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AIRCRAFT GROUND ICING GENERAL RESEARCH ACTIVITIES DURING THE 2024-25 WINTER



Prepared for:

**Transport Canada
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Innovation Centre**

In cooperation with:

**Federal Aviation Administration
William J. Hughes Technical Center for
Advanced Aerospace**

**Transport Canada
Civil Aviation**

**Federal Aviation Administration
Flight Standards – Air Carrier Operations**





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Prepared by:

APS Aviation Inc.

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Prepared by: APS Aviation Inc.

Reviewed and
Approved by:



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John D'Avirro, Eng., PBDM
Vice President – Aviation Services

Date

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PREFACE

Under contract to the Transport Canada Programs Group 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 conduct testing to determine holdover times for Type II, III, and IV fluids in snow at temperatures below -14°C ;
- To evaluate and develop the use of artificial snow machines for holdover time development;
- To conduct wind tunnel testing with a thin high performance wing model to support the development of guidance material for operating in ice pellet conditions;
- To conduct comparative endurance time testing and evaluate endurance times in several mixed conditions;
- To conduct general and exploratory de/anti-icing research;
- To conduct analysis to support harmonization of the Transport Canada and the Federal Aviation Administration visibility table guidance;
- To finalize the publication and delivery of current and 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 2024-25 are documented in five reports. The titles of the reports are as follows:

- TP 15692E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2024-25 Winter;
- TP 15693E Regression Coefficients and Equations Used to Develop the Winter 2025-26 Aircraft Ground Deicing Holdover Time Tables;
- TP 15684E Aircraft Ground Icing General Research Activities During the 2024-25 Winter;
- TP 15685E Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2024-25; and
- TP 15686E Testing and Evaluation of Mixed Phase Icing Conditions: Winter 2024-25.

In addition, the following interim report is being prepared:

- *Artificial Snow Research Activities for the 2024-25 Winter.*

This report, TP 15684E, has the following objective:

- To document the exploratory research and general activities carried out during the winter of 2024-25.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by the Transport Canada Programs Group Innovation Centre, with support from the Federal Aviation Administration William J. Hughes Technical Center for Advanced Aerospace, 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, Steven D. Baker, David Beals, Benjamin Bernier, Chloë Bernier, Megane Brien, Sarah Chadzak, Kasandra Cook, Devin Costain, John D’Avirro, Peter Dawson, Sean Devine, Akvile Gigaite, Tyler Groleau, Cassidy Kinderman-McCormick, Kyra Kinderman-McCormick, Peter Kitchener, Francine De Ladurantaye, Shamim Nakhaei, Dany Posteraro, Marc Quesnel, Salvatore Rosato, Marco Ruggi, Javad Safari, James Smyth, Yi Tian, Jeffrey Wajsberg, and Ian Wittmeyer.

Special thanks are extended to Antoine Lacroix, Yvan Chabot, Carlos Carreiro, Warren Underwood, Timothy McClain, Timothy G. Smith, Stephanie Divito, and Thomas Natoli 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

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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 are available from the TC Programs Group 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. (APS) related to aircraft ground deicing research in the winter of 2024-25. The activities documented in this report were carried out in addition to the main research projects completed in the winter of 2024-25, which are documented in separate reports. The nine activities described in this report are listed as follows: 1) Further Characterization of the Relationship between Snowfall Intensity and Prevailing Visibility; 2) A Comprehensive Evaluation of Mist and Freezing Fog Deposition Rates; 3) Development of Guidance for Mixed Icing Conditions; 4) Evaluation of HOT Regression Methodology for Fluids with Non-Standard Temperature-Endurance Time Relationships; 5) Evaluation of Fluid Viscosity Profile Impact on Fluid Endurance Times and Effects on Holdover Times; 6) Support Industry Efforts to Further Develop Viscosity Standards (AS9968); 7) Technical Review, Finalization, and Publication of Historical Reports; 8) Publication of Holdover Time Guidance Materials; and 9) Presentations, Fluid Manufacturer Reports, and Test Procedures for 2024-25.				
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		14. Agent de projet Antoine Lacroix		
15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.) Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada (TC). Ils sont disponibles auprès du Centre d'innovation du groupe de programmes 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 Ce rapport fait état des activités générales menées par APS Aviation Inc. (APS) en matière de recherche sur le dégivrage d'aéronefs au sol au cours de l'hiver 2024-2025. Les activités dont fait état ce rapport ont été effectuées en plus des principaux projets de recherche menés pendant l'hiver 2024-2025, qui sont documentés dans des rapports distincts. Les neuf activités qui font l'objet du présent rapport sont énumérées ci-dessous : 1) Caractérisation supplémentaire du lien entre l'intensité des chutes de neige et la visibilité dominante; 2) Évaluation exhaustive des taux de dépôt de brume et de brouillard verglaçant; 3) Mise au point de lignes directrices relatives aux conditions de givrage mixtes; 4) Évaluation de la méthodologie de régression des durées d'efficacité pour les liquides présentant des liens températures-durées d'endurance non standards; 5) Évaluation de l'incidence du profil de viscosité des liquides sur les durées d'endurance des liquides et des effets sur les durées d'efficacité; 6) Soutien aux efforts déployés par l'industrie pour poursuivre l'élaboration de normes en matière de viscosité (AS9968); 7) Examen technique, finalisation et publication de rapports historiques; 8) Publication de documents d'orientation sur les durées d'efficacité; 9) Présentations, rapports aux fabricants de liquides et procédures d'essais pour 2024-2025.				
17. Mots clés Durée d'efficacité, lignes directrices, brume, brouillard verglaçant, visibilité, viscosité, METAR, conditions mixtes de givrage, durée d'endurance, pratiques recommandées en aérospatiale, rapports, présentations, procédures		18. Diffusion Disponible auprès du Centre d'innovation du groupe de programmes de Transports Canada		
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EXECUTIVE SUMMARY

This report documents the exploratory research and general activities completed in the winter of 2024-25 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 nine activities that were carried out in addition to the main research projects in the winter of 2024-25.

Further Characterization of the Relationship between Snowfall Intensity and Prevailing Visibility (Section 2)

To support harmonization of the existing TC/FAA visibility table guidance, APS conducted an analysis of the historical and modern sensor visibility versus precipitation rate data. Applying the established analytical methodologies to the combined data set did not support the harmonization of the snowfall intensities within the tables. New analyses found that harmonization of temperature bands could be achieved by including -1°C in the cold category. Further data collection, data cleaning, and alternative analytical approaches could support more accurate and harmonized tables.

A Comprehensive Evaluation of Mist and Freezing Fog Deposition Rates (Section 3)

Mist and freezing fog are commonly reported weather phenomena that can occur alone or in conjunction with other precipitation types. Although similar to fog, mist is said to be present when the visibility is between 0.6 and 1.2 statute miles ($\approx 1\text{-}2\text{ km}$), while fog reduces it to less than 0.6 statute miles ($\approx 1\text{ km}$). With respect to holdover times (HOTs), mist deposition rates were first quantified, and guidance was introduced in the generic HOT tables in 2020-21. Information related to freezing fog indicates that deposition rates between 2 and 5 $\text{g/dm}^2/\text{h}$ may be possible. To substantiate the rates, mist and freezing fog/fog deposition rates were measured using two similar methodologies that are related to the historical characterization of freezing fog.

An analysis was conducted using data from both the wet and dry pans. The wet pan rate was shown to be consistently higher than that of the dry pan. The results indicated that at 2°C and below, the maximum observed rates for the fog/freezing fog taxiing and stationary wet pan were 2.4 $\text{g/dm}^2/\text{h}$ and 0.6 $\text{g/dm}^2/\text{h}$, respectively. The mist/freezing mist taxiing and stationary wet pan rates were 1.65 $\text{g/dm}^2/\text{h}$ and 0.44 $\text{g/dm}^2/\text{h}$, respectively. Given that aircraft are not constantly taxiing, an operational analysis was also conducted using the average of both the dry and wet pan. The operationally relevant rate range experienced by an aircraft for fog/freezing

fog was determined to be between 0.62 and 0.92 g/dm²/h, while for mist/freezing mist, the operationally relevant rate range was 0.33 to 0.51 g/dm²/h. The fog/freezing fog rate range was also compared to pristine freezing fog data, which was obtained from the National Center for Atmospheric Research (NCAR). The rate range corresponded to the 82nd and 90th percentiles, respectively, showing considerable conservatism in the experimental data.

The range of rates observed to date demonstrates that the present HOT tables are adequate to ensure safe operations with Freezing Fog, Mist, and Ice Crystals.

Development of Guidance for Mixed Icing Conditions (Section 4)

Research was conducted to support the development of HOT and allowance time (AT) guidance for mixed icing conditions not currently included in the published TC/FAA guidance material. With support from the METAR working group (MWG), testing was conducted in four mixed conditions, which resulted in changes to the guidance for three of the conditions tested.

Evaluation of HOT Regression Methodology for Fluids with Non-Standard Temperature-Endurance Time Relationships (Section 5)

APS conducted a review and analysis of the HOT test data sets for all Type II, Type III, and Type IV fluids listed in the 2024-25 TC/FAA HOT Guidelines to determine the frequency of non-standard temperature-ET relationships and evaluate the risks associated with the current HOT determination methodology.

Eighteen percent of the data sets were found to have non-standard relationships, with this phenomenon occurring more frequently with ethylene glycol (EG)-based fluids.

Fluids with non-standard temperature relationships do not currently have a temperature-driven safety buffer like that which exists within standard fluid HOTs. The current methodology produces HOTs that can be greater than the true endurance time (ET) of fluids with these non-standard relationships in certain conditions.

Methods for addressing this have been proposed, which involve reductions in HOTs. Further evaluation of the current level of risk for standard fluids and additional testing to characterize the temperature relationship in freezing precipitation are required before changes are made. It is recommended that these tasks be carried out alongside the drafting of further formalized data handling methodologies for fluids with non-standard temperature-ET relationships.

Evaluation of Fluid Viscosity Profile Impact on Fluid Endurance Times and Effects on Holdover Times (Section 6)

Aircraft anti-icing fluids play a critical role in ensuring safe winter operations. These fluids are included in industry guidelines only after undergoing a series of tests using specifically determined viscosities. Current practice assumes that the lowest on-wing viscosity (LOWV) represents the most conservative case for ET testing, while the highest on-wing viscosity (HOWV) represents the most conservative case for aerodynamic performance testing.

During the project year of 2024-25, the FAA and TC conducted an evaluation to determine whether this long-standing assumption remains valid. The program examined ETs across multiple viscosity samples of the same fluid. Observations from the work indicate that the low-viscosity sample does not consistently yield the shortest ET under all precipitation and temperature conditions. This finding highlights the need for more comprehensive testing to ensure the accuracy and reliability of published HOT Guidelines.

The observations from this work highlight the need for further investigation through comprehensive HOT comparison testing, in which multiple viscosity samples are evaluated in parallel to determine their impact on published HOTs.

Support Industry Efforts to Further Develop Viscosity Standards (AS9968) (Section 7)

Since project year 2014-15, the FAA and TC have published the LOWV for all thickened fluids in the annual HOT Guidelines. Beginning in project year 2022-23, the HOWV was also added to help decrease operational risks. Both parameters are determined using the standardized methodology outlined in Aerospace Standard (AS) 9968.

For project year 2024-25, the FAA and TC initiated a review to explore how viscosity standards could be further supported to help operators determine whether a fluid is within the published LOWV and HOWV limits.

Fluid samples are routinely collected and tested to confirm that the viscosity remains within the specified operating range. However, industry quality control operators have raised concerns that the increasing number of approved methods in recent years has slowed verification. Frequent setup changes required by different methods add complexity and delay, making it more difficult to quickly confirm that fluids are in-spec.

This project aims to assess the feasibility of reducing the number of viscosity test methods within the current HOT Guidance and to investigate standardizing testing to a single or limited number of methods under AS9968 while maintaining accuracy, precision, and reliability in fluid quality control.

Technical Review, Finalization, and Publication of Historical Reports (Section 8)

APS has conducted research related to ground icing, which involved writing over 235 reports on behalf of TC and the FAA, since the early 1990s. 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. As of October 31, 2025, 20 reports remain to be published, excluding the current year reports for 2024-25. As well, there are 19 published historical reports that require improved graphics quality.

Publication of Holdover Time Guidance Materials (Section 9)

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 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 2024-25 (Section 10)

APS prepared several presentations, fluid manufacturer reports, and test procedures as part of the winter 2024-25 test program. These deliverables are documented within this report.

SOMMAIRE

Ce rapport fait état de la recherche exploratoire et des activités générales menées au cours de l'hiver 2024-2025 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 fait état des neuf activités effectuées en plus des principaux projets de recherche menés pendant l'hiver 2024-2025.

Caractérisation supplémentaire du lien entre l'intensité des chutes de neige et la visibilité dominante (Section 2)

Afin d'étayer l'harmonisation des lignes directrices actuelles du tableau de visibilité de TC et de la FAA, APS a effectué une analyse des données historiques et modernes comparant la visibilité des détecteurs et les taux de précipitations. L'application de méthodologies analytiques établies aux ensembles de données combinées n'a pas permis d'étayer l'harmonisation des intensités de chutes de neige des tableaux. De nouvelles analyses ont révélé que l'harmonisation des plages de températures pourrait être atteinte en incluant la température de -1 °C dans la catégorie « froid ». Une collecte de données supplémentaires, un nettoyage des données et d'autres approches analytiques pourraient étayer des tableaux plus précis et harmonisés.

Évaluation exhaustive des taux de dépôt de brume et de brouillard verglaçant (Section 3)

La brume et le brouillard verglaçant sont des phénomènes météorologiques couramment rapportés qui peuvent se produire seuls ou avec d'autres types de précipitations. Bien que la brume soit semblable au brouillard, on considère qu'il y a présence de brume lorsque la visibilité est comprise entre 0,6 et 1,2 mille terrestre (environ 1 à 2 km), et qu'il y a présence de brouillard lorsque la visibilité est inférieure à 0,6 mille terrestre (environ 1 km). C'est en 2020-2021 qu'on a pour la première fois quantifié les taux de dépôt de brume et introduit des lignes directrices à ce sujet dans les tableaux des durées d'efficacité génériques. Les informations relatives au brouillard verglaçant indiquent que des taux de dépôt compris entre 2 et 5 g/dm²/h peuvent être possibles. Afin d'étayer ces valeurs, les taux de dépôt de brume et de brouillard verglaçant/brouillard ont été mesurés à l'aide de deux méthodologies semblables qui sont liées à la caractérisation historique du brouillard verglaçant.

Une analyse a été effectuée en utilisant les données recueillies à l'aide de bacs en conditions humides et sèches. Le taux observé dans le cas des bacs en conditions humides était systématiquement plus élevé que celui observé dans le cas des bacs

en conditions sèches. Les résultats indiquent qu'à des températures inférieures ou égales à 2 °C, les taux maximaux observés dans le cas des bacs en conditions humides en circulation au sol et stationnaires en présence de brouillard et de brouillard verglaçant étaient de 2,4 g/dm²/h et de 0,6 g/dm²/h, respectivement. Les taux observés dans le cas du bac en conditions humides en circulation au sol et stationnaire en présence de brume et de brume verglaçante étaient de 1,65 g/dm²/h et de 0,44 g/dm²/h, respectivement. Étant donné que les aéronefs ne sont pas perpétuellement en circulation au sol, une analyse opérationnelle a également été effectuée en utilisant la moyenne des données recueillies à l'aide des bacs en conditions sèches et humides. Il a été déterminé que la gamme de taux opérationnellement pertinents auxquels un aéronef est soumis en présence de brouillard et de brouillard verglaçant se situe entre 0,62 et 0,92 g/dm²/h, alors qu'en présence de brume et de brume verglaçante, la gamme de taux opérationnellement pertinents était de 0,33 à 0,51 g/dm²/h. La gamme de taux en conditions de brouillard et de brouillard verglaçant a également été comparée aux données de référence pour les conditions de brouillard verglaçant, lesquelles ont été obtenues auprès du National Center for Atmospheric Research (NCAR). La gamme de taux correspondait aux 82^e et 90^e percentiles, respectivement, indiquant un degré de prudence considérable dans les données expérimentales.

La gamme de taux observés à ce jour démontre que les tableaux actuels des durées d'efficacité sont adéquats pour assurer des manœuvres sécuritaires en présence de brouillard verglaçant, de brume et de cristaux de glace.

Mise au point de lignes directrices relatives aux conditions de givrage mixtes (Section 4)

Des études ont été effectuées pour étayer la mise au point de lignes directrices relatives aux durées d'efficacité et aux marges de tolérance sur les conditions de givrage mixtes qui ne sont pas actuellement incluses dans les lignes directrices publiées par TC et la FAA. Avec le soutien du groupe de travail METAR, des essais ont été effectués dans quatre conditions mixtes, ce qui a entraîné la modification des lignes directrices pour trois des conditions mises à l'essai.

Évaluation de la méthodologie de régression des durées d'efficacité pour les liquides présentant des liens températures-durées d'endurance non standards (Section 5)

APS a effectué une revue et une analyse des ensembles de données d'essais sur les durées d'efficacité pour tous les liquides de type II, de type III et de type IV qui figurent dans les lignes directrices relatives aux durées d'efficacité de 2024-2025 de TC et de la FAA afin de déterminer la fréquence des liens températures-durées d'endurance non standards et d'évaluer les risques associés à la méthodologie actuelle de détermination des durées d'efficacité.

Dix-huit pour cent des ensembles de données présentaient des liens non standards, le phénomène se produisant plus fréquemment dans le cas des liquides à base d'éthylène glycol (EG).

Les liquides qui présentent des liens de températures non standards ne disposent pas actuellement d'une marge de sécurité en fonction de la température comme celle qui existe dans le cas des durées d'efficacité des liquides standards. La méthodologie actuelle permet d'obtenir des durées d'efficacité pouvant être supérieures à la durée d'endurance réelle des liquides présentant des liens non standards dans certaines conditions.

Des méthodes pour résoudre ce problème ont été proposées, et comprennent la réduction des durées d'efficacité. Avant d'apporter des modifications, il convient de mener une évaluation plus poussée du niveau de risque actuel des liquides standards et des essais supplémentaires pour caractériser les liens de températures lors de précipitations verglaçantes. Il est recommandé de réaliser ces tâches parallèlement à l'élaboration d'autres méthodologies de traitement de données structurées pour les liquides présentant des liens températures-durées d'endurance non standards.

Évaluation de l'incidence du profil de viscosité des liquides sur les durées d'endurance des liquides et des effets sur les durées d'efficacité (Section 6)

Les liquides d'antigivrage d'aéronefs jouent un rôle essentiel pour garantir la sécurité des opérations hivernales. Ces liquides ne sont inclus dans les lignes directrices de l'industrie qu'après avoir fait l'objet d'une série d'essais à l'aide de viscosités précisément déterminées. Les pratiques actuelles supposent que les valeurs de viscosité les plus basses sur l'aile (LOWV) représentent le cas le plus prudent dans le cadre des essais sur les durées d'endurance, alors que les valeurs de viscosité les plus hautes sur l'aile (HOWV) représentent le cas le plus prudent dans le cadre des essais de performance aérodynamique.

Pendant l'année du projet de 2024-2025, la FAA et TC ont mené une évaluation afin de déterminer si cette supposition de longue date demeure valide. Le programme a examiné les durées d'endurance de divers échantillons de viscosité du même liquide. Les observations réalisées dans le cadre de ces travaux indiquent que l'échantillon de faible viscosité ne permet pas d'obtenir systématiquement la durée d'endurance la plus courte dans toutes les conditions de précipitations et de températures. Cette constatation met en lumière la nécessité de procéder à des essais plus exhaustifs pour s'assurer de l'exactitude et de la fiabilité des lignes directrices publiées relatives aux durées d'efficacité.

Les observations réalisées dans le cadre de ces travaux mettent en lumière la nécessité d'effectuer des recherches supplémentaires par l'entremise d'essais de comparaison exhaustifs des durées d'efficacité, qui permettraient d'évaluer divers

échantillons de viscosité en parallèle pour déterminer leur incidence sur les durées d'efficacité publiées.

Soutien aux efforts déployés par l'industrie pour poursuivre l'élaboration de normes en matière de viscosité (AS9968) (Section 7)

Depuis l'année du projet de 2014-2015, la FAA et TC ont publié les LOWV pour tous les liquides épaissis dans les lignes directrices annuelles relatives aux durées d'efficacité. Au début de l'année du projet de 2022-2023, les HOWV ont également été ajoutées afin de réduire les risques opérationnels. Les deux paramètres sont déterminés à l'aide de la méthodologie normalisée décrite dans la norme aérospatiale AS 9968.

Pour l'année du projet de 2024-2025, la FAA et TC ont amorcé un examen visant à explorer des façons de mieux étayer les normes en matière de viscosité afin d'aider les exploitants à déterminer si un liquide se situe dans les limites des LOWV et des HOWV publiées.

Des échantillons de liquides sont régulièrement recueillis et mis à l'essai pour confirmer que la viscosité demeure dans la plage opérationnelle déterminée. Cependant, des exploitants de contrôle de la qualité de l'industrie s'inquiètent du ralentissement de la vérification causé par le nombre croissant de méthodes approuvées au cours des dernières années. Les changements de configuration fréquents qu'exigent les différentes méthodes ajoutent de la complexité et des retards, rendant plus difficile la confirmation que les liquides se situent dans la plage déterminée.

Ce projet vise à évaluer la faisabilité de la réduction du nombre de méthodes d'essais de viscosité dans les lignes directrices actuelles relatives aux durées d'efficacité et à étudier la possibilité de normaliser les essais à l'aide d'une seule méthode ou d'un nombre limité de méthodes, en vertu de l'AS 9968, tout en conservant l'exactitude, la précision et la fiabilité du contrôle de la qualité des liquides.

Examen technique, finalisation et publication de rapports historiques (Section 8)

APS a effectué des études sur le givrage au sol qui ont supposé la rédaction de plus de 235 rapports pour le compte de TC et de la FAA depuis le début des années 1990. 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. En date du 31 octobre 2025, à l'exception des rapports annuels actuels de 2024-2025, 20 rapports devaient encore être publiés. En outre, il reste à améliorer la qualité graphique de 19 rapports historiques publiés.

Publication de documents d'orientation sur les durées d'efficacité (Section 9)

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 2024-2025 (Section 10)

APS a produit plusieurs présentations, rapports aux fabricants de liquides et procédures d'essais pour le programme d'essais de l'hiver 2024-2025. Ces produits livrables sont documentés dans le présent rapport.

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CONTENTS	Page
1. INTRODUCTION	1
1.1 Activities Completed in 2024-25	1
1.2 Activities Completed with Limited Scope	2
1.2.1 Update AIR 6284 Forced Air Document	2
1.2.2 Support to the SAE G-12 Aerodynamics Working Group	3
1.2.3 Support to the METAR Working Group	3
1.2.4 Support to the SAE G-12 Rotorcraft Working Group	3
1.2.5 Holdover Time Committee	3
2. FURTHER CHARACTERIZATION OF THE RELATIONSHIP BETWEEN SNOWFALL INTENSITY AND PREVAILING VISIBILITY	5
2.1 Background	5
2.2 Previous Work	6
2.3 Objective	6
2.4 Data	7
2.4.1 Data Collection	7
2.4.2 Data Cleaning	7
2.5 Analysis	10
2.5.1 Harmonization of Temperature Breakpoint	11
2.5.2 Frequency Analysis	13
2.6 Conclusions	22
2.7 Future Development	23
2.7.1 Regression Methodology	23
2.7.2 Additional Data Cleaning	24
2.7.3 METAR Versus Sensor Visibilities	25
2.8 Recommendations	25
3. A COMPREHENSIVE EVALUATION OF MIST AND FREEZING FOG DEPOSITION RATES	29
3.1 Background	29
3.2 Objective	29
3.3 Overview of Research Conducted	30
3.3.1 2020-21 Testing Summary	30
3.3.2 2021-22 and 2022-23 Testing Summary	31
3.3.3 2023-24 Testing Summary	31
3.3.4 2024-25 Testing Summary	31
3.4 Mist and Freezing Fog Forecasting	31
3.5 Testing Procedure	32
3.5.1 Procedural Updates Implemented as of Winter 2021-22	33
3.6 Data Collected	33
3.6.1 Historic APS Data Collected in 2001-02	34
3.6.2 NCAR METAR Data	34
3.6.3 APS Data Collected in 2020-21	35
3.6.4 Data Collected in 2021-22	36
3.6.5 Data Collected in 2022-23	37
3.6.6 Data Collected in 2023-24	38
3.6.7 Data Collected in 2024-25	39
3.6.8 Summary of Data Collected from 2001-02 and from 2020-21 Through 2024-25	39
3.7 Data Analysis	40

3.7.1	Summary of Most Conservative Rates at 2°C and Below	41
3.7.2	Combined Fog/Freezing Fog and Mist/Freezing Mist Data (All Data) Wet Taxiing and Stationary Pan Analysis	44
3.7.3	Combined Fog/Freezing Fog and Mist/Freezing Mist Data (All Data) Dry Taxiing and Stationary Pan Analysis	45
3.7.4	Correlation Between Reported and Observed Visibility for Fog/Freezing Fog Deposition Rates with a Taxiing and Stationary Wet and Dry Pan	46
3.7.5	Correlation Between Reported and Observed Visibility for Mist/Freezing Mist Deposition Rates with a Taxiing and Stationary Wet and Dry Pan	51
3.7.6	Hypothesis Affecting Rates and Visibility	54
3.7.7	Understanding the Limitations of Collected Deposition Rate Data	55
3.7.8	Simulation of Aircraft Taxi Trajectory	55
3.7.9	Fog/Freezing Fog and Mist/Freezing Mist Wet and Dry Pan Taxiing Temperature Data Analysis	58
3.8	Discussion of Operational Considerations in Fog/Freezing Fog and Mist/Freezing Mist Conditions	60
3.9	Conclusions	61
3.10	Recommendations.....	62
4.	DEVELOPMENT OF GUIDANCE FOR MIXED ICING CONDITIONS	67
4.1	Background	67
4.2	Previous Work	67
4.3	Objective	67
4.4	Research Activities 2024-25	68
4.5	Conclusions	68
4.6	Recommendations.....	68
5.	EVALUATION OF HOT REGRESSION METHODOLOGY FOR FLUIDS WITH NON-STANDARD TEMPERATURE-ENDURANCE TIME RELATIONSHIPS.....	69
5.1	Background	69
5.2	Previous Work	69
5.3	Objective	70
5.4	Data	70
5.5	Frequency Analysis	72
5.6	HOT Analysis	73
5.6.1	Problem Definition.....	73
5.6.2	Natural Snow	76
5.6.3	Freezing Precipitation	80
5.7	Conclusions	87
5.8	Recommendations.....	88
6.	EVALUATION OF FLUID VISCOSITY PROFILE IMPACT ON FLUID ENDURANCE TIMES AND EFFECTS ON HOLDOVER TIMES.....	89
6.1	Background	89
6.2	Previous Work	89
6.3	Objective	90
6.4	Test Methodology	90
6.4.1	Fluid Sample Preparation.....	90
6.4.2	Endurance Time Tests	91
6.4.3	Test Procedures.....	91
6.5	Data Collected.....	92
6.6	Data Analysis	93

6.6.1	Natural Snow Data Analysis	94
6.6.2	Freezing Precipitation Data Analysis	95
6.6.3	Summary of Results	95
6.7	Conclusions	96
6.8	Recommendations.....	96
7.	SUPPORT INDUSTRY EFFORTS TO FURTHER DEVELOP VISCOSITY STANDARDS (AS9968)	97
7.1	Background	97
7.2	Objective	97
7.3	Data Collected.....	97
7.3.1	Review of Published Test Methods.....	97
7.3.2	Review of Viscosity Measurement Repeatability and Reproducibility.....	99
7.3.3	Evaluation of Alternate Standardized Methods.....	99
7.4	Summary of Observations	100
7.5	Recommendations.....	100
8.	TECHNICAL REVIEW, FINALIZATION, AND PUBLICATION OF HISTORICAL REPORTS	101
8.1	Background	101
8.2	Objective	101
8.3	Publication Process and Delivery of Technical Reports	101
8.4	Enhancement of Graphics Quality in Historical Published Reports.....	103
8.5	Overall Publication Status of Technical Reports	104
8.6	Conclusions	105
8.7	Recommendations.....	106
9.	PUBLICATION OF HOLDOVER TIME GUIDANCE MATERIALS.....	107
9.1	Background	107
9.2	APS Contribution to Holdover Time Guidance Materials	107
9.3	Winter 2025-26 Holdover Time Guidance Materials.....	108
9.4	Future Responsibilities	109
10.	PRESENTATIONS, FLUID MANUFACTURER REPORTS, AND TEST PROCEDURES FOR 2024-25.....	111
10.1	Presentations	111
10.1.1	SAE G-12 Holdover Time (HOT) Committee Meeting, Montreal, Canada, November 2024	111
10.1.2	SAE G-12 Aerodynamic Working Group (AWG) Committee Meeting, Montreal, Canada, November 2024.....	112
10.1.3	SAE G-12 Equipment Committee Meeting, Montreal, Canada, November 2024.....	112
10.1.4	SAE G-12 Holdover Time (HOT) Committee Meeting, Málaga, Spain, May 2025.....	112
10.1.5	SAE G-12 Aerodynamic Working Group (AWG) Committee Meeting, Málaga, Spain, May 2025	112
10.2	Fluid Manufacturer Reports	113
10.2.1	Holdover Time Testing Reports 2024-25.....	113
10.3	Test Procedures.....	114
REFERENCES		117

LIST OF APPENDICES

- A Transport Canada Statement of Work Excerpt – Aircraft & Anti-Icing Fluid Winter Testing 2024-25
- B Log of Visibility Testing Conducted for Testing Season 2024-25
- C Analysis Report: Investigation of Historical METAR Reports at CYUL to Determine Frequency of Fog and Mist with No Other Weather Type
- D Procedure: Simulated Taxiing and Stationed Aircraft Tests to Investigate the Deposition Rate of Mist and Substantiation of Freezing Fog
- E Log of Fog/Freezing Fog & Mist/Freezing Mist Tests 2020-21 through 2024-25
- F Theoretical Water Content in Air at Saturation and Supersaturation During Mist and Freezing Fog Testing
- G Non-Standard Temperature-Endurance Time Relationship Analysis Database
- H Presentations for 2024-25

LIST OF TABLES	Page
Table 2.1: 2018-25 Data Collection Summary	7
Table 2.2: Data Set	8
Table 2.3: Removal Justification for 2018-2025 Data	8
Table 2.4: Removal Justification for 1995-2002 Data	9
Table 2.5: 2024-25 Event Log of Cleaned Data Points	9
Table 2.6: Difference in Expected Precipitation Rate by Temperature and Data Set	12
Table 2.7: Visibilities and Associated Snow Precipitation Rates (Below -1 °C, Day)	15
Table 2.8: Visibilities and Associated Snow Precipitation Rates (-1 °C and Above, Day)	15
Table 2.9: Visibilities and Associated Snow Precipitation Rates (Below -1 °C, Night)	16
Table 2.10: Visibilities and Associated Snow Precipitation Rates (-1 °C and Above, Night)	16
Table 2.11: Data Distribution of Combined Data set	17
Table 2.12: Analysis Recommendations with Combined Data (vs. TC Table)	17
Table 2.13: Analysis Recommendations with Combined Data (vs. FAA Table)	18
Table 2.14: Visibilities and Associated Snow Precipitation Rates (Below -1 °C, Day) Using Modern Data Only	19
Table 2.15: Visibilities and Associated Snow Precipitation Rates (-1 °C and Above, Day) Using Modern Data Only	19
Table 2.16: Visibilities and Associated Snow Precipitation Rates (Below -1 °C, Night) Using Modern Data Only	20
Table 2.17: Visibilities and Associated Snow Precipitation Rates (-1 °C and Above, Night) Using Modern Data Only	20
Table 2.18: Data Distribution of Modern Data set	21
Table 2.19: Analysis Recommendations with Modern Data (vs. TC Table)	21
Table 2.20: Analysis Recommendations with Modern Data (vs. FAA Table)	22
Table 2.21: Example Effect of Unstable Rate Period	24
Table 3.1: Summary of Work	30
Table 3.2: Fog/Freezing Fog Deposition Measurement Summary	34
Table 3.3: Parameters Associated with Figure 3.2	35
Table 3.4: Summary of Fog/Freezing Fog Data Collected in 2001-02 and from 2020-21 Through 2024-25	40
Table 3.5: Summary of Mist/Freezing Mist Data Collected from 2020-21 Through 2024-25	40
Table 3.6: Determined Statistical Parameters for Fog/Freezing Fog Using Wet Pan APS Data	42
Table 3.7: Determined Statistical Parameters for Fog/Freezing Fog Using Dry Pan APS Data	42
Table 3.8: Determined Statistical Parameters for Mist/Freezing Mist Using Wet Pan APS Data	43
Table 3.9: Determined Statistical Parameters for Mist/Freezing Mist Using Dry Pan APS Data	43
Table 3.10: Most Conservative Observed Rates for Fog/Freezing Fog and Mist/Freezing Mist at 2 °C and Cooler	44
Table 3.11: Empirical Fog/Freezing Fog Combined Wet and Dry Pan Rate Using Different Combinations of Taxi and Stationary Times at 2 °C and Below	57
Table 3.12: Empirical Mist/Freezing Mist Combined Wet and Dry Pan Rate Using Different Combinations of Taxi and Stationary Times at 2 °C and Below	57
Table 3.13: Operational Rate Range for Fog/Freezing Fog and Mist/Freezing Mist	57
Table 3.14: Possible Testing Rates for Freezing Fog at Different Temperatures	59
Table 3.15: Possible Testing Rates for Freezing Mist at Different Temperatures	60
Table 5.1: Fluid Data Count by Precipitation Type, Dilution, and Temperature	71
Table 5.2: Frequency of Non-Standard Temperature Relationships	72
Table 5.3: Comparative Risk Analysis for Temperature-Independent Fluids in Warm Snow	78
Table 5.4: Risk Parameter Comparison for Temperature-Independent Warm Snow by Methodology	79
Table 5.5: Impact of 66% Prediction-Interval Methodology on Example Fluid's Warm Snow HOTs	80

Table 5.6: HOT for Example Reversed Relationship Light Freezing Rain	82
Table 5.7: Comparison of Estimated ET and Unrounded HOT for Fluid in ZR with a Reversed Relationship	84
Table 5.8: Impact of Shortest Band Methodology on Example Fluid's ZR HOTs.....	85
Table 6.1: Viscosity Measured of the Fluid Samples Tested.....	90
Table 6.2: Test Log of Completed Tests	92
Table 6.3: Summary of Type II and IV Fluids	96
Table 7.1: Count of Current Viscosity Test Methods Used in the 2024-25 HOT Guidelines	98
Table 7.2: Details of Viscosity Test Methods Available	98
Table 7.3: Viscosity Test Setups.....	99
Table 8.1: List of Published Technical Reports (2024-25).....	104
Table 8.2: Detailed Status of Reports as of October 31, 2025.....	105
Table 9.1: Latest 2025-26 HOT Guidance Documents	109
Table 10.1: List of Procedures 2024-25.....	115

LIST OF FIGURES

Page

Figure 2.1: Differences in TC/FAA Visibility Table Values	6
Figure 2.2: 2018-25 Database – Retained and Removed Data	10
Figure 2.3: Precipitation Rate vs. Visibility by Temperature Category	11
Figure 2.4: Example Regression Methodology (2018-2025 Data, Cold, Day).....	24
Figure 3.1: Illustration of Varying Mist and Fog Rates	33
Figure 3.2: Pristine Freezing Fog METAR Data Obtained from NCAR.....	35
Figure 3.3: Effect of Temperature on Wet Taxiing Deposition Rates	44
Figure 3.4: Effect of Temperature on Wet Stationary Deposition Rates	45
Figure 3.5: Effect of Temperature on Dry Taxiing Deposition Rates	46
Figure 3.6: Effect of Temperature on Dry Stationary Deposition Rates	46
Figure 3.7: Wet Taxiing Fog/Freezing Fog Deposition Reported Visibility	47
Figure 3.8: Dry Taxiing Fog/Freezing Fog Deposition Reported Visibility	47
Figure 3.9: Wet Taxiing Fog/Freezing Fog Deposition Actual Visibility.....	48
Figure 3.10: Dry Taxiing Fog/Freezing Fog Deposition Actual Visibility.....	48
Figure 3.11: Wet Stationed Fog/Freezing Fog Deposition Reported Visibility	49
Figure 3.12: Dry Stationed Fog/Freezing Fog Deposition Reported Visibility	49
Figure 3.13: Wet Stationed Fog/Freezing Fog Deposition Actual Visibility.....	50
Figure 3.14: Dry Stationed Fog/Freezing Fog Deposition Actual Visibility	50
Figure 3.15: Wet Taxiing Mist/Freezing Mist Deposition Reported Visibility	51
Figure 3.16: Dry Taxiing Mist/Freezing Mist Deposition Reported Visibility	52
Figure 3.17: Wet Stationed Mist/Freezing Mist Deposition Reported Visibility	53
Figure 3.18: Dry Stationed Mist/Freezing Mist Deposition Reported Visibility	53
Figure 3.19: Illustration of a Typical Aircraft Trajectory at an Airport.....	56
Figure 3.20: Effect of Temperature on Fog/Freezing Fog Wet and Dry Pan Taxiing Rates	58
Figure 3.21: Effect of Temperature on Mist/Freezing Mist Wet and Dry Pan Taxiing Rates	59
Figure 5.1: Safety Buffer from Standard Fluids	74
Figure 5.2: Risk of Fluids with Reversed Temperature-ET Relationships.....	75
Figure 5.3: Risk of Fluids with Temperature-Independent Relationship	75
Figure 5.4: Example of Standard Relationship in Warm Snow	77
Figure 5.5: Example of Temperature-Independent Relationship in Warm Snow	77
Figure 5.6: Temperature-Independent Fluid in Warm Snow with Prediction Interval	79
Figure 5.7: Example of Standard Relationship in Freezing Precipitation.....	81
Figure 5.8: Example of Reversed Relationship in Freezing Precipitation.....	81
Figure 5.9: Full Temperature Range Regression for Reversed Relationship in ZR.....	83
Figure 5.10: Example of Temperature-Independent Freezing Drizzle at Low Rate	86

Figure 5.11: Example of Temperature-Independent Freezing Drizzle with 66% Prediction Intervals.....	87
Figure 6.1: Test Stand Setup for Endurance Time Tests.....	91
Figure 6.2: Type II PG – Natural Snow Tests	94
Figure 6.3: Type IV PG – Natural Snow Tests.....	94
Figure 6.4: Type II & IV PG – Freezing Precipitation Tests.....	95
Figure 8.1: Reports Management Process.....	102

LIST OF PHOTOS

Page

Photo 2.1: Parsivel ² Disdrometer	27
Photo 3.1: Method 1 – Simulated Taxiing Aircraft.....	63
Photo 3.2: Method 2 – Simulated Stationed Aircraft	63
Photo 3.3: Mist Visible – Reported by METAR	64
Photo 3.4: Mist Visible – Reported by METAR	64
Photo 3.5: Mist Visible – Not Reported by METAR.....	65
Photo 3.6: Method 1 – Simulated Taxiing Aircraft – Addition of Dry Pan Next to Wet Pan.....	65
Photo 3.7: Method 2 – Simulated Stationed Aircraft – Addition of Dry Pan Next to Wet Pan.....	66

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GLOSSARY

AIR	Aerospace Information Report
AMS	Aerospace Material Specification
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
AWG	G-12 Aerodynamics Working Group
CARs	Canadian Aviation Regulations
CEF	Climatic Engineering Facility
DND	Department of National Defence
DSHOT	Degree-Specific Holdover Time
EG	Ethylene Glycol
ET	Endurance Time
FAA	Federal Aviation Administration
HOT	Holdover Time
HOWV	Highest On-Wing Viscosity
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LWC	Liquid Water Content
MIT	Massachusetts Institute of Technology
MOR	Meteorological Optical Range
MWG	METAR Working Group

NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
OAT	Outside Air Temperature
PEG	Polyethene Glycol
PG	Propylene Glycol
RWG	Rotorcraft Working Group
SAE	SAE International
TC	Transport Canada
VCS	Very Cold Snow
YMX	Montréal–Mirabel International Airport
YOW	Ottawa International Airport
YUL	Montréal–Pierre Elliott Trudeau International Airport

1. INTRODUCTION

Under winter precipitation conditions, aircraft surfaces 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, enhance safety, and advance 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 and other icing conditions.

Under contract to the TC Programs Group Innovation Centre, with support from the FAA William J. Hughes Technical Center for Advanced Aerospace, TC Civil Aviation, and FAA Flight Standards – Air Carrier Operations, APS Aviation Inc. (APS) carried out research in the winter of 2024-25 in support of the aircraft ground icing research program. Each major project completed as part of the 2024-25 research is documented in a separate individual report. This report documents the remaining general activities and smaller research projects.

1.1 Activities Completed in 2024-25

The general activities and smaller research projects completed in 2024-25 are documented in this report. Each activity is detailed in a separate section as follows (section number in parentheses):

- a) Further Characterization of the Relationship Between Snowfall Intensity and Prevailing Visibility (Section 2);

- b) A Comprehensive Evaluation of Mist and Freezing Fog Deposition Rates (Section 3);
- c) Development of Guidance for Mixed Icing Conditions (Section 4);
- d) Evaluation of HOT Regression Methodology for Fluids with Non-Standard Temperature-Endurance Time Relationships (Section 5);
- e) Evaluation of Fluid Viscosity Profile Impact on Fluid Endurance Times and Effects on Holdover Times (Section 6);
- f) Support for Industry Efforts to Further Develop Viscosity Standards (AS9968) (Section 7);
- g) Technical Review, Finalization, and Publication of Historical Reports (Section 8);
- h) Publication of Holdover Time Guidance Materials (Section 9); and
- i) Presentations, Fluid Manufacturer Reports, and Test Procedures for 2024-25 (Section 10)

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 referenced in Subsection 1.1, five activities with limited scope were completed during the winter of 2024-25. These activities are described in the following subsections.

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

1.2.1 Update AIR 6284 Forced Air Document

The focus of the Aerospace Information Report (AIR) 6284 document is to provide guidance on the removal of frozen contaminants from aircraft surfaces using forced air or forced air/fluid equipment. In 2023, the document, now sponsored by APS, underwent a revision based on the feedback from the SAE International (SAE) G-12 Equipment Committee. A working group was formed to address the activities required.

The updated AIR6284 Revision A was published in December 2024. A final presentation was given to the SAE G12 Equipment Committee in May 2025 to summarize the progress made.

It is anticipated that communication with the working group shall continue to include email and teleconference discussions on an as-needed basis in conjunction with the standard SAE G-12 Equipment Committee meetings.

1.2.2 Support to the SAE G-12 Aerodynamics Working Group

APS provides support to the SAE G-12 Aerodynamics Working Group (AWG). This includes participation in all meetings and, when required, collecting data, completing data analysis, and providing expert opinion on specific topics. For the winter of 2024-25, APS attended several online meetings in conjunction with the SAE G-12 biannual meetings and participated in related group discussions.

1.2.3 Support to the METAR Working Group

APS provides support to the METAR Working Group (MWG), which includes technical experts and meteorologists from TC, the FAA, APS, and the National Center for Atmospheric Research (NCAR). This includes participation in all meetings, framing project objectives, discussing technical content, identifying areas of research, and directing research efforts. For the winter of 2024-25, APS attended several working group meetings and participated in related group discussions via email and through online meetings.

1.2.4 Support to the SAE G-12 Rotorcraft Working Group

APS provides support to the Rotorcraft Working Group (RWG), which includes technical experts, operators, and airframe manufacturers such as NRC, the Department of National Defence (DND), Bell Flight, Sikorsky, and others. APS participates in meetings to develop and discuss technical content to support the RWG goal of developing guidance material to support rotorcraft ground icing operations. For the winter of 2024-25, APS attended several working group meetings and participated in related group discussions via email and through online meetings.

1.2.5 Holdover Time Committee

APS provides support to the SAE G-12 Holdover Time (HOT) Committee by providing a qualified individual to serve as the committee secretary. The role of this individual includes participating in the committee meetings, assisting the committee co-chairs with any preparation tasks, and recording and editing the meeting minutes for distribution.

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2. FURTHER CHARACTERIZATION OF THE RELATIONSHIP BETWEEN SNOWFALL INTENSITY AND PREVAILING VISIBILITY

This section describes the work conducted by APS Aviation Inc. (APS) in 2024-25 to further characterize the relationship between snowfall intensity and prevailing visibility.

2.1 Background

Pilots determine snowfall intensity as part of the holdover time (HOT) determination process by using visibility as a reference point. Transport Canada (TC) and the Federal Aviation Administration (FAA) provide guidance on this determination through a “Snowfall Intensities as a Function of Prevailing Visibility” reference table published within their respective HOT Guidelines. These tables (referred to as the “visibility tables”) allow pilots to estimate the snowfall intensity category using the current visibility, temperature, and lighting conditions.

Each organization publishes a version of the visibility table within their respective HOT Guidelines publications, with some differences existing between the two versions. In recent years, TC and the FAA have attempted to harmonize their respective ground deicing guidance wherever possible. In support of this, both TC and the FAA updated their visibility guidance prior to the 2022-23 winter season following additional analysis and evaluation of the tables and the underlying data used to support them. This research is documented in the TC report, TP 15536E, *Aircraft Ground Icing General Research Activities During the 2021-22 Winter* (1).

One of the recommendations that came from the above research was to collect additional paired visibility and precipitation rate data to support further characterization of the relationship between snowfall intensity and prevailing visibility, with the long-term goal of further harmonizing the TC/FAA visibility table guidance.

