200ADV
3D half model of B737-200ADV
2D section of B737-200ADV
LS(1)-0417 Wing
80 Knots
Satisfactory
<??% Lift Loss
Review
??% to ??%
Not Acceptable
>??% Lift Loss
"Mid-Speed" Ramp
10mm BLDT
Pass Criteria
APS/NRC 3x6 IWT 2D Tests
Small-Scale Flat Plate (AAT)
Transports Canada
Transport Canada
APS


Type III Allowance Times
Preliminary data supports the current high speed (>100 knots) Type III allowance times for use with lower rotation speeds (>80 knots)
– Aerodynamic and visual data support times
– Data indicates potential to increase times as well
Precipitation Type
Outside Air Temperature
-5°C and above
Below -5 to -10°C
Below -10°C²
Light Ice Pellets
10 minutes
10 minutes
Light Ice Pellets Mixed with Snow
10 minutes
Light Ice Pellets Mixed with Freezing Drizzle
5 minutes
Light Ice Pellets Mixed with Freezing Rain
7 minutes
5 minutes
Light Ice Pellets Mixed
7 minutes³
Moderate Ice Pellets (or Small Hail)⁴
5 minutes
5 minutes
Caution:
No allowance times currently exist
Currently only applies to high speed.
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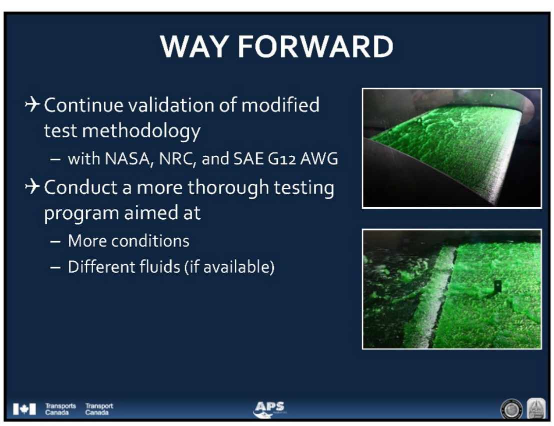
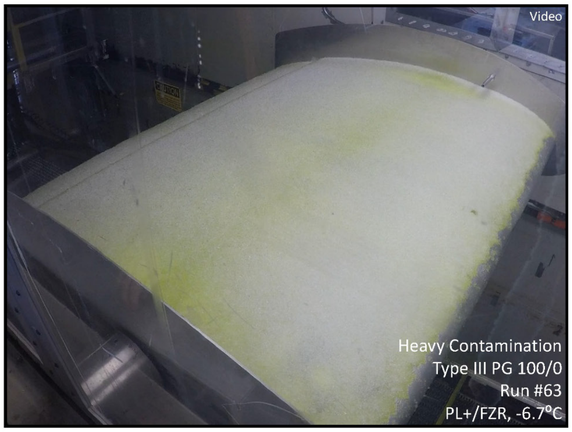
Transport Canada
APS


WAY FORWARD
Continue validation of modified test methodology
– with NASA, NRC, and SAE G12 AWG
Conduct a more thorough testing program aimed at
– More conditions
– Different fluids (if available)
Transports Canada
Transport Canada
APS


App Store
Marco Ruggi
mruggi@apsaviation.ca
www.APSAviation.ca


Video
Heavy Contamination
Type III PG 100/0
Run #63
PL+/FZR, -6.7ºC

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