APS acquired a Parsivel² laser disdrometer for use in data collection efforts in the 2023-24 winter season. The sensor can measure visibility in real time and has been installed at the APS test site to enable paired precipitation rate and visibility data collection during snowfall events.

The sensor chosen was the same model as a unit that had been installed at the APS test site in 2018 by the National Center for Atmospheric Research (NCAR) for use in another research project. The historical data logged by this unit remains available and was used to supplement the data collected with the new APS sensor.

The APS Parsivel² unit is depicted in Photo 2.1 for reference.

2.2 Previous Work

This research is a continuation of work begun in 2020-21. The previous work is most recently documented in the TC report, TP 15608E, *Aircraft Ground Icing General Research Activities During the 2023-24 Winter* (2).

It was determined that collection of additional paired visibility and precipitation rate data, particularly in the conditions where guidance discrepancies exist, would support future guidance harmonization efforts.

The current differences in the TC/FAA visibility table cell values are summarized in Figure 2.1.

Visibility		Day				Night			
Statute Miles	Meters	≤-1°C FAA	<-1°C TC	>-1°C FAA	≥-1°C TC	≤-1°C FAA	<-1°C TC	>-1°C FAA	≥-1°C TC
≤1/4 (≤3/8)	≤400 (≤600)	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy
1/2 (>3/8 to ≤5/8)	800 (>600 to ≤1000)	Mod	Mod	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy
3/4 (>5/8 to ≤7/8)	1200 (>1000 to ≤1400)	Mod	Mod	Mod	Mod	Mod	Heavy	Heavy	Heavy
1 (>7/8 to ≤1 1/8)	1600 (>1400 to ≤1800)	Light	Light	Light	Light	Mod	Mod	Mod	Heavy
1 ¼ (>1 1/8 to ≤1 3/8)	2000 (>1800 to ≤2200)	Light	Light	Light	Light	Mod	Mod	Mod	Mod
1 ½ (>1 3/8 to ≤1 5/8)	2400 (>2200 to ≤2600)	Light	Light	Light	Light	Mod	Mod	Mod	Mod
1 ¾ (>1 5/8 to ≤1 7/8)	2800 (>2600 to ≤3000)	VLS	Light	Light	Light	Light	Light	Light	Light
2 (>1 7/8 to ≤2 ¼)	3200 (>3000 to ≤3600)	VLS	VLS	VLS	VLS	Light	Light	Light	Light
2 ½ (>2 ¼ to ≤2 ¾)	4000 (>3600 to ≤4400)	VLS	VLS	VLS	VLS	VLS	Light	VLS	Light
3 (>2 ¾ to ≤3 ¼)	4800 (>4400 to ≤5200)	VLS	VLS	VLS	VLS	VLS	VLS	VLS	Light
3 ½ (>3 ¼ to ≤3 ¾)	5600 (>5200 to ≤6000)	VLS	VLS	VLS	VLS	VLS	VLS	VLS	VLS
≥4 (>3 ¾)	≥6400 (> 6000)	VLS	VLS	VLS	VLS	VLS	VLS	VLS	VLS

Figure 2.1: Differences in TC/FAA Visibility Table Values

2.3 Objective

The objectives of this project were as follows:

1. Collect paired visibility and snow precipitation rate data at the Montréal–Pierre Elliott Trudeau International Airport (YUL) test site; and
2. Determine if the addition of modern data can support further harmonization of the TC and FAA visibility tables, including addressing the following:
 - a. Difference in the warm/cold temperature breakpoint; and
 - b. Differences in snowfall intensities in key cells.

2.4 Data

This subsection presents the data collection and the data cleaning processes required before conducting the snowfall intensity versus precipitation rate analysis.

2.4.1 Data Collection

The process of data collection involves collecting visibility data alongside precipitation rate data.

- **Precipitation rate:** Rate data is acquired during standard HOT testing or as a result of other research initiatives at the YUL test site; and
- **Visibility sensor data:** Visibility (meteorological optical range [MOR]) is recorded at either 10- or 60-second intervals by two Parsivel² laser disdrometers: one owned by NCAR and installed in 2018, and another owned by TC/FAA and installed in 2023.

A rate–visibility data point is made up of the measured rate over those 10 minutes and the average MOR visibility that was measured with those sensors during that same period. As displayed in Table 2.1, from 2018 onward, the sensors aided in collecting over 4000 data points across 102 natural snow events. Of those data points, 607 were collected across 19 events in the 2024-25 season.

Table 2.1: 2018-25 Data Collection Summary

Season	Event Count	Data Point Count
2018-19	11	431
2019-20	14	713
2020-21	16	649
2021-22	14	640
2022-23	15	539
2023-24	13	476
2024-25	19	607
Total	102	4055

2.4.2 Data Cleaning

Data cleaning is necessary to ensure that the database contains only appropriate natural snow events.

The primary data filter is weather conditions. Data points with any forms of fog, rain, drizzle, or ice pellets have been removed. These conditions result in visibilities that are either much higher or lower than expected for a given precipitation rate, significantly impacting the subsequent analysis. Weather reporting from Environment Canada or visual observations during natural snow testing was used to identify and flag these data points.

Other secondary filters were applied with the goal of providing the best data set to analyse the relationship, including the following:

- **Unusable rates:** This includes rates below a 0.5 g/dm²/h threshold, incorrect rates, and error sensor values; and
- **Significant outliers:** This includes invalid data points that can be explained by faulty rates or sensor errors. These were defined as data points where the visibility was 200 percent below or 600 percent greater than the expected visibility for a given rate.

Table 2.2 presents the number of data points in the modern, historical, and combined data sets before and after data cleaning.

Table 2.2: Data Set

Data Set	2018-2025	1995-2002	Combined
Original	4055	7939	11994
Cleaned	3086	5894	8980
Difference	-969	-2045	-3014

Table 2.3 and Table 2.4 present the justification for the removed data points in the modern and historical data sets.

Table 2.3: Removal Justification for 2018-2025 Data

Removal Reason	# of Data Points
Unacceptable Weather	444
Unusable Rate (Error or Below 0.5 g/dm ² /h Threshold)	428
Sensor or Rate Errors	67
Suspected Mixed Conditions	23
Significant Outliers	7
Total	969

Table 2.4: Removal Justification for 1995-2002 Data

Year Removed	Reason for Flagging Data	# of Data Points Flagged
Removed in 2002-03	Incorrect Weather Type	897
Removed in 2021-22	Incorrect Timestamp on Data or Other Data Entry Issue	121
	Inconclusive Precipitation Type	497
	Presence of Fog	100
	Presence of Ice Pellets	156
	Presence of Rain/Freezing Drizzle/Freezing Rain	109
	Presence of Multiple Non-Snow Precipitation Types	35
	No Snow (Clear/No Precipitation)	23
Removed in 2024-25	Unusable Rate (Error or Below 0.5 g/dm ² /h Threshold)	107
Total		2045

Table 2.5 presents the log of 2024-25 natural snow test events, including the average temperature and precipitation rate throughout these events and the number of cleaned data points added to the data set. A detailed log of these data points can be found in Appendix B.

Table 2.5: 2024-25 Event Log of Cleaned Data Points

Start Date	Average Temperature (°C)	Average Rate (g/dm²/h)	Number of Data Points
09-Dec-24	-6.0	10.8	26
23-Dec-24	-7.7	10.2	26
07-Jan-25	-8.0	3.4	17
08-Jan-25	-12.9	4.1	39
27-Feb-25	-0.8	9.2	17
04-Dec-24	-1.0	3.0	39
07-Dec-24	-4.0	6.9	36
23-Jan-25	-8.4	3.6	22
27-Jan-25	-1.4	4.8	29
29-Jan-25	-14.1	6.8	33
30-Jan-25	-10.5	2.2	18
06-Feb-25	-11.8	12.8	32
12-Feb-25	-11.5	16.9	35
16-Feb-25	-10.1	30.9	73
04-Mar-25	0.5	8.1	28
24-Mar-25	-1.8	13.8	7
Average/Total	-7.5	11.2	477

Figure 2.2 displays the relationship between precipitation rate and visibility using the modern 2018-2025 data, highlighting the points that have been removed from the analysis.

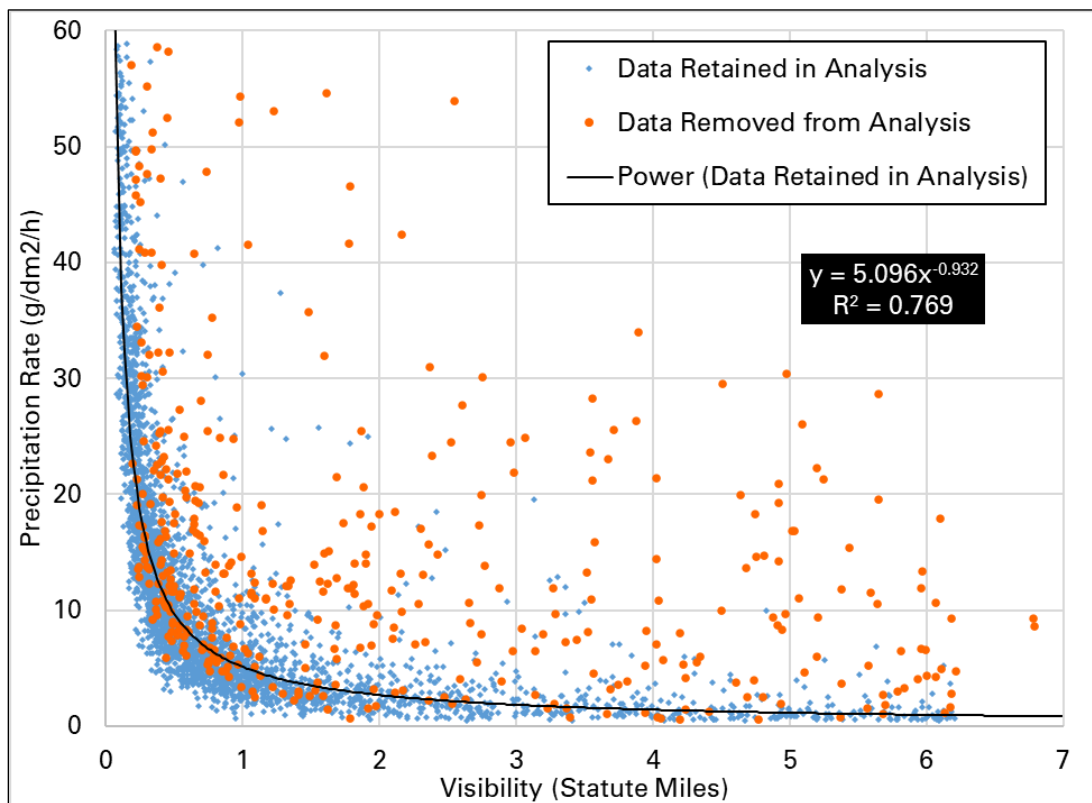


Figure 2.2: 2018-25 Database – Retained and Removed Data

While many outliers have been removed from the data set, there are still many data points that do not conform to the expected rate–visibility relationship and affect the ability to produce less restrictive guidance.

2.5 Analysis

This subsection presents the snowfall intensity versus precipitation rate data analysis.

2.5.1 Harmonization of Temperature Breakpoint

As the temperature approaches or surpasses 0°C, higher rates are typically observed for equal visibilities (this is the reason for the temperature distinction in the visibility table guidance).

The temperature effect on visibility is handled differently in the TC and FAA versions of the visibility tables:

- For TC, -1°C is included in the warm category (“-1°C and above”); and
- For the FAA, -1°C is included in the cold category (“-1°C and below”).

When operating at -1°C, the snowfall intensity classifications provided by the TC visibility table could be more restrictive than the FAA table. The cleaned visibility database was re-examined to provide a recommendation for harmonization.

To identify the correct temperature breakpoint, the concept of expected precipitation rate will be introduced.

Figure 2.2 first highlighted the power-law relationship between precipitation rate and visibility. Figure 2.3 presents that relationship separated by the TC temperature categories.

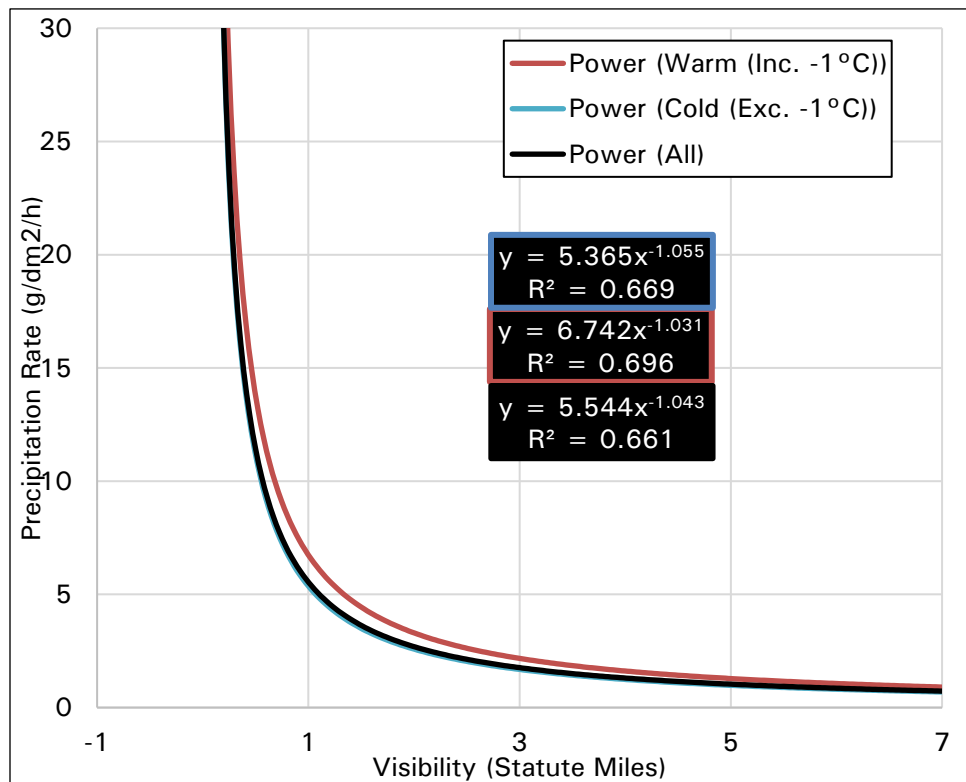


Figure 2.3: Precipitation Rate vs. Visibility by Temperature Category

These trendlines or relationships can be used to calculate an expected precipitation rate for a given measured visibility. As expected, greater visibilities were associated with lower precipitation rates (and vice versa). Additionally, the expected precipitation rate for warm temperature data was typically greater than for equivalent cold temperature data.

This predictive relationship can be used to compare the measured rates to their expected rates.

Table 2.6 presents the average percent difference between the measured rate and the expected rate, as determined by the full data set regression, at each temperature. It also has been divided between the historical and modern data sets.

Positive percentages indicate that, on average, the rates were greater than expected, meaning the snowfall intensity was heavier than expected. Negative percentages indicate that, on average, the precipitation rates were less than expected, meaning the snowfall intensity was lighter than expected.

Table 2.6: Difference in Expected Precipitation Rate by Temperature and Data Set

Temperature (°C)	1995-2002	2018-2025	Combined
1	31%	149%	90%
0	72%	90%	74%
-1	43%	15%	23%
-2	38%	17%	22%
-3	35%	24%	21%
-4	41%	13%	17%
-5	38%	6%	29%

The change in precipitation rate vs. expectation seen at 0°C suggests that this is the temperature at which the visibility relationship changes. Future revisions to the guidance could target this temperature as the harmonization breakpoint between warm and cold.

2.5.2 Frequency Analysis

This subsection presents the updated frequency analysis as it was initially performed in the TC report, TP 14151E, *Relationship Between Visibility and Snowfall Intensity* (3), and repeated in TP 15536E (1). This analysis is performed using the updated combined data set and the modern data set only to determine the impact on the resulting visibility table value recommendations. The resulting recommendations will be presented for each condition and data set.

2.5.2.1 Methodology

The frequency analysis consisted of examining the snowfall intensity rates associated with each of the standard METAR-reported visibilities.

The data points within the database were first categorized according to their snowfall intensity. The snowfall intensity categories and associated rate limits used were equivalent to the limits used in standard HOT development, as follows:

- **Heavy Snow:** $> 25 \text{ g/dm}^2/\text{h}$;
- **Moderate Snow:** 10 to $25 \text{ g/dm}^2/\text{h}$;
- **Light Snow:** 4 to $10 \text{ g/dm}^2/\text{h}$; and
- **Very Light Snow:** 3 to $4 \text{ g/dm}^2/\text{h}$.

Based on the assigned snowfall intensity of a standard METAR-reported visibility category, a data point can be categorized as an accurate estimate, an overestimate, or an underestimate:

- **Accurate:** The assigned visibility category matches the measured snowfall intensity;
- **Overestimate:** The assigned visibility category is more conservative than the measured snowfall intensity; and
- **Underestimate:** The assigned visibility category is less conservative than the measured snowfall intensity.

Each of the standard METAR-reported visibility categories was assigned the least severe snowfall intensity category where the percentage of underestimates at that visibility did not exceed 14 percent. The 14 percent limit was chosen to reflect the same acceptable risk level employed in the analysis used to create the original visibility table guidance. This process was applied to the combined data set as well as the newly collected modern data set to produce new recommendations.

As was done in the original analysis, separate evaluations were performed for data collected at -1 °C and above and for data collected below -1 °C.

The recommended snowfall intensity values derived from this analysis would only be applicable for daylight conditions, as the sensor from which the visibility data in the database was obtained reports visibilities as a human observer would in daylight, regardless of the lighting condition when the data was collected.

At the time when the original TP 14151E (3) analysis was performed, Rasmussen et al. deduced a formula for converting daytime visibility values to the equivalent human observer nighttime values. This formula was originally published in *The Estimation of Snowfall Rate Using Visibility* (4) and in the report TP 12893E, *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (5), and is shown below.

$$V_d = \frac{\ln(E)V_n}{\ln(C_{DB}V_n/I_o)} \quad \text{where}$$

V_d	=	Daytime visibility
E	=	Visual contrast threshold
V_n	=	Nighttime visibility
C_{DB}	=	Constant of proportionality
I_o	=	Luminous intensity

This formula makes several assumptions, including the following:

- $E = 0.055$;
- $C_{DB} = 0.084 \text{ mi}^{-1}$; and
- $I_o = 25 \text{ candles}$.

Like in TP 15536E (1), to determine the recommended snowfall intensity values for nighttime visibility conditions, the visibility values within the updated database were converted to equivalent nighttime values using the above formula, and the analysis was repeated on the converted “night” database.

2.5.2.2 Combined Data Set Results

Following the addition of the modern data and removal of the flagged data, the frequency analysis was performed using the updated combined data set. Summaries of these analyses are shown below in Table 2.7 (for data collected below -1 °C) and in Table 2.8 (for data collected at -1 °C and above).

For each commonly reported visibility value, the assigned snowfall intensity has been shown on the right. Cells representing snowfall rates that exceed the assigned snowfall intensity are shaded in red. The final columns indicate the underestimate percentages at the recommended snowfall intensity and if the assigned snowfall intensity was one category less intense (i.e., “Very Light” instead of “Light”).

Table 2.7: Visibilities and Associated Snow Precipitation Rates (Below -1°C, Day)

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	6%	49%	45%	Heavy	1101	0.0%	16.1%
0.5	1%	30%	64%	5%	Moderate	1604	5.3%	69.0%
0.75	6%	67%	27%	0%	Moderate	1647	0.3%	27.1%
1	22%	69%	9%	0%	Light	1038	9.2%	78.2%
1.25	40%	58%	2%	0%	Light	682	1.9%	60.0%
1.5	65%	34%	1%	0%	Light	429	0.9%	35.4%
1.75	75%	24%	1%	0%	Light	233	1.3%	24.9%
2	90%	10%	0%	0%	Very Light	243	10.3%	N/A
2.5	93%	7%	0%	0%	Very Light	231	7.4%	N/A
3	93%	6%	1%	0%	Very Light	115	7.0%	N/A
3.5 +	98%	2%	0%	0%	Very Light	313	2.2%	N/A

Table 2.8: Visibilities and Associated Snow Precipitation Rates (-1°C and Above, Day)

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥25				
0.25	0%	1%	30%	70%	Heavy	135	0.0%	20.0%
0.5	1%	14%	63%	21%	Heavy	256	0.0%	0.8%
0.75	3%	55%	40%	2%	Moderate	178	1.7%	42.1%
1	29%	63%	8%	0%	Light	111	8.1%	71.2%
1.25	42%	47%	9%	1%	Light	99	10.1%	57.6%
1.5	69%	31%	0%	0%	Light	68	0.0%	30.9%
1.75	60%	40%	0%	0%	Light	48	0.0%	39.6%
2	80%	19%	2%	0%	Light	54	1.9%	20.4%
2.5	77%	18%	5%	0%	Light	56	5.4%	23.2%
3	68%	28%	5%	0%	Light	40	5.0%	32.5%
3.5 +	88%	10%	2%	0%	Very Light	128	12.5%	N/A

To determine the recommended snowfall intensity values for nighttime visibility conditions, the analysis was repeated on the converted “night” database. Summaries of these analyses are shown below in Table 2.9 (for data collected below -1 °C) and in Table 2.10 (for data collected at -1 °C and above).

Table 2.9: Visibilities and Associated Snow Precipitation Rates (Below -1 °C, Night)

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	0%	9%	91%	Heavy	211	0.0%	49.3%
0.5	0%	2%	54%	45%	Heavy	488	0.0%	11.7%
0.75	0%	17%	67%	16%	Heavy	895	0.0%	2.2%
1	1%	32%	64%	4%	Moderate	809	3.6%	67.1%
1.25	4%	59%	37%	0%	Moderate	1182	0.3%	36.8%
1.5	9%	71%	19%	0%	Moderate	1034	0.3%	19.4%
1.75	23%	66%	11%	0%	Light	590	11.0%	76.9%
2	37%	61%	2%	0%	Light	760	2.1%	63.0%
2.5	63%	36%	1%	0%	Light	615	0.7%	36.6%
3	82%	17%	1%	0%	Light	303	1.0%	17.8%
3.5 +	95%	5%	0%	0%	Very Light	749	5.2%	N/A

Table 2.10: Visibilities and Associated Snow Precipitation Rates (-1 °C and Above, Night)

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	0%	0%	100%	Heavy	12	0.0%	75.0%
0.5	0%	0%	17%	83%	Heavy	75	0.0%	21.3%
0.75	0%	2%	58%	40%	Heavy	122	0.0%	2.5%
1	1%	20%	59%	20%	Heavy	124	0.0%	0.8%
1.25	2%	39%	57%	1%	Moderate	155	1.3%	58.7%
1.5	7%	62%	29%	2%	Moderate	107	1.9%	30.8%
1.75	37%	57%	6%	0%	Light	67	6.0%	62.7%
2	35%	53%	11%	1%	Light	92	12.0%	65.2%
2.5	64%	36%	0%	0%	Light	111	0.0%	36.0%
3	67%	33%	0%	0%	Light	51	0.0%	33.3%
3.5+	81%	15%	4%	0%	Very Light	257	18.7% *	N/A

*Accepted due to the removal of rates below 0.5 g/dm²/h.

The percentage of total data points within the combined data set categorized as accurate, underestimates, or overestimates is presented in Table 2.11.

Table 2.11: Data Distribution of Combined Data set

Category	Day		Night		Average
	Below -1°C	-1°C and Above	Below -1°C	-1°C and Above	
Underestimate	3%	4%	2%	2%	3%
Accurate	50%	34%	41%	28%	38%
Overestimate	47%	62%	57%	69%	59%

The high percentage of overestimates in Table 2.11 highlights how the frequency methodology currently used to establish the guidance often results in overestimation of the snowfall intensity.

Table 2.12 and Table 2.13 present the results of the combined data frequency analysis. The cells with red font indicate a change to a more restrictive category.

Table 2.12: Analysis Recommendations with Combined Data (vs. TC Table)

Statute Miles	Meters	Day		Night	
		Below -1°C Below 30°F	-1°C and above 30°F and above	Below -1°C Below 30°F	-1°C and above 30°F and above
≤1/4 (≤3/8)	≤400 (≤600)	Heavy	Heavy	Heavy	Heavy
1/2 (>3/8 to ≤5/8)	800 (>600 to ≤1000)	Moderate	Heavy	Heavy	Heavy
3/4 (>5/8 to ≤7/8)	1200 (>1000 to ≤1400)	Moderate	Moderate	Heavy	Heavy
1 (>7/8 to ≤1 1/8)	1600 (>1400 to ≤1800)	Light	Light	Moderate	Heavy
1 ¼ (>1 1/8 to ≤1 3/8)	2000 (>1800 to ≤2200)	Light	Light	Moderate	Moderate
1 ½ (>1 3/8 to ≤1 5/8)	2400 (>2200 to ≤2600)	Light	Light	Moderate	Moderate
1 ¾ (>1 5/8 to ≤1 7/8)	2800 (>2600 to ≤3000)	Light	Light	Light	Light
2 (>1 7/8 to ≤2 ¼)	3200 (>3000 to ≤3600)	Very Light	Light	Light	Light
2 ½ (>2 ¼ to ≤2 ¾)	4000 (>3600 to ≤4400)	Very Light	Light	Light	Light
3 (>2 ¾ to ≤3 ¼)	4800 (>4400 to ≤5200)	Very Light	Light	Light	Light
≥3 ½ (>3 ¼)	≥5600 (>5200)	Very Light	Very Light	Very Light	Very Light

Table 2.13: Analysis Recommendations with Combined Data (vs. FAA Table)

Statute Miles	Meters	Day		Night	
		Below -1°C Below 30°F	-1°C and above 30°F and above	Below -1°C Below 30°F	-1°C and above 30°F and above
≤1/4 (≤3/8)	≤400 (≤600)	Heavy	Heavy	Heavy	Heavy
1/2 (>3/8 to ≤5/8)	800 (>600 to ≤1000)	Moderate	Heavy	Heavy	Heavy
3/4 (>5/8 to ≤7/8)	1200 (>1000 to ≤1400)	Moderate	Moderate	Heavy	Heavy
1 (>7/8 to ≤1 1/8)	1600 (>1400 to ≤1800)	Light	Light	Moderate	Heavy
1 ¼ (>1 1/8 to ≤1 3/8)	2000 (>1800 to ≤2200)	Light	Light	Moderate	Moderate
1 ½ (>1 3/8 to ≤1 5/8)	2400 (>2200 to ≤2600)	Light	Light	Moderate	Moderate
1 ¾ (>1 5/8 to ≤1 7/8)	2800 (>2600 to ≤3000)	Light	Light	Light	Light
2 (>1 7/8 to ≤2 ¼)	3200 (>3000 to ≤3600)	Very Light	Light	Light	Light
2 ½ (>2 ¼ to ≤2 ¾)	4000 (>3600 to ≤4400)	Very Light	Light	Light	Light
3 (>2 ¾ to ≤3 ¼)	4800 (>4400 to ≤5200)	Very Light	Light	Light	Light
≥3 ½ (>3 ¼)	≥5600 (>5200)	Very Light	Very Light	Very Light	Very Light

The results derived using the combined data set lead to more restrictive recommendations and thus no harmonization of the intensities.

2.5.2.3 Modern Data Set Results

This analysis can be repeated with only the modern data collected from 2018 through 2025. Summaries of these analyses are shown below in Table 2.14 (for data collected below -1 °C) and in Table 2.15 (for data collected at -1 °C and above).

For each commonly reported visibility value, the assigned snowfall intensity has been shown on the right. Cells representing snowfall rates that exceed the assigned snowfall intensity are shaded in red. The final columns indicate the underestimate percentages at the recommended snowfall intensity and if the assigned snowfall intensity was one category less intense (i.e., “Very Light” instead of “Light”).

**Table 2.14: Visibilities and Associated Snow Precipitation Rates (Below -1°C, Day)
Using Modern Data Only**

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	8%	54%	38%	Heavy	836	0.0%	14.2%
0.5	2%	61%	36%	1%	Moderate	456	1.3%	37.5%
0.75	22%	67%	10%	0%	Light	278	10.8%	77.7%
1	39%	53%	7%	0%	Light	213	7.5%	60.6%
1.25	60%	40%	0%	0%	Light	116	0.0%	39.7%
1.5	81%	19%	0%	0%	Light	102	0.0%	18.6%
1.75	77%	22%	2%	0%	Light	60	1.7%	23.3%
2	84%	15%	1%	0%	Light	68	1.5%	16.2%
2.5	89%	9%	1%	0%	Very Light	75	10.7%	N/A
3	92%	5%	3%	0%	Very Light	39	7.7%	N/A
3.5 +	98%	2%	0%	0%	Very Light	209	2.4%	N/A

**Table 2.15: Visibilities and Associated Snow Precipitation Rates (-1°C and Above, Day)
Using Modern Data Only**

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	1%	28%	71%	Heavy	112	0.0%	21.4%
0.5	3%	22%	70%	5%	Moderate	101	5.0%	75.2%
0.75	4%	64%	27%	4%	Moderate	70	4.3%	31.4%
1	28%	62%	11%	0%	Light	47	10.6%	72.3%
1.25	25%	53%	19%	3%	Light	32	21.9% *	75.0%
1.5	54%	46%	0%	0%	Light	24	0.0%	45.8%
1.75	67%	33%	0%	0%	Light	12	0.0%	33.3%
2	61%	35%	4%	0%	Light	23	4.3%	39.1%
2.5	71%	17%	13%	0%	Light	24	12.5%	29.2%
3	67%	22%	11%	0%	Light	18	11.1%	33.3%
3.5 +	86%	11%	3%	0%	Very Light	101	13.9%	N/A

*Accepted due to lower underestimate percentage at a lesser visibility range.

To determine the recommended snowfall intensity values for nighttime visibility conditions, the analysis was repeated on the converted “night” database. Summaries of these analyses are shown below in Table 2.16 (for data collected below -1°C) and in Table 2.17 (for data collected at -1°C and above).

**Table 2.16: Visibilities and Associated Snow Precipitation Rates (Below -1°C, Night)
Using Modern Data Only**

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	0%	9%	91%	Heavy	211	0.0%	49.3%
0.5	0%	2%	67%	31%	Heavy	367	0.0%	3.8%
0.75	0%	31%	65%	4%	Moderate	399	3.5%	68.7%
1	2%	66%	31%	1%	Moderate	268	0.7%	32.1%
1.25	12%	74%	14%	0%	Light	186	14.0%	87.6%
1.5	31%	61%	7%	1%	Light	168	7.7%	69.0%
1.75	36%	56%	8%	1%	Light	144	8.3%	63.9%
2	58%	40%	2%	0%	Light	143	2.1%	42.0%
2.5	78%	22%	0%	0%	Light	136	0.0%	22.1%
3	82%	17%	1%	0%	Light	82	1.2%	18.3%
3.5 +	95%	5%	1%	0%	Very Light	348	5.5%	N/A

**Table 2.17: Visibilities and Associated Snow Precipitation Rates (-1°C and Above, Night)
Using Modern Data Only**

Visibility Value (miles)	Precipitation Range				Assigned Snowfall Intensity	# of Rate Data Points in Visibility Range	Underestimate %	
	Very Light	Light	Moderate	Heavy			At Current Assigned Snowfall Intensity	At Less Intense Snowfall Intensity
	0 to 4	4 to 10	10 to 25	≥ 25				
0.25	0%	0%	0%	100%	Heavy	12	0.0%	75.0%
0.5	0%	0%	18%	82%	Heavy	71	0.0%	19.7%
0.75	0%	4%	77%	20%	Heavy	56	0.0%	3.6%
1	2%	28%	63%	7%	Moderate	54	7.4%	70.4%
1.25	6%	47%	45%	2%	Moderate	51	2.0%	47.1%
1.5	5%	72%	19%	5%	Moderate	43	4.7%	23.3%
1.75	34%	54%	11%	0%	Light	35	11.4%	65.7%
2	21%	55%	21%	3%	Light	33	24.2% *	78.8%
2.5	51%	49%	0%	0%	Light	37	0.0%	48.6%
3	64%	36%	0%	0%	Light	14	0.0%	35.7%
3.5 +	79%	15%	6%	0%	Very Light	158	20.9% **	N/A

* Accepted due to lower underestimate percentage at a lesser visibility range.

** Accepted due to removal of rates below 0.5 g/dm²/h.

The percentage of total data points within the modern data set categorized as accurate, underestimates, or overestimates is presented in Table 2.18.

Table 2.18: Data Distribution of Modern Data set

Category	Day		Night		Day
	Below -1°C	-1°C and Above	Below -1°C	-1°C and Above	
Underestimate	3%	7%	4%	9%	6%
Accurate	40%	49%	49%	49%	47%
Overestimate	57%	44%	47%	42%	47%

Once again, this methodology leads to a very small percentage of underestimates and an equal chance of an overestimation as an accurate estimation.

Table 2.19 and Table 2.20 present the results of the frequency analysis using only the modern data. Cells with red font indicate a change to a more restrictive category, while cells with blue font indicate a change to a less restrictive category.

Table 2.19: Analysis Recommendations with Modern Data (vs. TC Table)

Statute Miles	Meters	Day		Night	
		Below -1°C Below 30°F	-1°C and above 30°F and above	Below -1°C Below 30°F	-1°C and above 30°F and above
≤1/4 (≤3/8)	≤400 (≤600)	Heavy	Heavy	Heavy	Heavy
1/2 (>3/8 to ≤5/8)	800 (>600 to ≤1000)	Moderate	Moderate	Heavy	Heavy
3/4 (>5/8 to ≤7/8)	1200 (>1000 to ≤1400)	Light	Moderate	Moderate	Heavy
1 (>7/8 to ≤1 1/8)	1600 (>1400 to ≤1800)	Light	Light	Moderate	Moderate
1 ¼ (>1 1/8 to ≤1 3/8)	2000 (>1800 to ≤2200)	Light	Light	Light	Moderate
1 ½ (>1 3/8 to ≤1 5/8)	2400 (>2200 to ≤2600)	Light	Light	Light	Moderate
1 ¾ (>1 5/8 to ≤1 7/8)	2800 (>2600 to ≤3000)	Light	Light	Light	Light
2 (>1 7/8 to ≤2 ¼)	3200 (>3000 to ≤3600)	Light	Light	Light	Light
2 ½ (>2 ¼ to ≤2 ¾)	4000 (>3600 to ≤4400)	Very Light	Light	Light	Light
3 (>2 ¾ to ≤3 ¼)	4800 (>4400 to ≤5200)	Very Light	Light	Light	Light
≥3 ½ (>3 ¼)	≥5600 (>5200)	Very Light	Very Light	Very Light	Very Light

Table 2.20: Analysis Recommendations with Modern Data (vs. FAA Table)

Statute Miles	Meters	Day		Night	
		-1°C and below 30°F and below	Above -1°C Above 30°F	-1°C and below 30°F and below	Above -1°C Above 30°F
≤1/4 (≤3/8)	≤400 (≤600)	Heavy	Heavy	Heavy	Heavy
1/2 (>3/8 to ≤5/8)	800 (>600 to ≤1000)	Moderate	Moderate	Heavy	Heavy
3/4 (>5/8 to ≤7/8)	1200 (>1000 to ≤1400)	Light	Moderate	Moderate	Heavy
1 (>7/8 to ≤1 1/8)	1600 (>1400 to ≤1800)	Light	Light	Moderate	Moderate
1 ¼ (>1 1/8 to ≤1 3/8)	2000 (>1800 to ≤2200)	Light	Light	Light	Moderate
1 ½ (>1 3/8 to ≤1 5/8)	2400 (>2200 to ≤2600)	Light	Light	Light	Moderate
1 ¾ (>1 5/8 to ≤1 7/8)	2800 (>2600 to ≤3000)	Light	Light	Light	Light
2 (>1 7/8 to ≤2 ¼)	3200 (>3000 to ≤3600)	Light	Light	Light	Light
2 ½ (>2 ¼ to ≤2 ¾)	4000 (>3600 to ≤4400)	Very Light	Light	Light	Light
3 (>2 ¾ to ≤3 ¼)	4800 (>4400 to ≤5200)	Very Light	Light	Light	Light
≥3 ½ (>3 ¼)	≥5600 (>5200)	Very Light	Very Light	Very Light	Very Light

The results derived using the modern data set lead to more restrictive recommendations at higher visibilities and some less restrictive recommendations at lower visibilities. However, this data set is limited in comparison to the historical data set. As a result, the recommendations from the combined data set should be prioritized until the modern data set is more robust.

2.6 Conclusions

Following the addition of modern sensor visibility data collected from 2018 to 2025 to the visibility data collected from 1995 to 2002, the combined and modern data sets were analysed with the objective of harmonizing the differences between the TC and FAA visibility tables.

The combined data set did not support further harmonization of the snowfall intensities within the visibility tables. The obstacle to harmonization is primarily driven by the presence of outliers and the conservative nature of the frequency approach, especially if the 14 percent underestimate percentage is taken as a hard limit. This approach results in overestimation of snowfall intensity more frequently than accurate classification.

However, analysing the impact of temperature on visibility within the modern and historical data sets produced results suggesting that harmonization of temperature bands could be achieved by including -1°C in the cold category.

Additionally, there was also a noticeable difference between the historical and modern data sets, with the modern data supporting a slightly less restrictive recommendation. This could be due to the higher precision and resolution of the more modern sensors.

The outliers within the modern data set can be examined, and alternative methodologies for evaluating the appropriate snowfall intensities should be further explored with the goal of approaching harmonization between the TC and FAA tables.

2.7 Future Development

This subsection will present new research paths and analysis methodologies to be included in the future development of the visibility tables.

2.7.1 Regression Methodology

A regression-based methodology could be employed as an alternative to the previously used frequency methodology. This method would utilise the power-law relationship that exists between visibility and precipitation rate to more accurately assign visibility ranges with their appropriate snowfall intensity. It would also eliminate irregularities caused by poor data distribution and provide more nuance to the risk of underestimates.

Figure 2.4 displays the power-law relationship between precipitation rate and visibility using the modern unconverted daytime data in temperatures at or below -1°C . It also includes upper and lower bounds that represent the expected extremes of precipitation rates given a measured visibility. The upper bound would indicate the worst-case precipitation rate for a given visibility at a specified confidence level. This value can then be compared to the precipitation rate limit of the assigned snowfall intensity to evaluate the buffer or risk that exists.

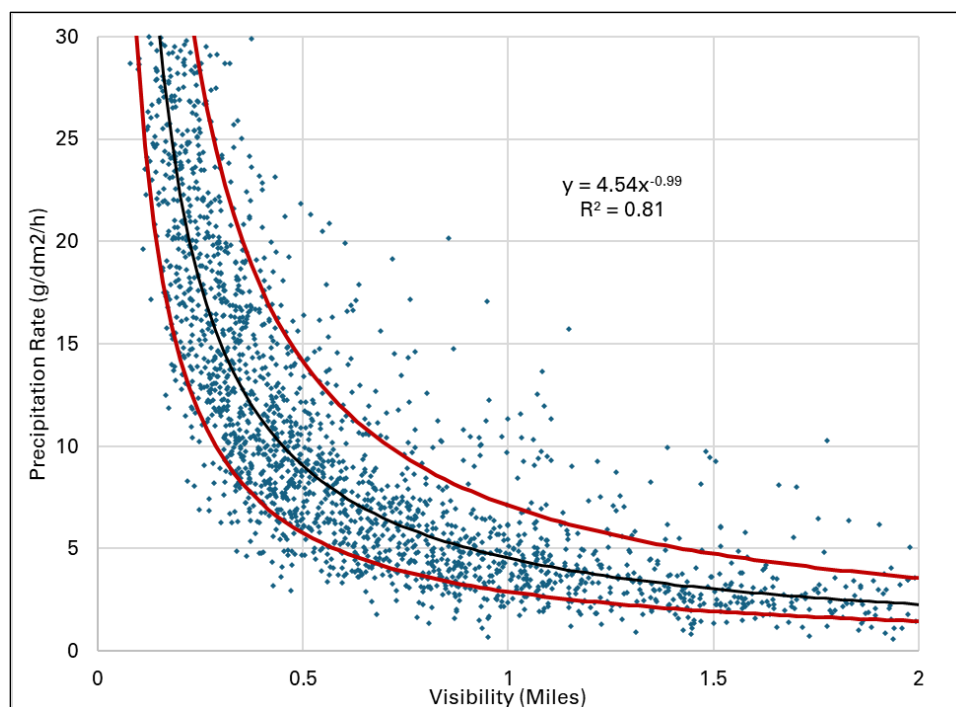


Figure 2.4: Example Regression Methodology (2018-2025 Data, Cold, Day)

2.7.2 Additional Data Cleaning

The reasons for a large portion of the outliers within the data sets are understood and sometimes accounted for. However, issues with data collection or data handling have never been explored. Preliminary analyses have indicated that the current methodology, which acquires data points by averaging instantaneous visibility measurements recorded over a given rate period, could be resulting in averaged visibilities that are inaccurate to the true measured visibilities. Table 2.21 presents an example of an unstable rate period.

Table 2.21: Example Effect of Unstable Rate Period

Period	Precipitation Rate (g/dm²/h)	Visibility (miles)
First 5 Minutes	1.0	3.1
Last 5 Minutes	10.0	0.6
Average (10 Minutes)	5.5	1.8
Expected	5.5	0.9
Difference from Expected	0%	100%

Averaging the visibility across an unstable rate period artificially linearizes the relationship and leads to averaged visibilities that are not representative of the actual measured rate versus visibility relationship in those weather conditions.

It is possible that a large portion of the observed variance in measured visibilities can be attributed to this methodology. Therefore, the modern data set should be re-examined, removing data points from unstable rate periods. Future work is required to correctly identify the level of stability that constitutes a usable stable data point and to complete the analysis with only these data points.

2.7.3 METAR Versus Sensor Visibilities

As part of a validation exercise, reported human-observed METAR visibilities at YUL from 2018 to 2025 were compared to the equivalent sensor visibilities found in the modern data set. Preliminary analyses showed that, even when controlling for time of day, the METAR visibilities were greater than the sensor visibilities. This finding could suggest that if pilots use the YUL METAR visibilities, the likelihood of underestimating the snowfall intensity increases. Further studies are required to explore the extent of this issue and evaluate if it is only isolated to YUL or if it is systemic to human observers.

2.8 Recommendations

The research and analysis conducted in 2024-25 led to the following recommendations for future work related to the development and harmonization of the TC and FAA visibility tables.

- Investigating the found discrepancies between the sensor visibilities and the YUL METAR visibilities and exploring if this issue exists at other airports.
- Continuing to bolster the data set through passive data collection. The improved resolution and accuracy at lower visibilities indicate that less restrictive guidance could be possible through more data collection.
- Harmonizing the temperature categories. The current data suggests a real possibility.
- Developing and accepting a new regression-based methodology and defining the acceptable risk in this method.
- Further data cleaning based on pruning data points with unstable rates. This also includes defining what stability is required for a valid data point.

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Photo 2.1: Parsivel² Disdrometer



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3. A COMPREHENSIVE EVALUATION OF MIST AND FREEZING FOG DEPOSITION RATES

This section documents the work completed during the period between 2020-21 and 2024-25 related to the investigation of mist and freezing fog deposition rates. The data obtained during these yearly periods is included in this report and kept separate for simplicity. A comprehensive analysis comprising all data from all years was also conducted.

3.1 Background

Mist (METAR code BR) and freezing fog (METAR code FZFG) are commonly reported weather phenomena. Both are considered obscurations rather than precipitation types and can be reported alone or in conjunction with other weather conditions, such as snow and freezing rain. In terms of visibility, mist can reduce visibility to between 0.6 and 1.2 statute miles (≈ 1 -2 km), while fog reduces it to less than 0.6 statute mile (≈ 1 km).

The deposition rates for freezing fog were quantified in the early 2000s and re-evaluated in 2021-22 through 2024-25. Historical research simulating an aircraft taxiing in freezing fog indicated that the deposition rates can increase significantly when in motion. After much discussion, freezing fog rates of 2 to 5 g/dm²/h were selected for developing holdover times (HOTs). For more information concerning this study, see Subsection 2.9 of the Transport Canada (TC) report, TP 13826E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2000-01 Winter* (6).

The deposition rates for mist were first quantified in 2020-21, and the scope of the research was expanded in 2021-22 and beyond to include freezing fog as well. This research is set to continue in the winter of 2025-26 as part of the Mixed Phase Icing Conditions Project and is required to support the continued development of HOT guidance for both mist and freezing fog.

3.2 Objective

The objective of this study is to determine the range of deposition rates that occur naturally in conditions of mist or freezing fog alone. This research is required to support and develop guidance for the appropriate investigation of mist and freezing fog for HOT determination.

3.3 Overview of Research Conducted

The following subsections describe the research conducted during the winters of 2020-21 through 2024-25. A summary of the work conducted, as well as the respective reports, is included in Table 3.1.

Table 3.1: Summary of Work

Winter Testing	Report	Data Included	Comments
2020-21	TP 15496E	2020-21	Data collection was limited to mist. Recommendation was to include mist in the HOT tables when mist is reported alone.
2021-22	TP 15536E	2021-22	Report included data from 2021-22 only. Mist, freezing fog, and fog data were collected. No analysis was conducted as testing was to continue in Winter 2022-23.
2022-23	TP 15559E	2021-22 & 2022-23	Report included data from 2021-22 and 2022-23. Mist, freezing fog, and fog data were collected. No analysis was conducted as testing was to continue in Winter 2023-24.
2023-24	TP 15608E	2001-02 & 2020-24	Report included data from 2001-02 and from 2020-24. Mist, freezing fog, and fog data were collected. Comprehensive analysis was conducted. Testing will continue in Winter 2024-25 to complete data requirements.
2024-25	TP 15608E	2001-02 & 2020-25	Report included data from 2001-02 and from 2020-25. Mist, freezing fog, and fog data were collected. A final comprehensive analysis was conducted for the time being. Research to continue in near future focusing on additional data collection with freezing drizzle and a corresponding detailed risk assessment.

3.3.1 2020-21 Testing Summary

During the winter of 2020-21, APS Aviation Inc. (APS) was tasked by TC and the Federal Aviation Administration (FAA) to conduct testing to determine the deposition rates of mist alone. Mist deposition rates were thus determined using the standard HOT methodology. The mist accretion rate was found to be 0.2 g/dm²/h, on average, for the stationary tests. The taxiing tests increased this accretion rate to 0.3 g/dm²/h, on average. The range of mist rates was thus calculated to be between 0.08 and 0.4 g/dm²/h. This range is comparable to that of frost but still greater than the maximum rate of frost ever observed within the last two decades. Therefore, to ensure operational safety, freezing mist was added to the “Freezing Fog and Ice Crystals” column of the generic HOT tables and not to that of the generic HOTs of frost.

3.3.2 2021-22 and 2022-23 Testing Summary

As mentioned in Subsection 3.1, freezing fog and fog testing emerged from discussions within the SAE International (SAE) G-12 HOT Committee (May 2021 SAE conference). Prior to this, freezing fog deposition rates were determined in the early 2000s. The committee recommended that the substantiation of freezing fog deposition rates be conducted to provide an intensity comparison to those of mist.

An analysis of the data obtained in 2021-22 and 2022-23 was not performed, as the obtained data was limited due to infrequent testing events. Therefore, an analysis was to be conducted in a subsequent year so that a more comprehensive assessment for both mist and freezing fog could be done. This assessment was to include all data collected from all years.

3.3.3 2023-24 Testing Summary

As mentioned in Subsection 3.3.2, no analysis was conducted in 2022-23 due to the limited data from infrequent testing events. However, by the end of the 2023-24 testing season, enough data was collected so that a comprehensive analysis could be done involving all years. This analysis is included in Subsection 3.7 of this report.

3.3.4 2024-25 Testing Summary

Although a significant amount of data was collected in previous years up to the 2024-25 season, data in the cooler temperatures was lacking. Therefore, the focus during the 2024-25 winter season was to obtain data in the colder temperatures of 2°C and below. A comprehensive analysis was then conducted with all available data and is presented in Subsection 3.7 of this report.

3.4 Mist and Freezing Fog Forecasting

The winter weather conditions listed below were targeted when trying to forecast mist or freezing fog conditions for testing purposes.

- Mist: Surface visibility greater than or equal to 5/8 statute mile (≈ 1 km) and less than 7 miles (≈ 11 km).
- Freezing fog: Surface visibility less than 5/8 statute mile (≈ 1 km).
- Outside air temperature (OAT) $< 2^{\circ}\text{C}$. Most mist and freezing fog observations are at temperatures above -4°C , with many occurring near 0°C . Mist and freezing fog are also infrequently reported at temperatures colder than -4°C .

- High relative humidity > 90 percent, best if closer to 100 percent.
- Overcast sky cover. Low ceiling suggests more intense mist or freezing fog below 800 ft. (≈ 240 m).
- No precipitation concurrent with mist or freezing fog (for the purpose of this research).
- Sustained wind speed < 9 knots (≈ 15 km/h).
- Precipitation occurring before the expected period of mist, as this increases relative humidity in the air.

An analysis of historical METAR reports from the Montréal–Pierre Elliott Trudeau International Airport (YUL) was conducted to determine the ideal time for the occurrence of mist or fog alone. It was found that the beginning of winter, early mornings, and temperatures around the freezing point (0°C) are the most favourable winter conditions. More details on this analysis can be found in Appendix C.

3.5 Testing Procedure

During the winters of 2020-21 through 2024-25, mist and freezing fog/fog tests were carried out at the APS test facility in Montreal, at the Montréal–Mirabel International Airport (YMX), in Chomedey (Laval), Beaconsfield (Montreal), and Senneville (Montreal). As this study was comparative in nature, mist deposition rates were captured simultaneously using two measurement methods. The first and second methods simulated a taxiing and a stationary aircraft, respectively. Both testing methods were conducted using the standard precipitation collection pan, which is used for standard HOT testing. For the first method (taxiing), the rate pan was mounted on the top of a test vehicle and driven for 30 minutes at approximately 30 km/h, as seen in Photo 3.1. The second method (stationary) was performed using the standard method of collecting precipitation rates (using a test stand), as seen in Photo 3.2.

Generally, the tests began on the hour, in coordination with issued METAR reports. The targeted METARs were those that stated mist or fog to be present and confirmed as visible by the researcher, as seen in Photo 3.3 and Photo 3.4. However, in some instances, mist or fog was visually observed but not reported by METAR (see Photo 3.5). Therefore, the decision was made to conduct testing for all events that forecasted mist or fog (within reason), regardless of mist or fog being reported by METAR, if it was visually observed at the time of testing. For a more detailed description of the methodologies employed during mist or fog testing, refer to Appendix D. For an illustration of visually observed mist or fog at various rates, refer to Figure 3.1.



Figure 3.1: Illustration of Varying Mist and Fog Rates

3.5.1 Procedural Updates Implemented as of Winter 2021-22

The results of the 2020-21 testing were presented to the SAE G-12 HOT Committee at the May 2021 conference, and the stakeholders recommended the following changes/additions to the testing procedure:

- Addition of dry rate pans to determine if mist or freezing fog accretion rates are similar when comparing a dry wing to a fluid-covered wing (Photo 3.6 and Photo 3.7); and
- Addition of temperature loggers to determine freezing or non-freezing conditions.

3.6 Data Collected

The following subsections describe the data that was collected in 2001-02 and from 2020-21 through 2024-25.

3.6.1 Historic APS Data Collected in 2001-02

Five tests were conducted during 2001-02 at various times of the day and night. One of the tests was carried out two years earlier and has been included with this report. Two of these six tests included a stationary test. The tests are listed in Table 3.2. The table shows the OAT, the average travel speed, the rate in relation to visibility for each test, and the rate normalized to a travel speed of 30 km/h so that a direct comparison can be made to the data collected from 2020-25. An important note from that study suggested that using rates of 2 and 5 g/dm²/h as endurance time (ET) parameters appears to be conservative since the Canadian Aviation Regulations (CARs) 624.14 and 725.34 indicated that the lowest actual visibility limit for departures under instrument meteorological conditions is 183 m (600 ft.).

Table 3.2: Fog/Freezing Fog Deposition Measurement Summary

Date	Test Type	Visibility (m)	OAT (°C)	Travel Speed (km/h)	Observed Rate (g/dm ² /h)	Rate Normalized to 30 km/h (g/dm ² /h)
2000	Taxi	152	14.0	27.0	1.29	1.43
01-Nov-01	Taxi	201	3.0	31.0	0.36	0.35
05-Nov-01	Taxi	137	5.5	38.6	1.80	1.40
06-Dec-01	Taxi	46	11.1	34.4	2.50	2.18
24-Dec-01	Taxi	457	-3.9	23.3	0.16	0.21
31-Mar-02	Taxi	274	0.1	38.9	0.68	0.52
06-Dec-01	Stationary	46	11.1	Static	0.22	-
24-Dec-01	Stationary	457	-3.9	Static	0.11	-

3.6.2 NCAR METAR Data

METAR data for pristine freezing fog was obtained from the National Center for Atmospheric Research (NCAR), as illustrated in Figure 3.2. This data corresponds to 508 freezing fog events between the years 2010 and 2022 at locations in the United States. In addition to this, several parameters associated with the data were also obtained and are shown in Table 3.3. Note that from Table 3.3, the 82nd percentile was determined by APS using the data in Figure 3.2 and is thus an approximate value.

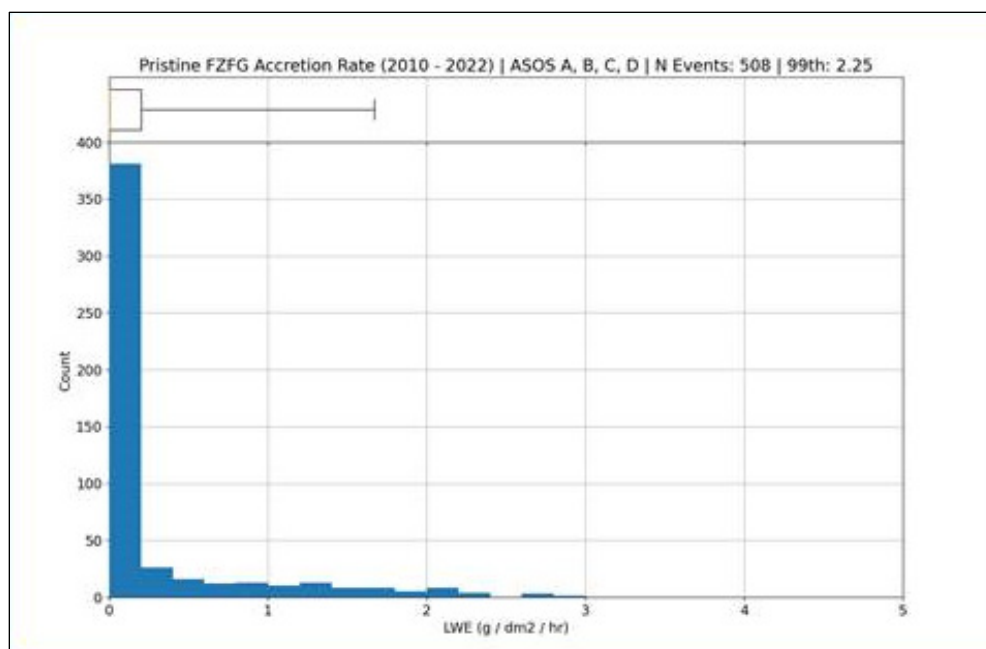


Figure 3.2: Pristine Freezing Fog METAR Data Obtained from NCAR

Table 3.3: Parameters Associated with Figure 3.2

Average Rate	Standard Deviation	50 th Percentile	67 th Percentile	*82 nd Percentile	90 th Percentile	95 th Percentile	99 th Percentile
0.27	0.56	0.2	0.2	0.55	1.1	1.6	2.25

Note: All parameters are in units of g/dm²/h.

* Approximate value determined by APS.

3.6.3 APS Data Collected in 2020-21

The following subsections describe the data that was collected during the Winter 2020-21 testing season. In total, 37 tests were conducted at YUL, Ottawa International Airport (YOW), and YMX. Of the 37 tests, 13 occurred with mist being visibly present regardless of whether it was reported by METAR, while one was reported by METAR but not visibly present. These tests were included in the analysis and are presented in the following subsections.

The remaining 23 tests were conducted on December 4 and 5, 2020, and on January 13 and 15, March 10 and 21, and April 7, 2021, when mist was neither visually present nor reported by METAR. Collection for these tests was done due to previous mist forecasts. On average, the precipitation rates ranged from 0 to 0.06 g/dm²/h according to both test methods. These positive rates may have been obtained from mist and/or any other type of precipitation (e.g., light freezing rain, freezing drizzle). Due to the unknown form of precipitation, these 23 tests were excluded from the analysis.

3.6.3.1 Tests with Mist Reported by METAR but NOT Visible

In total, one test was conducted with mist being reported by METAR but *not* visibly present during the 2020-21 testing season. Table 1 in Appendix E presents the information collected related to that data point.

3.6.3.2 Tests with Visible Mist and Mist Reported by METAR

In total, five tests were conducted with mist being visible and reported by METAR during the 2020-21 testing season. Table 2 in Appendix E presents a summary of the data collected.

3.6.3.3 Tests with Visible Mist and Mist NOT Reported by METAR

In total, eight tests were conducted with mist being visible but *not* reported by METAR during the 2020-21 testing season. Table 3 in Appendix E presents a summary of the data collected.

3.6.3.4 Tests Not Included in Data Set

In total, 23 tests were omitted from the test logs in Table 2 and Table 3 found in Appendix E. For 22 of the tests, no mist or fog was observed or reported, while one was omitted due to the unreliable verification of mist being present. Table 4 in Appendix E summarizes the data pertaining to these tests.

3.6.4 Data Collected in 2021-22

The following subsections describe the data that was collected during the Winter 2021-22 testing season.

In total, 40 tests were conducted at YUL, YMX, Chomedey (Laval), and the Beaconsfield suburb of Montreal. Of the 40 tests, 35 occurred with mist or fog being visibly present regardless of whether it was reported by METAR. The remaining five tests were conducted on October 8 and 13, 2021, and on March 25, 2022, when mist was no longer visible during testing regardless of whether it was reported by METAR. Collection for these tests was done due to preceding mist forecasts. The rates were 0 g/dm²/h using both test methods.

The data is separated into two categories: data with visible mist/fog and reported by METAR and data with visible mist/fog but NOT reported by METAR. The two types of data are presented in the following subsections.

3.6.4.1 Tests with Visible Mist/Freezing Fog/Fog Reported by METAR

In total, 18 tests were conducted with mist being visible and reported by METAR during the 2021-22 testing year. Table 2 in Appendix E summarizes the data collected.

3.6.4.2 Tests with Visible Mist/Freezing Fog/Fog NOT Reported by METAR

In total, 16 tests were conducted with mist being visible but NOT reported by METAR during the 2021-22 testing year. Table 3 in Appendix E summarizes the data collected.

3.6.4.3 Tests Not Included in Data Set

In total, six tests were omitted from the test logs in Table 2 and Table 3 found in Appendix E. For two of the tests, no mist or fog was observed or reported, while the other four were omitted due to unreliable data or errors. Table 4 in Appendix E summarizes the data pertaining to these tests.

3.6.5 Data Collected in 2022-23

The following subsections describe the data that was collected during the Winter 2022-23 testing season.

In total, 48 tests were conducted at YUL and the Senneville suburb of Montreal. Of the 48 tests, 44 occurred with mist or fog being visibly present regardless of whether it was reported by METAR. The remaining four tests were conducted on April 17, 2023, when no mist was visually present or reported by METAR. Collection for these tests was done due to preceding mist forecasts. The rates were on average 0.18 g/dm²/h using both test methods.

As explained in Subsection 3.6.4, the data collected in 2022-23 was also separated into two categories, as outlined in the following subsections.

3.6.5.1 Tests with Visible Mist/Freezing Fog/Fog Reported by METAR

In total, 10 tests were conducted with mist being visible and reported by METAR during the 2022-23 testing year. Table 2 in Appendix E summarizes the data collected.

3.6.5.2 Tests with Visible Mist/Freezing Fog/Fog NOT Reported by METAR

In total, 34 tests were conducted with mist or fog being visible but NOT reported by METAR during the 2022-23 testing year. Table 3 in Appendix E summarizes the data collected.

3.6.5.3 Tests Not Included in Data Set

In total, four tests were omitted from the test logs in Table 2 and Table 3 found in Appendix E. For all tests, no mist or fog was observed or reported. Table 4 in Appendix E summarizes the data pertaining to these tests.

3.6.6 Data Collected in 2023-24

The following subsections describe the data that was collected during the Winter 2023-24 testing season.

In total, 24 tests were conducted at YUL. Of the 24 tests, 14 occurred with mist or fog being visibly present regardless of whether it was reported by METAR. The remaining 10 tests were conducted on January 31, 2024, and March 3, 2024. Collection for these tests was done due to preceding mist forecasts when mist was neither visually present nor reported by METAR or reported by METAR in conjunction with light drizzle. On average, the rates ranged from 0 to 1.53 g/dm²/h using both test methods. These 10 tests were excluded from the analysis.

As explained in Subsection 3.6.4, the data collected in 2023-24 was also separated into two categories, as outlined in the following subsections.

3.6.6.1 Tests with Visible Mist/Freezing Fog/Fog Reported by METAR

In total, six tests were conducted with mist being visible and reported by METAR during the 2023-24 testing year. Table 2 in Appendix E summarizes the data collected.

3.6.6.2 Tests with Visible Mist/Freezing Fog/Fog NOT Reported by METAR

In total, eight tests were conducted with mist or fog being visible but NOT reported by METAR during the 2023-24 testing year. Table 3 in Appendix E summarizes the data collected.

3.6.6.3 Tests Not Included in Data Set

In total, 10 tests were omitted from the test logs in Table 2 and Table 3 found in Appendix E. For two tests, no mist or fog was observed or reported, while for the remaining eight tests, light drizzle/mist was reported by METAR. Table 4 in Appendix E summarizes the data pertaining to these tests.

3.6.7 Data Collected in 2024-25

The following subsections describe the data that was collected during the Winter 2024-25 testing season.

In total, 26 tests were conducted at YUL. All tests occurred with mist or fog being visibly present regardless of whether it was reported by METAR.

As explained in Subsection 3.6.4, the data collected in 2024-25 was also separated into two categories, as outlined in the following subsections.

3.6.7.1 Tests with Visible Mist/Freezing Fog/Fog Reported by METAR

In total, 20 tests were conducted with mist or freezing fog/fog being visible and reported by METAR during the 2024-25 testing year. Table 2 in Appendix E summarizes the data collected.

3.6.7.2 Tests with Visible Mist/Freezing Fog/Fog NOT Reported by METAR

In total, six tests were conducted with mist being visible but NOT reported by METAR during the 2024-25 testing year. Table 3 in Appendix E summarizes the data collected.

3.6.8 Summary of Data Collected from 2001-02 and from 2020-21 Through 2024-25

A summary of the data collected for both fog/freezing fog and mist/freezing mist is presented in Table 3.4 and Table 3.5. For details pertaining to each data point collected in the latter conditions from 2020-21 through 2024-25, a log of tests has been compiled and can be found in Appendix E. For data pertaining to testing from 2001-02, the details can be found in Table 3.2.

Table 3.4: Summary of Fog/Freezing Fog Data Collected in 2001-02 and from 2020-21 Through 2024-25

Number of Data Points (#)	Type of Test Conducted (Taxi or Stationary)	Pan Used (Wet or Dry)	Temperature Range (°C)	Fog/Freezing Fog Rate Range (g/dm ² /h)
20	Taxi	Wet	-4 to 14	0.21 to 2.4
16	Stationary	Wet	-4 to 11	0.11 to 0.6
14	Taxi	Dry	0 to 10	0 to 0.7
15	Stationary	Dry	0 to 10	0 to 0.6

Table 3.5: Summary of Mist/Freezing Mist Data Collected from 2020-21 Through 2024-25

Number of Data Points (#)	Type of Test Conducted (Taxi or Stationary)	Pan Used (Wet or Dry)	Temperature Range (°C)	Mist/Freezing Mist Rate Range (g/dm ² /h)
53	Taxi	Wet	-5 to 17	0.1 to 1.65
53	Stationary	Wet	-5 to 17	0 to 0.5
43	Taxi	Dry	-5 to 17	0 to 0.4
45	Stationary	Dry	-5 to 17	0 to 0.26

3.7 Data Analysis

An analysis of the data obtained in 2001-02 and from 2020-21 through 2024-25 was conducted, and the result of that assessment is presented in this subsection. Although the data from 2020-21 through 2024-25 was obtained by referencing METAR-observed Fog/Mist and/or visually observed Fog/Mist data (see Appendix E), for this analysis, all data was combined and exclusively separated by condition and capturing medium. This enabled a more comprehensive understanding of the results for both mist and freezing fog. The four categories that ensued from this separation are as follows:

- Fog/Freezing Fog using wet pan;
- Fog/Freezing Fog using dry pan;
- Mist/Freezing Mist using wet pan; and
- Mist/Freezing Mist using dry pan.

Note that for each of the above categories, both stationary and taxi tests were conducted.

For each category, the following parameters were determined:

- Number of tests conducted;
- Average rate;
- Rate range;
- Standard deviation;
- 90th percentile rate;
- One standard deviation rate;
- Rate obtained by regression analysis; and
- Most conservative rate.

A METAR data plot obtained from NCAR for the condition of Pristine Freezing Fog was also used as a means of comparison to all the data obtained by APS (historic and recent).

In addition to this, for each of the four categories listed above, the obtained data was further divided using specific temperature limits to better understand observed rates. Each of the parameters listed above was then determined and is presented in Table 3.6 through Table 3.9.

3.7.1 Summary of Most Conservative Rates at 2°C and Below

Although freezing mist and freezing fog only occur at temperatures below 0°C (32°F), from an operational perspective, the statistical data corresponding to a temperature of 2°C and below is considered conservative enough to mitigate the potential risk of freezing contamination without being too restrictive. This was determined by conducting a sensitivity analysis, which examined the obtained data separated into different temperature bands. This is reasonable to assume since the deposition rate is expected to be less at a temperature lower than 2°C, as subsequently explained. This is also in line with scientific literature. As such, the most conservative rates (highest) observed at 2°C and below for both the stationary and taxiing tests are considered the most relevant in terms of operations. A compilation of the most conservative rates observed from Table 3.6 through Table 3.9 at 2°C is provided in Table 3.10.

Table 3.6: Determined Statistical Parameters for Fog/Freezing Fog Using Wet Pan APS Data

Fog/Freezing Fog Wet Taxi								
Years 2001-02 & 2020-25	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	20	1.16	0.21 - 2.4	0.62	2.02	1.78	-	2.40
4°C and Cooler	13	1.03	0.21 - 2.4	0.72	1.96	1.75	0.974	2.40
2°C and Cooler	12	1.09	0.21 - 2.4	0.72	1.98	1.81	0.843	2.40
0°C and Cooler	4	0.42	0.21 - 0.52	0.14	0.51	0.57	0.731	0.52

Fog/Freezing Fog Wet Stationary								
Years 2001-02 & 2020-25	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	16	0.64	0.11 - 0.6	0.13	0.50	0.77	-	0.60
4°C and Cooler	11	0.38	0.11 - 0.6	0.14	0.50	0.52	0.36	0.60
2°C and Cooler	11	0.38	0.11 - 0.6	0.14	0.50	0.52	0.34	0.60
0°C and Cooler	3	0.29	0.11 - 0.39	0.15	0.38	0.44	0.32	0.39

Note: All data is in units of g/dm²/h.**Table 3.7: Determined Statistical Parameters for Fog/Freezing Fog Using Dry Pan APS Data**

Fog/Freezing Fog Dry Taxi								
Years 2020-25	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	14	0.19	0 - 0.7	0.22	0.47	0.41	-	0.70
4°C and Cooler	10	0.21	0.3 - 0.7	0.25	0.52	0.46	0.18	0.70
2°C and Cooler	10	0.21	0.3 - 0.7	0.25	0.52	0.46	0.20	0.70
0°C and Cooler	2	0.04	0.02 - 0.05	0.02	0.05	0.06	0.23	0.05

Fog/Freezing Fog Dry Stationary								
Years 2020-25	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	15	0.17	0 - 0.6	0.18	0.41	0.35	-	0.60
4°C and Cooler	10	0.17	0 - 0.6	0.18	0.33	0.34	0.17	0.60
2°C and Cooler	10	0.17	0 - 0.6	0.18	0.33	0.34	0.18	0.60
0°C and Cooler	2	0.05	0.03 - 0.07	0.03	0.07	0.08	0.18	0.07

Note: All data is in units of g/dm²/h.

Table 3.8: Determined Statistical Parameters for Mist/Freezing Mist Using Wet Pan APS Data

Mist/Freezing Mist Wet Taxi								
Years 2020-24	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	53	0.71	0.1 - 1.65	0.42	1.30	1.13	-	1.65
4°C and Cooler	39	0.59	0.1 - 1.65	0.40	1.12	1.00	0.584	1.65
2°C and Cooler	29	0.54	0.1 - 1.65	0.43	1.25	0.97	0.504	1.65
0°C and Cooler	17	0.38	0.2 - 1.0	0.25	0.78	0.62	0.434	1.00

Mist/Freezing Mist Wet Stationary								
Years 2020-24	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	53	0.24	0 - 0.5	0.11	0.40	0.35	-	0.50
4°C and Cooler	39	0.21	0 - 0.44	0.11	0.32	0.32	0.24	0.44
2°C and Cooler	29	0.20	0 - 0.44	0.12	0.32	0.31	0.22	0.44
0°C and Cooler	17	0.16	0 - 0.3	0.09	0.30	0.25	0.20	0.30

Note: All data is in units of g/dm²/h.**Table 3.9: Determined Statistical Parameters for Mist/Freezing Mist Using Dry Pan APS Data**

Mist/Freezing Mist Dry Taxi								
Years 2020-24	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	43	0.08	0 - 0.4	0.08	0.18	0.16	-	0.4
4°C and Cooler	28	0.07	0 - 0.4	0.08	0.10	0.15	0.07	0.4
2°C and Cooler	18	0.07	0 - 0.1	0.04	0.10	0.10	0.07	0.1
0°C and Cooler	7	0.07	0 - 0.1	0.04	0.10	0.11	0.07	0.1

Mist/Freezing Mist Dry Stationary								
Years 2020-24	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation	90 th Percentile Rate	One Standard Deviation Rate	Regression Equation Rate	Most Conservative Rate
All Data	45	0.07	0 - 0.26	0.06	0.10	0.13	-	0.26
4°C and Cooler	28	0.07	0 - 0.2	0.05	0.12	0.13	0.07	0.20
2°C and Cooler	18	0.09	0 - 0.2	0.05	0.12	0.13	0.07	0.20
0°C and Cooler	7	0.07	0 - 0.1	0.04	0.10	0.11	0.07	0.10

Note: All data is in units of g/dm²/h.

Table 3.10: Most Conservative Observed Rates for Fog/Freezing Fog and Mist/Freezing Mist at 2°C and Cooler

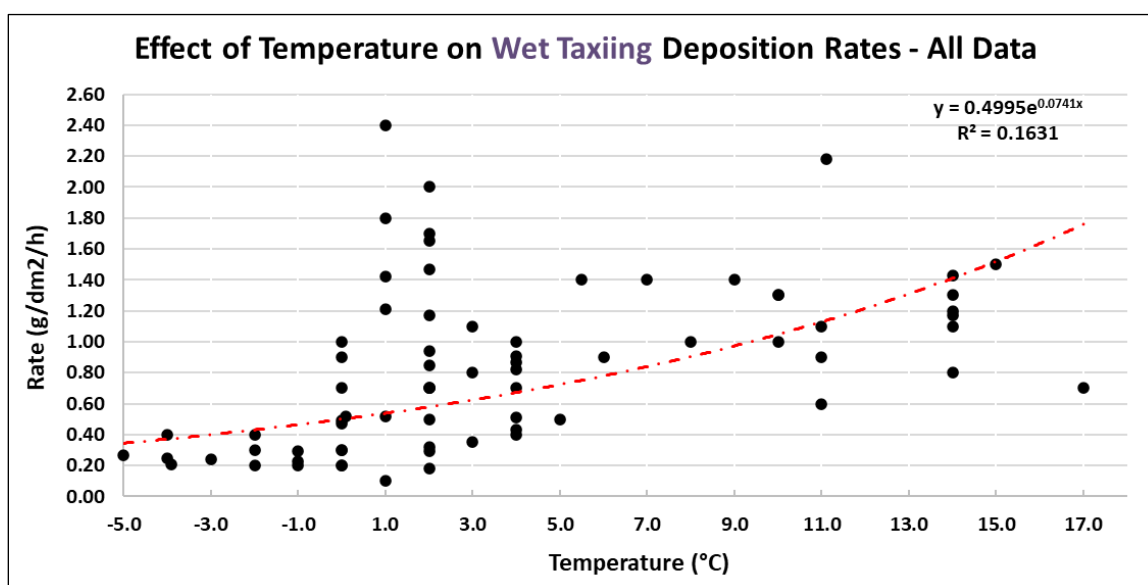
Simulated Taxiing				
Temperature	Fog/Freezing Fog Wet Pan	Fog/Freezing Fog <u>Dry</u> Pan	Mist/Freezing Mist Wet Pan	Mist/Freezing Mist <u>Dry</u> Pan
2°C and Cooler	2.4	0.7	1.65	0.1

Simulated Stationary				
Temperature	Fog/Freezing Fog Wet Pan	Fog/Freezing Fog <u>Dry</u> Pan	Mist/Freezing Mist Wet Pan	Mist/Freezing Mist <u>Dry</u> Pan
2°C and Cooler	0.6	0.6	0.44	0.2

Note: All data is in units of g/dm²/h.

3.7.2 Combined Fog/Freezing Fog and Mist/Freezing Mist Data (All Data) Wet Taxiing and Stationary Pan Analysis

All wet pan data obtained from 2001-02 and 2020-21 through 2024-25 was combined and plotted, as shown in Figure 3.3 for the wet taxiing pan and in Figure 3.4 for the wet stationary pan.

**Figure 3.3: Effect of Temperature on Wet Taxiing Deposition Rates**

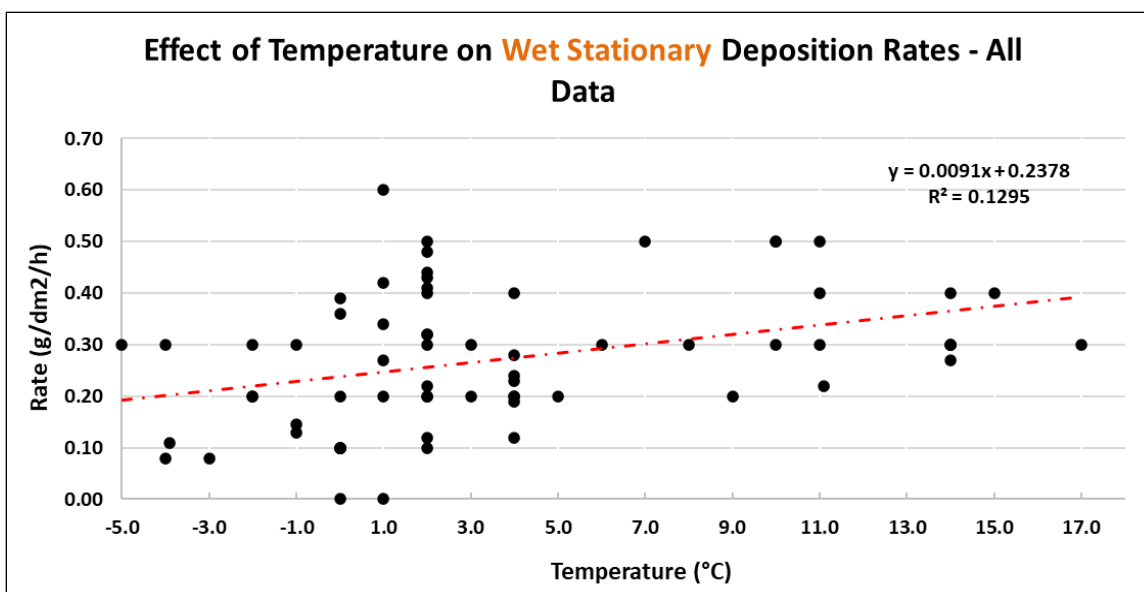


Figure 3.4: Effect of Temperature on Wet Stationary Deposition Rates

Figure 3.3 and Figure 3.4 illustrate the increasing trend that is observed when the rate is plotted with respect to temperature for both the wet taxiing and stationary pans. It is important to note that the trend in Figure 3.3 also corresponds to what is accepted in scientific literature (e.g., using the Antoine equation that represents the non-linear thermodynamic relationship between equilibrium vapor pressure, P , and temperature, T). Although a linear trend is observed in Figure 3.4, it is reasonable to assume that if more data is collected, the same non-linear trend would be observed as that seen in Figure 3.3.

3.7.3 Combined Fog/Freezing Fog and Mist/Freezing Mist Data (All Data) Dry Taxiing and Stationary Pan Analysis

The dry pan data for both the taxiing and stationary data was combined and analysed similarly to the wet pan analysis in Subsection 3.7.2; however, this data does not show any trend and, therefore, does not correlate to accepted literature. This is most likely due to the lack of a catching medium in this testing method. It is important to note that although no trend is observed with the dry pans, these rates are not considered as conservative as the wet pan rates. Therefore, focus should be placed exclusively on the wet pan data for determining any overall trends that are expected and accepted in scientific literature. Figure 3.5 and Figure 3.6 depict all the data obtained using the dry pans.

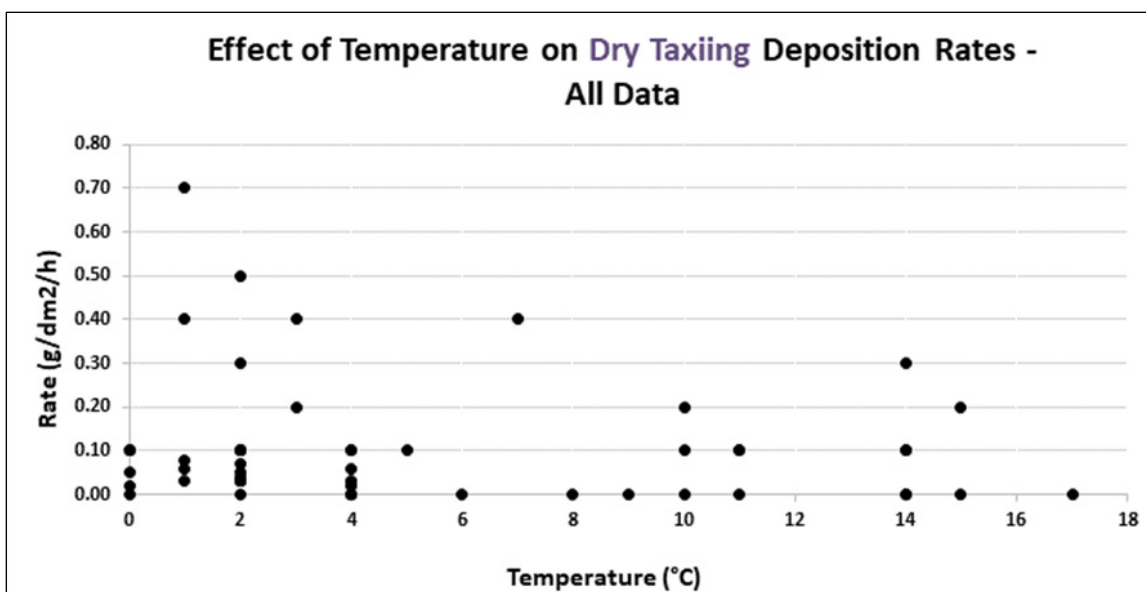


Figure 3.5: Effect of Temperature on Dry Taxiing Deposition Rates

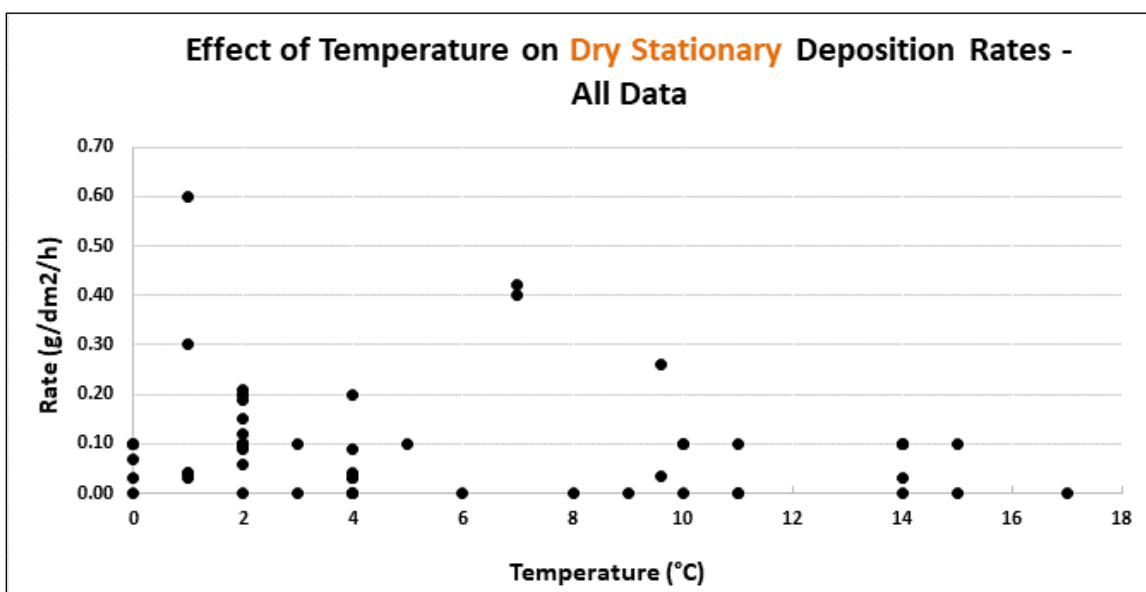


Figure 3.6: Effect of Temperature on Dry Stationary Deposition Rates

3.7.4 Correlation Between Reported and Observed Visibility for Fog/Freezing Fog Deposition Rates with a Taxiing and Stationary Wet and Dry Pan

The *METAR-reported* visibility was plotted against the fog/freezing fog wet taxiing and dry pan deposition rates to determine if a correlation exists, respectively. As seen in Figure 3.7 and Figure 3.8, no correlation is observed. The same uncorrelated trend is observed when plotting the *actual* visibility against the fog/freezing fog

deposition rates, as shown in Figure 3.9 and Figure 3.10. This is unexpected, as the visibility is anticipated to be reduced as the fog/freezing fog deposition rate increases, indicating that another factor is influencing the correlation. The justification describing this factor is discussed in Subsection 3.7.6.

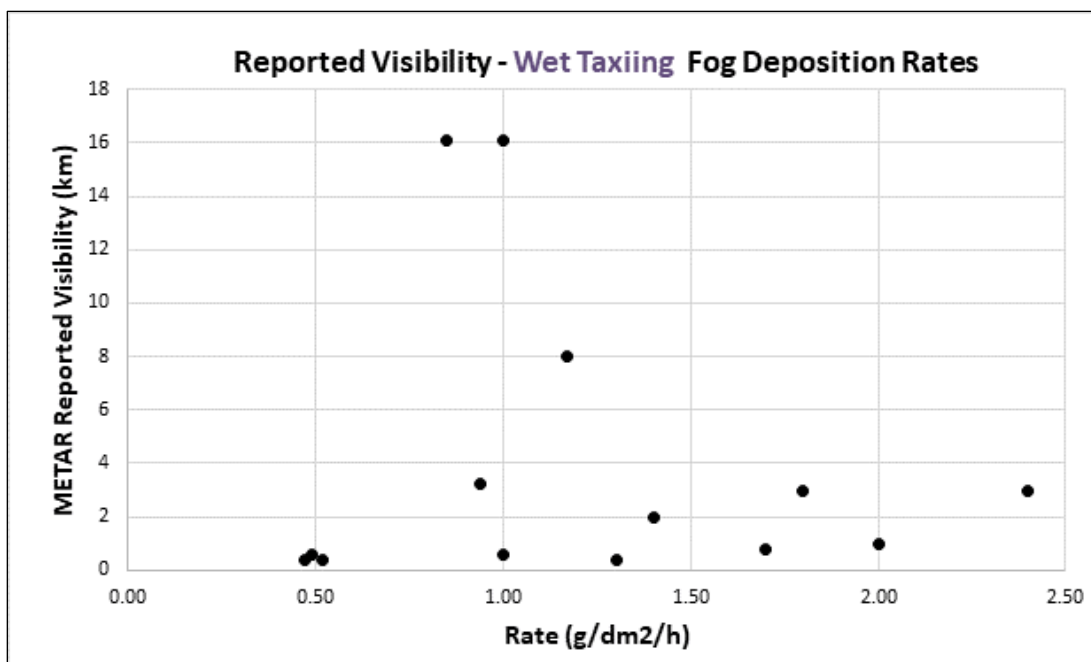


Figure 3.7: Wet Taxiing Fog/Freezing Fog Deposition Reported Visibility

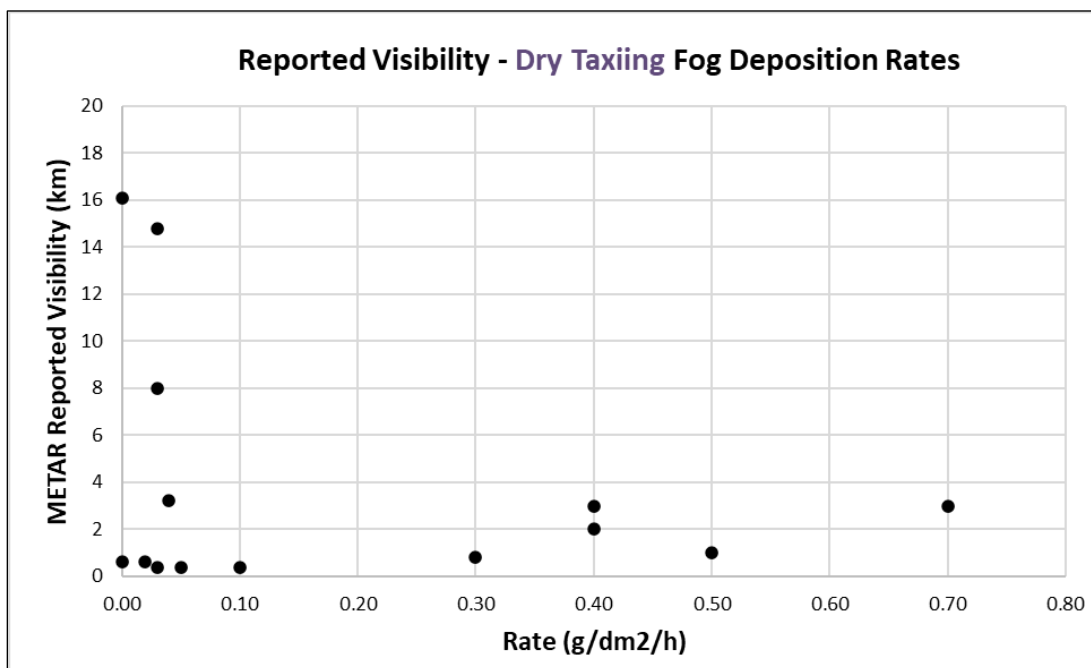


Figure 3.8: Dry Taxiing Fog/Freezing Fog Deposition Reported Visibility

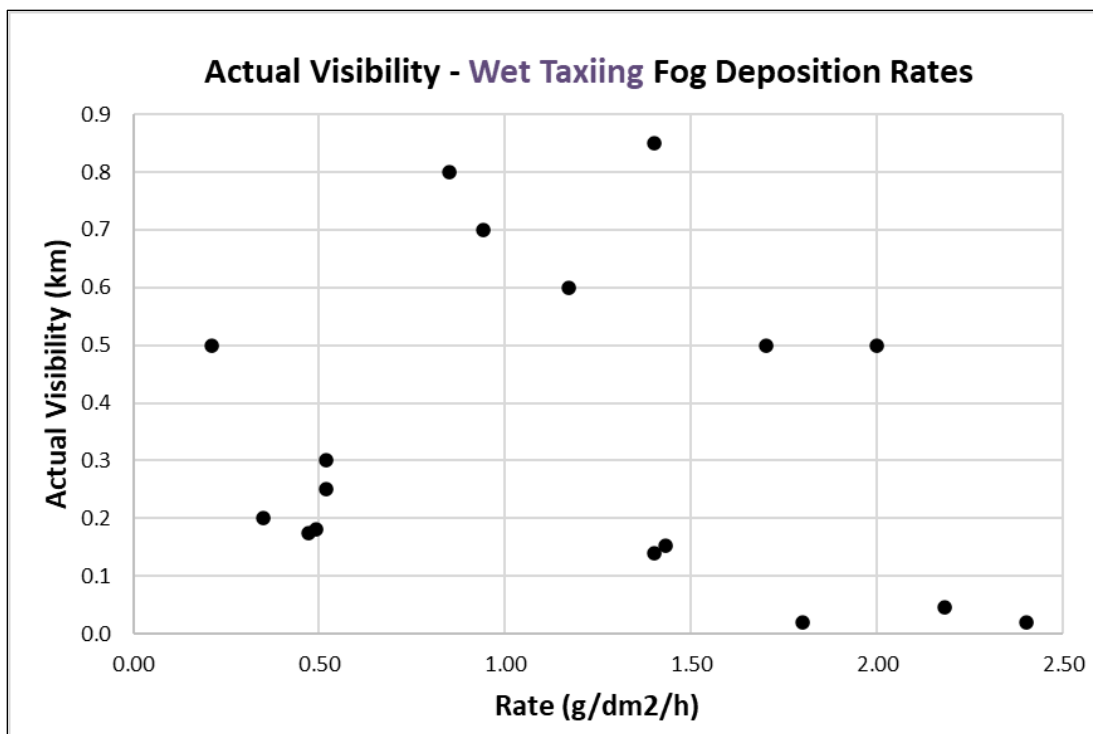


Figure 3.9: Wet Taxiing Fog/Freezing Fog Deposition Actual Visibility

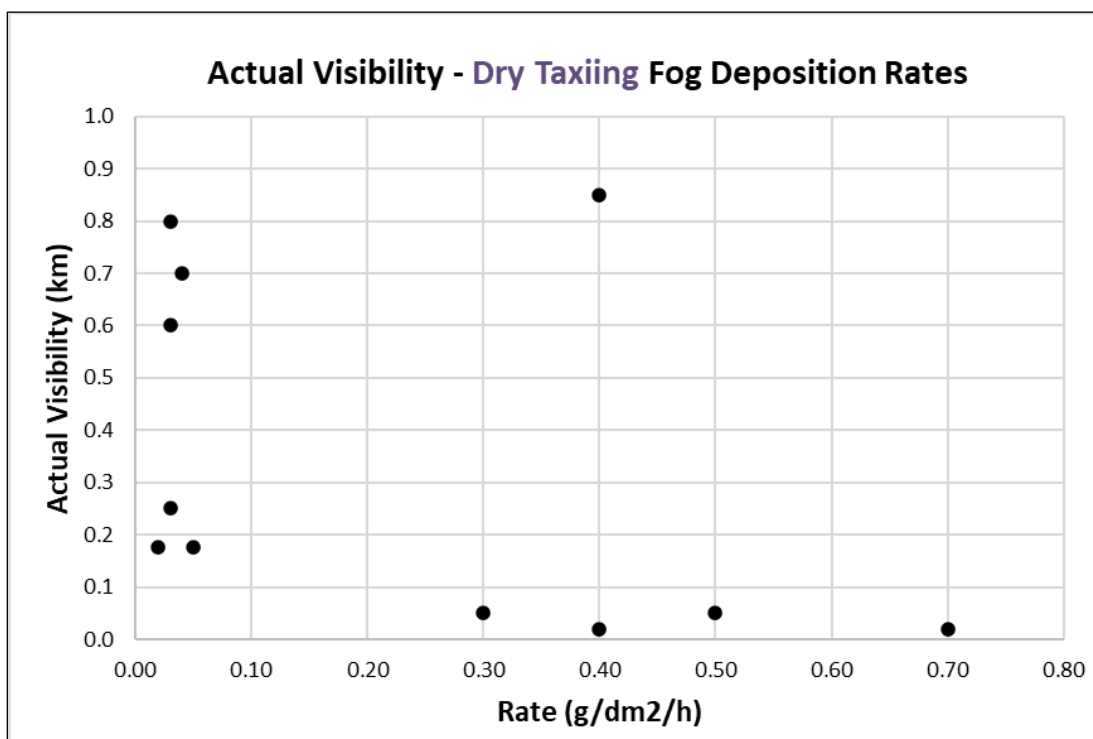


Figure 3.10: Dry Taxiing Fog/Freezing Fog Deposition Actual Visibility

When considering the stationary wet and dry pan, the same uncorrelated trend is observed for both the *reported* and *actual* visibilities, as seen in Figure 3.11, Figure 3.12, Figure 3.13, and Figure 3.14. Again, the factor affecting this correlation is discussed in Subsection 3.7.6.

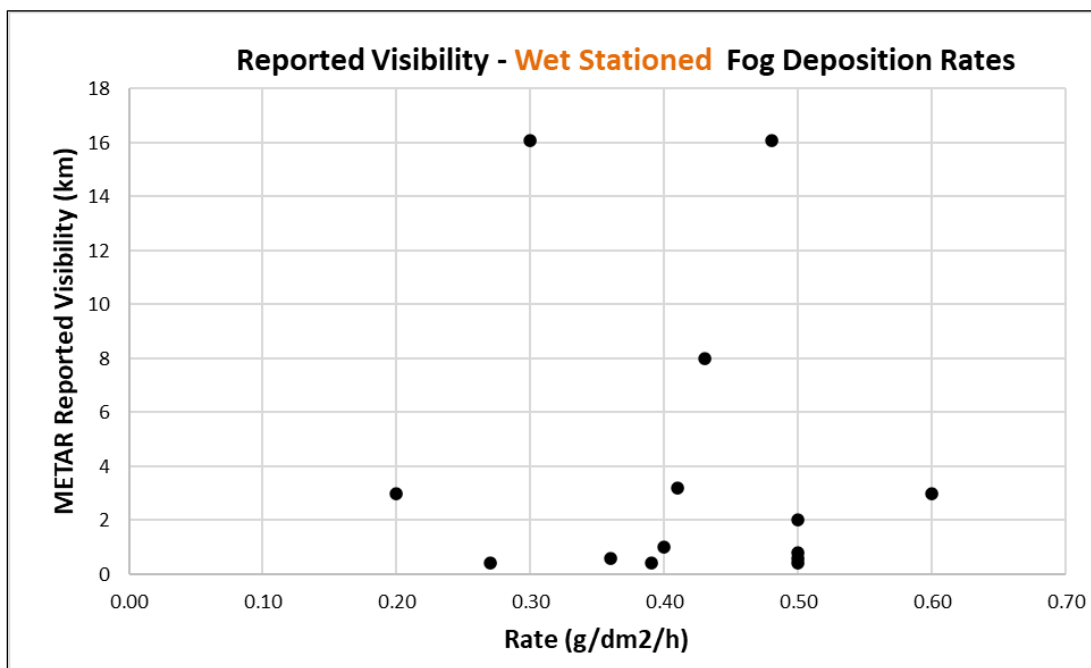


Figure 3.11: Wet Stationed Fog/Freezing Fog Deposition Reported Visibility

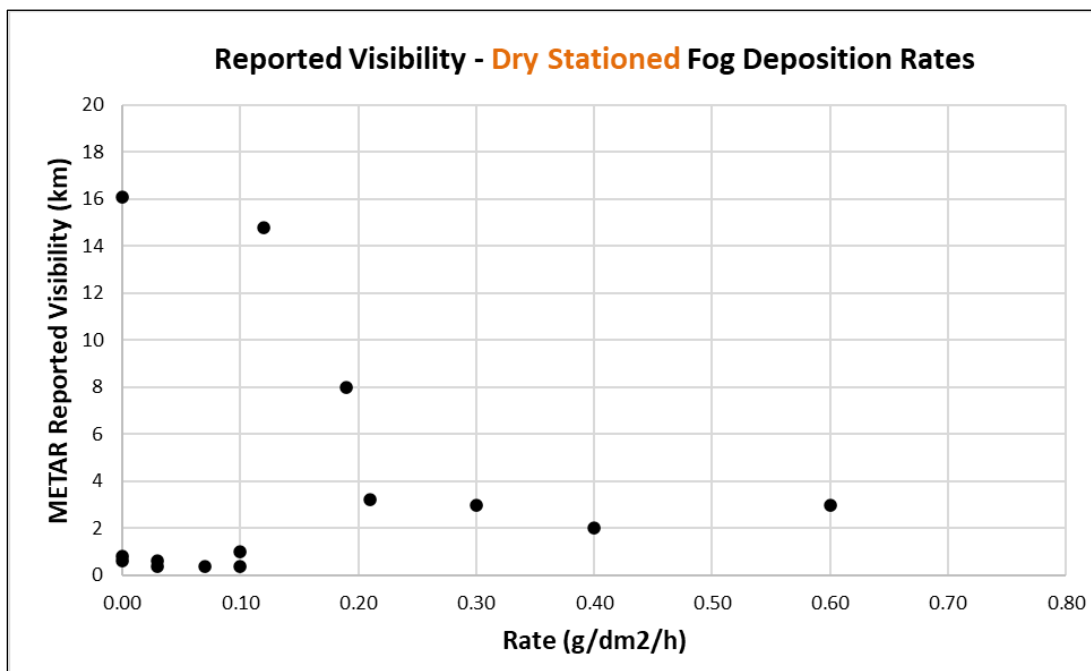


Figure 3.12: Dry Stationed Fog/Freezing Fog Deposition Reported Visibility

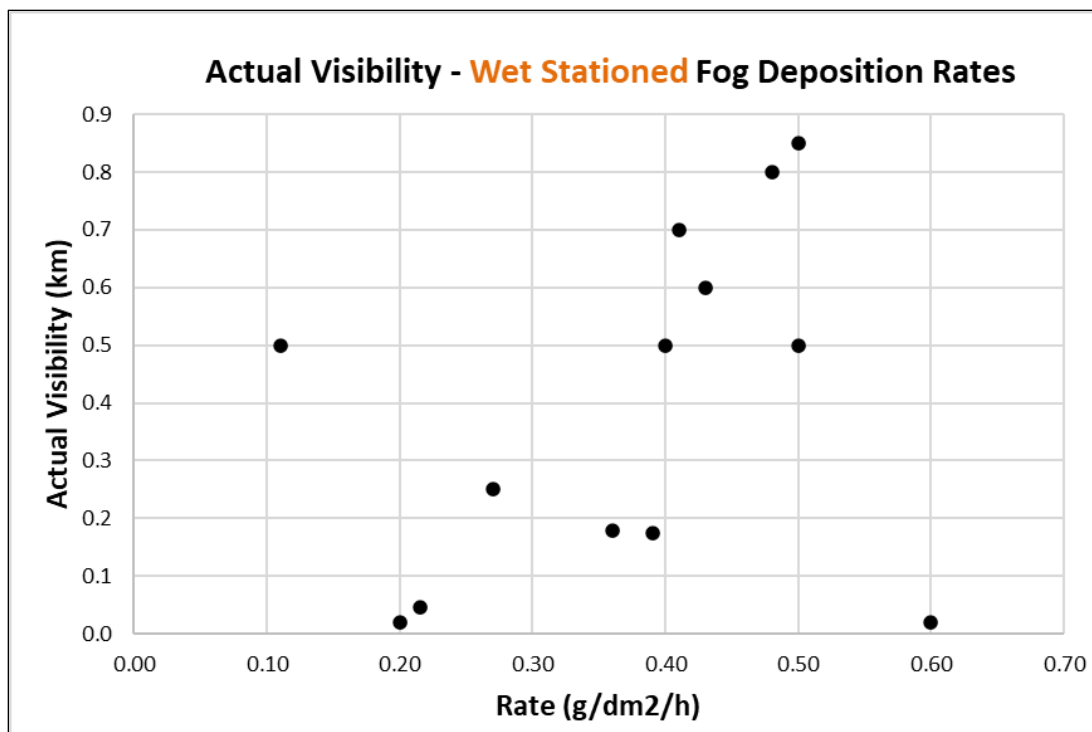


Figure 3.13: Wet Stationed Fog/Freezing Fog Deposition Actual Visibility

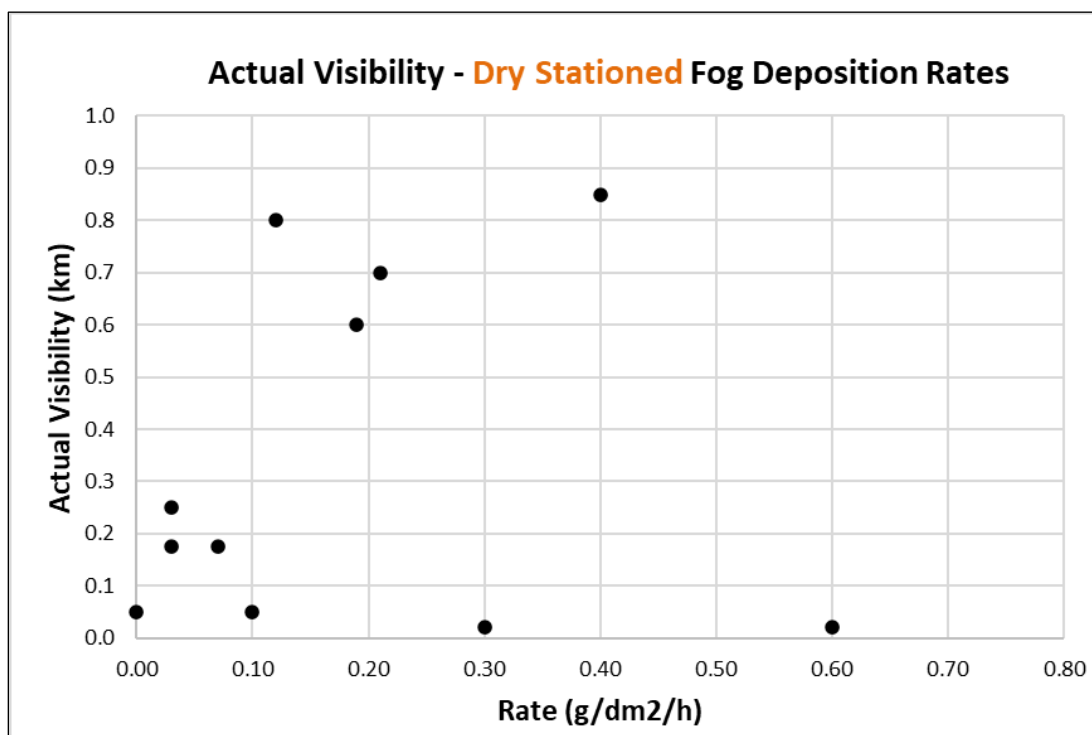


Figure 3.14: Dry Stationed Fog/Freezing Fog Deposition Actual Visibility

3.7.5 Correlation Between Reported and Observed Visibility for Mist/Freezing Mist Deposition Rates with a Taxiing and Stationary Wet and Dry Pan

The METAR-*reported* visibility was plotted against the mist/freezing mist wet taxiing and dry pan deposition rates to determine if a correlation exists. As seen in Figure 3.15 and Figure 3.16, no correlation is observed. This is unexpected, as the visibility is anticipated to be reduced as the mist/freezing mist deposition rate increases. As mentioned in Subsection 3.7.4, the justification for this trend is discussed in Subsection 3.7.6. When considering the *actual* visibility, the only plausible observation is that the visibility is greater than 1 km. This is due to the nature of the testing.

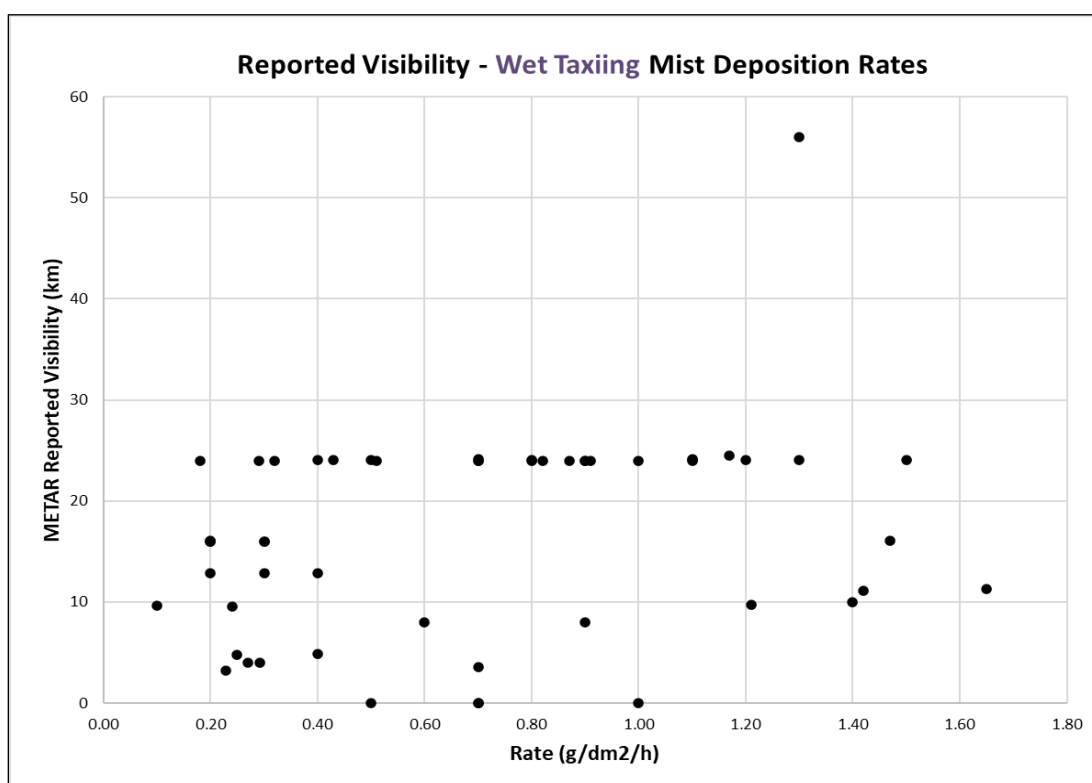


Figure 3.15: Wet Taxiing Mist/Freezing Mist Deposition Reported Visibility

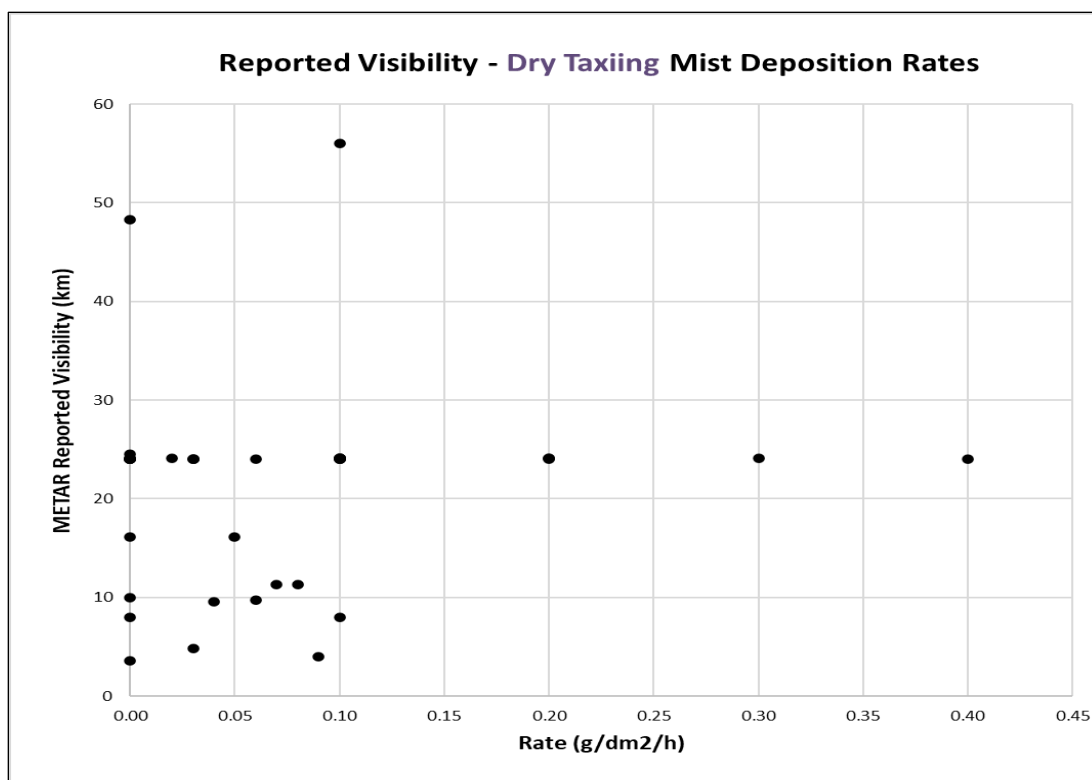


Figure 3.16: Dry Taxiing Mist/Freezing Mist Deposition Reported Visibility

When considering the stationary wet and dry pan, the same uncorrelated trend is observed for the *reported* visibility, as seen in Figure 3.17 and Figure 3.18. Again, the factor affecting this correlation is discussed in Subsection 3.7.6. When considering the *actual* visibility, the only plausible observation is that the visibility is greater than 1 km. This again is due to the nature of the testing.

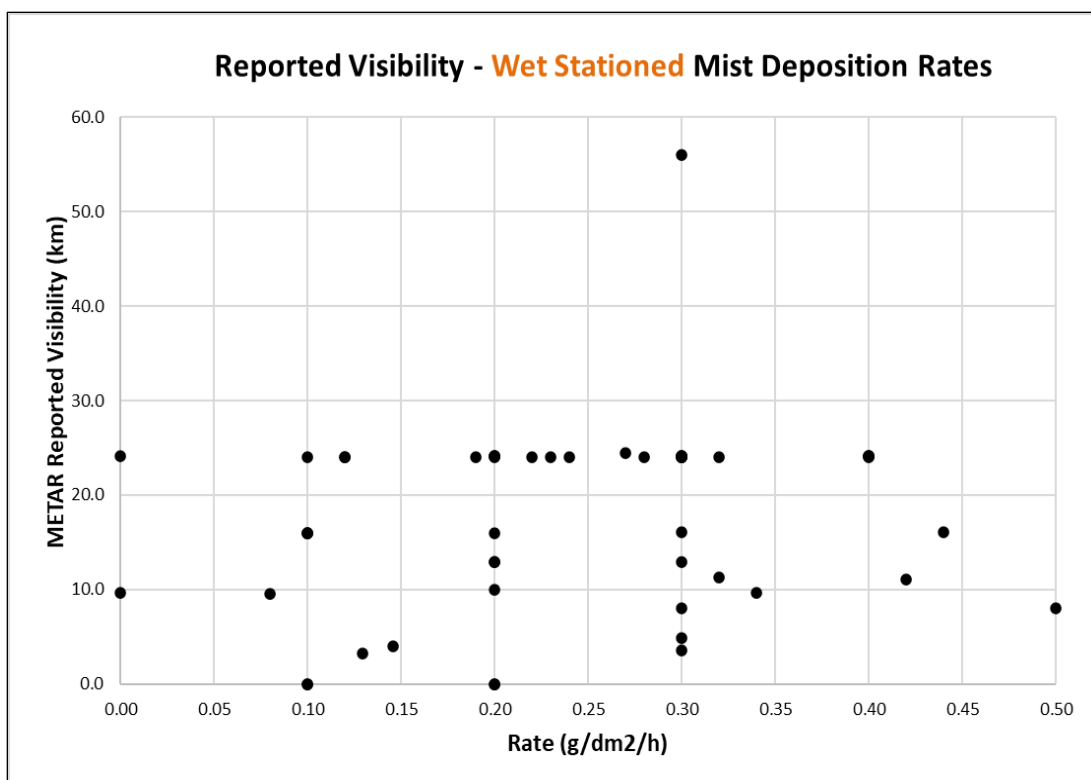


Figure 3.17: Wet Stationed Mist/Freezing Mist Deposition Reported Visibility

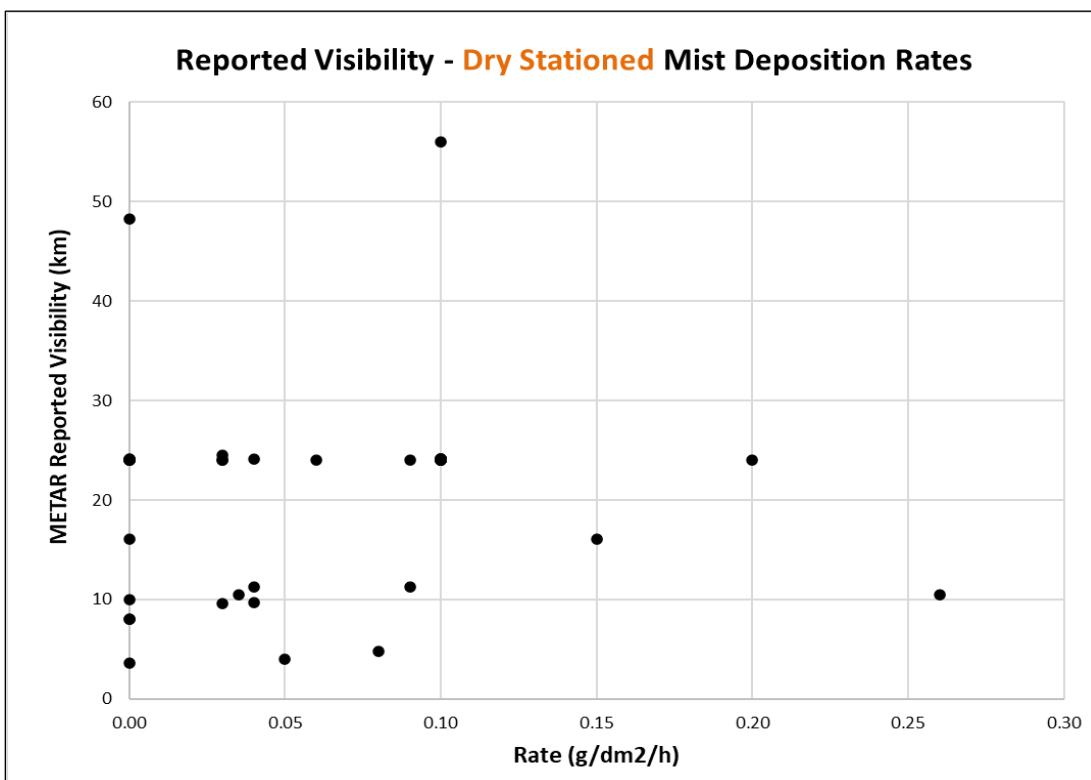


Figure 3.18: Dry Stationed Mist/Freezing Mist Deposition Reported Visibility

3.7.6 Hypothesis Affecting Rates and Visibility

A recent study conducted by Liu et al. (2023) from the Massachusetts Institute of Technology (MIT) indicated that polyethylene glycol (PEG) can absorb water vapor at various temperatures. In other words, testing conducted using deicing fluids, which are propylene glycol (PG)- and ethylene glycol (EG)-based solutions, have the potential to absorb not only the condensate, which forms mist and fog, but also the water vapor that is present in the air. Given that the formation of mist and fog occurs when the air is saturated (or supersaturated) with a relative humidity of 100 percent (or more) water vapor, it is likely that the rates collected using Type IV deicing fluids contain both the condensate and the water vapor. In addition, the level of supersaturation during a given event is an unknown quantity and affects both the wet and dry pans. This, in turn, explains the uncorrelated visibility data obtained, as is illustrated in all figures in Subsection 3.7.4 and Subsection 3.7.5. To help validate this hypothesis, the water content in the vapor phase (uncondensed) at 100 percent and 125 percent humidity at 2°C was theoretically calculated and compared to experimentally obtained data. At 100 percent humidity, the theoretical value of 1.67 g/dm²/h is very similar to the highest observed mist rate of 1.65 g/dm²/h and less than the highest observed fog rate of 2.4 g/dm²/h. This is expected, as the theoretical value is the portion of water that is in the vapor phase only and not part of the liquid phase (the condensate). Therefore, the expected experimental value should be close to or higher than the theoretical value obtained since it would account for both the water content that is present in the vapor phase and the condensate (assuming an ideal system). This is in line with the overall maximum rate analysis as shown in Table 3.6, Table 3.8, and Table 3.10. Appendix F contains a detailed breakdown of the theoretically determined rate at 100 percent humidity and 2°C compared to the experimentally obtained rate. It also shows that at a relative humidity of 125 percent (25 percent supersaturated), the theoretical rate is approximately 2 g/dm²/h at 1°C and slightly below the highest fog rate obtained, which is again in line with expectations. It is important to note that most of the data obtained falls below the theoretically determined values. This is due to the nature of this testing, as it is not 100 percent efficient at capturing all the condensate and available water vapor due to aerodynamic streamlines, which are created while driving 30 km/h. Other inefficiencies, such as possible cross winds and turns while driving, can affect the results.

In order to accurately account for the higher wet pan rates and reduce them to a more representative value, the dry pans were considered. The dry pans can be seen as a less restrictive obtained rate since the condensate is not completely captured, as there is no capturing medium. The methodology used was therefore to average both the dry and wet pan to obtain a combined rate that is to be used in calculating the minimum and maximum rates experienced by an aircraft, as seen in Subsection 3.7.8.

3.7.7 Understanding the Limitations of Collected Deposition Rate Data

Following discussions with TC and the FAA as part of the METAR Working Group (MWG), information pertaining to the limitations of weather sensors used to provide a METAR was revealed. In the US and Canada, weather stations can report mist (BR) when drizzle/freezing drizzle (DZ/FZDZ) is actually occurring. This can happen because of the following reasons:

- The reporting of mist in the METAR is based on visibility;
- The sensors cannot detect drizzle-sized droplets, so the sensor system will not automatically report DZ or FZDZ; and
- Drizzle's presence can affect visibility.

Drizzle/freezing drizzle being reported as BR in the METAR reports means it is observed by itself, i.e., as BR, or it can be in combination with a precipitation condition, such as SN BR. This means that METAR reports of BR can indicate the presence of drizzle/freezing drizzle (not mist), and METAR reports of SN BR can indicate the presence of drizzle/freezing drizzle with snow and not actually mist with snow. Therefore, it is important to note that DZ/FZDZ will only be reported by an observer or researcher conducting the test. For this work, significant effort was undertaken to ensure that no precipitation was observed, and that only mist/freezing mist or fog/freezing fog was occurring while data was collected.

3.7.8 Simulation of Aircraft Taxi Trajectory

An analysis simulating a typical aircraft trajectory under fog/freezing fog or mist/freezing mist conditions was performed to better understand the impacts of both the taxiing and stationary deposition rates experienced by the aircraft.

To gain better insight into the operationally relevant ranges of rates experienced by an aircraft under mixed combinations of taxiing and stationary times, representative scenarios were hypothesized. The proposed trajectories were simulated using the combined wet and dry pan rate, a specific time frame the aircraft would be taxiing and stationary, and the specific reference temperature of 2°C. Assuming the combined wet and dry taxi pan rate is too conservative given that aircraft are not perpetually in motion, it is reasonable to assume that developing guidance based solely on the average wet and dry pan taxi rate may be excessively restrictive. In addition, depending on the condition and the fluid used, the Freezing Fog HOTs can be as long as four hours; therefore, there is no urgency for aircraft to take off. In other words, to determine a more representative deposition rate for both mist and freezing fog, an operational analysis was conducted in which both the taxi and stationary times of an aircraft varied between 5 and 10 minutes and between 10 and

230 minutes (post anti-icing and hold period), respectively. The final deposition rates were determined for the various timing and trajectory scenarios proposed. An illustration of a typical aircraft trajectory at an airport is presented in Figure 3.19.

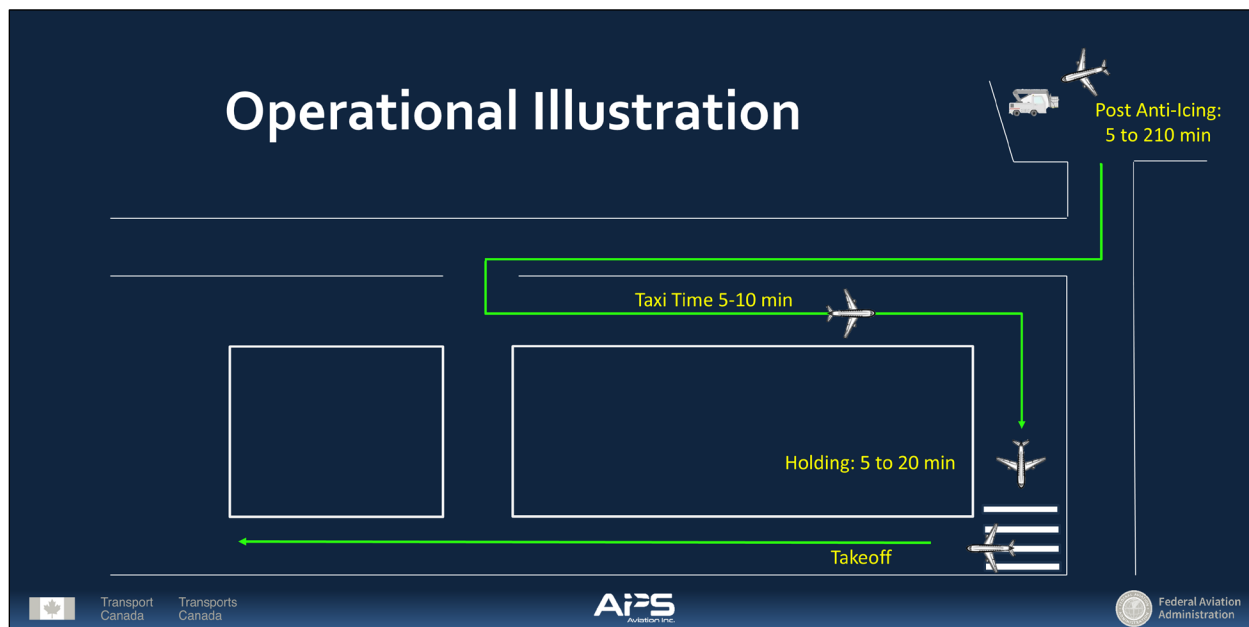


Figure 3.19: Illustration of a Typical Aircraft Trajectory at an Airport

The final deposition rates for simulated taxi time and trajectories were determined for fog/freezing fog (using both wet and dry pans) and mist/freezing mist (using both wet and dry pans). The results of this simulation are presented in Table 3.11 and Table 3.12. Table 3.13 summarizes the minimum (on average) and maximum (most conservative) combined deposition rates during a realistic operational scenario for each test type.

Table 3.11: Empirical Fog/Freezing Fog Combined Wet and Dry Pan Rate Using Different Combinations of Taxi and Stationary Times at 2°C and Below

Scenario Number	Taxi Time (min)	Stationary Time (min)	Total Time (min)	Taxi Time (%)	Stationary Time (%)	Combined Wet and Dry Taxi Fog Rate (g/dm ² /h)	Combined Wet and Dry Stationary Fog Rate (g/dm ² /h)	Final Fog Rate (g/dm ² /h)
1	5	10	15	33	67	1.55	0.60	0.92
2	10	20	30	33	67			0.92
3	5	110	115	4	96			0.64
4	5	230	235	2	98			0.62

Table 3.12: Empirical Mist/Freezing Mist Combined Wet and Dry Pan Rate Using Different Combinations of Taxi and Stationary Times at 2°C and Below

Scenario Number	Taxi Time (min)	Stationary Time (min)	Total Time (min)	Taxi Time (%)	Stationary Time (%)	Combined Wet and Dry Taxi Mist Rate (g/dm ² /h)	Combined Wet and Dry Stationary Mist Rate (g/dm ² /h)	Final Mist Rate (g/dm ² /h)
1	5	10	15	33	67	0.88	0.32	0.51
2	10	20	30	33	67			0.51
3	5	110	115	4	96			0.34
4	5	230	235	2	98			0.33

Table 3.13: Operational Rate Range for Fog/Freezing Fog and Mist/Freezing Mist

Temperature	Operational Rate Range	
	Fog/Freezing Fog	Mist/Freezing Mist
2°C and Cooler	0.62 - 0.92	0.33 - 0.51

Note: All data is in units of g/dm²/h.

3.7.9 Fog/Freezing Fog and Mist/Freezing Mist Wet and Dry Pan Taxiing Temperature Data Analysis

An analysis of both the fog/freezing fog and mist/freezing mist wet and dry pan data was conducted. This was done to determine if any trends exist and to calculate empirical rates that would be operationally observed at different temperatures. These calculated rates can then be used to simulate any operationally relevant objective, such as the testing of mixed conditions at the specific HOT test temperature bands of -3°C , -10°C , -14°C , -25°C , and the fluid-specific lowest operational use temperature (LOUT). Figure 3.20 and Figure 3.21 illustrate the observed trend for fog/freezing fog and mist/freezing mist, while Table 3.14 and Table 3.15 show the rates that were calculated and are to be used at temperatures of -3°C , -10°C , -14°C , and -25°C , respectively. The minimum and maximum rates were determined using the slope of the curve adjusted to respect the actual observed rates experienced by an aircraft, that is, by using the simulated aircraft trajectory analysis (final minimum and maximum rates). These rates therefore represent the acceptable limits for use during testing.

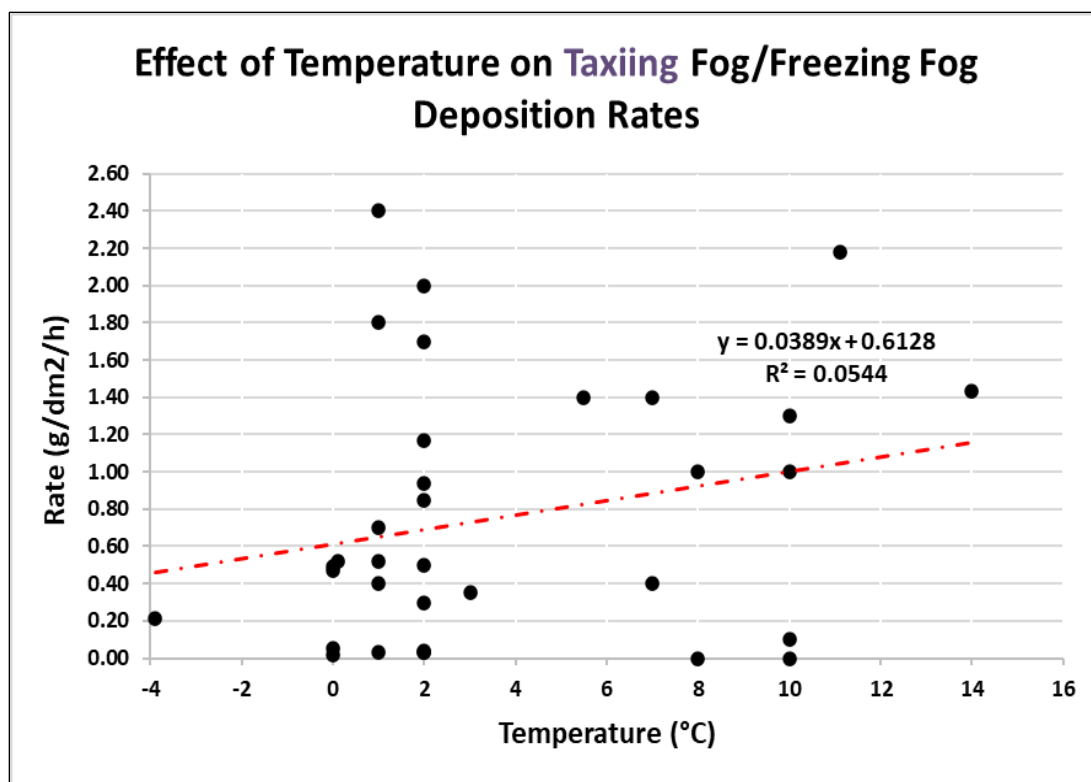


Figure 3.20: Effect of Temperature on Fog/Freezing Fog Wet and Dry Pan Taxiing Rates

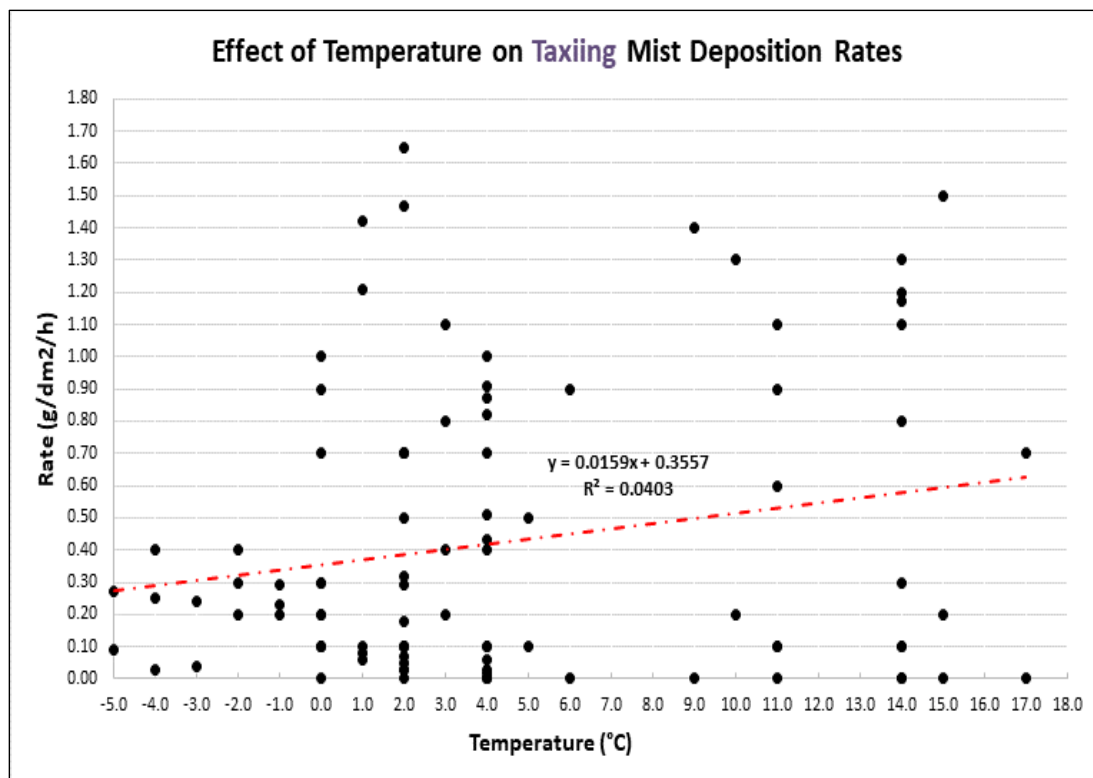


Figure 3.21: Effect of Temperature on Mist/Freezing Mist Wet and Dry Pan Taxiing Rates

Table 3.14: Possible Testing Rates for Freezing Fog at Different Temperatures

Empirically Determined Rates for Fog/Freezing Fog Testing		
Temperature (°C)	Minimum Rate (g/dm ² /h)	Maximum Rate (g/dm ² /h)
2	0.62	0.92
-3	0.43	0.73
-10	0.15	0.45
-14	0.07	0.37
-25	0.03	0.33

Table 3.15: Possible Testing Rates for Freezing Mist at Different Temperatures

Empirically Determined Rates for Mist/Freezing Mist Testing		
Temperature (°C)	Minimum Rate (g/dm ² /h)	Maximum Rate (g/dm ² /h)
2	0.33	0.51
-3	0.25	0.43
-10	0.14	0.32
-14	0.08	0.26
-25	0.03	0.21

3.8 Discussion of Operational Considerations in Fog/Freezing Fog and Mist/Freezing Mist Conditions

As described in Subsection 3.4, the formation of mist/freezing fog/fog occurs when specific weather parameters (humidity, temperature, wind speed, etc.) are favourable. As a weather phenomenon, mist can be present and reported by METAR at any given temperature, while fog is reported when the temperature is above 0°C (32°F), and freezing fog is reported when the temperature is at 0°C (32°F) or below. Freezing mist, on the other hand, is never reported by METAR; however, it can occur when mist is present at 0°C (32°F) and below.

Although freezing mist and freezing fog only occur at temperatures of 0°C (32°F) or below, it was determined that, from an operational perspective, the statistical data corresponding to temperatures of 2°C and below is considered conservative enough to mitigate the potential risk of freezing contamination without being too restrictive. This is reasonable to assume since the deposition rate is expected to be lower at a temperature below 2°C, as illustrated in Figure 3.3 and Figure 3.4 (decreasing trend when cooling). This is also in line with the scientific literature. The most conservative rates observed for fog/freezing fog and mist/freezing mist using both the wet and dry pans while taxiing or stationary at 2°C and cooler are shown in Table 3.10. It is important to note that although these rates are the most conservative observed, they are not anomalies, rendering them statistically significant. The combination of these rates was thus used to determine the final deposition rates during a hypothetical scenario, as illustrated in Subsection 3.7.2 through Subsection 3.7.5.

From Table 3.11 and Table 3.12, the minimum (on average) and maximum (most conservative) final deposition rates during a realistic operational scenario were determined. These results are summarized in Table 3.13.

Table 3.13 illustrates that the most conservative cases for both fog/freezing fog and mist/freezing mist are obtained using the average of the wet and dry pans. The operational usage range for fog/freezing fog and mist/freezing mist should therefore be between 0.62 and 0.92 g/dm²/h and 0.33 and 0.51 g/dm²/h, respectively. When comparing the rate ranges obtained for Fog/Freezing Fog to the NCAR database of Pristine Fog, the range approximately corresponds to the 82nd and 90th percentiles, respectively. This supports the proposed operational usage range obtained with the APS data.

The ranges of rates observed during this work suggest that the liquid water content (LWC) of freezing mist, mist, freezing fog, and fog are adequately reflected in the current HOT tables. The highest-observed rate for fog (limited to YUL and its surroundings) was 2.4 g/dm²/h; however, this could be higher in areas with valleys or near bodies of water. Therefore, with the information available to date, the grouping of Freezing Mist, Freezing Fog, or Ice Crystals in the HOT tables, for which the associated rate of precipitation is 2 to 5 g/dm²/h, is still warranted. However, it may be possible that, with more data pertaining to freezing mist, the HOT tables could be adjusted to better reflect the lower rates of freezing mist as observed in nature. The same could also be done with freezing fog, possibly reducing the present maximum rate of 5 g/dm²/h to a more representative value.

3.9 Conclusions

An analysis was conducted using data from both the wet and dry pans to ensure a better representative value. The wet pan rate was shown to be consistently higher than that of the dry pan. The results indicated that at 2°C and below, the maximum observed rates for the fog/freezing fog taxiing and stationary wet pan were 2.4 g/dm²/h and 0.6 g/dm²/h, respectively. The mist/freezing mist taxiing and stationary wet pan rates were 1.65 g/dm²/h and 0.44 g/dm²/h, respectively. Given that aircraft are not perpetually taxiing, an operational analysis was also conducted using the average of both the dry and wet pans. The operationally relevant rate range experienced by an aircraft for fog/freezing fog was determined to be between 0.62 and 0.92 g/dm²/h, while for mist/freezing mist, the operationally relevant rate range was between 0.33 to 0.51 g/dm²/h. The fog/freezing fog rate range was also compared to pristine freezing fog data, which was obtained from the NCAR. The rate range corresponded to the 82nd and 90th percentile, respectively, showing considerable conservatism in the experimental data.

The ranges of rates observed to date demonstrate that the present HOT tables are adequate to ensure safe operations with Freezing Fog, Freezing Mist, or Ice Crystals. From Table 3.13, these rates are well below the associated rate range of precipitation between 2 and 5 g/dm²/h.

3.10 Recommendations

For the winter of 2025-26 and beyond, due to the present limitations of mist and fog METAR reporting, which can include drizzle, it is recommended to continue data collection for both mist and freezing fog with the presence of drizzle for a direct comparison with pure mist or freezing fog. This data can be captured using the procedure mentioned in this report coupled with a visual verification of drizzle being present. This would provide significant insight into the rates that are presently affecting operations and that can pose a potential flight risk. This information would then allow for comprehensive risk assessment for flight operations.

In addition, consideration should be given to other strategic locations with potential for higher mist and freezing fog intensities to capture the most conservative cases (e.g., valleys). To date, results have shown that, for testing with freezing fog and freezing mist, the rates to be used vary with temperature, as provided in Table 3.14 and Table 3.15. The updates to this work will also continue to support a related research project currently being investigated, dealing with mixed phase icing research.

Photo 3.1: Method 1 – Simulated Taxiing Aircraft

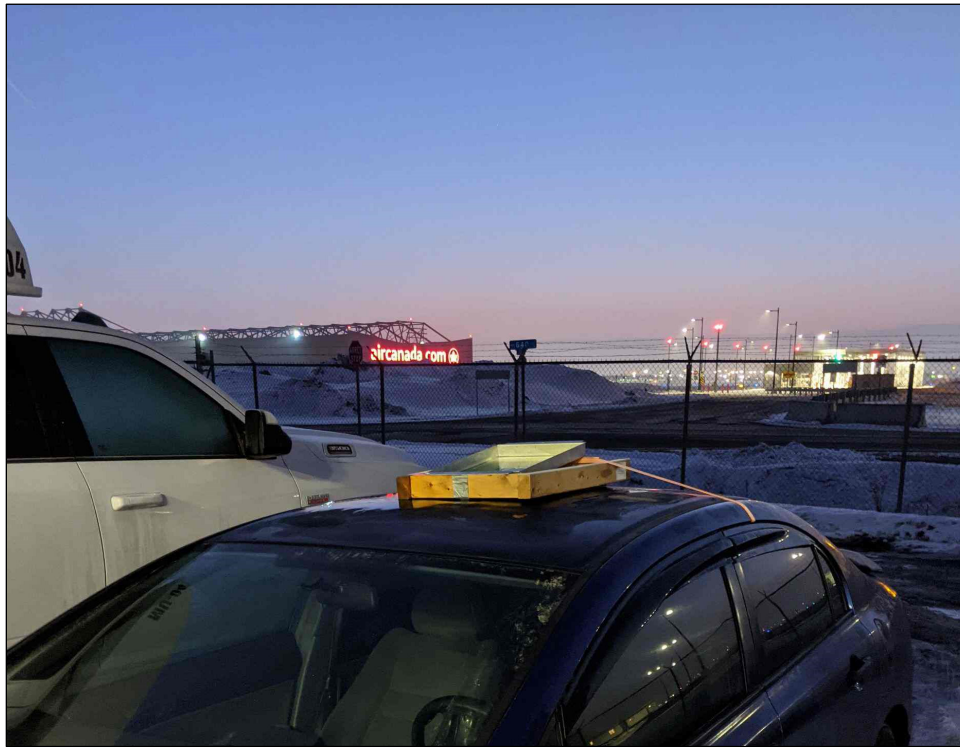


Photo 3.2: Method 2 – Simulated Stationed Aircraft



**Photo 3.3: Mist Visible – Reported by METAR
(January 15, 2021 – Ottawa, Ontario)**



**Photo 3.4: Mist Visible – Reported by METAR
(April 27, 2023 – Montreal, Quebec)**



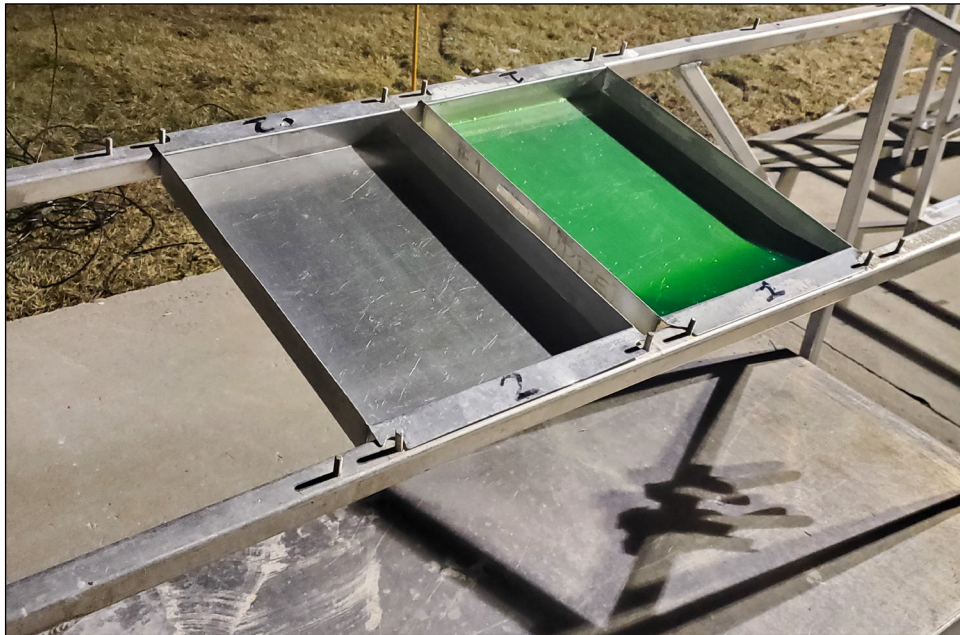
**Photo 3.5: Mist Visible – Not Reported by METAR
(January 15, 2021 – Montreal, Quebec)**



Photo 3.6: Method 1 – Simulated Taxiing Aircraft – Addition of Dry Pan Next to Wet Pan



Photo 3.7: Method 2 – Simulated Stationed Aircraft – Addition of Dry Pan Next to Wet Pan



4. DEVELOPMENT OF GUIDANCE FOR MIXED ICING CONDITIONS

This section describes the ongoing work conducted by APS Aviation Inc. (APS) in 2024-25 to develop holdover time (HOT) and allowance time guidance for mixed icing conditions.

4.1 Background

When aircraft are operating in adverse weather conditions, METAR-reported weather conditions may not always have corresponding HOT or allowance time guidance to allow for safe departure. This is especially true for mixed conditions, and industry has requested additional guidance for operating in mixed icing conditions.

4.2 Previous Work

In 2019-20, a multi-airport METAR analysis was conducted; further information can be found in the Transport Canada (TC) report, TP 15452E, *Aircraft Ground Icing General Research Activities During the 2019-20 Winter* (7). This study examined a large sample of METAR data collected primarily at major airports in the United States and Canada that encounter winter precipitation, including mixed precipitation conditions. In 2020-21, the METAR Working Group (MWG) was formed, which included technical experts and meteorologists from the Federal Aviation Administration (FAA), TC, APS, and the National Center for Atmospheric Research (NCAR). The MWG utilised the data collected from the METAR analysis to develop a “master list” that groups similar conditions and organizes the groups (or “bins”) by frequency of occurrence, level of effort required (from analytical to long-term research), and industry demand.

Research has since been ongoing with the aim of developing guidance for conditions identified through the MWG and prioritized based on frequency of occurrence, operational impacts, etc. The MWG continues to meet on a quarterly basis.

4.3 Objective

The objective of this ongoing project is to support the development of HOT or allowance time guidance for mixed icing conditions not currently included in the published TC/FAA guidance material.

4.4 Research Activities 2024-25

The following research activities were undertaken by APS in 2024-25 to support further mixed icing guidance development by TC and the FAA.

Climatic chamber simulation testing was conducted in the following mixed conditions:

- Snow mixed with Rain;
- Snow mixed with Mist;
- Snow mixed with Freezing Fog; and
- Very Light or Light Snow mixed with Rain or Drizzle.

The research and testing conducted resulted in updated or validated guidance for all conditions listed except for Snow mixed with Mist. The details of this research can be found in the TC report, TP 15686E, *Testing and Evaluation of Mixed Phase Icing Conditions: Winter 2024-25* (8).

It should be noted that no exploratory mixed icing research was conducted in the wind tunnel during the winter of 2024-25.

4.5 Conclusions

With support from the MWG, research was conducted to evaluate four mixed conditions and resulted in changes to the guidance for three of the conditions tested.

4.6 Recommendations

Mixed icing guidance development is an ongoing task that will continue to evolve as further analysis and research activities are accomplished. It is recommended that the MWG continue to collaborate on the further development of expanded HOT and allowance time guidance for mixed precipitation conditions.

5. EVALUATION OF HOT REGRESSION METHODOLOGY FOR FLUIDS WITH NON-STANDARD TEMPERATURE-ENDURANCE TIME RELATIONSHIPS

5.1 Background

Precipitation type, precipitation rate, and outdoor ambient temperature are the three environmental parameters that are commonly understood to be the primary determinants of anti-icing fluid holdover time (HOT) performance in winter conditions.

For most commercially available anti-icing fluids, decreases in ambient temperature are associated with reductions in fluid performance. However, in recent years, there has been an increase in the number of fluids submitted for HOT testing whose results have displayed atypical temperature-performance relationships.

Much of the regulatory framework surrounding winter aviation operations has assumed that lower temperatures lead to reduced fluid performance (as well as the inverse belief that warmer temperatures lead to improved fluid performance). Given this, Transport Canada (TC) and the Federal Aviation Administration (FAA) have tasked APS Aviation Inc. (APS) with conducting a review and analysis of the available historical HOT test data to assess the prevalence of fluids with non-standard temperature relationships, any trends associated with the phenomenon, and their impact on the produced HOTs.

5.2 Previous Work

The frequency of non-standard temperature-endurance time (ET) relationships within the 2023-24 HOT Guidelines was first examined in TP 15608E (2).

It was found that a non-insignificant percentage of fluids displayed a non-standard temperature-ET relationship and that this behaviour occurred more frequently within ethylene glycol (EG)-based fluid than within propylene glycol (PG)-based fluids as well as within freezing rain conditions as compared to other simulated freezing precipitation conditions.

The recommendations were to begin drafting a formalized methodology for handling fluids that demonstrated reversed or temperature-independent HOT performance for possible inclusion in the appropriate SAE International (SAE) standard documents.

5.3 Objective

The objectives of this project were as follows:

- Reviewing and updating the historical analytical material relating to fluids with non-standard temperature-ET relationships;
- Examining the risks associated with fluids with non-standard temperature-ET relationships; and
- Exploring alternative HOT methodologies for fluids with non-standard temperature-ET relationships.

5.4 Data

The test data and associated regression information outputs for the 36 total anti-icing fluids listed in the 2024-25 TC/FAA HOT Guidelines were collected for review. This list comprises the following:

- 10 Type II fluids;
- 1 Type III fluid; and
- 25 Type IV fluids.

From this test data, a database was created to evaluate the fluid data sets and their temperature relationship. Each entry in the database represents a combination of the following parameters:

- Fluid name;
- Fluid dilution;
- Precipitation type; and
- Temperature category (natural snow and freezing fog only): warm or cold (for tests conducted above -14°C vs. at -14°C and below).

The numbers of tested fluids per precipitation type and dilution are presented in Table 5.1.

Table 5.1: Fluid Data Count by Precipitation Type, Dilution, and Temperature

Dilution	SN		ZF		ZR	ZD	Total
	Warm	Cold	Warm	Cold			
100/0	36	24	36	34	36	36	202
75/25	13	0	13	0	12	12	50
50/50	13	0	0	0	0	0	13
Total	62	24	49	34	48	48	265

For each fluid, the freezing precipitation test data was grouped and logged with other tests conducted at the same precipitation rate target (high or low).

The following descriptive information was also included with each entry for analysis:

- Fluid manufacturer;
- Year submitted for HOT testing;
- Fluid type: II, III, or IV;
- Fluid base: EG or PG; and
- P-value of temperature regression coefficient (Natural Snow only).

For each entry, the temperature relationship was assessed and classified into one of the following three categories:

- **Standard temperature relationship:** Defined as one where decreases in temperature were associated with shorter ETs;
- **Temperature-independent relationship:** Defined as one where changes in temperature had no impact on the fluid ETs (temperature-independent); or
- **Reversed temperature relationship:** Defined as one where decreases in temperature were associated with longer ETs.

For natural snow, the regression outputs were used to classify the type of temperature relationship. First, the p-value was used to determine if the relationship was temperature-independent. A fluid can be classified as temperature-independent when the p-value is greater than 0.05. Otherwise, the relationship is standard or reversed. Next, if the fluid was not temperature-independent, the temperature coefficient was used to determine if the relationship is standard or reversed. A negative temperature coefficient is indicative of a standard relationship, while a positive coefficient indicates that the relationship is reversed.

For freezing precipitation data sets, the classifications were made by visually assessing the associated regression curves. Individual fluids were categorized as temperature-independent or reversed if that relationship was observed for at least

one end of the tested rates (high, low, or both). For example, a fluid with a reversed relationship at either end is categorized as reversed (even if the other end is temperature-independent or standard), and a fluid is categorized as temperature-independent if either end is categorized as such, with the other end categorized the same or standard.

The full database is included with this report as Appendix G.

5.5 Frequency Analysis

This subsection analyses the frequency of non-standard temperature-ET relationships with the fluids listed in the 2024-25 HOT Guidelines.

To analyse the frequency without weighting any specific parameters, the data has been separated by fluid base, dilution, temperature, and precipitation. The frequency of the relationship classifications within each category is presented in Table 5.2.

Table 5.2: Frequency of Non-Standard Temperature Relationships

Fluid – Dilution	Temp.	Precip. Type	Standard	Independent	Reversed	Total	Standard	Non-Standard		
								Independent	Reversed	Total
EG – 100%	Warm	SN	6	5	0	11	55%	45%	0%	45%
		ZD	6	3	2	11	55%	27%	18%	45%
		ZR	1	3	7	11	9%	27%	64%	91%
		ZF	5	1	5	11	45%	9%	45%	55%
	Cold	SN	8	1	0	9	89%	11%	0%	11%
		ZF	10	0	1	11	91%	0%	9%	9%
PG – 100%	Warm	SN	25	0	0	25	100%	0%	0%	0%
		ZD	24	0	1	25	96%	0%	4%	4%
		ZR	25	0	0	25	100%	0%	0%	0%
		ZF	22	2	1	25	88%	8%	4%	12%
	Cold	SN	15	0	0	15	100%	0%	0%	0%
		ZF	20	1	2	23	87%	4%	9%	13%
PG – 75%	Warm	SN	11	2	0	13	85%	15%	0%	15%
		ZD	11	1	0	12	92%	8%	0%	8%
		ZR	10	1	1	12	83%	8%	8%	17%
		ZF	11	0	2	13	85%	0%	15%	15%
PG – 50%	Warm	SN	8	5	0	13	62%	38%	0%	38%
Combined			218	25	22	265	82%	9%	8%	18%

Table 5.2 helps identify several trends related to the frequency of non-standard temperature relationships.

Most fluids have standard temperature-ET relationships, representing 82 percent of all data entries within the database.

Non-standard temperature relationships (both temperature-independent and reversed) occur more frequently within EG fluid data sets (as opposed to PG fluids). At warmer temperatures ($\geq -10^{\circ}\text{C}$), EG fluids exhibited non-standard temperature relationships from 45 percent to 91 percent of the time depending on the precipitation type. For PG fluids, this frequency was 17 percent or less. The PG fluids that did show non-standard temperature relationships were most typically 75/25 and 50/50 dilutions. This is believed to be partly due to smaller sample sizes and decreased overall ETs within these data sets. The 50/50 PG fluids are only tested across a narrow range of temperatures ($\geq -5^{\circ}\text{C}$), so non-standard temperature relationships are more likely to occur.

Fluids tested in freezing rain were more likely to exhibit a non-standard temperature relationship than any other precipitation type. In freezing rain, 91 percent of the EG fluids had a reversed or temperature-independent relationship at at least one end of the tested rates.

In natural snow, no reversed temperature relationships were found. Of the undiluted fluids, only EG fluids were found to have non-standard relationships. Of the 11 EG fluids in the 2024-25 HOT Guidelines, five fluids (representing 45 percent) demonstrated a temperature-independent relationship in their warm temperature data set.

Non-standard temperature relationships were also more likely to occur at warmer temperatures than at colder temperatures.

5.6 HOT Analysis

The following subsections examine the risks associated with fluids with non-standard temperature-ET relationships and present alternative HOT methodologies for these fluids.

5.6.1 Problem Definition

Fluids with a standard temperature-ET relationship have longer ETs at warmer temperatures than at colder temperatures. This assumption is built into the current HOT methodologies so that conservative HOTs are produced.

Snow HOTs are derived from regression curves that use the lowest temperature in the band. For example, “Below -3 to -8°C” HOTs are derived using -8°C as the temperature input.

For freezing precipitation, the HOT regression curves are derived from tests conducted at a single temperature. These test temperatures are always at or below the minimum temperature in the band. For example, HOTs for “Below -3 to -8°C” freezing rain tests are derived from tests conducted at -10°C.

If the assumption regarding the temperature-ET relationship holds, this method results in conservative HOTs at all temperatures other than the coldest temperature in the band. A simplified visual representation of the resulting safety buffer from the current HOT methodology is illustrated in Figure 5.1.

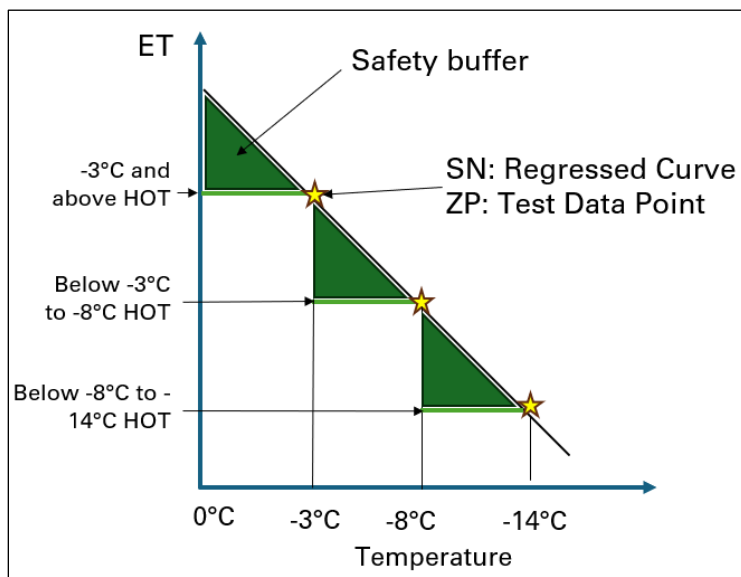


Figure 5.1: Safety Buffer from Standard Fluids

If a fluid has a reversed or temperature-independent relationship, then the safety buffer added by using the coldest temperature as an input is no longer present.

5.6.1.1 Reversed Temperature-ET Relationship

Fluids with a reversed temperature-ET relationship have decreased ETs at warmer temperatures. When fluids have a reversed temperature-ET relationship, calculating the HOT using the coldest temperature in the band results in HOTs that are shorter than the expected ETs in that temperature band. This is especially the case at the warmest temperatures in the band (i.e., -4°C, -9°C). In this case, the existing safety buffers are replaced by risk areas. A simplified visual representation of this is illustrated in Figure 5.2.

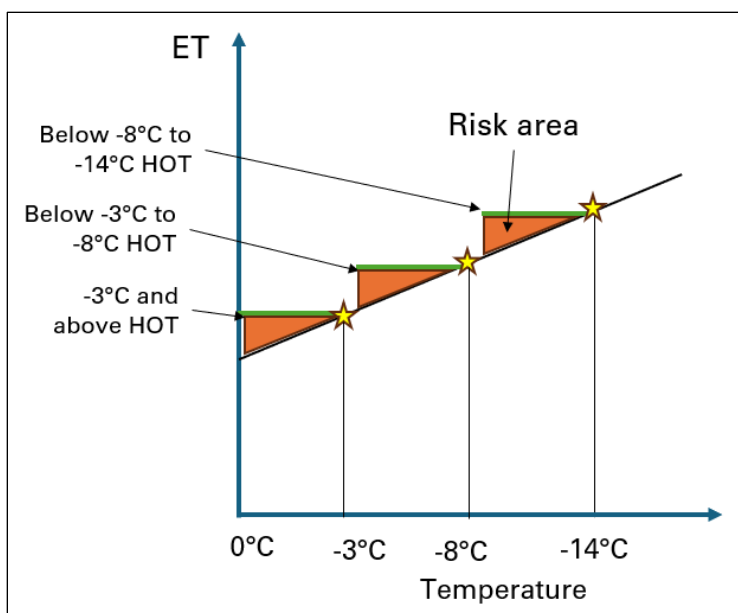


Figure 5.2: Risk of Fluids with Reversed Temperature-ET Relationships

5.6.1.2 Temperature-Independent Relationship

Fluids with a temperature-independent relationship have ETs that are not affected by temperature. For these fluids, calculating the HOT using the coldest temperature in the band results in HOTs based only on the precipitation rate input used with no additional safety buffer provided by temperature. A simplified visual representation of this is illustrated in Figure 5.3.

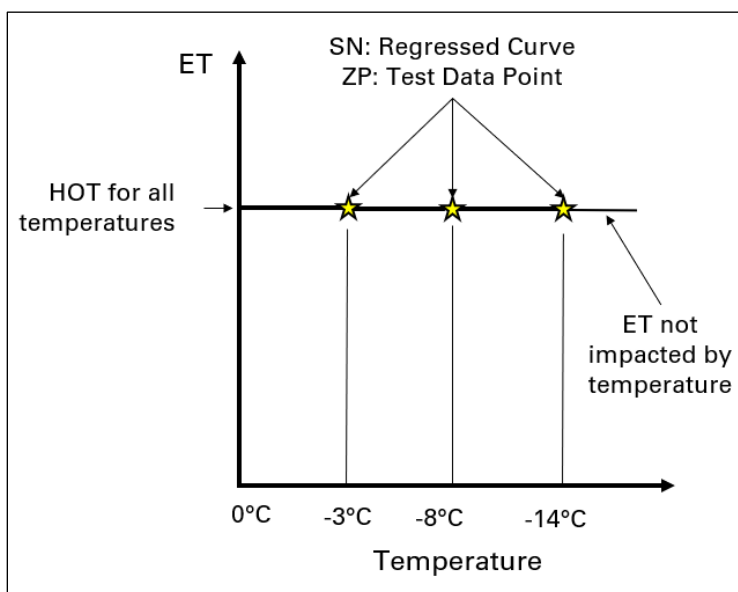


Figure 5.3: Risk of Fluids with Temperature-Independent Relationship

5.6.2 Natural Snow

This subsection explores the associated risks of the current snow HOT methodology on non-standard fluids and details possible updated methodologies.

5.6.2.1 *Reversed Temperature-ET Relationship*

As seen in Figure 5.2, when fluids have a reversed temperature-ET relationship, calculating the HOT using the coldest temperature in the band results in HOTs that are shorter than the expected ETs in that temperature band. As seen in Table 5.2, no reversed temperature-ET relationships were found for snow. While this is currently the case, reversed temperature relationships have been observed in the past. To account for this possibility, the current SAE standards indicate that the regression curves that establish HOTs must be calculated using “the most restrictive temperature in the band.” For example, “Below -3°C to -8°C” HOTs for fluids with a reversed relationship would be calculated using -4°C as the input temperature.

5.6.2.2 *Temperature-Independent Relationship*

As seen in Figure 5.3, HOTs produced for temperature-independent fluids do not contain a temperature-derived safety buffer like standard fluids. The frequency of temperature-independent relationships is significant, with 45 percent of undiluted EG fluids showing this relationship in warm temperatures. The frequency of these occurrences, combined with the decreased safety buffer, leads to the importance of introducing an updated HOT methodology.

Figure 5.4 and Figure 5.5 depict examples of the ET data and resulting regression curves for a standard fluid and a temperature-independent fluid.

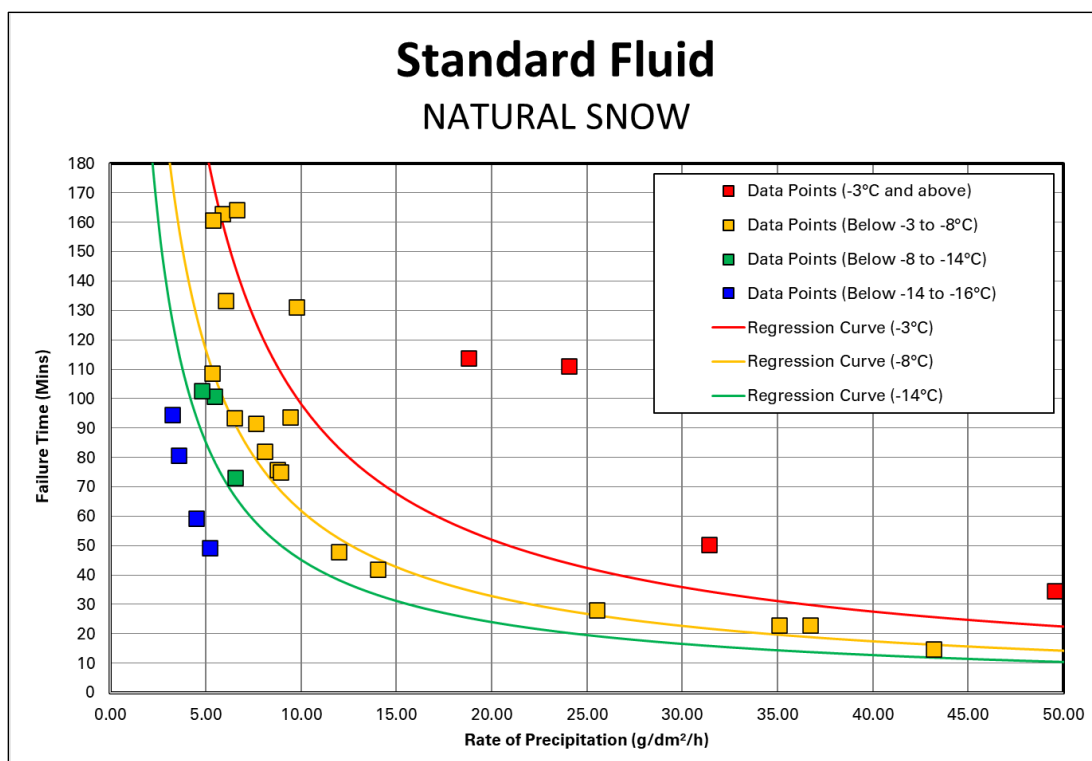


Figure 5.4: Example of Standard Relationship in Warm Snow

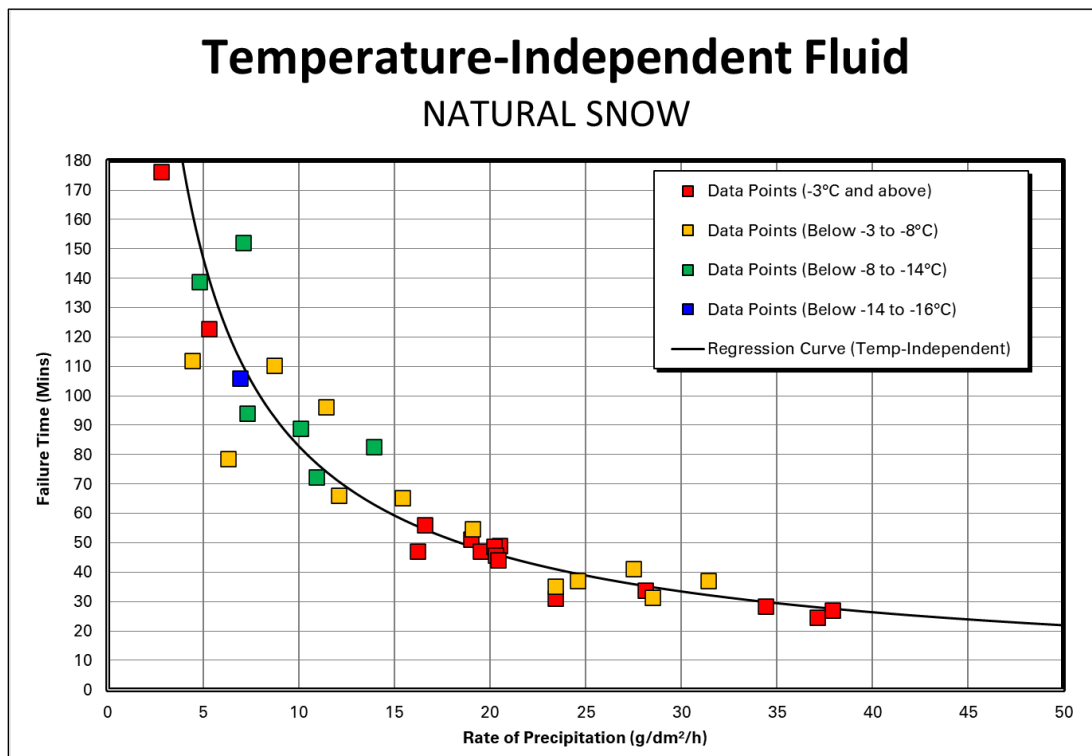


Figure 5.5: Example of Temperature-Independent Relationship in Warm Snow

The data points of the standard fluid in Figure 5.4 mostly fall above their respective regression curves, while the data points of the temperature-independent fluid in Figure 5.5 are split above and below the single regression curve. The risk posed by the current methodology can be expressed quantitatively through two parameters:

- The frequency of data points that fall below the regression curve, or where the test ET was below the expected ET as calculated by the regression equation; and
- The average of the differences (or buffer) between the test ETs and the expected ET at that precipitation rate. This can be expressed in minutes or as a percent difference.

These parameters can be used to compare the level of risk of a standard fluid and a temperature-independent fluid. An example comparison is presented in Table 5.3.

Table 5.3: Comparative Risk Analysis for Temperature-Independent Fluids in Warm Snow

Risk Parameter	Standard Fluid	Temperature-Independent Fluid
% of Data Below Regression Curve	10%	54%
Average Difference from Regression Curve (mins)	38.8	1.8
Average Difference from Regression Curve (%)	47%	2%

With the standard fluid, only 10 percent of the data points fell below their regression curve, and there was an average safety buffer of 39 minutes, or 47 percent. With the temperature-independent fluid, 54 percent of the data points fell below their regression curve, with virtually no temperature-driven safety buffer. Similar results are observed when analysing the risk parameters of all the fluids in the 2024-25 HOT Guidelines that were temperature-independent in natural snow.

To ensure that temperature-independent fluids have the same level of safety as standard fluids, it is recommended that methods to provide a safety buffer to their Natural Snow HOTs be evaluated.

One possible method of doing so is by applying a prediction interval. Figure 5.6 displays a temperature-independent fluid regression curve generated using the lower end of a 66 percent prediction interval (equivalent to one standard deviation) derived from the fluid data.

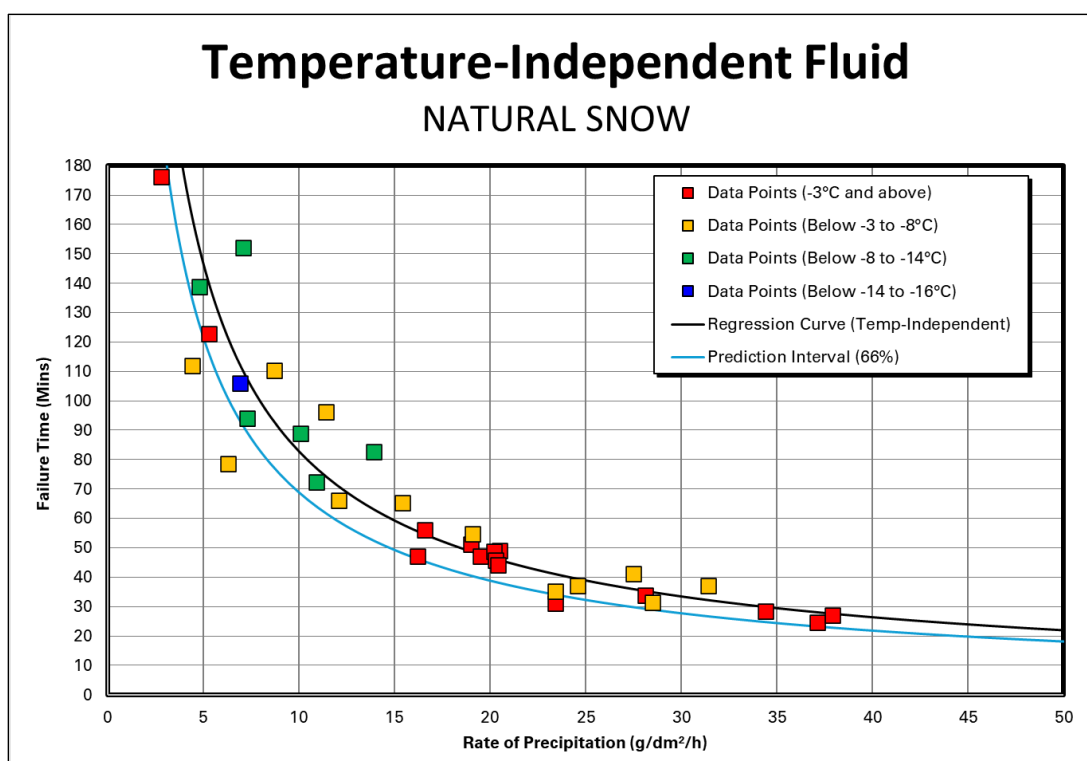


Figure 5.6: Temperature-Independent Fluid in Warm Snow with Prediction Interval

The risk parameters can be compared for the example temperature-independent fluid with and without the prediction interval methodology. The results of this comparison are presented in Table 5.4.

Table 5.4: Risk Parameter Comparison for Temperature-Independent Warm Snow by Methodology

Risk Parameter	Temperature-Independent Fluid		Standard Fluid
	No Prediction Interval	With Prediction Interval	
% of Data Below Regression Curve	54%	10%	10%
Average Difference from Regression Curve (mins)	1.8	17.6	38.8
Average Difference from Regression Curve (%)	2%	23%	47%

Without the prediction interval, 54 percent of the data points fall below the regression curve. Using the 66 percent prediction interval, this percentage decreases to 10 percent, with an average buffer of 18 minutes, or 23 percent. These three metrics are much closer to those of the standard fluid, indicating that this methodology could be a way to provide temperature-independent fluids with a safety buffer comparable to that of standard fluids.

It should be noted, however, that adopting this methodology would result in shorter HOTs for temperature-independent fluids as compared to the current methodology. For reference, Table 5.5 presents the impact of using the 66 percent prediction interval curve on the current example fluid's Warm Snow TC HOTs (Snow HOTs capped at two hours).

Table 5.5: Impact of 66% Prediction-Interval Methodology on Example Fluid's Warm Snow HOTs

Outside Air Temperature	Fluid Dilution	Very Light Snow, Snow Grains or Snow Pellets		Light Snow, Snow Grains or Snow Pellets		Moderate Snow, Snow Grains or Snow Pellets	
		Current	Proposed	Current	Proposed	Current	Proposed
-3 °C and above (27 °F and above)	100/0	2:00 - 2:00	2:00 - 2:00	1:25 - 2:00	1:10 - 2:00	0:40 - 1:25	0:30 - 1:10
below -3 to -8 °C (below 27 to 18 °F)	100/0	2:00 - 2:00	2:00 - 2:00	1:25 - 2:00	1:10 - 2:00	0:40 - 1:25	0:30 - 1:10
below -8 to -14 °C (below 18 to 7 °F)	100/0	2:00 - 2:00	2:00 - 2:00	1:25 - 2:00	1:10 - 2:00	0:40 - 1:25	0:30 - 1:10

This methodology would result in HOT decreases of 10 to 15 minutes in the light and moderate snowfall intensities. This change would result in a similar reduction to seven of the 36 fluids in the 2024-25 Guidelines. However, further analysis is required to evaluate the existing safety buffer of the currently published fluids with standard temperature-ET relationships to properly set the prediction interval percentage so that temperature-independent fluids are not overly penalized.

5.6.3 Freezing Precipitation

This subsection explores the associated risks of the current freezing precipitation HOT methodology on non-standard fluids and details possible updated methodologies.

5.6.3.1 Reversed Temperature-ET Relationship

As seen in Table 5.2, the frequency of reversed temperature-ET relationships is much greater in freezing precipitation than in natural snow. Additionally, the reversed temperature-ET relationships can potentially present more risk than temperature-independent relationships from an HOT perspective. Figure 5.7 and Figure 5.8 depict examples of the ET data and resulting regression curves for a standard fluid and a reversed fluid in light freezing rain.

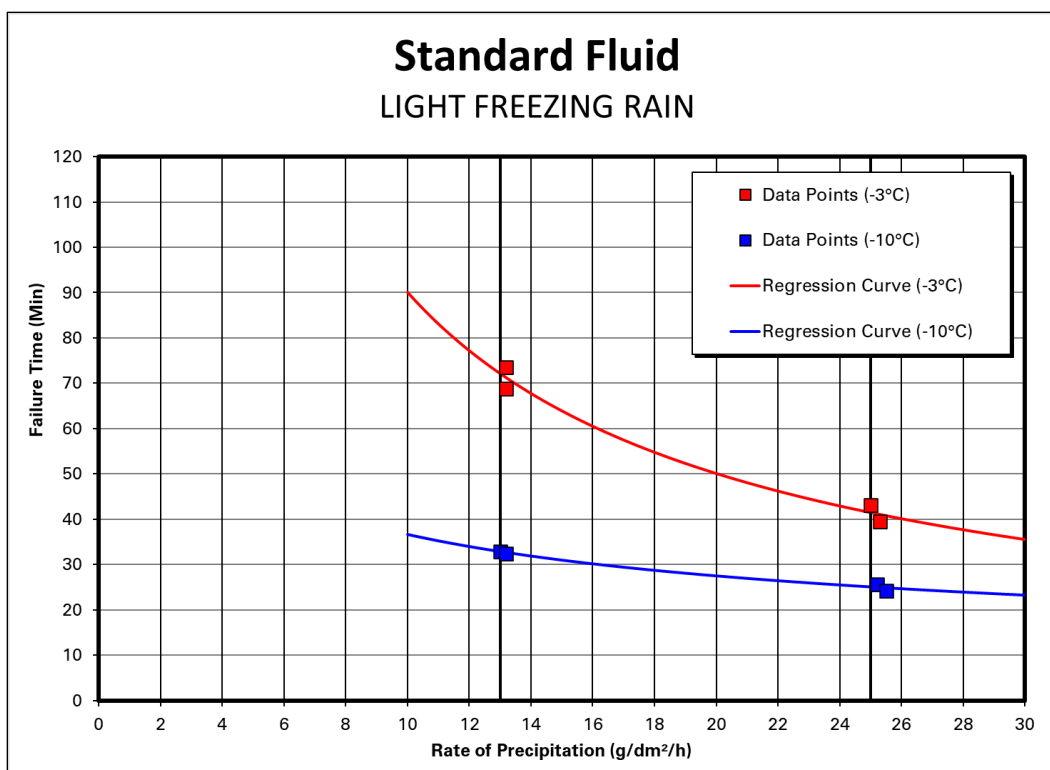


Figure 5.7: Example of Standard Relationship in Freezing Precipitation

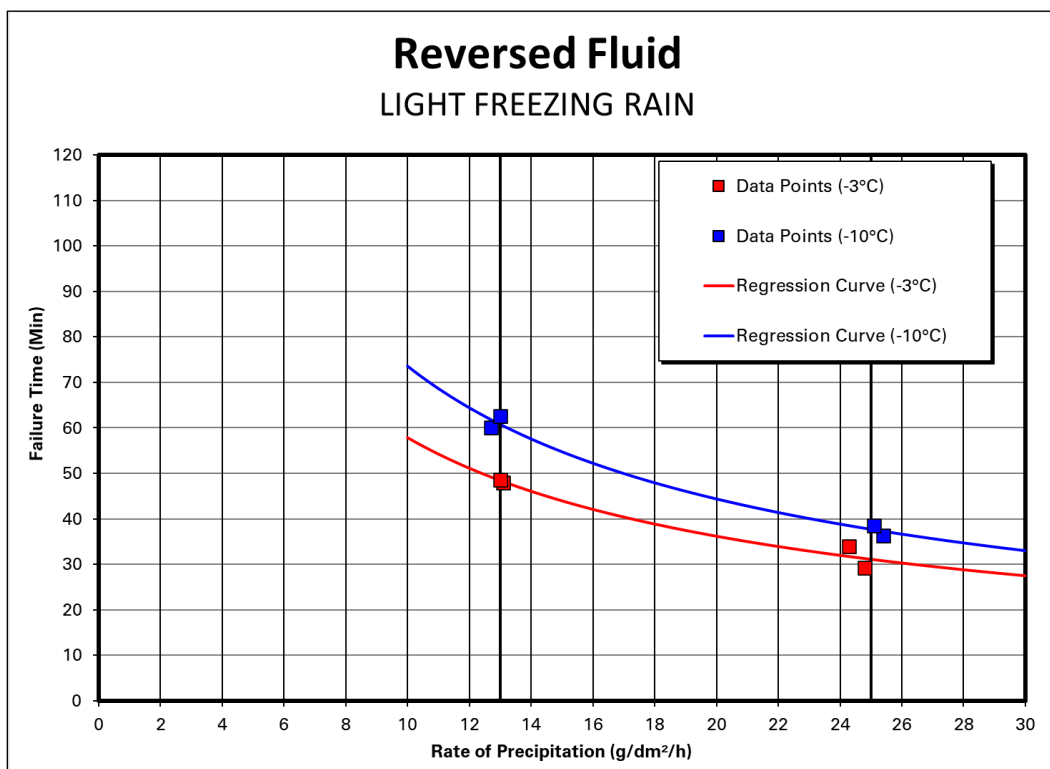


Figure 5.8: Example of Reversed Relationship in Freezing Precipitation

The resulting HOTs for Light Freezing Rain using the current methodology are presented in Table 5.6.

Table 5.6: HOT for Example Reversed Relationship Light Freezing Rain

Outside Air Temperature	Fluid Dilution	Light Freezing Rain
-3°C and Above (27°F and Above)	100/0	0:30 - 0:50
	75/25	N/A
	50/50	N/A
Below -3 to -8°C (Below 27 to 18°F)	100/0	0:40 - 1:00
	75/25	N/A
Below -8 to -10°C (Below 18 to 7°F)	100/0	0:40 - 1:00
	75/25	N/A

Under the current methodology, the HOTs at temperatures below -3°C would be longer than at temperatures of -3°C and above. As highlighted in Figure 5.2, the issue with this methodology is that the HOT provided for temperatures between -4°C and -9°C may be longer than the expected fluid ETs. In other words, the expected ET of this fluid at -4°C (the warmest temperature in the band) is shorter than the provided HOT, which was determined based on tests conducted at -8°C (the coldest temperature in the band).

To address this issue, two modifications to the HOT methodology are possible.

5.6.3.1.1 Method 1 for Addressing HOT Issues for Reversed Fluids in Freezing Precipitation

For fluids with a reversed temperature-ET relationship, the shortest ET is expected to occur at the warmest temperature in the band (i.e., -4°C, for the “Below -3°C to -8°C” range). Since freezing precipitation tests are only conducted at the coldest temperature in the band (i.e., -8°C), the expected ET at the warmest temperature in the band (i.e., -4°C), would have to be estimated.

Like with natural snow, regressing over the full temperature set is possible. The formulas for these different regression methodologies are outlined below:

Typical freezing precipitation regression formula (regressed at test temperature):

$$t = 10^I R^A$$

Full temperature range regression formula (same as natural snow):

$$t = 10^I R^A (2 - T)^B$$

The full temperature range methodology is not currently done with freezing precipitation, as the rate relationship can differ across the test temperatures, resulting in regression curves that are not congruent with the test ETs. In the above example, the rate coefficients are similar between the -3°C and -10°C curves, so regressing over the full temperature range provides results very similar to regressing at the individual temperatures.

Using the full regression methodology allows for expected ETs at temperatures other than the test temperatures to be calculated as well. The data and resulting full-range regression curves, including temperatures other than -3°C and -10°C , are presented in Figure 5.9.

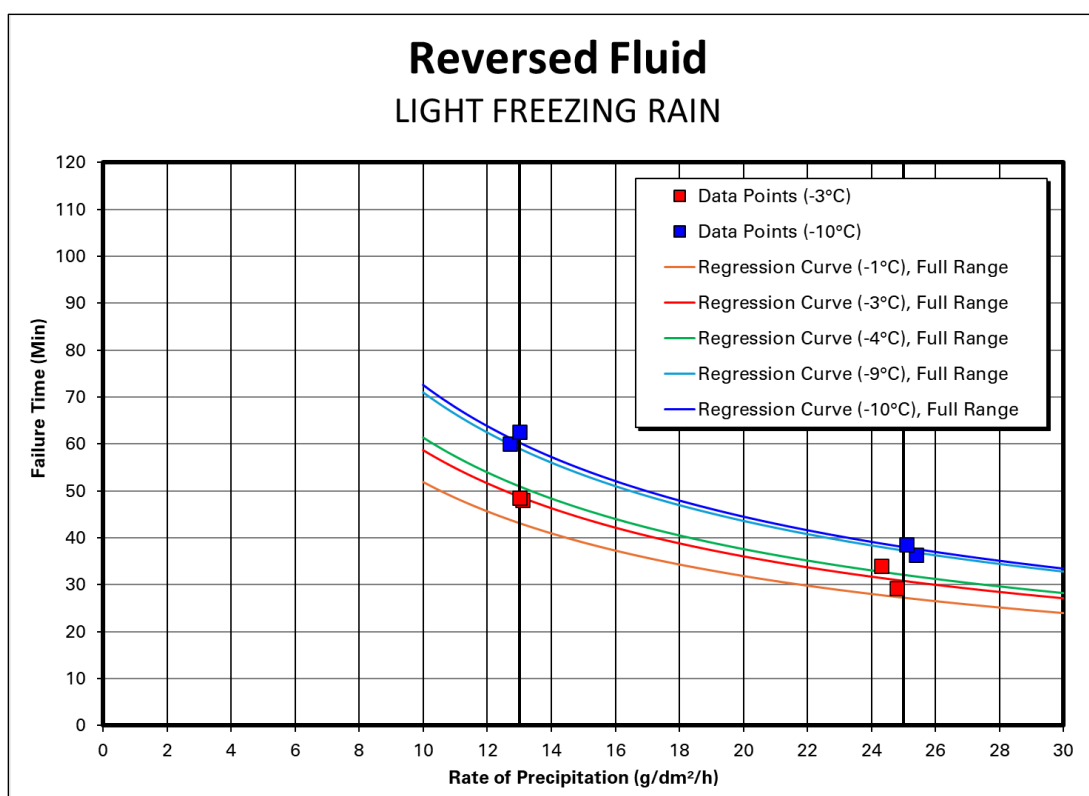


Figure 5.9: Full Temperature Range Regression for Reversed Relationship in ZR

The expected fluid ETs at these temperatures can then be estimated using the regression curves. Table 5.7 presents both the unrounded HOTS as they are calculated according to the standard HOT methodology, as well as the estimated ETs calculated using the full temperature range regression. These times and the difference between the times are presented at different temperatures within the standard HOT temperature bands.

Table 5.7: Comparison of Estimated ET and Unrounded HOT for Fluid in ZR with a Reversed Relationship

HOT		Temperature				
		-3°C and Above		Below -3 to -8°C & Below -8 to -10°C		
Rate Range	Method	-1°C	-3°C	-4°C	-9°C	-10°C
High Rate	Standard HOT	31	31	38	38	38
	Estimated ET	28	31	33	37	37
	Difference	-9%	1%	-14%	-3%	-1%
Low Rate	Standard HOT	48	48	61	61	61
	Estimated ET	42	48	51	60	61
	Difference	-14%	-1%	-17%	-2%	1%

It can be observed that, at the warmest temperatures within their respective temperature bands (-1°C, -4°C, and -9°C), there are large differences between the estimated fluid ETs and the unrounded HOTs.

It should be noted, however, that the calculated temperature coefficient was derived from tests at only two temperatures and may not properly capture the relationship between temperature and ET. Freezing precipitation test data collected at additional temperatures would be necessary to better characterize the temperature relationship.

As such, this methodology is currently better used as a method of evaluating the current risk. It could not be applied as a formal methodology without testing additional temperatures.

5.6.3.1.2 Method 2 for Addressing HOT Issues for Reversed Fluids in Freezing Precipitation

In the case where fluids have a reversed temperature-ET relationship in ZR (or ZF/ZD), the HOTs at below -3 to -8°C and below -8 to -14°C are longer than that of -3°C and above. However, since the -4°C ETs are expected to be very similar to the -3°C ETs, a conservative approach would be to apply the shorter HOTs of the warmer range to the colder ranges. This would remove the current risk that exists when operating at very typical conditions of -4°C and slightly below. However, it is more restrictive when operating near the -10°C temperature at which the longer ETs were observed.

Table 5.8 displays the current Light Freezing Rain HOTs for the example fluid as well as the proposed HOTs using the shortest band methodology (Method 2) on the temperature ranges below -3°C. The impact in minutes and percentage difference is also presented.

Table 5.8: Impact of Shortest Band Methodology on Example Fluid's ZR HOTs

Outside Air Temperature	Fluid Dilution	Light Freezing Rain HOT						HOT Impact			
		Current			Proposed			Low		High	
-3°C and Above (27°F and Above)	100/0	0:30	-	0:50	0:30	-	0:50	0	0%	0	0%
	75/25		N/A			N/A					
	50/50		N/A			N/A					
Below -3 to -8°C (Below 27 to 18°F)	100/0	0:40	-	1:00	0:30	-	0:50	-10	-25%	-10	-17%
	75/25		N/A			N/A					
Below -8 to -10°C (Below 18 to 14°F)	100/0	0:40	-	1:00	0:30	-	0:50	-10	-25%	-10	-17%
	75/25		N/A			N/A					

Applying this methodology would decrease the Light Freezing Rain HOTs of this fluid by 17 percent to 25 percent.

If this methodology were applied to the fluids within the 2024-25 HOT Guidelines, seven of the 36 fluids would have reduced Light Freezing Rain HOTs. This methodological modification would cause decreases in the Freezing Fog and Freezing Drizzle HOTs as well, but with fewer and less significant decreases.

While replacing the colder temperature range HOTs with the shorter HOTs from the warmer bands is essential to addressing the current safety risk, it would result in significant HOT decreases that are overly restrictive in temperatures below -8°C. Testing additional temperatures would help properly characterize the temperature relationship and allow for HOTs that preserve the safety buffer without over-restricting certain temperature ranges.

5.6.3.2 Temperature-Independent Relationship

As explained in Subsection 5.6.1.2, using the standard HOT methodology with temperature-independent relationships results in HOTs that have less of a safety buffer than that of standard fluids.

The methodology proposed in Subsection 5.6.2.2 for addressing this in natural snow was to use prediction intervals to create a safety buffer at all temperatures. However, that methodology requires a more robust data set. Otherwise, tests with little variability (i.e., where the duplicate tests at the same temperature and rate result in almost equal ETs) will have prediction intervals that are too small, while tests with greater variability will have prediction intervals that are too large and too restrictive.

Figure 5.10 presents an example of a temperature-independent relationship in freezing drizzle at low rates.

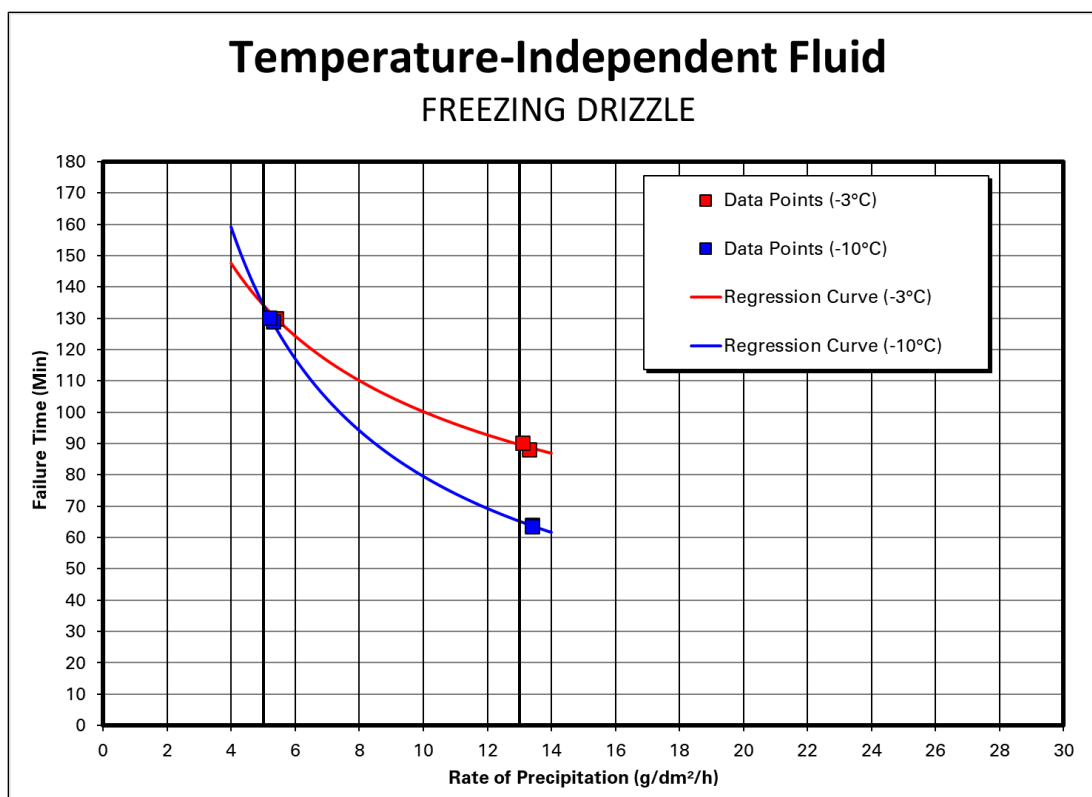


Figure 5.10: Example of Temperature-Independent Freezing Drizzle at Low Rate

As highlighted in Figure 5.11, due to the low sample size and lack of variability that can come from using equivalent test conditions, the resulting 66 percent prediction interval would have no impact on the produced HOT.

In these cases, additional testing would be required to properly characterize the nature of the temperature-ET relationship and evaluate a methodology that provides a better safety buffer.

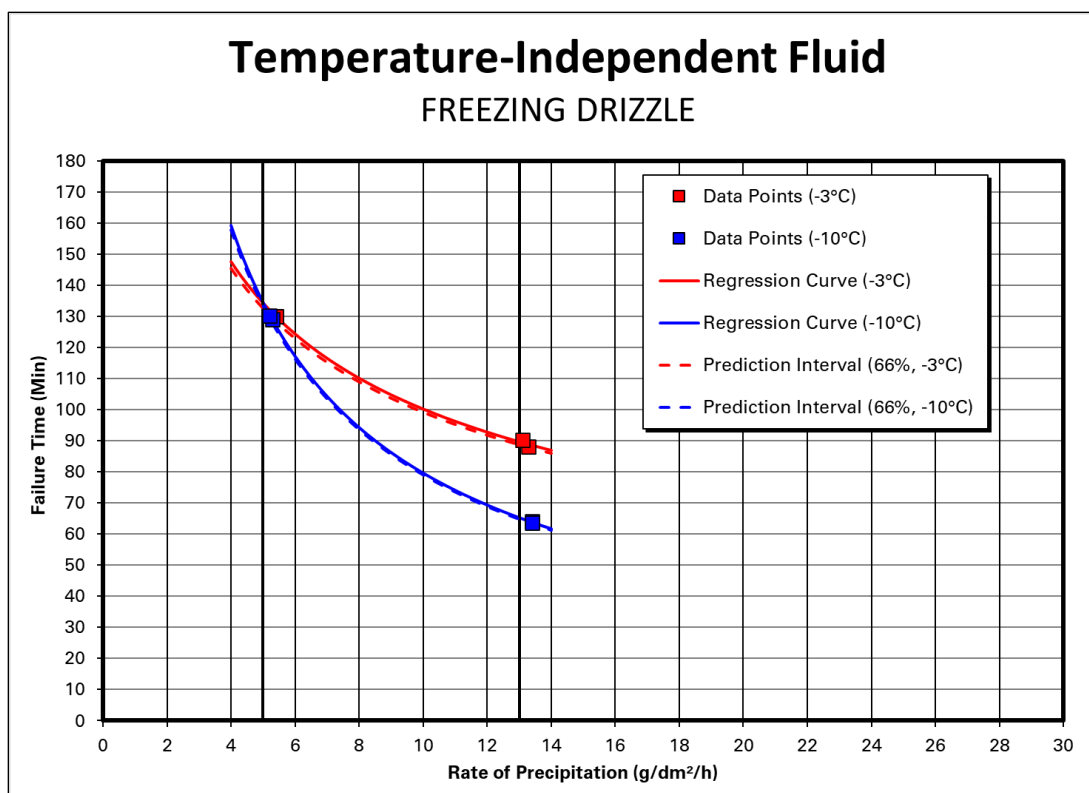


Figure 5.11: Example of Temperature-Independent Freezing Drizzle with 66% Prediction Intervals

5.7 Conclusions

A total of 36 fluids within the 2024-25 HOT Guidelines were examined with the objective of determining the frequency of non-standard temperature-ET relationships and evaluating the risks associated with the current HOT methodology. Each fluid (13 of which were also tested at dilutions of 75/25 and 50/50) was analysed for every temperature range and precipitation type, for a total of 265 unique data sets. From this analysis, the following conclusions can be drawn:

- 18 percent of the fluid data sets were found to have a non-standard temperature relationship;
- Non-standard temperature relationships occurred more frequently within EG-based fluid data sets than PG-based fluids; and
- Non-standard temperature relationships occurred more frequently at warmer temperatures.

These non-standard temperature relationships impact the safety buffer of the fluid HOTs:

- With a reversed relationship, HOTs at temperatures other than the coldest in the temperature band are shorter than their expected ETs; and
- With a temperature-independent relationship, the HOTs are equal to the expected ETs at all temperatures, meaning no temperature-driven safety buffer exists.

To address the risk of temperature-independent relationships in snow, a prediction interval methodology could be employed to establish a safety buffer.

To address the risk of reversed temperature relationships in freezing precipitation, two methods have been proposed:

- Applying the shorter times of the warmer temperature band to colder bands; or
- Using a regression methodology that evaluates the temperature impact. While less restrictive, this methodology would require testing at additional temperatures.

Further evaluation of the current level of risk for standard fluids is needed before refining and implementing any new data handling methodologies. Additionally, freezing precipitation tests at more temperatures are needed to properly characterize the temperature relationship in freezing precipitation and provide HOTs that address the current safety risk without over-restricting certain temperature ranges.

5.8 Recommendations

It is recommended that TC/FAA continue to evaluate the HOT development methodologies for fluids with non-standard ET relationships, with the goal of determining the best practice for establishing guidance in the future.

The following activities are recommended for the 2025-26 project year to further support this research:

- Conducting freezing precipitation tests at intermediate temperatures, which will enable further characterization of the non-standard relationships observed (and could identify any anomalies potentially being introduced by the testing process employed);
- Evaluating the risk level of currently published fluids with standard temperature-ET relationships; and
- Revisiting the proposed methodologies for the evaluation and HOT development of fluids with non-standard temperature-ET relationships and determining the best path for implementation into guidance materials.

6. EVALUATION OF FLUID VISCOSITY PROFILE IMPACT ON FLUID ENDURANCE TIMES AND EFFECTS ON HOLDOVER TIMES

This section documents the work completed during the 2024-25 winter on testing and evaluating the impact of fluid viscosity profiles on endurance and holdover times (HOTS).

6.1 Background

SAE International (SAE) has published standards detailing the current practices for obtaining and publishing HOTS for Type II/III/IV anti-icing fluids. The Aerospace Recommended Practice (ARP) 5485 document and Aerospace Material Specification (AMS) 1428 document outline these practices for Type II/III/IV anti-icing fluids, respectively. These documents define the “specifically determined/artificially created” fluid viscosity requirements for endurance time (ET) testing, aerodynamic testing, and all technical requirement testing.

The Federal Aviation Administration (FAA) and Transport Canada (TC) publish the lowest on-wing viscosity (LOWV) and highest on-wing viscosity (HOWV) in the HOT Guidelines, defining the production ranges for fluids.

When manufacturers supply test samples for endurance time testing, it is generally assumed that LOWV will yield a more conservative performance value than HOWV, as the greater fluid thickness of the latter provides extended protection time.

In recent years, fluid manufacturers have increasingly provided mid-production samples to support research and development efforts. Further analysis revealed that the assumption of LOWV being more conservative was not always accurate under specific temperature and precipitation rate conditions.

6.2 Previous Work

Previous research programs within industry have evaluated fluid samples with production viscosity that falls between the LOWV and HOWV. These samples have generally been assumed to provide longer endurance than LOWV and more favourable aerodynamic performance than HOWV. When comparing endurance times obtained during such research efforts with the published HOT tables, inconsistencies were identified. In some cases, endurance times observed in testing were lower than the published HOT values. These discrepancies provided the basis for the 2024-25 testing program, which aimed to systematically evaluate the impact of viscosity on endurance times.

6.3 Objective

The purpose of this testing is to assess the impact on endurance time across different artificially created viscosities of the same fluid sample, determining whether the lowest viscosity consistently represents the most conservative performance under all conditions.

6.4 Test Methodology

The two following subsections describe the methodology for both the fluid sample preparation and testing methodology.

6.4.1 Fluid Sample Preparation

Two commercialized propylene glycol (PG)-based fluids were selected for testing, one Type II and one Type IV from two separate manufacturers. Each fluid was prepared using three different viscosity levels: high, mid, and low. The artificially created fluid viscosities were prepared using a Waring 7012G seven-speed blender at a specified revolution (per minute) and five different blending times. The process resulted in six fluid samples in total. The prepared samples were stored for 24 hours prior to viscosity measurement and were monitored throughout the testing season to ensure stability. Table 6.1 provides a summary of the viscosity measurements of the fluid samples tested.

Table 6.1: Viscosity Measured of the Fluid Samples Tested

Fluid Type	Fluid Base	Fluid Production Range	Fluid Code	RPM	Shear time	Viscosity Method	Measured Viscosity (mPa)
II	PG	High Viscosity	153A	n/a	0 minutes	a ¹	14,180
		Mid Viscosity	154A	2,800	15 minutes		10,200
		Low Viscosity	155A	2,800	35 minutes		8,620
IV	PG	High Viscosity	156A	n/a	0 minutes	f ²	16,200
		Mid Viscosity	157A	2,800	5 minutes		8,400
		Low Viscosity	158A	2,800	15 minutes		4,800

1. Method "a": LV1 (with guard leg), 600 mL low form (Griffin) beaker, 575 mL, 20°C, 0.3 rpm, 10 minutes.

2. Method "f": SC4-34/13R, small sample adapter, 10 mL, 20°C, 0.3 rpm, 10 minutes.

6.4.2 Endurance Time Tests

Comparative endurance time testing was conducted to evaluate the fluid performance. A subset of tests was conducted with each of the fluid samples of the HOT precipitation conditions described in ARP5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type II, III, and IV* (9). Natural snow was targeted within a temperature range of 0°C to -14°C, and additional data was collected in the freezing precipitation conditions of light freezing rain and freezing fog. The objective was to obtain a broad range of temperatures and precipitation rates that encompass the vast majority of observed test conditions.

6.4.3 Test Procedures

Tests were conducted under natural snow conditions at the APS Aviation Inc. (APS) test site facility located at the Montréal–Pierre Elliott Trudeau International Airport (YUL) in Montreal, while simulated conditions testing was conducted at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) facility located in Ottawa.

Standard endurance time test and rate collection protocols were followed during the execution of these tests. A six-position test stand with an adjacent rate collection station was used, as shown in Figure 6.1.

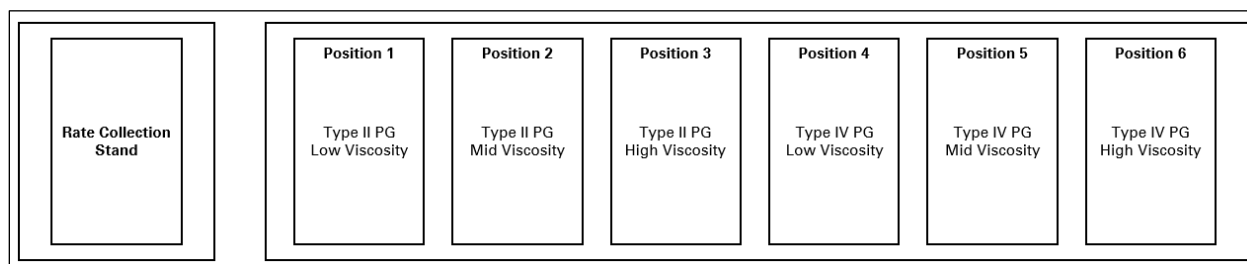


Figure 6.1: Test Stand Setup for Endurance Time Tests

6.5 Data Collected

In total, 54 tests were conducted, of which 42 were completed in natural snow at the APS test site in Montreal, and 12 tests were conducted in simulated freezing fog and light freezing rain conditions at the NRC CEF in Ottawa. Table 6.2 provides a list of all tests conducted.

Table 6.2: Test Log of Completed Tests

Test #	Date	Fluid Code	Fluid Production Range	Test Condition	Temperature Category	Endurance Time (mins)	Actual Temperature (°C)	Average Rate (g/dm ² /h)
1	04-Dec-24	156A	High Viscosity	Natural Snow	Above -3°C	337.6	-1.1	3.0
2	04-Dec-24	157A	Mid Viscosity	Natural Snow	Above -3°C	291.0	-1.1	3.0
3	04-Dec-24	158A	Low Viscosity	Natural Snow	Above -3°C	277.6	-1.1	2.9
4	07-Dec-24	153A	High Viscosity	Natural Snow	-3°C to -8°C	147.1	-5.5	6.6
5	07-Dec-24	154A	Mid Viscosity	Natural Snow	-3°C to -8°C	108.6	-5.8	7.2
6	07-Dec-24	155A	Low Viscosity	Natural Snow	-3°C to -8°C	92.7	-6.0	7.1
7	07-Dec-24	156A	High Viscosity	Natural Snow	Above -3°C	186.9	-2.6	7.4
8	07-Dec-24	158A	Low Viscosity	Natural Snow	Above -3°C	163.9	-2.7	7.5
9	07-Dec-24	157A	Mid Viscosity	Natural Snow	Above -3°C	163.8	-2.7	7.5
10	09-Dec-24	156A	High Viscosity	Natural Snow	-3°C to -8°C	134.1	-6.1	11.5
11	09-Dec-24	157A	Mid Viscosity	Natural Snow	-3°C to -8°C	133.8	-6.1	11.5
12	09-Dec-24	158A	Low Viscosity	Natural Snow	-3°C to -8°C	130.7	-6.1	11.6
13	30-Jan-25	153A	High Viscosity	Natural Snow	-8°C to -14°C	232.3	-11.0	1.2
14	30-Jan-25	155A	Low Viscosity	Natural Snow	-8°C to -14°C	240.8	-10.9	1.3
15	30-Jan-25	154A	Mid Viscosity	Natural Snow	-8°C to -14°C	228.1	-11.0	1.2
16	03-Feb-25	158A	Low Viscosity	Natural Snow	-3°C to -8°C	116.8	-3.5	10.4
17	03-Feb-25	157A	Mid Viscosity	Natural Snow	-3°C to -8°C	114.8	-3.5	10.5
18	03-Feb-25	156A	High Viscosity	Natural Snow	-3°C to -8°C	106.9	-3.5	10.0
19	03-Feb-25	155A	Low Viscosity	Natural Snow	-3°C to -8°C	92.3	-3.5	9.9
20	03-Feb-25	154A	Mid Viscosity	Natural Snow	-3°C to -8°C	65.3	-3.6	10.3
21	03-Feb-25	153A	High Viscosity	Natural Snow	-3°C to -8°C	65.1	-3.6	10.3
22	03-Feb-25	155A	Low Viscosity	Natural Snow	-3°C to -8°C	66.7	-3.2	16.6
23	03-Feb-25	154A	Mid Viscosity	Natural Snow	-3°C to -8°C	59.2	-3.2	16.5
24	03-Feb-25	153A	High Viscosity	Natural Snow	-3°C to -8°C	57.5	-3.2	16.5
25	03-Feb-25	158A	Low Viscosity	Natural Snow	-3°C to -8°C	95.3	-3.2	14.6
26	03-Feb-25	157A	Mid Viscosity	Natural Snow	-3°C to -8°C	91.0	-3.2	14.6
27	03-Feb-25	156A	High Viscosity	Natural Snow	-3°C to -8°C	94.4	-3.2	14.6
28	13-Feb-25	153A	High Viscosity	Natural Snow	-8°C to -14°C	40.3	-11.8	11.1
29	13-Feb-25	154A	Mid Viscosity	Natural Snow	-8°C to -14°C	40.1	-11.8	11.1
30	13-Feb-25	155A	Low Viscosity	Natural Snow	-8°C to -14°C	50.7	-11.8	13.4
31	16-Feb-25	156A	High Viscosity	Natural Snow	-8°C to -14°C	64.4	-10.2	14.9
32	16-Feb-25	157A	Mid Viscosity	Natural Snow	-8°C to -14°C	69.6	-10.2	15.5

Table 6.2: Test Log of Completed Tests (cont'd)

Test #	Date	Fluid Code	Fluid Production Range	Test Condition	Temperature Category	Endurance Time (mins)	Actual Temperature (°C)	Average Rate (g/dm ² /h)
33	16-Feb-25	158A	Low Viscosity	Natural Snow	-8°C to -14°C	75.1	-10.2	16.1
34	16-Feb-25	153A	High Viscosity	Natural Snow	-8°C to -14°C	42.4	-10.2	13.8
35	16-Feb-25	154A	Mid Viscosity	Natural Snow	-8°C to -14°C	37.2	-10.2	13.8
36	16-Feb-25	155A	Low Viscosity	Natural Snow	-8°C to -14°C	42.5	-10.2	13.1
37	16-Feb-25	156A	High Viscosity	Natural Snow	-8°C to -14°C	41.9	-9.9	33.6
38	16-Feb-25	157A	Mid Viscosity	Natural Snow	-8°C to -14°C	42.1	-9.9	33.8
39	16-Feb-25	158A	Low Viscosity	Natural Snow	-8°C to -14°C	42.7	-9.9	33.9
40	16-Feb-25	153A	High Viscosity	Natural Snow	-8°C to -14°C	24.6	-10.0	30.4
41	16-Feb-25	154A	Mid Viscosity	Natural Snow	-8°C to -14°C	24.4	-9.9	30.5
42	16-Feb-25	155A	Low Viscosity	Natural Snow	-8°C to -14°C	25.5	-9.9	30.9
43	18-Mar-25	153A	High Viscosity	Freezing Fog	-25°C	24.6	-25	5.0
44	18-Mar-25	154A	Mid Viscosity	Freezing Fog	-25°C	30.1	-25	5.0
45	18-Mar-25	155A	Low Viscosity	Freezing Fog	-25°C	35.8	-25	5.0
46	18-Mar-25	156A	High Viscosity	Freezing Fog	-25°C	7.8	-25	5.0
47	18-Mar-25	157A	Mid Viscosity	Freezing Fog	-25°C	12.1	-25	5.0
48	18-Mar-25	158A	Low Viscosity	Freezing Fog	-25°C	12.2	-25	5.0
49	26-Mar-25	153A	High Viscosity	Light Freezing Rain	-10°C	14.0	-10	13.0
50	26-Mar-25	154A	Mid Viscosity	Light Freezing Rain	-10°C	32.0	-10	13.0
51	26-Mar-25	155A	Low Viscosity	Light Freezing Rain	-10°C	33.9	-10	13.0
52	27-Mar-25	156A	High Viscosity	Light Freezing Rain	-10°C	20.9	-10	25.0
53	27-Mar-25	157A	Mid Viscosity	Light Freezing Rain	-10°C	20.6	-10	25.0
54	27-Mar-25	158A	Low Viscosity	Light Freezing Rain	-10°C	22.9	-10	25.0

6.6 Data Analysis

The two following subsections describe the data analysis conducted for the tests performed in natural snow and freezing precipitation conditions.

A side-by-side comparison enables the calculation of a performance ratio for the mid- and high-viscosity fluid samples relative to the low-viscosity sample. The performance ratio is determined as follows:

$$\text{Performance Ratio (\%)} = \frac{\text{Endurance Time}_{\text{Mid or High Viscosity}}}{\text{Endurance Time}_{\text{Low Viscosity}}} * 100$$

For this analysis, the low-viscosity sample was selected as the baseline for comparison with the mid- and high-viscosity samples to evaluate the effect of increasing viscosity on fluid performance. In essence, a performance ratio of greater than 100 percent indicates a better performance than the standard low-viscosity sample, and vice versa.

6.6.1 Natural Snow Data Analysis

Fourteen comparative test runs were conducted in natural snow conditions, comprising seven Type II PG and seven Type IV PG runs. This data is presented in both Figure 6.2 and Figure 6.3.

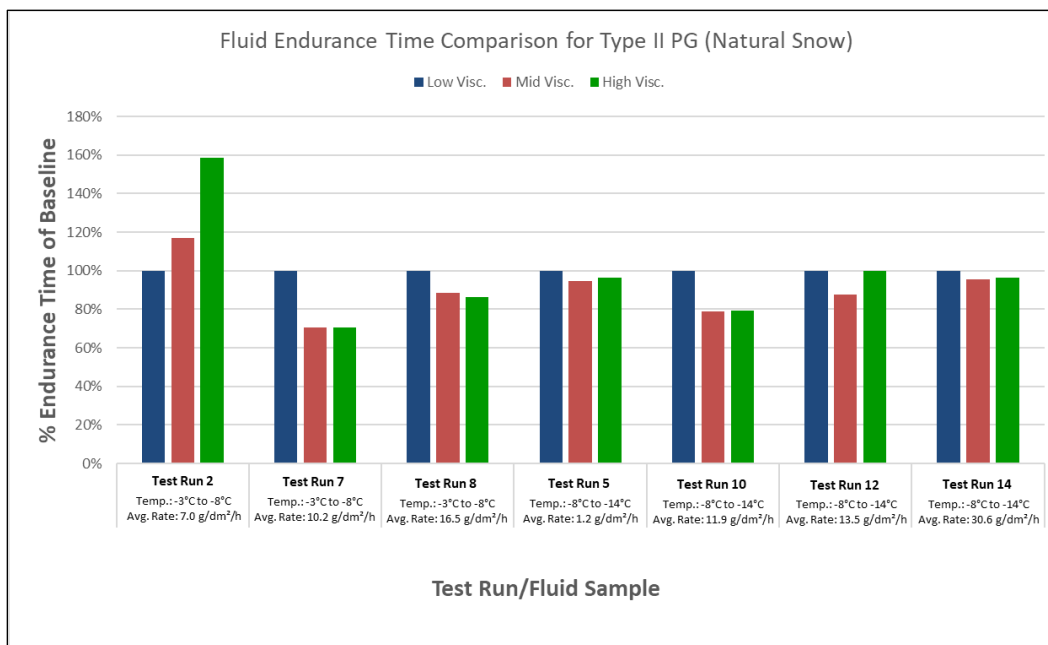


Figure 6.2: Type II PG – Natural Snow Tests

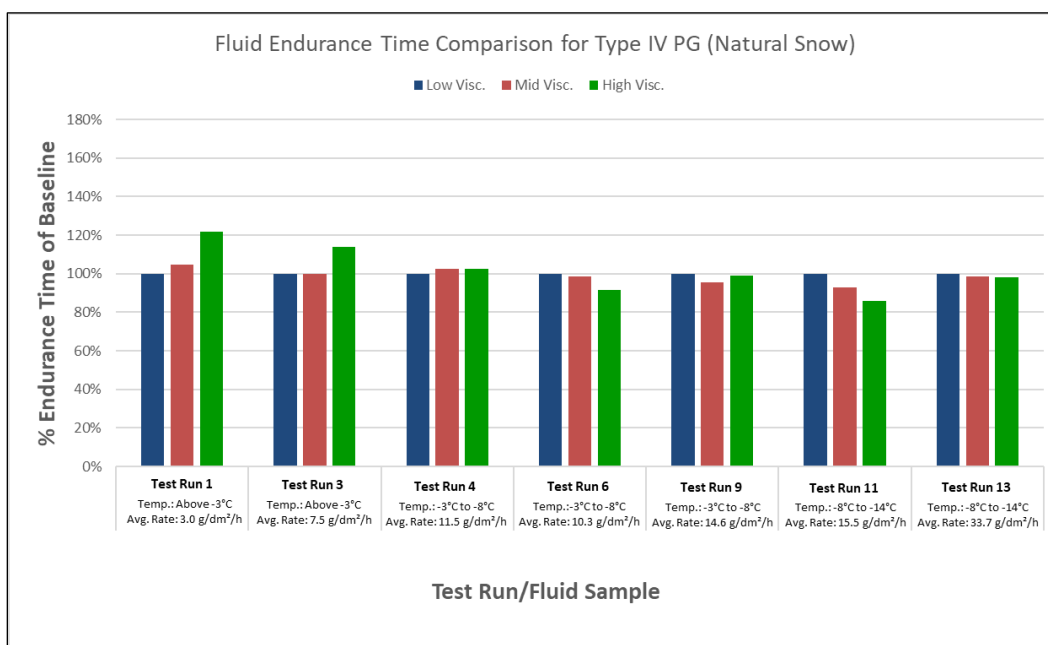


Figure 6.3: Type IV PG – Natural Snow Tests

6.6.2 Freezing Precipitation Data Analysis

Four comparative test runs using both Type II and Type IV PG were conducted under freezing precipitation conditions, which included two runs in freezing fog and two runs in light freezing rain. This data is presented in Figure 6.4.

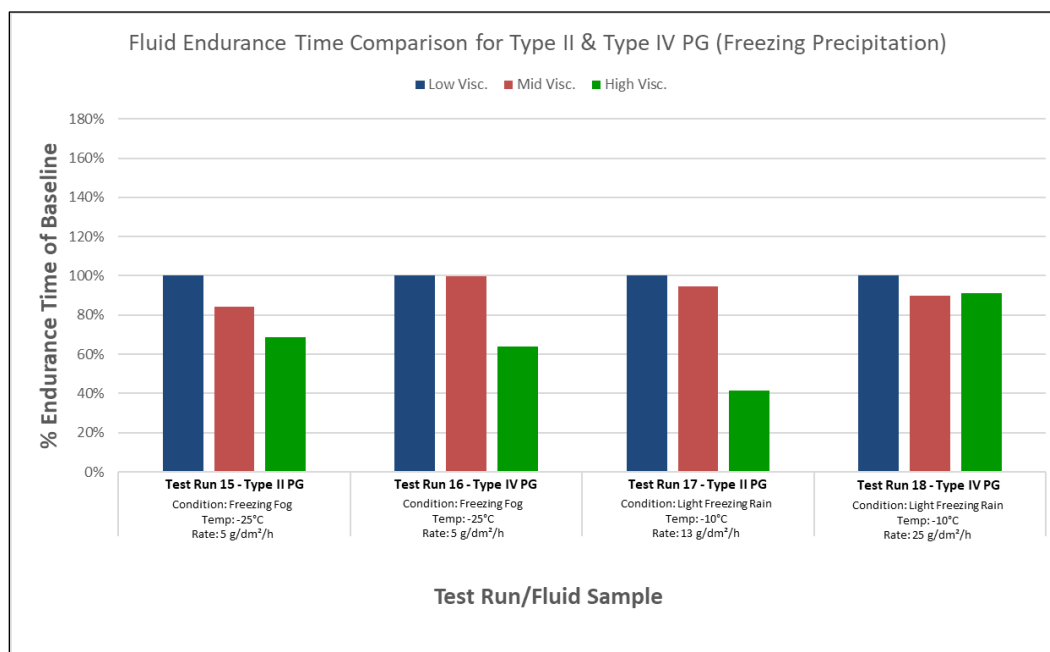


Figure 6.4: Type II & IV PG – Freezing Precipitation Tests

6.6.3 Summary of Results

To assess the impact of fluid viscosity on endurance time, all relevant data from this testing was combined and subsequently segregated by test condition. The outcomes of this analysis are summarized in Table 6.3.

Although only a limited number of tests were conducted, as noted in Subsection 6.1, the results demonstrate significant performance differences between the mid- and high-viscosity fluids relative to the low-viscosity reference. Based on the minimum ratios observed, both the mid- and high-viscosity samples indicated performance up to 59 percent lower than the low-viscosity sample. This was observed using a Type II PG fluid under light freezing rain conditions at -10 °C (Test Run 17). On average, the mid- and high-viscosity fluids performed at or below the level of the low-viscosity fluid.

Table 6.3: Summary of Type II and IV Fluids

Condition	Number of Runs	Average Ratio Compared to Baseline		Minimum Ratio Compared to Baseline		Maximum Ratio Compared to Baseline	
		Mid Viscosity	High Viscosity	Mid Viscosity	High Viscosity	Mid Viscosity	High Viscosity
Natural Snow	14	95 %	100%	71 %	70 %	117 %	159 %
Freezing Fog	2	92 %	66 %	84 %	64 %	100 %	69 %
Light Freezing Rain	2	92 %	66 %	90 %	41 %	94 %	91 %
Grand Total	18	93 %	77 %	71 %	41 %	117 %	159 %

6.7 Conclusions

The testing program demonstrated that the lowest-viscosity sample does not consistently yield the shortest endurance times under all precipitation and temperature conditions. In most cases, both the mid- and high-viscosity samples produced more restrictive endurance times than the low-viscosity reference. These findings challenge the long-standing assumption that the lowest-viscosity fluid samples always represent the most conservative case for endurance testing. Relying solely on low-viscosity fluid samples for HOT development could therefore result in overestimation of protection times, potentially reducing the integrity of published operational guidance.

6.8 Recommendations

Based on the findings of this test program, the following actions are recommended:

- Continuing to evaluate the impact of fluid viscosity on endurance times and the effects on HOTs by conducting a research project wherein manufacturers are requested to submit multiple viscosity samples for standard HOT testing and evaluate the resulting operational impacts;
- Measuring changes to fluid viscosity across a range of temperatures and assessing the impact on endurance times; and
- Developing potential testing options for TC and the FAA to evaluate to ensure continued safe operations and giving due consideration to current commercialized fluids.

7. SUPPORT INDUSTRY EFFORTS TO FURTHER DEVELOP VISCOSITY STANDARDS (AS9968)

This section documents the work completed during the 2024-25 winter supporting the further development of a single standardized viscosity testing method within Aerospace Standard (AS) AS9968.

7.1 Background

The publication of the Holdover Time (HOT) Guidelines prior to 2021 included both a manufacturer-specific method and a standardized method for determining fluid viscosity under AS9968. Following the most recent update to the standard, manufacturers are now allowed to choose their preferred viscosity testing method and are no longer required to adhere to a standardized method. As a result, quality control technicians in field operations have expressed concerns that the multiple testing methods add complexity, slow down the verification process, and reduce daily sample throughput.

7.2 Objective

The objective of this project is to assess the feasibility of adopting a single standardized viscosity testing method under AS9968 to improve efficiency in quality control checks while maintaining the repeatability, precision, and accuracy in determining whether fluids are within the published lowest on-wing viscosity (LOWV) and highest on-wing viscosity (HOWV). This review considers current industry concerns regarding multiple testing methods and their impact on quality control timelines.

7.3 Data Collected

The following subsections provide a detailed overview of the data collected for this research.

7.3.1 Review of Published Test Methods

As part of the assessment to determine whether a single viscosity test method is predominantly used for each fluid in the 2024-25 HOT Guidelines published by the Federal Aviation Administration (FAA) and Transport Canada (TC), a detailed count of all methods was conducted. Table 7.1 summarizes the frequency of each method's inclusion, while Table 7.2 provides detailed descriptions of the viscosity testing methods identified.

Table 7.1: Count of Current Viscosity Test Methods Used in the 2024-25 HOT Guidelines

Viscosity Method	LOWV Count			HOWV Count			Total Count
	Type II	Type III	Type IV	Type II	Type III	Type IV	
a	12	0	10	6	0	4	32
b	0	0	0	0	0	0	0
c	2	0	3	9	0	8	22
d	0	0	0	0	0	1	1
e	9	0	3	0	0	0	12
f	2	0	3	1	0	2	8
g	0	0	1	0	0	0	1
h	0	0	3	0	0	3	6
i	2	0	1	8	0	3	14
j	0	0	2	0	0	2	4
k	0	0	0	0	0	2	2
l	0	0	0	0	0	0	0
m	0	0	1	0	0	1	2
n	0	0	2	0	0	1	3
o	0	1	0	0	1	0	2
p	0	0	2	0	0	0	2
q	0	0	1	3	0	6	10

Table 7.2: Details of Viscosity Test Methods Available

Method	Brookfield Spindle	Container	Fluid Volume	Temp.	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL	20°C	0.3 rpm	10.0 minutes
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL	20°C	0.3 rpm	33.3 minutes
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	425 mL	20°C	0.3 rpm	10.0 minutes
d	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	575 mL	20°C	0.3 rpm	10.0 minutes
e	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	135 mL	20°C	0.3 rpm	10.0 minutes
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
g	SC4-34/13R	small sample adapter	10 mL	0°C	0.3 rpm	30.0 minutes
h	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
i	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	30.0 minutes
j	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10.0 minutes
k	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	30.0 minutes
l	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	15.0 minutes
m	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	10.0 minutes
n	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	30.0 minutes
o	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	65.0 minutes
p	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10.0 minutes
q	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10.0 minutes

7.3.2 Review of Viscosity Measurement Repeatability and Reproducibility

A review was conducted of past reports focusing on the repeatability and reproducibility of viscosity measurements. Section 6 of the TC report, TP 15559E, *Aircraft Ground Icing General Research Activities During the 2022-23 Winter* (10) summarizes the repeatability of viscosity values through both intra- and inter-laboratory testing. The key recommendation from this subsection is that, to achieve repeatable and reproducible results, laboratories should follow the manufacturer's recommended viscosity test method rather than relying solely on a standardized method that may not be suitable for all fluids.

7.3.3 Evaluation of Alternate Standardized Methods

Reverting to the previous standardized test methods (i.e., Methods A and C, as detailed in the above tables), which used two spindles at a single temperature, may not be appropriate. Feedback from fluid manufacturers indicated that the prior test parameters were not well suited to their products, particularly regarding spindle type and test temperature.

An evaluation of the current test methods, as shown in Subsection 7.3.1, identified six viable test setups applicable across all fluids, as summarized in Table 7.3. These configurations address manufacturers' key concerns related to spindle type and test temperature while avoiding the need for specialized equipment.

This approach could substantially reduce the number of viscosity test methods required for quality control. However, supporting data is lacking to confirm its suitability, as factors such as fluid volume and test duration have not yet been assessed.

Table 7.3: Viscosity Test Setups

Test Setup #	Spindle Type	Test Temperature
1	LV1	20°C
2	LV2-disc	20°C
3	SC4-34/13R	20°C
4	SC4-34/13R	0°C
5	SC4-31/13R	20°C
6	SC4-31/13R	0°C

7.4 Summary of Observations

The final observations below were made from conducting this project:

- A wide variety of viscosity testing methods are currently published in the 2024-25 HOT Guidelines, reflecting diverse fluid profiles;
- Historical reviews show that following manufacturer-specific viscosity methods generally results in better repeatability and reproducibility, as standardized methods are often not appropriate for all fluid types due to their complexities; and
- Streamlining viscosity testing methods could improve operational efficiency but requires careful consideration to ensure all fluid profiles are properly supported.

7.5 Recommendations

To streamline operations and improve efficiency, it is recommended to minimize the current list of viscosity testing methods. Reducing the number of standardized methods would allow quality control operators to perform tests more quickly and consistently. Further research should be conducted to evaluate the six proposed standardized methods by assessing fluid viscosity variability across different setups. This will help confirm consistency and reliability across all fluid types.

A reassessment of the “Falling Ball” method is also advised, as it could provide additional support and validation for current quality control practices.

While advanced technologies such as rheometers can offer deeper insight into fluid behaviour, their adoption presents challenges due to limited baseline data for existing fluids, higher costs, and increased training requirements.

8. TECHNICAL REVIEW, FINALIZATION, AND PUBLICATION OF HISTORICAL REPORTS

This section outlines 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 summarizes the status of the technical review of historical reports within the publication process and provides guidance for their subsequent handling.

8.1 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. The backlog is the result of limited resources and shifting priorities within TC and the FAA. To address this, APS was tasked with developing a prioritized list of unpublished reports, expediting their progress through the publication process, and delivering them as Final Version 1.0.

8.2 Objective

The objective of this project for 2024-25 was to handle eight reports, with the aim to publish them as Final Version 1.0. Targets for subsequent years will be determined at the completion of each year.

8.3 Publication Process and Delivery of Technical Reports

APS produces annual reports 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 continuously refined. Figure 8.1 illustrates the updated Reports Management Process, providing an overview of the progression from "Draft" to "Final" stages of publication. The figure depicts all phases, associated milestones, and detailed tasks from initiation to publication.

The process consists of eight phases. The first four (Phases 1-4) are internal to APS, while the subsequent four (Phases 5-8) pertain to the publication of reports. Reports generally pass through all eight phases before the delivery of Final Version 1.0.

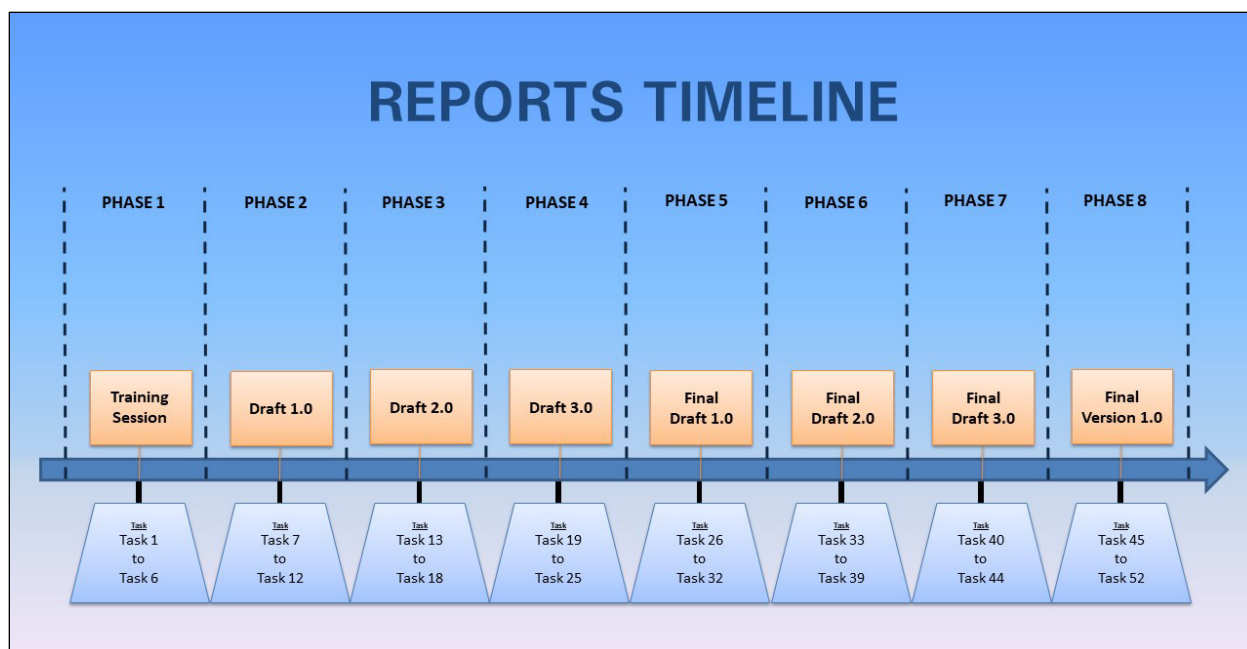


Figure 8.1: Reports Management Process

For 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 the TC report, TP 15374E, *Aircraft Ground Icing General Research Activities During the 2016-17 Winter* (11).

For 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 the TC report, TP 15398E, *Aircraft Ground Icing General Research Activities During the 2017-18 Winter* (12). These reports were published and delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2018-19, APS achieved the goal of 20 reports and published 20 reports in total. The details of the reports published in 2018-19 are provided in the TC report, TP 15427E, *Aircraft Ground Icing General Research Activities During the 2018-19 Winter* (13). These reports were published and delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2019-20, APS advanced a total of six unpublished reports to the Final Draft 2.0 stage and published a total of 14 reports. The details of the reports published in 2019-20 are provided in TP 15452E (7). The 14 published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2020-21, APS advanced a total of eight unpublished reports to the Final Draft 2.0 stage and published a total of 15 reports. The details of the reports published in 2020-21 are provided in the TC report, TP 15496E, *Aircraft Ground Icing General Research Activities During the 2020-21 Winter* (14). The 15 published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2021-22, APS progressed a total of six unpublished reports to the Final Draft 2.0 stage and published a total of 10 reports. The details of the reports published in 2021-22 are provided in TP 15536E (1). The 10 published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2022-23, APS published a total of seven reports. The details of the reports published in 2022-23 are provided in TP 15559E (10). The seven published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2023-24, APS published a total of five reports. The details of the reports published in 2023-24 are provided in TP 15608E (2). The five published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

For 2024-25, APS progressed a total of four unpublished reports to the Final Draft 2.0 stage and published a total of eight reports; the published reports are displayed in Table 8.1. The eight published reports were delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

8.4 Enhancement of Graphics Quality in Historical Published Reports

APS has identified several previously published historical TC reports containing black-and-white or low-quality colour photographs, graphs, and tables. Based on preliminary research, 19 such reports have been identified as requiring enhancements to align with the current publication quality standards.

For 2024-25, APS enhanced and republished one historical TC report to align with current publication standards. The republished report was delivered to TC and the FAA as Final Version 1.0 via “WeTransfer” and USB drives.

8.5 Overall Publication Status of Technical Reports

The overall status of the reports as of October 31, 2024, was as follows:

- Published reports: 174;
- Non-published reports: 56;
 - Non-published reports in draft stages: 23;
 - Interim reports that were incorporated into a TP report: 28;
 - Interim reports not to be published: 2; and
 - Protected reports: 3.
- Total reports: 230.

Detailed in Table 8.1, eight reports were delivered to TC and the FAA as Final Version 1.0.

Table 8.1: List of Published Technical Reports (2024-25)

No.	TP Number	Year	Report Title	Category	Latest Version	Publication Date
1	TP 15606E	2023-24	Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2023-24 Winter	HOT	Final Version 1.0	Mar 31, 2025
2	TP 15607E	2023-24	Regression Coefficients and Equations Used to Develop the Winter 2024-25 Aircraft Ground Deicing Holdover Time Tables	Regression	Final Version 1.0	Feb 14, 2025
3	TP 15608E	2023-24	Aircraft Ground Icing General Research Activities During the 2023-24 Winter	G & E	Final Version 1.0	Mar 31, 2025
4	TP 15609E	2023-24	Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2023-24*	Ice Pellet	Final Version 1.0	Mar 14, 2025
5	TP 15610E	2023-24	Testing and Evaluation of Mixed Phase Icing Conditions: Winter 2023-24	Mixed Icing Conditions	Final Version 1.0	Apr 24, 2025
6	TP 14451E	2004-05	Aircraft Ground Icing General Research Activities During the 2004-05 Winter	G & E	Final Version 1.0	Jul 28, 2025
7	TP 14719E	2005-06	Aircraft Ground Icing General Research Activities During the 2005-06 Winter	G & E	Final Version 1.0	Jul 28, 2025
8	TP 14781E	2006-07	Aircraft Ground Icing General Research Activities During the 2006-07 Winter	G & E	Final Version 1.0	Jul 28, 2025

The overall status of the reports as of October 31, 2025, was as follows:

- Published reports: 182;
- Non-published reports: 53; and
 - Non-published reports in draft stages: 20;
 - Interim reports that were incorporated into a TP report: 28;
 - Interim reports not to be published: 2; and
 - Protected reports: 3.
- Total reports: 235.

The details of the status and progression of report publication as of October 31, 2025, are presented in Table 8.2.

Table 8.2: Detailed Status of Reports as of October 31, 2025

Category	Description	(# of reports as of Oct. 31, 2025)
Published Reports	TP reports that are published as Final Version 1.0.	182
Non-Published Reports	TP reports that are still in Draft stages.	20
Interim Reports Incorporated into a TP Report	Reports initially produced as interim reports and subsequently incorporated into TP reports.	28
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 subsequent TP reports.	2
Protected Reports	Reports that are not for distribution (two reports for the Department of National Defence [DND] and one OPS Survey report for TC).	3
Total Reports Produced	Total number of reports produced by APS.	235

8.6 Conclusions

APS has been involved in writing and publishing technical reports on behalf of TC and the FAA since the early 1990s. Since 2016-17, APS was tasked with developing a prioritized list of unpublished reports that need to be published.

For 2024-25, APS published a total of eight reports as Final Version 1.0.

8.7 Recommendations

Given APS's increased involvement in completing this project, it is recommended that adequate resources continue to be allocated to support the annual publication of the remaining technical reports.

9. PUBLICATION OF HOLDOVER TIME GUIDANCE MATERIALS

This section describes the work completed by APS Aviation Inc. (APS) in the winter of 2024-25 in support of Transport Canada (TC) and the Federal Aviation Administration (FAA) holdover time (HOT) guidance materials.

9.1 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.

9.2 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:

- Develops fluid-specific HOT and regression tables for new Type II, III, and IV anti-icing fluids that undergo endurance time (ET) testing;
- Maintains a Degree-Specific Holdover Time (DSHOT) database for Type II, III, and IV 100/0 fluids in snow conditions (including Snow, Snow Grains, Snow Pellets, Snow mixed with Freezing Fog, and Snow mixed with Ice Crystals);
- Requests, collects, and reviews information provided by fluid manufacturers related to fluid qualification dates, fluid viscosity, and lowest operational use temperatures (LOUTs), which results in updates being made to the list of fluids in the HOT Guidelines;
- Recommends changes to the HOT guidance materials based on new research findings;
- Maintains an ongoing list of potential changes to the HOT guidance materials, schedules and runs meetings to review and discuss these changes with TC and the FAA, and implements changes as required;
- Drafts HOT Guidelines and HOT regression information documents on an annual basis, including TC English, TC French, and FAA versions;
- Provides support for the update of the FAA Ground Deicing Program documents;

- Provides support for the update of the TC report, TP 14052E, *Guidelines for Aircraft Ground Icing Operations (Tenth Edition)* (15), in both English and French; and
- Provides the latest HOT Guidelines and regression information to the TC and FAA publications departments for them to update their websites on an annual basis (or more frequently if updates to the HOT Guidelines and associated documents are necessary).

9.3 Winter 2025-26 Holdover Time Guidance Materials

In August 2025, the 2025-26 HOT Guidelines, DSHOTs database, and regression information documents were finalized. The changes made to the documents are summarized in the documents themselves and are described in detail in the following two TC reports:

1. **Holdover Time Guidelines and DSHOTs Database:** TP 15692E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2024-25 Winter* (16); and
2. **Holdover Time Regression Information:** TP 15693E, *Regression Coefficients and Equations Used to Develop the Winter 2025-26 Aircraft Ground Deicing Holdover Time Tables* (17).

The titles of the 2025-26 documents are listed in Table 9.1. Final drafts of the TC and FAA documents were provided to their respective publications departments for publication on August 12, 2025.

The FAA finalized and published its Ground Deicing Program documents on August 12, 2025.

TC finalized and published TP 14052E (15) (Tenth Edition), both in English and in French, in October 2025.

Table 9.1: Latest 2025-26 HOT Guidance Documents

HOT Guidelines	1. Transport Canada Holdover Time (HOT) Guidelines Winter 2025-2026, Original Issue, August 12, 2025
	2. Guide de Transports Canada sur les durées d'efficacité Hiver 2025-2026, version originale, 12 août 2025
	3. FAA Holdover Time Guidelines Winter 2025-2026, Original Issue, August 12, 2025
DSHOTs Database	4. Transport Canada Degree-Specific Holdover Times, Winter 2025-2026, Original Issue, August 12, 2025
	5. Guide de Transports Canada sur les durées d'efficacité selon le degré Hiver 2025-2026, version originale, 12 août 2025
	6. FAA Degree-Specific Holdover Time Data, Winter 2025-2026, Original Issue, August 12, 2025
Regression Information	7. Transport Canada HOT Guidelines Regression Information Winter 2025-2026, Original Issue, August 12, 2025
	8. Transports Canada Guide des durées d'efficacité Information de régression Hiver 2025-2026, version originale, 12 août 2025
	9. FAA Holdover Time Regression Information Winter 2025-2026, Original Issue, August 12, 2025

9.4 Future Responsibilities

APS will continue contributing to the development of the TC and FAA HOT guidance materials in the winter of 2025-26. Specifically, APS will continue carrying out the tasks listed in Subsection 9.2.

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10. PRESENTATIONS, FLUID MANUFACTURER REPORTS, AND TEST PROCEDURES FOR 2024-25

This section provides an overview of the presentations, fluid manufacturer reports, and test procedures prepared by APS Aviation Inc. (APS) during the winter of 2024-25.

10.1 Presentations

The SAE International (SAE) G-12 committees convene multiple times annually. During these and other meetings, APS presents findings from the work conducted throughout the year. Most of the research presented at these meetings is also eventually documented in various reports.

In 2024-25, APS gave presentations at the following meetings:

- 1) SAE G-12 Holdover Time (HOT) Committee Meeting, Montreal, Canada, November 2024;
- 2) SAE G-12 Aerodynamics Working Group (AWG) Committee Meeting, Montreal, Canada, November 2024;
- 3) SAE G-12 Equipment Committee Meeting, Montreal, Canada, November 2024;
- 4) SAE G-12 Holdover Time (HOT) Committee Meeting, Málaga, Spain, May 2025; and
- 5) SAE G-12 Aerodynamics Working Group (AWG) Committee Meeting, Málaga, Spain, May 2025.

The presentations delivered by APS at these meetings are outlined in the following subsections. Copies of each presentation listed are included in Appendix H.

10.1.1 SAE G-12 Holdover Time (HOT) Committee Meeting, Montreal, Canada, November 2024

The following seven presentations were prepared and presented at the SAE G-12 HOT Committee meeting held in Montreal, Canada, in November 2024:

- 1) SAE G-12 HOT Committee: Documents Update;
- 2) 2024-25 Endurance Time Testing Program;
- 3) 2024-25 Wind Tunnel Testing Program;
- 4) Mixed Icing Conditions Research;

- 5) Documentation of Fluid Failure: Reference Guide;
- 6) Update: Investigation of Mist & Freezing Fog Deposition Rates; and
- 7) Artificial Snow Machines and Endurance Time Research.

10.1.2 SAE G-12 Aerodynamic Working Group (AWG) Committee Meeting, Montreal, Canada, November 2024

The following two presentations were prepared and presented at the SAE G-12 AWG Committee meeting held in Montreal, Canada, in November 2024:

- 1) Exploratory 3D Photogrammetry to Support in Fluid Failure Characterization; and
- 2) Wind Tunnel Testing Update.

10.1.3 SAE G-12 Equipment Committee Meeting, Montreal, Canada, November 2024

The following presentation was prepared and presented at the SAE G-12 Equipment Committee meeting held in Montreal, Canada, in November 2024:

- 1) Forced Air Working Group Update.

10.1.4 SAE G-12 Holdover Time (HOT) Committee Meeting, Málaga, Spain, May 2025

The following four presentations were prepared and presented at the SAE G-12 HOT Committee meeting held in Málaga, Spain, in May 2025:

- 1) SAE G-12 HOT Committee: Documents Update;
- 2) Winter 2024-25 Endurance Time Testing Update;
- 3) 2024-25 Mixed Phase Icing Testing to Support Guidance Development; and
- 4) Icing Wind Tunnel Research Simulating Ice Pellet Conditions.

10.1.5 SAE G-12 Aerodynamic Working Group (AWG) Committee Meeting, Málaga, Spain, May 2025

The following presentation was prepared and presented at the SAE G-12 AWG Committee meeting held in Málaga, Spain, in May 2025:

- 1) Allowance Time Validation Testing – Fluid Sample Impact on Test Results.

10.2 Fluid Manufacturer Reports

As part of the HOT research program, new fluids are tested annually to assess their HOT performance. Data for fluids that have been commercialized is published in the corresponding TP 15692E (16). Reports for non-commercialized fluids are provided directly to the respective fluid manufacturers for internal research and development purposes.

10.2.1 Holdover Time Testing Reports 2024-25

The following subsections describe the fluid manufacturer reports produced for fluids submitted in 2024-25.

10.2.1.1 Combined Standard Holdover Time and Very Cold Snow Testing Reports 2024-25

Six reports were prepared to document HOT and very cold snow (VCS) testing conducted using fluids submitted during the winter of 2024-25. Copies of these reports were provided to the respective fluid manufacturers and to the Transport Canada (TC) and Federal Aviation Administration (FAA) project managers in July 2025.

Six of the reports were for commercialized fluids; these reports are included as appendices of TP 15692E (16).

The reports were for the following fluids:

- 1) Type II: Nordwing PG2;
- 2) Type IV: Clear IV Flight;
- 3) Type IV: Clearice-IV;
- 4) Type IV: FCY-EGIV PLUS;
- 5) Type IV: Green Flo Type IV; and
- 6) Type IV: Nordwing PG4.

A companion document detailing the methodologies used in endurance time testing of Type II, III, and IV fluids was also prepared and distributed to the manufacturers. Copies of these methodology reports are included in TP 15692E (16).

10.2.1.2 Standard Holdover Time Testing Reports 2024-25

Two reports were prepared to document HOT testing conducted using fluids submitted during the winter of 2024-25. Copies of these reports were provided to the respective fluid manufacturers and to the TC and FAA project managers in July 2025.

The two reports pertained to experimental fluids that were not subsequently commercialized.

10.2.1.3 Very Cold Snow Testing Reports 2024-25

Three reports were prepared to document VCS testing. Copies of these reports were provided to the respective fluid manufacturers and to the TC and FAA project managers in July 2025.

The reports were for the following fluids:

- 1) Type II: COREICEPHOB TYPE II;¹
- 2) Type IV: PROFLIGHT EG4;¹ and
- 3) Type IV: PROFLIGHT PG4.¹

10.3 Test Procedures

Several procedures were developed to guide and support the research team during testing conducted in the winter of 2024-25. Table 10.1 lists these procedures, each of which has been included as an appendix to the relevant Winter 2024-25 report. The final column of Table 10.1 indicates the specific report associated with each procedure.

¹ This fluid was commercialized in 2023-24 and received the updated data in 2024-25.

Table 10.1: List of Procedures 2024-25

Program Element #	ID#	Contract Program Element	Name of Procedure	Report
3	3.1	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	ENDURANCE TIME TESTING IN SIMULATED FREEZING PRECIPITATION WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS	HOT
3	3.2	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	ENDURANCE TIME TESTING IN NATURAL SNOW WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS	HOT
3	3.3	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	ENDURANCE TIME TESTING IN ARTIFICIAL SNOW WITH SAE TYPE I, II, III, AND IV FLUIDS	HOT
3	3.4	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	ENDURANCE TIME TESTING IN ACTIVE FROST WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS	HOT
1	1.1	MIXED ICING ANALYSIS, RESEARCH, AND TESTING TO SUPPORT METAR WORKING GROUP AND HOT GUIDANCE DEVELOPMENT	EVALUATION OF ENDURANCE TIMES IN MIXED ICING CONDITIONS WITH SAE TYPE I, II, III, AND IV DE/ANTI-ICING FLUIDS	Mixed Icing Conditions
2	2.1	CHARACTERIZATION OF THE RATE OF MIST AND FREEZING FOG TO SUPPORT HOT GUIDANCE DEVELOPMENT	SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST	G&E
3	3.5	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	OVERALL PROGRAM OF TESTS AT NRC, MARCH 2025	HOT
3	3.6	ENDURANCE TIME TESTING FOR MAINTENANCE AND PUBLICATION OF HOT GUIDANCE MATERIAL	OVERALL PROGRAM OF TESTS AT PMG, APRIL 2025	HOT
4	4.2	ARTIFICIAL SNOW RESEARCH: ARTIFICIAL CONDITIONS TESTING TO SUPPORT AND EVALUATION OF ARTIFICIAL VS. NATURAL DATA	TEST PROGRAM: ARTIFICIAL SNOW TESTING AT NCAR	ASR
7	7.1	FURTHER EVALUATION OF THE RELATIONSHIP BETWEEN SNOWFALL INTENSITY AND PREVAILING VISIBILITY	PRECIPITATION RATE DATA COLLECTION TO SUPPORT VISIBILITY TABLE DEVELOPMENT	G&E
9	9.1	EVALUATE FLUID VISCOSITY PROFILE IMPACT ON FLUID ENDURANCE TIMES AND EFFECTS ON HOLDOVER TIMES	EVALUATION OF FLUID VISCOSITY IMPACT ON ENDURANCE TIMES WITH TYPE II, AND IV ANTI-ICING FLUIDS	G&E
12	12.1	WIND TUNNEL TESTING – ICE PELLET ALLOWANCE TIME TESTING	WIND TUNNEL TESTS TO EXAMINE FLUID REMOVED FROM AIRCRAFT DURING TAKEOFF WITH MIXED ICE PELLET PRECIPITATION CONDITIONS	WT

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REFERENCES

1. APS Aviation Inc., *Aircraft Ground Icing General Research Activities During the 2021-22 Winter*, APS Aviation Inc., Transport Canada, Montreal, December 2022, TP 15536E, 76.
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APPENDIX A

**TRANSPORT CANADA
STATEMENT OF WORK EXCERPT –
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2024-25**

**TRANSPORT CANADA
STATEMENT OF WORK EXCERPT –
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2024-25**

1. Mixed Icing Analysis, Research, and Testing to Support METAR Working Group and Guidance Development

- a) Review and update the list of mixed icing conditions identified by the METAR working group (MWG) and categorize the identified conditions by level-of-effort required for HOT guidance development;
- b) Review and refine existing test methodologies and procedures for simulating mixed icing precipitation conditions including:
 - i. Snow mixed with Freezing Fog;
 - ii. Snow mixed with Rain;
 - iii. Snow mixed with Freezing Mist; and
 - iv. Any other priority mixed icing conditions identified by the MWG.
- c) Conduct comparative endurance time testing at the NRC-CEF in the above-listed conditions (expected 10 days testing at climatic facility);
- d) Analyze comparative test results;
- e) Hold technical discussions with TC/FAA and develop necessary guidance material;
- f) Prepare presentation for SAE G-12; and
- g) Prepare a report.

2. Characterization of the Rates of Freezing Mist and Freezing Fog to Support HOT Guidance Development

- a) Review and update existing project plan and coordinate testing activities.
- b) Conduct data collection at the Dorval test site or remotely (as required) in the following conditions:
 - i. Natural Freezing Mist (Primary Activity); and
 - ii. Natural Freezing Fog.
- c) Analyse the characterization of the rate of freezing mist and freezing fog.

- d) Participate in meetings with TC/FAA to discuss the data, analysis, and recommended changes to guidance materials.
- e) Prepare presentation for SAE G-12.
- f) Prepare a report.

5. Exploratory Research and Standards (SAE Standards, AWG, MWG, RWG, HOT Committee, and Other R&D)

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) Provide support for further development of SAE aircraft ground deicing standards, as needed);
- b) Support activities of the SAE G-12 Aerodynamics Working Group;
- c) Support activities of the METAR Working Group;
- d) Support activities of the SAE G-12 Rotorcraft Working Group;
- e) Provide support to the SAE G-12 Holdover Time Committee, including providing a qualified individual to serve as the committee's secretary; and
- f) Provide technical support services and exploratory testing to address unexpected operationally-driven industry incidents, concerns, and questions.

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 development of guidance material for small airport and small operations;
- ii. Support updates to TP 14052E and provide additional technical support, as needed;
- iii. Provide support for general SAE ground icing committee activities, as needed;
- iv. Provide research and development support for airport and ground operations, as needed;
- v. Prepare technical material and participate in the SAE International Conference on Icing of Aircraft, Engines, and Structures;

- vi. Conduct additional analysis relating to rate tolerance in endurance time testing with the goal of further developing ARP5485;
- vii. Conduct additional analysis relating to the use of half-plates in endurance time testing with the goal of further developing ARP5485;
- viii. Evaluate the feasibility of developing degree-specific HOTs for freezing precipitation conditions;
- ix. Conduct testing and analysis to evaluate the effects of intermittently starting and stopping precipitation on fluid integrity;
- x. Conduct testing and analysis to evaluate the effects of precipitation intensity fluctuations on fluid holdover times;
- xi. Conduct testing and analysis to further evaluate the relationship between temperature and fluid performance (power-law);
- xii. Conduct testing and analysis to further characterize the variability of HOT testing results at the NRC Climatic Engineering Facility;
- xiii. Conduct testing and analysis to further evaluate the existing Type I composite fluid holdover times;
- xiv. Conduct testing and analysis to further evaluate the use of standard mix Type I fluid in active frost conditions;
- xv. Conduct analysis of historical ice pellet allowance time data since inception of test program, and develop a tracking system for removal of obsolete fluid data;
- xvi. Develop updated ice pellet and snow dispensing systems for use in anti-icing fluid testing;
- xvii. Investigate new technologies to support the modernization of the ground icing research program;
- xviii. Support development of photogrammetry and laser scanning technologies for use in fluid testing;
- xix. Conduct testing and analysis to evaluate technologies being employed in hangar deicing operations (both with and without fluid);
- xx. General research or activities related to weather, de/anti-icing fluids, aircraft performance, deicing operations, sensors, environment, research information dissemination, and testing facilities and infrastructures;
- xxi. Evaluate aircraft coatings (i.e., ICEX, ice phobic products, nanotechnology) for their impact on de/anti-icing fluid holdover times; and
- xxii. Evaluate forced air technologies and their application in deicing operations.

6. Update AIR 6284 Forced Air Document

- a) Draft the necessary changes to SAE AIR 6284 as identified in a previous document review and hold consultations with key stakeholders to validate changes;
- b) Ballot the updated revision of AIR 6284 for adoption, if necessary;
- c) Prepare presentation material for the SAE G-12 meetings, as required; and
- d) Prepare a report on the findings, as required.

7. Further Evaluation of the Relationship Between Snowfall Intensity and Prevailing Visibility

- a) Conduct combined precipitation rate and visibility data collection in natural snow at the P.E.T. test site (in some cases, travel to other locations may be necessary to collect data at desired precipitation rates).
- b) Coordinate filing, log entry, and charting of test data.
- c) Analyze the collected precipitation rate and visibility data and conduct an evaluation of the current visibility table guidance;
- d) Hold technical discussions with TC/FAA and discuss potential changes to guidance material, as required;
- e) Prepare presentation material for the SAE G-12 meetings, as required; and
- f) Prepare a report on the findings, as required.

8. Evaluate HOT Regression Methodology for Fluids with Non-Standard Temperature-Endurance Time Relationships: Data Review and Update

- a) Review and update historical analytical material relating to fluids with non-standard temperature endurance time relationships;
- b) Draft formalized methodologies for evaluation and HOT development of fluids with non-standard temperature-ET relationships;
- c) Participate in meetings with TC/FAA and any other related stakeholders to discuss proposed methodologies and implementation into guidance materials, as required;
- d) Prepare presentation material for the SAE G-12 meetings, as required; and
- e) Prepare a report on the findings.

9. Evaluate Fluid Viscosity Profile Impact on Fluid Endurance Times and Effects on Holdover Times

- a) Conduct endurance time tests in natural snow conditions using Type II and Type IV anti-icing fluids artificially sheared to create multiple samples with differing viscosities;
- b) Analyze the test results obtained to assess the impact of fluid viscosity on the resulting endurance times;
- c) Participate in meetings with TC/FAA and any other related stakeholders to discuss data, analysis, and relevant findings;
- d) Prepare presentation material for the SAE G-12 meetings, as required; and
- e) Prepare a report on the findings.

11. Support Industry Efforts to Further Develop Viscosity Standards (AS9968)

- a) Conduct a review of the SAE viscosity standard AS9968 to identify gaps and opportunities for improvement;
- b) Conduct a review of the viscosity methods outlined in TC and FAA guidelines to determine if these can be standardized;
- c) Draft recommended changes to SAE AS9968 and the TC/FAA HOT Guidelines as determined by review.
- d) Prepare presentation material for the SAE G-12 meetings, as required; and
- e) Prepare a report on the findings, as required.

13. Support for Development of Wind Tunnel Testing Capabilities at Alternate Facilities

- a) Participate in ongoing technical discussions with TC and the FAA related to the development of a wind tunnel allowance time testing platform at alternate testing facilities;
- b) Conduct any scoping or development activities identified through consultations with the stakeholders, as required; and
- c) Prepare a report on the findings, as required.

14. Technical Review, Approval, and Publishing of Technical Report

- a) Coordinate and manage the Master List of Reports, the Master List of References, et cetera.
- b) Review, revise, and train staff on the Reports Training Manual.
- c) Develop prioritized list of approximately 5 to 9 reports to be published as Final Version 1.0 and create and maintain schedule.
- d) Coordinate technical review of additional reports, as resources permit. Coordinate and schedule editorial reviews, technical reviews, and French translation of applicable reports.
- e) Perform modernization and revamping of selected historical black and white reports, as resources permit.
- f) Perform editorial review for applicable reports and make changes with author(s) to reports.
- g) Perform technical review for applicable reports and make changes with author(s) to reports.
- h) Perform French translation for applicable reports and make changes to reports.
- i) Format applicable reports for final TC approval (including references, signatures, front matter, et cetera).
- j) Support the TC approval and publishing of applicable reports.
- k) Upload published reports to the APS website on behalf of TC/FAA.

15. 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 April 30th; and Phase 2: Annual updates to be integrated prior to the publication expected at the end of July):

- 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 and verify the TC and FAA degree-specific HOTs databases.
- f) Update regression coefficients document (detailed activity costed as part of a separate program element including discussions and implementation).
- g) Provide support for publication of documents.

16. Provision for Project Support Services

- a) Provide support services for program coordination (progress reporting, setup of meetings, coordinate travel, et cetera).
- b) Manage, schedule, and plan current year reports to Final Draft 1.0 level.
- c) Develop current year reports from Draft 1.0 to Final Draft 1.0 including report components and appendices.
- d) Format and finalize reports for ISO review.
- e) Deliver Final Draft 1.0 to TC/FAA.
- f) Coordinate, create, and manage the “General and Exploratory Research” report.
- g) Coordinate and manage the list of reports (costed as part of a separate program element).

18. 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.
- d) Maintain log of fluid inventory and viscosity information.

Preparation and Setup for Natural 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) 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, as required.
- d) Prepare an updated procedure for testing fluids in frost, as required.
- e) Evaluate current methods for measuring snowfall intensity or holdover times.
- f) Develop improved, more efficient methods to measure snowfall intensity or holdover times, as required.
- g) 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, as required.
- d) Conduct calibration to attain appropriate test conditions for each weather condition represented in the holdover time tables.
- 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.
- f) Update and maintain the NRC Rate Calculation software.

Preparation and Setup for Simulated Snow Testing at PMG

- a) Prepare a general top-level plan to coordinate all simulated artificial snow testing required by the research program. Testing will be conducted at PMG Technologies in Blainville, Quebec.
- b) Coordinate scheduling and test plans with PMG personnel.
- c) Prepare an updated test procedure for the conduct of endurance time tests in simulated artificial snow at PMG, as required.
- d) Arrange for support from NCAR personnel, as required during the testing session.
- e) Arrange for the transport of equipment to and from the facility, as required.

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.
- e) Prepare reports.

19. 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.
- d) Maintain log of fluid inventory and viscosity information.

Preparation and Setup for Natural 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) 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, as required.
- d) Prepare an updated procedure for testing fluids in frost, as required.
- e) Evaluate current methods for measuring snowfall intensity or holdover times.
- f) Develop improved, more efficient methods to measure snowfall intensity or holdover times, as required.
- g) 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, as required.
- 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.
- f) Update and maintain the NRC Rate Calculation software.

Preparation and Setup for Simulated Snow Testing at PMG

- a) Prepare a general top-level plan to coordinate all simulated artificial snow testing required by the research program. Testing will be conducted at PMG Technologies in Blainville, Quebec.
- b) Coordinate scheduling and test plans with PMG personnel.
- c) Prepare an updated test procedure for the conduct of endurance time tests in simulated artificial snow at PMG, as required.
- d) Arrange for support from NCAR personnel, as required during the testing session.
- e) Arrange for the transport of equipment to and from the facility, as required.

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.
- e) Prepare reports.

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APPENDIX B

LOG OF VISIBILITY TESTING CONDUCTED FOR TESTING SEASON 2024-25

Log of Visibility Testing Conducted for Testing Season 2024-25

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
4-Dec-24	2:19:46 PM	2:30:24 PM	0.00	-0.72	20000	9999	NO	Unusable Rate
4-Dec-24	2:30:33 PM	2:43:25 PM	-0.18	-1.10	19967	9999	NO	Unusable Rate
4-Dec-24	2:43:34 PM	2:53:56 PM	1.27	-1.10	4989	5201	YES	N/A
4-Dec-24	2:54:05 PM	3:02:41 PM	4.70	-1.10	1994	1553	YES	N/A
4-Dec-24	3:02:50 PM	3:11:26 PM	2.68	-1.10	3833	2657	YES	N/A
4-Dec-24	3:11:35 PM	3:21:17 PM	3.25	-1.10	3254	3032	YES	N/A
4-Dec-24	3:21:26 PM	3:30:35 PM	6.16	-1.11	1786	1430	YES	N/A
4-Dec-24	3:30:44 PM	3:39:37 PM	3.54	-1.30	2951	2371	YES	N/A
4-Dec-24	3:39:46 PM	3:48:46 PM	2.77	-1.30	4084	3765	YES	N/A
4-Dec-24	3:48:55 PM	3:58:28 PM	3.84	-1.30	2693	2348	YES	N/A
4-Dec-24	3:58:37 PM	4:08:00 PM	2.91	-1.30	3727	3101	YES	N/A
4-Dec-24	4:08:09 PM	4:18:01 PM	3.29	-1.30	2443	1899	YES	N/A
4-Dec-24	4:18:10 PM	4:28:23 PM	5.06	-1.30	1106	1061	YES	N/A
4-Dec-24	4:28:32 PM	4:38:20 PM	4.36	-1.39	1507	1287	YES	N/A
4-Dec-24	4:38:29 PM	4:49:51 PM	4.47	-1.40	1307	1152	YES	N/A
4-Dec-24	4:50:00 PM	4:59:17 PM	7.24	-1.40	959	881	YES	N/A
4-Dec-24	4:59:26 PM	5:08:37 PM	7.11	-1.40	1166	940	YES	N/A
4-Dec-24	5:08:46 PM	5:18:59 PM	5.89	-1.40	1431	1150	YES	N/A
4-Dec-24	5:19:08 PM	5:29:19 PM	1.62	-1.40	7307	3977	YES	N/A
4-Dec-24	5:29:28 PM	5:38:48 PM	0.45	-0.83	10404	8249	NO	Unusable Rate
4-Dec-24	5:38:57 PM	5:51:27 PM	0.56	-0.80	11704	7496	YES	N/A
4-Dec-24	5:51:36 PM	6:00:12 PM	1.09	-0.80	2599	2057	YES	N/A
4-Dec-24	6:00:21 PM	6:10:55 PM	1.51	-0.80	4145	3274	YES	N/A
4-Dec-24	6:11:04 PM	6:20:19 PM	1.02	-0.80	4794	4275	YES	N/A
4-Dec-24	6:20:28 PM	6:29:51 PM	1.15	-0.80	5784	4464	YES	N/A
4-Dec-24	6:30:00 PM	6:39:03 PM	1.92	-0.70	4338	2819	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
4-Dec-24	6:39:12 PM	6:48:46 PM	1.38	-0.70	7439	4698	YES	N/A
4-Dec-24	6:48:55 PM	6:58:18 PM	0.10	-0.70	15346	9462	NO	Unusable Rate
4-Dec-24	6:58:27 PM	7:09:05 PM	1.19	-0.70	7317	5010	YES	N/A
4-Dec-24	7:09:14 PM	7:18:21 PM	1.19	-0.70	7835	5589	YES	N/A
4-Dec-24	7:18:30 PM	7:28:14 PM	2.37	-0.70	2903	2536	YES	N/A
4-Dec-24	7:28:23 PM	7:38:08 PM	3.66	-1.03	1721	1353	YES	N/A
4-Dec-24	7:38:17 PM	7:48:27 PM	6.10	-1.10	NA	790	YES	N/A
4-Dec-24	7:48:36 PM	7:57:27 PM	3.66	-1.10	NA	1066	YES	N/A
4-Dec-24	7:57:36 PM	8:06:51 PM	3.76	-1.10	NA	895	YES	N/A
4-Dec-24	8:07:00 PM	8:17:12 PM	2.26	-1.10	NA	1957	YES	N/A
4-Dec-24	8:17:21 PM	8:29:57 PM	1.38	-1.10	NA	2263	YES	N/A
4-Dec-24	8:30:06 PM	8:38:39 PM	2.36	-0.80	NA	1722	YES	N/A
4-Dec-24	8:38:48 PM	8:48:15 PM	1.79	-0.80	NA	2333	YES	N/A
4-Dec-24	8:48:24 PM	8:57:23 PM	2.09	-0.80	NA	2532	YES	N/A
4-Dec-24	8:57:32 PM	9:12:07 PM	1.19	-0.80	NA	2400	YES	N/A
4-Dec-24	9:12:16 PM	9:19:11 PM	1.56	-0.80	NA	2098	YES	N/A
4-Dec-24	9:19:20 PM	9:32:11 PM	1.72	-0.78	NA	1536	YES	N/A
4-Dec-24	9:32:20 PM	9:33:50 PM	1.57	-0.70	NA	1507	NO	Unusable Rate
7-Dec-24	8:48:41 PM	8:57:24 PM	2.97	-6.60	1674	1287	YES	N/A
7-Dec-24	8:57:33 PM	9:06:40 PM	2.58	-6.60	1928	1528	YES	N/A
7-Dec-24	9:06:49 PM	9:16:08 PM	4.79	-6.60	1236	977	YES	N/A
7-Dec-24	9:16:17 PM	9:26:46 PM	3.99	-6.60	1677	1286	YES	N/A
7-Dec-24	9:26:55 PM	9:36:34 PM	3.60	-6.33	1562	1270	YES	N/A
7-Dec-24	9:36:43 PM	9:46:15 PM	6.06	-6.20	923	807	YES	N/A
7-Dec-24	9:46:24 PM	9:55:28 PM	7.26	-6.20	781	588	YES	N/A
7-Dec-24	9:55:37 PM	10:04:59 PM	9.89	-6.20	626	499	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
7-Dec-24	10:05:08 PM	10:14:44 PM	7.93	-6.20	835	640	YES	N/A
7-Dec-24	10:14:53 PM	10:23:27 PM	6.25	-6.20	895	803	YES	N/A
7-Dec-24	10:23:36 PM	10:32:14 PM	10.13	-5.81	597	556	YES	N/A
7-Dec-24	10:32:23 PM	10:42:02 PM	10.23	-4.70	544	477	YES	N/A
7-Dec-24	10:42:11 PM	10:52:09 PM	8.63	-4.70	598	581	YES	N/A
7-Dec-24	10:52:18 PM	11:01:57 PM	6.82	-4.70	769	739	YES	N/A
7-Dec-24	11:02:06 PM	11:11:51 PM	4.39	-4.70	1339	1287	YES	N/A
7-Dec-24	11:12:00 PM	11:21:10 PM	5.79	-4.70	919	1054	YES	N/A
7-Dec-24	11:21:19 PM	11:45:40 PM	4.17	-4.19	1892	1773	YES	N/A
7-Dec-24	11:45:49 PM	11:54:22 PM	3.46	-3.90	1797	1594	YES	N/A
7-Dec-24	11:54:46 PM	12:04:06 AM	3.17	-3.90	1729	1621	YES	N/A
8-Dec-24	12:04:15 AM	12:14:06 AM	4.63	-3.90	1349	1282	YES	N/A
8-Dec-24	12:14:15 AM	12:24:06 AM	7.35	-3.90	801	834	YES	N/A
8-Dec-24	12:24:15 AM	12:34:02 AM	11.77	-3.28	491	525	YES	N/A
8-Dec-24	12:34:11 AM	12:44:06 AM	13.08	-2.40	475	434	YES	N/A
8-Dec-24	12:44:15 AM	12:53:54 AM	10.03	-2.40	644	682	YES	N/A
8-Dec-24	12:54:03 AM	1:03:04 AM	8.50	-2.40	751	692	YES	N/A
8-Dec-24	1:03:13 AM	1:12:29 AM	7.46	-2.40	808	733	YES	N/A
8-Dec-24	1:12:38 AM	1:21:55 AM	6.38	-2.40	827	767	YES	N/A
8-Dec-24	1:22:04 AM	1:31:27 AM	7.51	-2.32	687	643	YES	N/A
8-Dec-24	1:31:36 AM	1:40:49 AM	8.26	-1.90	520	475	YES	N/A
8-Dec-24	1:40:58 AM	1:49:53 AM	8.59	-1.90	619	487	YES	N/A
8-Dec-24	1:50:02 AM	1:59:07 AM	8.18	-1.90	742	611	YES	N/A
8-Dec-24	1:59:16 AM	2:10:48 AM	6.56	-1.90	845	709	YES	N/A
8-Dec-24	2:10:57 AM	2:19:01 AM	6.64	-1.90	900	614	YES	N/A
8-Dec-24	2:19:10 AM	2:35:37 AM	6.69	-1.87	903	640	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
8-Dec-24	2:35:46 AM	2:49:50 AM	7.18	-1.80	1094	820	YES	N/A
8-Dec-24	2:49:59 AM	2:53:15 AM	6.47	-1.80	1096	966	YES	N/A
9-Dec-24	4:59:04 PM	5:12:27 PM	0.07	-6.50	14489	9614	NO	Unusable Rate
9-Dec-24	5:12:36 PM	5:21:21 PM	2.04	-6.50	5696	5148	YES	N/A
9-Dec-24	5:21:30 PM	5:30:54 PM	3.70	-6.48	3767	2962	YES	N/A
9-Dec-24	5:31:03 PM	5:41:26 PM	6.93	-6.30	1733	1644	YES	N/A
9-Dec-24	5:41:35 PM	5:45:42 PM	10.16	-6.30	1331	1106	YES	N/A
9-Dec-24	5:45:51 PM	5:53:58 PM	9.61	-6.30	1258	1148	YES	N/A
9-Dec-24	5:54:07 PM	6:03:21 PM	11.50	-6.30	1023	926	YES	N/A
9-Dec-24	6:03:30 PM	6:09:33 PM	16.39	-6.30	896	722	YES	N/A
9-Dec-24	6:09:42 PM	6:12:51 PM	12.98	-6.30	1035	833	YES	N/A
9-Dec-24	6:13:00 PM	6:21:01 PM	14.01	-6.30	1078	883	YES	N/A
9-Dec-24	6:21:10 PM	6:29:35 PM	11.22	-6.30	1077	926	YES	N/A
9-Dec-24	6:29:44 PM	6:38:30 PM	12.12	-6.01	999	831	YES	N/A
9-Dec-24	6:38:39 PM	6:42:01 PM	12.15	-6.00	819	812	YES	N/A
9-Dec-24	6:42:10 PM	6:51:23 PM	13.41	-6.00	875	739	YES	N/A
9-Dec-24	6:51:32 PM	6:56:27 PM	13.96	-6.00	841	700	YES	N/A
9-Dec-24	6:56:36 PM	7:05:06 PM	14.54	-6.00	805	686	YES	N/A
9-Dec-24	7:05:15 PM	7:12:49 PM	12.98	-6.00	1099	955	YES	N/A
9-Dec-24	7:12:58 PM	7:21:31 PM	11.76	-6.00	1298	1056	YES	N/A
9-Dec-24	7:21:40 PM	7:30:35 PM	12.18	-5.97	1368	1078	YES	N/A
9-Dec-24	7:30:44 PM	7:31:56 PM	9.40	-5.60	2026	1363	NO	Unusable Rate
9-Dec-24	7:32:05 PM	7:38:28 PM	10.01	-5.60	1705	1294	YES	N/A
9-Dec-24	7:38:37 PM	7:47:28 PM	10.46	-5.60	1593	1328	YES	N/A
9-Dec-24	7:47:37 PM	7:57:15 PM	9.56	-5.60	1660	1342	YES	N/A
9-Dec-24	7:57:24 PM	8:06:14 PM	7.08	-5.60	2328	1715	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
9-Dec-24	8:06:23 PM	8:15:20 PM	7.56	-5.60	2112	1986	YES	N/A
9-Dec-24	8:15:29 PM	8:24:08 PM	12.55	-5.60	1851	1600	YES	N/A
9-Dec-24	8:24:17 PM	8:33:10 PM	11.32	-5.46	1994	1562	YES	N/A
9-Dec-24	8:33:19 PM	8:42:52 PM	11.32	-5.20	1893	1324	YES	N/A
9-Dec-24	8:43:01 PM	8:44:33 PM	6.74	-5.20	2341	1797	NO	Unusable Rate
18-Dec-24	2:25:10 PM	2:35:41 PM	3.22	1.86	18742	9999	NO	Unacceptable Weather
18-Dec-24	2:35:50 PM	2:46:18 PM	6.78	1.40	13873	9999	NO	Unacceptable Weather
18-Dec-24	2:46:27 PM	2:56:45 PM	8.62	1.40	11921	9943	NO	Unacceptable Weather
18-Dec-24	2:56:54 PM	3:05:19 PM	9.27	1.40	12036	9796	NO	Unacceptable Weather
18-Dec-24	3:05:28 PM	3:21:26 PM	10.86	1.40	6296	6710	NO	Unacceptable Weather
18-Dec-24	3:21:35 PM	3:31:44 PM	10.60	1.26	4486	4072	NO	Unacceptable Weather
18-Dec-24	3:31:53 PM	3:47:28 PM	10.50	0.60	3680	3690	NO	Unacceptable Weather
18-Dec-24	3:47:37 PM	3:57:20 PM	8.13	0.60	5860	5473	NO	Unacceptable Weather
18-Dec-24	3:57:29 PM	4:08:13 PM	7.05	0.60	3974	3304	NO	Unacceptable Weather
18-Dec-24	4:08:22 PM	4:18:05 PM	9.14	0.60	2772	2212	NO	Unacceptable Weather
18-Dec-24	4:18:28 PM	4:28:35 PM	11.48	0.60	1775	1646	NO	Unacceptable Weather
18-Dec-24	4:28:44 PM	4:39:42 PM	14.14	0.42	1620	1340	NO	Unacceptable Weather
18-Dec-24	4:39:51 PM	4:49:21 PM	11.58	0.40	1300	1278	NO	Unacceptable Weather
18-Dec-24	4:49:30 PM	4:59:08 PM	12.34	0.40	1811	1680	NO	Unacceptable Weather
18-Dec-24	4:59:17 PM	5:08:29 PM	11.29	0.40	1702	1714	NO	Unacceptable Weather
18-Dec-24	5:08:38 PM	5:19:10 PM	10.58	0.40	3116	3061	NO	Unacceptable Weather
18-Dec-24	5:19:19 PM	5:33:07 PM	11.07	0.42	1751	1759	NO	Unacceptable Weather
18-Dec-24	5:33:16 PM	5:53:26 PM	9.56	0.50	2140	2123	NO	Unacceptable Weather
18-Dec-24	5:53:35 PM	6:03:58 PM	7.56	0.50	3461	3291	NO	Unacceptable Weather
18-Dec-24	6:04:27 PM	6:17:06 PM	6.50	0.50	3609	3696	NO	Unacceptable Weather
18-Dec-24	6:17:15 PM	6:26:42 PM	10.99	0.50	1585	1555	NO	Unacceptable Weather

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
18-Dec-24	6:26:51 PM	6:35:18 PM	7.06	0.56	2398	2291	NO	Unacceptable Weather
18-Dec-24	6:26:51 PM	6:35:18 PM	7.06	0.56	2398	2291	NO	Unacceptable Weather
23-Dec-24	4:42:23 PM	6:39:32 PM	-0.07	-7.89	19992	9999	NO	Unusable Rate
23-Dec-24	6:39:46 PM	6:51:35 PM	-0.04	-7.50	20000	9999	NO	Unusable Rate
23-Dec-24	6:51:49 PM	7:01:54 PM	0.14	-7.50	19820	9966	NO	Unusable Rate
23-Dec-24	7:02:08 PM	7:10:32 PM	0.06	-7.50	19896	9999	NO	Unusable Rate
23-Dec-24	7:10:46 PM	7:19:34 PM	1.07	-7.50	10371	6643	YES	N/A
23-Dec-24	7:19:48 PM	7:29:52 PM	4.81	-7.50	1572	1437	YES	N/A
23-Dec-24	7:30:06 PM	7:42:25 PM	9.39	-8.10	783	682	YES	N/A
23-Dec-24	7:42:39 PM	7:48:33 PM	11.63	-8.10	580	530	YES	N/A
23-Dec-24	7:48:47 PM	7:56:12 PM	11.28	-8.10	526	520	YES	N/A
23-Dec-24	7:56:26 PM	8:05:31 PM	8.80	-8.10	823	737	YES	N/A
23-Dec-24	8:05:45 PM	8:11:22 PM	7.03	-8.10	1150	1149	YES	N/A
23-Dec-24	8:11:36 PM	8:20:42 PM	7.39	-8.10	1028	1088	YES	N/A
23-Dec-24	8:20:56 PM	8:26:12 PM	9.10	-8.10	804	843	YES	N/A
23-Dec-24	8:26:26 PM	8:28:24 PM	9.32	-8.10	802	840	NO	Unusable Rate
23-Dec-24	8:28:38 PM	8:42:16 PM	10.34	-7.83	606	636	YES	N/A
23-Dec-24	8:42:30 PM	8:48:17 PM	15.12	-7.80	365	360	YES	N/A
23-Dec-24	8:48:31 PM	8:53:45 PM	14.73	-7.80	371	355	YES	N/A
23-Dec-24	8:54:11 PM	9:00:24 PM	14.82	-7.80	346	326	YES	N/A
23-Dec-24	9:00:38 PM	9:04:52 PM	13.88	-7.80	288	312	YES	N/A
23-Dec-24	9:05:06 PM	9:16:00 PM	12.76	-7.80	348	308	YES	N/A
23-Dec-24	9:16:14 PM	9:25:37 PM	9.77	-7.80	569	486	YES	N/A
23-Dec-24	9:25:51 PM	9:31:16 PM	7.29	-7.73	696	578	YES	N/A
23-Dec-24	9:31:30 PM	9:35:51 PM	8.64	-7.50	561	527	YES	N/A
23-Dec-24	9:36:05 PM	9:42:19 PM	9.58	-7.50	530	511	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
23-Dec-24	9:42:33 PM	9:52:37 PM	8.82	-7.50	570	485	YES	N/A
23-Dec-24	9:52:51 PM	9:58:53 PM	9.19	-7.50	454	450	YES	N/A
23-Dec-24	9:59:07 PM	10:09:15 PM	11.36	-7.50	440	423	YES	N/A
23-Dec-24	10:09:29 PM	10:17:34 PM	10.18	-7.50	524	497	YES	N/A
23-Dec-24	10:17:48 PM	10:27:39 PM	11.79	-7.50	501	473	YES	N/A
23-Dec-24	10:27:53 PM	10:34:50 PM	14.13	-7.43	434	429	YES	N/A
23-Dec-24	10:35:04 PM	10:46:54 PM	13.42	-7.40	490	449	YES	N/A
23-Dec-24	10:47:08 PM	10:49:03 PM	13.73	-7.40	495	493	NO	Unusable Rate
7-Jan-25	9:28:28 AM	9:39:53 AM	3.79	-8.50	NA	1760	YES	N/A
7-Jan-25	9:40:02 AM	9:49:52 AM	4.73	-8.50	NA	1616	YES	N/A
7-Jan-25	9:50:01 AM	10:00:14 AM	3.27	-8.50	NA	1686	YES	N/A
7-Jan-25	10:00:23 AM	10:11:27 AM	6.50	-8.50	NA	1538	YES	N/A
7-Jan-25	10:11:36 AM	10:34:54 AM	1.86	-8.44	NA	1955	YES	N/A
7-Jan-25	10:35:03 AM	10:41:39 AM	4.34	-8.20	NA	1665	YES	N/A
7-Jan-25	10:41:48 AM	10:51:08 AM	2.97	-8.20	NA	2183	YES	N/A
7-Jan-25	10:51:17 AM	11:01:16 AM	5.70	-8.20	NA	1675	YES	N/A
7-Jan-25	11:01:25 AM	11:12:27 AM	5.92	-8.20	NA	1433	YES	N/A
7-Jan-25	11:12:36 AM	11:20:15 AM	4.30	-8.20	NA	1831	YES	N/A
7-Jan-25	11:20:24 AM	11:28:18 AM	2.20	-8.20	NA	3392	YES	N/A
7-Jan-25	11:28:27 AM	11:54:31 AM	3.50	-7.82	NA	2091	YES	N/A
7-Jan-25	11:54:40 AM	12:04:13 PM	2.90	-7.80	NA	4080	YES	N/A
7-Jan-25	12:04:22 PM	12:16:19 PM	1.61	-7.80	NA	9688	YES	N/A
7-Jan-25	12:16:28 PM	12:25:51 PM	-1.50	-7.80	NA	9999	NO	Unusable Rate
7-Jan-25	12:26:00 PM	12:34:34 PM	2.58	-7.43	NA	8936	YES	N/A
7-Jan-25	12:34:43 PM	12:44:21 PM	0.54	-7.10	NA	9313	YES	N/A
7-Jan-25	12:44:30 PM	12:55:12 PM	-1.10	-7.10	NA	9999	NO	Unusable Rate

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
7-Jan-25	12:55:21 PM	1:05:17 PM	0.00	-7.10	NA	9999	NO	Unusable Rate
7-Jan-25	1:05:26 PM	1:15:33 PM	0.05	-7.10	NA	9999	NO	Unusable Rate
7-Jan-25	1:15:42 PM	1:36:28 PM	0.79	-6.91	NA	9999	YES	N/A
8-Jan-25	9:34:21 AM	9:48:53 AM	0.23	-13.60	NA	9999	NO	Unusable Rate
8-Jan-25	9:49:02 AM	9:57:34 AM	0.94	-13.60	NA	9999	YES	N/A
8-Jan-25	9:57:43 AM	10:07:56 AM	0.60	-13.60	NA	9776	YES	N/A
8-Jan-25	10:20:31 AM	10:29:56 AM	7.14	-13.60	NA	1292	YES	N/A
8-Jan-25	10:30:05 AM	10:40:48 AM	13.90	-13.80	NA	365	YES	N/A
8-Jan-25	10:40:57 AM	10:49:57 AM	6.63	-13.80	NA	673	YES	N/A
8-Jan-25	10:50:06 AM	10:59:47 AM	4.66	-13.80	NA	1058	YES	N/A
8-Jan-25	10:59:56 AM	11:09:56 AM	6.35	-13.80	NA	782	YES	N/A
8-Jan-25	11:10:05 AM	11:19:45 AM	6.03	-13.80	NA	825	YES	N/A
8-Jan-25	11:19:54 AM	11:30:01 AM	5.34	-13.80	NA	1219	YES	N/A
8-Jan-25	11:30:10 AM	11:40:07 AM	0.66	-13.50	NA	1531	YES	N/A
8-Jan-25	11:40:16 AM	11:50:50 AM	2.36	-13.50	NA	1607	YES	N/A
8-Jan-25	11:50:59 AM	12:03:54 PM	2.84	-13.50	NA	1376	YES	N/A
8-Jan-25	12:04:03 PM	12:12:56 PM	1.32	-13.50	NA	1974	YES	N/A
8-Jan-25	12:13:05 PM	12:23:35 PM	3.22	-13.50	NA	1385	YES	N/A
8-Jan-25	12:23:44 PM	12:34:57 PM	5.99	-13.24	NA	1069	YES	N/A
8-Jan-25	12:35:06 PM	12:45:32 PM	7.88	-12.90	NA	1111	YES	N/A
8-Jan-25	12:45:41 PM	12:54:37 PM	3.79	-12.90	NA	1423	YES	N/A
8-Jan-25	12:54:46 PM	1:03:33 PM	4.92	-12.90	NA	1311	YES	N/A
8-Jan-25	1:03:42 PM	1:15:08 PM	4.40	-12.90	NA	1240	YES	N/A
8-Jan-25	1:15:17 PM	1:27:39 PM	3.46	-12.90	NA	1681	YES	N/A
8-Jan-25	1:27:48 PM	1:37:00 PM	1.12	-12.67	NA	3384	YES	N/A
8-Jan-25	1:37:09 PM	1:47:04 PM	0.81	-12.60	NA	3940	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
8-Jan-25	1:47:13 PM	2:00:31 PM	3.75	-12.60	NA	1339	YES	N/A
8-Jan-25	2:00:40 PM	2:09:51 PM	3.33	-12.60	NA	957	YES	N/A
8-Jan-25	2:10:00 PM	2:27:58 PM	4.87	-12.60	NA	729	YES	N/A
8-Jan-25	2:28:07 PM	2:39:07 PM	7.65	-12.27	NA	493	YES	N/A
8-Jan-25	2:39:16 PM	2:52:59 PM	6.27	-12.20	NA	634	YES	N/A
8-Jan-25	2:53:08 PM	3:05:20 PM	4.24	-12.20	NA	1022	YES	N/A
8-Jan-25	3:05:29 PM	3:15:19 PM	3.11	-12.20	NA	1279	YES	N/A
8-Jan-25	3:15:28 PM	3:25:02 PM	3.88	-12.20	NA	1444	YES	N/A
8-Jan-25	3:25:11 PM	3:35:44 PM	2.72	-12.15	NA	1568	YES	N/A
8-Jan-25	3:35:53 PM	3:44:30 PM	3.93	-12.10	NA	1316	YES	N/A
8-Jan-25	3:44:39 PM	3:54:36 PM	2.50	-12.10	NA	1564	YES	N/A
8-Jan-25	3:54:45 PM	4:05:28 PM	3.68	-12.10	NA	1479	YES	N/A
8-Jan-25	4:05:37 PM	4:14:46 PM	4.11	-12.10	NA	1536	YES	N/A
8-Jan-25	4:14:55 PM	4:21:59 PM	1.46	-12.10	NA	2363	YES	N/A
8-Jan-25	4:22:08 PM	4:32:41 PM	2.63	-12.07	NA	3634	YES	N/A
8-Jan-25	4:32:50 PM	4:39:11 PM	2.15	-12.00	NA	1311	YES	N/A
8-Jan-25	4:39:20 PM	4:46:02 PM	3.93	-12.00	NA	1673	YES	N/A
18-Jan-25	2:25:01 PM	2:33:39 PM	0.05	2.25	-	8334	NO	Unusable Rate
18-Jan-25	2:33:48 PM	2:42:25 PM	5.78	1.90	-	2712	NO	Unacceptable Weather
18-Jan-25	2:42:34 PM	2:52:34 PM	3.01	1.90	-	9317	NO	Unacceptable Weather
18-Jan-25	2:52:43 PM	3:03:31 PM	6.57	1.90	-	9641	NO	Unacceptable Weather
18-Jan-25	3:03:40 PM	3:09:28 PM	7.46	1.90	-	9999	NO	Unacceptable Weather
23-Jan-25	8:31:41 AM	8:59:49 AM	0.05	-8.80	NA	9999	NO	Unusable Rate
23-Jan-25	8:59:58 AM	9:19:23 AM	0.41	-8.80	NA	9317	NO	Unusable Rate
23-Jan-25	9:19:32 AM	9:29:43 AM	1.66	-8.80	NA	5733	YES	N/A
23-Jan-25	9:29:52 AM	9:39:56 AM	1.26	-8.90	NA	6366	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
23-Jan-25	9:40:05 AM	9:48:29 AM	2.07	-8.90	NA	3471	YES	N/A
23-Jan-25	9:48:38 AM	9:58:17 AM	3.17	-8.90	NA	2525	YES	N/A
23-Jan-25	9:58:26 AM	10:08:24 AM	2.22	-8.90	NA	3222	YES	N/A
23-Jan-25	10:08:33 AM	10:18:27 AM	2.99	-8.90	NA	2451	YES	N/A
23-Jan-25	10:18:36 AM	10:28:43 AM	3.34	-8.90	NA	1940	YES	N/A
23-Jan-25	10:28:52 AM	10:38:18 AM	5.13	-8.81	NA	1478	YES	N/A
23-Jan-25	10:38:27 AM	10:48:34 AM	5.67	-8.80	NA	1649	YES	N/A
23-Jan-25	10:48:43 AM	10:59:44 AM	3.92	-8.80	NA	1847	YES	N/A
23-Jan-25	10:59:53 AM	11:10:25 AM	3.57	-8.80	NA	2890	YES	N/A
23-Jan-25	11:10:34 AM	11:20:42 AM	2.55	-8.80	NA	2540	YES	N/A
23-Jan-25	11:20:51 AM	11:24:36 AM	9.27	-8.80	NA	2423	YES	N/A
23-Jan-25	11:24:45 AM	11:35:14 AM	0.85	-8.40	NA	2324	YES	N/A
23-Jan-25	11:35:41 AM	11:45:41 AM	3.05	-8.00	NA	2818	YES	N/A
23-Jan-25	11:45:50 AM	11:48:02 AM	10.25	-8.00	NA	2861	YES	N/A
23-Jan-25	11:48:11 AM	11:59:08 AM	-0.04	-8.00	NA	4047	NO	Unusable Rate
23-Jan-25	11:59:17 AM	12:10:43 PM	1.60	-8.00	NA	4009	YES	N/A
23-Jan-25	12:10:52 PM	12:21:32 PM	3.83	-8.00	NA	4815	YES	N/A
23-Jan-25	12:21:41 PM	12:30:24 PM	0.27	-7.98	NA	3638	NO	Unusable Rate
23-Jan-25	12:30:33 PM	12:39:50 PM	0.81	-7.60	NA	3543	YES	N/A
23-Jan-25	12:39:59 PM	12:50:32 PM	0.36	-7.60	NA	7589	NO	Unusable Rate
23-Jan-25	12:50:41 PM	12:59:12 PM	2.10	-7.60	NA	3051	YES	N/A
23-Jan-25	12:59:21 PM	1:05:02 PM	2.40	-7.60	NA	1999	YES	N/A
23-Jan-25	1:05:11 PM	1:14:30 PM	6.46	-7.60	NA	2826	YES	N/A
27-Jan-25	7:40:12 PM	7:48:48 PM	0.05	-0.40	NA	7115	NO	Unusable Rate
27-Jan-25	7:48:57 PM	7:56:46 PM	5.11	-0.40	NA	3966	YES	N/A
27-Jan-25	7:56:55 PM	8:04:24 PM	-1.38	-0.40	NA	5297	NO	Unusable Rate

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
27-Jan-25	8:04:33 PM	8:09:31 PM	4.54	-0.40	NA	1938	YES	N/A
27-Jan-25	8:09:40 PM	8:16:33 PM	2.87	-0.40	NA	2121	YES	N/A
27-Jan-25	8:16:42 PM	8:24:38 PM	1.42	-0.40	NA	5789	YES	N/A
27-Jan-25	8:24:47 PM	8:33:06 PM	0.00	-0.85	NA	8829	NO	Unusable Rate
27-Jan-25	8:33:15 PM	8:41:24 PM	1.79	-1.60	NA	5521	YES	N/A
27-Jan-25	8:41:33 PM	8:49:13 PM	2.08	-1.60	NA	2652	YES	N/A
27-Jan-25	8:49:22 PM	8:57:36 PM	4.74	-1.60	NA	1712	YES	N/A
27-Jan-25	8:57:45 PM	9:06:26 PM	3.68	-1.60	NA	2237	YES	N/A
27-Jan-25	9:06:35 PM	9:16:00 PM	3.14	-1.60	NA	2934	YES	N/A
27-Jan-25	9:16:09 PM	9:25:01 PM	2.33	-1.60	NA	3603	YES	N/A
27-Jan-25	9:25:10 PM	9:33:43 PM	2.25	-1.60	NA	2997	YES	N/A
27-Jan-25	9:33:52 PM	9:42:52 PM	3.81	-1.60	NA	2525	YES	N/A
27-Jan-25	9:43:01 PM	9:48:08 PM	1.19	-1.60	NA	3904	YES	N/A
27-Jan-25	9:48:17 PM	9:58:10 PM	3.57	-1.60	NA	2646	YES	N/A
27-Jan-25	9:58:19 PM	10:06:56 PM	4.04	-1.60	NA	2005	YES	N/A
27-Jan-25	10:07:05 PM	10:15:38 PM	4.01	-1.60	NA	1908	YES	N/A
27-Jan-25	10:15:47 PM	10:23:18 PM	4.94	-1.60	NA	1904	YES	N/A
27-Jan-25	10:23:27 PM	10:34:36 PM	5.82	-1.56	NA	2537	YES	N/A
27-Jan-25	10:34:45 PM	10:43:53 PM	2.21	-1.50	NA	3108	YES	N/A
27-Jan-25	10:44:02 PM	10:51:42 PM	2.08	-1.50	NA	3102	YES	N/A
27-Jan-25	10:51:51 PM	11:00:27 PM	6.01	-1.50	NA	2442	YES	N/A
27-Jan-25	11:00:36 PM	11:09:05 PM	5.87	-1.50	NA	1837	YES	N/A
27-Jan-25	11:09:14 PM	11:18:18 PM	11.20	-1.50	NA	731	YES	N/A
27-Jan-25	11:18:27 PM	11:27:41 PM	8.86	-1.50	NA	1045	YES	N/A
27-Jan-25	11:27:50 PM	11:34:03 PM	7.03	-1.57	NA	1114	YES	N/A
27-Jan-25	11:34:12 PM	11:43:50 PM	4.83	-1.60	NA	1426	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
27-Jan-25	11:43:59 PM	11:53:09 PM	7.79	-1.60	NA	831	YES	N/A
27-Jan-25	11:53:18 PM	12:00:42 AM	10.16	-1.60	NA	734	YES	N/A
28-Jan-25	12:00:51 AM	12:06:14 AM	11.79	-1.60	NA	506	YES	N/A
29-Jan-25	6:42:21 AM	6:51:39 AM	6.77	-13.30	NA	950	YES	N/A
29-Jan-25	6:51:48 AM	7:02:26 AM	9.59	-13.30	NA	657	YES	N/A
29-Jan-25	7:02:35 AM	7:11:40 AM	6.31	-13.30	NA	1010	YES	N/A
29-Jan-25	7:11:49 AM	7:20:33 AM	4.41	-13.30	NA	1329	YES	N/A
29-Jan-25	7:20:42 AM	7:29:38 AM	3.52	-13.30	NA	1295	YES	N/A
29-Jan-25	7:29:47 AM	7:37:33 AM	3.63	-14.37	NA	1339	YES	N/A
29-Jan-25	7:37:42 AM	7:46:34 AM	5.94	-14.40	NA	1136	YES	N/A
29-Jan-25	7:46:43 AM	7:55:13 AM	6.97	-14.40	NA	1071	YES	N/A
29-Jan-25	7:55:22 AM	8:04:18 AM	8.79	-14.40	NA	816	YES	N/A
29-Jan-25	8:04:27 AM	8:13:43 AM	9.84	-14.40	NA	629	YES	N/A
29-Jan-25	8:13:52 AM	8:21:57 AM	9.54	-14.40	NA	565	YES	N/A
29-Jan-25	8:22:06 AM	8:33:49 AM	14.60	-14.43	NA	471	YES	N/A
29-Jan-25	8:33:58 AM	8:42:45 AM	18.57	-14.50	NA	255	YES	N/A
29-Jan-25	8:43:13 AM	8:51:09 AM	13.69	-14.50	NA	298	YES	N/A
29-Jan-25	8:51:18 AM	8:58:51 AM	17.18	-14.50	NA	211	YES	N/A
29-Jan-25	8:59:00 AM	9:08:41 AM	10.24	-14.50	NA	398	YES	N/A
29-Jan-25	9:08:50 AM	9:18:00 AM	11.02	-14.50	NA	411	YES	N/A
29-Jan-25	9:18:09 AM	9:27:34 AM	11.88	-14.50	NA	457	YES	N/A
29-Jan-25	9:27:43 AM	9:37:02 AM	13.52	-14.50	NA	437	YES	N/A
29-Jan-25	9:37:11 AM	9:45:49 AM	7.02	-14.50	NA	806	YES	N/A
29-Jan-25	9:45:58 AM	9:54:43 AM	5.75	-14.50	NA	770	YES	N/A
29-Jan-25	9:54:52 AM	10:03:19 AM	2.39	-14.50	NA	1900	YES	N/A
29-Jan-25	10:03:28 AM	10:12:28 AM	1.04	-14.50	NA	5247	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
29-Jan-25	10:12:37 AM	10:21:48 AM	1.07	-14.50	NA	5108	YES	N/A
29-Jan-25	10:21:57 AM	10:31:49 AM	0.86	-14.39	NA	8012	YES	N/A
29-Jan-25	10:31:58 AM	10:41:26 AM	2.23	-13.90	NA	2239	YES	N/A
29-Jan-25	10:41:35 AM	10:51:00 AM	2.00	-13.90	NA	2241	YES	N/A
29-Jan-25	10:51:09 AM	11:00:57 AM	2.97	-13.90	NA	2124	YES	N/A
29-Jan-25	11:01:06 AM	11:11:11 AM	4.71	-13.90	NA	1196	YES	N/A
29-Jan-25	11:11:20 AM	11:22:23 AM	2.55	-13.90	NA	1515	YES	N/A
29-Jan-25	11:22:32 AM	11:32:08 AM	2.25	-13.61	NA	1277	YES	N/A
29-Jan-25	11:32:17 AM	11:42:00 AM	2.18	-12.60	NA	1505	YES	N/A
29-Jan-25	11:42:09 AM	11:52:04 AM	0.57	-12.60	NA	3117	YES	N/A
29-Jan-25	11:52:13 AM	11:54:40 AM	0.38	-12.60	NA	4226	NO	Unusable Rate
30-Jan-25	8:04:30 PM	8:15:18 PM	0.70	-12.40	NA	9999	YES	N/A
30-Jan-25	8:15:27 PM	8:23:48 PM	0.45	-12.40	NA	9875	NO	Unusable Rate
30-Jan-25	8:23:57 PM	8:34:51 PM	0.65	-12.27	NA	8541	YES	N/A
30-Jan-25	8:35:00 PM	8:44:01 PM	0.83	-12.10	NA	9677	YES	N/A
30-Jan-25	8:44:10 PM	8:55:39 PM	0.25	-12.10	NA	9999	NO	Unusable Rate
30-Jan-25	8:55:48 PM	9:04:35 PM	0.05	-12.10	NA	9999	NO	Unusable Rate
30-Jan-25	9:04:44 PM	9:14:00 PM	0.05	-12.10	NA	9999	NO	Unusable Rate
30-Jan-25	9:14:09 PM	9:23:12 PM	-0.16	-12.10	NA	9999	NO	Unusable Rate
30-Jan-25	9:23:21 PM	9:39:20 PM	0.12	-11.69	NA	9999	NO	Unusable Rate
30-Jan-25	9:39:29 PM	9:48:13 PM	0.05	-11.40	NA	9999	NO	Unusable Rate
30-Jan-25	9:48:22 PM	9:57:06 PM	0.05	-11.40	NA	9999	NO	Unusable Rate
30-Jan-25	9:57:15 PM	10:06:36 PM	0.00	-11.40	NA	9999	NO	Unusable Rate
30-Jan-25	10:06:45 PM	10:16:28 PM	0.00	-11.40	NA	9999	NO	Unusable Rate
30-Jan-25	10:16:37 PM	10:25:57 PM	0.10	-11.40	NA	9999	NO	Unusable Rate
30-Jan-25	10:26:06 PM	10:36:43 PM	0.13	-10.70	NA	9999	NO	Unusable Rate

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
30-Jan-25	10:36:52 PM	10:45:35 PM	0.00	-10.30	NA	9999	NO	Unusable Rate
30-Jan-25	10:45:44 PM	10:53:07 PM	0.51	-10.30	NA	7526	YES	N/A
30-Jan-25	10:53:16 PM	11:02:52 PM	1.08	-10.30	NA	5367	YES	N/A
30-Jan-25	11:03:01 PM	11:10:27 PM	1.14	-10.30	NA	3122	YES	N/A
30-Jan-25	11:10:36 PM	11:19:01 PM	2.01	-10.30	NA	2171	YES	N/A
30-Jan-25	11:19:10 PM	11:28:34 PM	4.40	-10.30	NA	966	YES	N/A
30-Jan-25	11:28:43 PM	11:37:53 PM	4.10	-9.96	NA	911	YES	N/A
30-Jan-25	11:38:02 PM	11:47:59 PM	4.53	-9.90	NA	1090	YES	N/A
30-Jan-25	11:48:08 PM	11:58:12 PM	3.97	-9.90	NA	1163	YES	N/A
30-Jan-25	11:58:21 PM	12:07:00 AM	2.72	-9.90	NA	1747	YES	N/A
31-Jan-25	12:07:09 AM	12:18:57 AM	2.47	-9.90	NA	1418	YES	N/A
31-Jan-25	12:19:06 AM	12:31:27 AM	3.12	-9.97	NA	1301	YES	N/A
31-Jan-25	12:31:36 AM	12:39:29 AM	4.83	-10.50	NA	649	YES	N/A
31-Jan-25	12:39:38 AM	12:48:46 AM	1.54	-10.50	NA	2057	YES	N/A
31-Jan-25	12:48:55 AM	12:54:34 AM	0.67	-10.50	NA	3884	YES	N/A
31-Jan-25	12:54:43 AM	1:01:29 AM	0.56	-10.50	NA	5221	YES	N/A
31-Jan-25	1:01:38 AM	1:10:38 AM	0.16	-10.50	NA	8775	NO	Unusable Rate
3-Feb-25	1:43:49 PM	1:52:36 PM	0.75	-3.80	13219	9675	NO	Unacceptable Weather
3-Feb-25	1:52:45 PM	2:02:00 PM	4.98	-3.80	2304	2380	NO	Unacceptable Weather
3-Feb-25	2:02:09 PM	2:11:20 PM	6.60	-3.80	1393	1148	NO	Unacceptable Weather
3-Feb-25	2:11:29 PM	2:20:28 PM	5.13	-3.80	1734	1778	NO	Unacceptable Weather
3-Feb-25	2:20:37 PM	2:29:58 PM	6.74	-3.80	1188	1260	NO	Unacceptable Weather
3-Feb-25	2:30:07 PM	2:39:15 PM	12.25	-3.40	648	594	NO	Unacceptable Weather
3-Feb-25	2:39:24 PM	2:48:42 PM	12.99	-3.40	679	652	NO	Unacceptable Weather
3-Feb-25	2:48:51 PM	2:58:42 PM	20.04	-3.40	434	434	NO	Unacceptable Weather
3-Feb-25	2:58:51 PM	3:07:10 PM	14.35	-3.40	711	594	NO	Unacceptable Weather

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
3-Feb-25	3:07:19 PM	3:18:10 PM	7.80	-3.40	881	809	NO	Unacceptable Weather
3-Feb-25	3:18:19 PM	3:27:54 PM	6.92	-3.40	980	853	NO	Unacceptable Weather
3-Feb-25	3:28:03 PM	3:36:56 PM	8.78	-3.24	825	741	NO	Unacceptable Weather
3-Feb-25	3:37:05 PM	3:46:47 PM	13.91	-3.20	630	655	NO	Unacceptable Weather
3-Feb-25	3:46:56 PM	3:54:58 PM	17.20	-3.20	437	425	NO	Unacceptable Weather
3-Feb-25	3:55:16 PM	4:06:48 PM	16.26	-3.20	495	428	NO	Unacceptable Weather
3-Feb-25	4:06:57 PM	4:14:49 PM	13.56	-3.20	518	514	NO	Unacceptable Weather
3-Feb-25	4:14:58 PM	4:19:50 PM	22.70	-3.20	352	265	NO	Unacceptable Weather
3-Feb-25	4:19:59 PM	4:28:53 PM	21.33	-3.20	389	344	NO	Unacceptable Weather
3-Feb-25	4:29:02 PM	4:36:58 PM	19.02	-3.20	395	325	NO	Unacceptable Weather
3-Feb-25	4:37:07 PM	4:46:24 PM	15.49	-3.20	418	436	NO	Unacceptable Weather
3-Feb-25	4:46:33 PM	4:55:42 PM	15.26	-3.20	458	427	NO	Unacceptable Weather
3-Feb-25	4:55:51 PM	5:03:34 PM	13.70	-3.20	501	457	NO	Unacceptable Weather
3-Feb-25	5:03:43 PM	5:11:56 PM	10.07	-3.20	605	567	NO	Unacceptable Weather
3-Feb-25	5:12:05 PM	5:20:43 PM	10.56	-3.20	760	638	NO	Unacceptable Weather
3-Feb-25	5:20:52 PM	5:30:14 PM	7.38	-3.19	765	798	NO	Unacceptable Weather
3-Feb-25	5:30:41 PM	5:39:30 PM	14.34	-2.90	470	443	NO	Unacceptable Weather
3-Feb-25	5:39:39 PM	5:49:33 PM	12.25	-2.90	536	498	NO	Unacceptable Weather
3-Feb-25	5:49:42 PM	6:00:03 PM	14.99	-2.90	502	447	NO	Unacceptable Weather
3-Feb-25	6:00:12 PM	6:10:08 PM	10.41	-2.90	722	658	NO	Unacceptable Weather
3-Feb-25	6:10:17 PM	6:19:33 PM	10.70	-2.90	712	666	NO	Unacceptable Weather
3-Feb-25	6:19:42 PM	6:28:40 PM	10.85	-2.90	757	582	NO	Unacceptable Weather
3-Feb-25	6:28:49 PM	6:37:46 PM	8.24	-1.69	916	787	NO	Unacceptable Weather
3-Feb-25	6:37:55 PM	6:46:05 PM	8.69	-1.50	914	827	NO	Unacceptable Weather
3-Feb-25	6:46:14 PM	6:55:04 PM	11.55	-1.50	741	617	NO	Unacceptable Weather
3-Feb-25	6:55:13 PM	7:03:41 PM	8.10	-1.50	1101	854	NO	Unacceptable Weather

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
3-Feb-25	7:03:50 PM	7:13:38 PM	7.77	-1.50	1169	681	NO	Unacceptable Weather
3-Feb-25	7:13:47 PM	7:23:13 PM	2.69	-1.50	5932	4169	NO	Unacceptable Weather
6-Feb-25	10:56:09 AM	11:05:55 AM	1.15	-12.80	5830	5004	YES	N/A
6-Feb-25	11:06:04 AM	11:14:50 AM	1.07	-12.80	10550	6399	YES	N/A
6-Feb-25	11:14:59 AM	11:23:56 AM	0.53	-12.80	16435	9999	YES	N/A
6-Feb-25	11:24:05 AM	11:32:29 AM	3.97	-12.47	3000	3846	YES	N/A
6-Feb-25	11:32:38 AM	11:41:14 AM	12.84	-11.70	780	806	YES	N/A
6-Feb-25	11:41:23 AM	11:50:46 AM	22.09	-11.70	432	398	YES	N/A
6-Feb-25	11:50:55 AM	11:58:07 AM	23.63	-11.70	398	368	YES	N/A
6-Feb-25	11:58:16 AM	12:07:35 PM	24.27	-11.70	433	363	YES	N/A
6-Feb-25	12:07:44 PM	12:14:26 PM	31.15	-11.70	338	285	YES	N/A
6-Feb-25	12:14:54 PM	12:23:46 PM	20.99	-11.70	361	365	YES	N/A
6-Feb-25	12:23:55 PM	12:32:51 PM	29.20	-12.08	323	265	YES	N/A
6-Feb-25	12:33:00 PM	12:41:50 PM	11.81	-12.90	809	609	YES	N/A
6-Feb-25	12:41:59 PM	12:50:47 PM	10.90	-12.90	875	756	YES	N/A
6-Feb-25	12:50:56 PM	12:59:51 PM	12.91	-12.90	743	656	YES	N/A
6-Feb-25	1:00:00 PM	1:06:29 PM	19.43	-12.90	526	498	YES	N/A
6-Feb-25	1:06:38 PM	1:15:27 PM	26.87	-12.90	443	411	YES	N/A
6-Feb-25	1:15:36 PM	1:25:00 PM	35.85	-12.90	352	271	YES	N/A
6-Feb-25	1:25:21 PM	1:33:04 PM	22.90	-12.38	608	432	YES	N/A
6-Feb-25	1:33:13 PM	1:42:22 PM	9.76	-11.60	2027	1450	YES	N/A
6-Feb-25	1:42:31 PM	1:53:35 PM	7.26	-11.60	2001	1399	YES	N/A
6-Feb-25	1:53:44 PM	2:02:41 PM	3.15	-11.60	6811	3273	YES	N/A
6-Feb-25	2:02:50 PM	2:12:37 PM	0.67	-11.60	16081	9999	YES	N/A
6-Feb-25	2:12:46 PM	2:22:59 PM	9.06	-11.60	1558	1862	YES	N/A
6-Feb-25	2:23:08 PM	2:33:23 PM	10.13	-11.27	1045	901	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
6-Feb-25	2:33:32 PM	2:42:41 PM	10.58	-10.60	1168	956	YES	N/A
6-Feb-25	2:42:50 PM	2:52:30 PM	8.17	-10.60	1593	1309	YES	N/A
6-Feb-25	2:52:39 PM	3:01:04 PM	8.66	-10.60	1354	1127	YES	N/A
6-Feb-25	3:01:13 PM	3:10:19 PM	6.09	-10.60	1822	1332	YES	N/A
6-Feb-25	3:10:28 PM	3:19:27 PM	4.92	-10.60	2511	1651	YES	N/A
6-Feb-25	3:19:36 PM	3:28:39 PM	5.71	-10.60	1746	1402	YES	N/A
6-Feb-25	3:28:48 PM	3:37:41 PM	7.35	-10.17	1590	1180	YES	N/A
6-Feb-25	3:37:50 PM	3:45:54 PM	7.34	-10.10	1358	1029	YES	N/A
12-Feb-25	11:31:00 PM	11:37:33 PM	1.36	-11.60	2620	2211	YES	N/A
12-Feb-25	11:37:42 PM	11:46:22 PM	1.79	-11.60	3492	2861	YES	N/A
12-Feb-25	11:46:31 PM	11:55:44 PM	1.53	-11.60	6625	4632	YES	N/A
12-Feb-25	11:55:53 PM	12:03:59 AM	1.51	-11.60	4814	3909	YES	N/A
13-Feb-25	12:04:08 AM	12:14:05 AM	0.28	-11.60	15264	8537	NO	Unusable Rate
13-Feb-25	12:14:14 AM	12:23:35 AM	0.80	-11.60	18510	9999	YES	N/A
13-Feb-25	12:23:44 AM	12:33:51 AM	2.56	-11.75	8060	7511	YES	N/A
13-Feb-25	12:34:00 AM	12:42:49 AM	3.94	-12.00	3900	3414	YES	N/A
13-Feb-25	12:42:58 AM	12:51:36 AM	3.43	-12.00	3632	3529	YES	N/A
13-Feb-25	12:51:45 AM	1:00:32 AM	3.80	-12.00	4004	3715	YES	N/A
13-Feb-25	1:00:41 AM	1:09:50 AM	5.09	-12.00	3171	3200	YES	N/A
13-Feb-25	1:09:59 AM	1:18:00 AM	5.80	-12.00	3320	3129	YES	N/A
13-Feb-25	1:18:09 AM	1:27:11 AM	4.21	-12.00	3582	2943	YES	N/A
13-Feb-25	1:27:20 AM	1:36:19 AM	5.23	-11.86	4025	3034	YES	N/A
13-Feb-25	1:36:28 AM	1:45:51 AM	8.01	-11.80	2924	2553	YES	N/A
13-Feb-25	1:46:00 AM	1:56:51 AM	9.27	-11.80	2155	1763	YES	N/A
13-Feb-25	1:57:00 AM	2:06:38 AM	15.61	-11.80	1193	1022	YES	N/A
13-Feb-25	2:06:47 AM	2:11:48 AM	22.86	-11.80	706	588	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
13-Feb-25	2:12:05 AM	2:20:00 AM	20.78	-11.80	577	465	YES	N/A
13-Feb-25	2:20:09 AM	2:32:21 AM	26.70	-11.72	464	369	YES	N/A
13-Feb-25	2:32:30 AM	2:39:07 AM	33.31	-11.40	444	326	YES	N/A
13-Feb-25	2:39:16 AM	2:43:27 AM	31.23	-11.40	496	376	YES	N/A
13-Feb-25	2:43:36 AM	2:50:24 AM	37.95	-11.40	629	420	YES	N/A
13-Feb-25	2:50:42 AM	2:58:24 AM	47.24	-11.40	595	425	YES	N/A
13-Feb-25	2:58:33 AM	3:05:34 AM	32.29	-11.40	485	398	YES	N/A
13-Feb-25	3:05:43 AM	3:13:08 AM	27.38	-11.40	511	382	YES	N/A
13-Feb-25	3:13:17 AM	3:22:44 AM	28.70	-11.40	614	419	YES	N/A
13-Feb-25	3:22:53 AM	3:28:28 AM	21.21	-11.40	815	652	YES	N/A
13-Feb-25	3:28:50 AM	3:38:45 AM	23.18	-11.14	774	492	YES	N/A
13-Feb-25	3:38:54 AM	3:46:44 AM	20.88	-11.10	974	845	YES	N/A
13-Feb-25	3:46:53 AM	3:54:59 AM	17.87	-11.10	1004	787	YES	N/A
13-Feb-25	3:55:17 AM	4:04:12 AM	22.51	-11.10	694	596	YES	N/A
13-Feb-25	4:04:21 AM	4:13:29 AM	31.13	-11.10	503	452	YES	N/A
13-Feb-25	4:13:38 AM	4:22:32 AM	29.89	-11.10	676	527	YES	N/A
13-Feb-25	4:22:41 AM	4:31:31 AM	21.87	-10.95	883	706	YES	N/A
13-Feb-25	4:31:40 AM	4:39:26 AM	19.49	-10.20	797	600	YES	N/A
16-Feb-25	8:36:12 AM	8:43:45 AM	4.54	-10.30	1774	1567	YES	N/A
16-Feb-25	8:43:54 AM	8:52:32 AM	6.91	-10.30	1535	1413	YES	N/A
16-Feb-25	8:52:41 AM	9:00:38 AM	7.98	-10.30	1135	1038	YES	N/A
16-Feb-25	9:00:47 AM	9:11:26 AM	9.27	-10.30	1033	889	YES	N/A
16-Feb-25	9:11:35 AM	9:20:49 AM	8.76	-10.30	1122	976	YES	N/A
16-Feb-25	9:20:58 AM	9:31:22 AM	14.82	-10.29	711	652	YES	N/A
16-Feb-25	9:31:31 AM	9:40:15 AM	14.80	-10.20	830	656	YES	N/A
16-Feb-25	9:40:24 AM	9:50:23 AM	11.25	-10.20	1035	879	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
16-Feb-25	9:50:32 AM	10:00:34 AM	12.18	-10.20	836	758	YES	N/A
16-Feb-25	10:00:43 AM	10:08:07 AM	14.48	-10.20	580	556	YES	N/A
16-Feb-25	10:08:16 AM	10:13:28 AM	16.18	-10.20	494	430	YES	N/A
16-Feb-25	10:14:42 AM	10:24:20 AM	18.83	-10.20	428	389	YES	N/A
16-Feb-25	10:24:29 AM	10:34:29 AM	17.20	-10.16	379	344	YES	N/A
16-Feb-25	10:34:38 AM	10:41:57 AM	22.55	-10.10	262	255	YES	N/A
16-Feb-25	10:42:06 AM	10:47:34 AM	25.10	-10.10	234	217	YES	N/A
16-Feb-25	10:47:55 AM	10:55:56 AM	26.85	-10.10	318	264	YES	N/A
16-Feb-25	10:56:05 AM	11:03:42 AM	30.17	-10.10	254	223	YES	N/A
16-Feb-25	11:03:51 AM	11:09:44 AM	28.44	-10.10	244	215	YES	N/A
16-Feb-25	11:09:53 AM	11:20:38 AM	23.92	-10.10	219	187	YES	N/A
16-Feb-25	11:20:47 AM	11:25:03 AM	23.02	-10.10	239	184	YES	N/A
16-Feb-25	11:25:33 AM	11:37:36 AM	29.99	-9.97	225	180	YES	N/A
16-Feb-25	11:37:45 AM	11:46:26 AM	30.74	-9.90	232	180	YES	N/A
16-Feb-25	11:46:35 AM	11:53:12 AM	36.16	-9.90	206	168	YES	N/A
16-Feb-25	11:53:21 AM	11:58:42 AM	36.72	-9.90	182	172	YES	N/A
16-Feb-25	11:58:51 AM	12:03:30 PM	42.25	-9.90	152	122	YES	N/A
16-Feb-25	12:04:02 PM	12:10:34 PM	51.29	-9.90	126	108	YES	N/A
16-Feb-25	12:10:43 PM	12:17:41 PM	49.86	-9.90	157	124	YES	N/A
16-Feb-25	12:17:50 PM	12:24:28 PM	58.38	-9.90	143	111	YES	N/A
16-Feb-25	12:24:37 PM	12:30:52 PM	48.80	-9.90	170	125	YES	N/A
16-Feb-25	12:31:01 PM	12:37:00 PM	45.87	-9.90	171	139	YES	N/A
16-Feb-25	12:37:09 PM	12:43:54 PM	43.38	-9.90	182	150	YES	N/A
16-Feb-25	12:44:38 PM	12:52:22 PM	47.28	-9.90	185	145	YES	N/A
16-Feb-25	12:52:31 PM	1:00:09 PM	52.52	-9.90	171	122	YES	N/A
16-Feb-25	1:00:18 PM	1:04:58 PM	43.61	-9.90	125	94	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
16-Feb-25	1:05:07 PM	1:12:36 PM	44.03	-9.90	142	109	YES	N/A
16-Feb-25	1:12:45 PM	1:18:34 PM	36.68	-9.90	141	113	YES	N/A
16-Feb-25	1:18:43 PM	1:21:55 PM	44.80	-9.90	151	95	YES	N/A
16-Feb-25	1:22:04 PM	1:23:22 PM	35.79	-9.90	131	109	NO	Unusable Rate
16-Feb-25	1:23:45 PM	1:31:44 PM	62.11	-9.88	162	111	YES	N/A
16-Feb-25	1:31:53 PM	1:36:07 PM	19.65	-9.80	199	155	YES	N/A
16-Feb-25	1:36:16 PM	1:43:04 PM	48.11	-9.80	213	164	YES	N/A
16-Feb-25	1:43:13 PM	1:49:27 PM	44.64	-9.80	221	146	YES	N/A
16-Feb-25	1:49:36 PM	1:59:00 PM	49.65	-9.80	214	156	YES	N/A
16-Feb-25	1:59:09 PM	2:03:10 PM	40.84	-9.80	205	178	YES	N/A
16-Feb-25	2:03:19 PM	2:09:15 PM	38.74	-9.80	176	133	YES	N/A
16-Feb-25	2:09:42 PM	2:17:39 PM	53.38	-9.80	196	135	YES	N/A
16-Feb-25	2:17:48 PM	2:22:15 PM	42.88	-9.80	294	180	YES	N/A
16-Feb-25	2:22:24 PM	2:31:27 PM	31.37	-9.86	399	277	YES	N/A
16-Feb-25	2:31:36 PM	2:41:07 PM	33.19	-10.20	435	262	YES	N/A
16-Feb-25	2:41:16 PM	2:48:51 PM	24.98	-10.20	557	361	YES	N/A
16-Feb-25	2:49:00 PM	2:58:30 PM	18.95	-10.20	636	447	YES	N/A
16-Feb-25	2:58:39 PM	3:10:28 PM	23.59	-10.20	394	263	YES	N/A
16-Feb-25	3:10:50 PM	3:16:35 PM	30.57	-10.20	312	197	YES	N/A
16-Feb-25	3:16:44 PM	3:23:29 PM	28.97	-10.20	380	246	YES	N/A
16-Feb-25	3:23:38 PM	3:29:52 PM	28.20	-10.20	451	308	YES	N/A
16-Feb-25	3:30:01 PM	3:35:36 PM	28.71	-10.20	479	330	YES	N/A
16-Feb-25	3:41:41 PM	3:47:40 PM	33.86	-10.20	390	303	YES	N/A
16-Feb-25	3:47:49 PM	3:53:41 PM	34.13	-10.20	314	177	YES	N/A
16-Feb-25	3:53:50 PM	3:59:15 PM	38.96	-10.20	315	203	YES	N/A
16-Feb-25	3:59:24 PM	4:06:36 PM	26.83	-10.20	447	280	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
16-Feb-25	4:06:45 PM	4:12:50 PM	23.33	-10.20	433	313	YES	N/A
16-Feb-25	4:12:59 PM	4:18:23 PM	35.69	-10.20	290	202	YES	N/A
16-Feb-25	4:18:52 PM	4:25:47 PM	32.28	-10.20	275	199	YES	N/A
16-Feb-25	4:25:56 PM	4:33:43 PM	34.06	-10.25	258	174	YES	N/A
16-Feb-25	4:33:52 PM	4:41:20 PM	38.71	-10.30	250	168	YES	N/A
16-Feb-25	4:41:29 PM	4:48:02 PM	28.34	-10.30	258	209	YES	N/A
16-Feb-25	4:48:24 PM	4:54:44 PM	37.92	-10.30	209	180	YES	N/A
16-Feb-25	4:54:53 PM	5:00:58 PM	34.38	-10.30	256	185	YES	N/A
16-Feb-25	5:01:19 PM	5:07:51 PM	29.93	-10.30	283	215	YES	N/A
16-Feb-25	5:08:00 PM	5:14:46 PM	24.10	-10.30	332	254	YES	N/A
16-Feb-25	5:14:55 PM	5:21:48 PM	23.08	-10.30	329	235	YES	N/A
16-Feb-25	5:22:10 PM	5:28:38 PM	17.01	-10.30	578	424	YES	N/A
16-Feb-25	5:28:47 PM	5:36:13 PM	17.07	-10.30	547	469	YES	N/A
16-Feb-25	5:36:22 PM	5:43:32 PM	16.00	-10.30	652	514	YES	N/A
27-Feb-25	8:19:06 AM	8:31:04 AM	5.62	-1.59	NA	1056	YES	N/A
27-Feb-25	8:31:13 AM	8:40:05 AM	6.52	-1.50	NA	1246	YES	N/A
27-Feb-25	8:40:14 AM	8:50:20 AM	6.24	-1.50	NA	1078	YES	N/A
27-Feb-25	8:50:29 AM	9:00:45 AM	10.62	-1.50	NA	702	YES	N/A
27-Feb-25	9:00:54 AM	9:10:00 AM	16.32	-1.50	NA	537	YES	N/A
27-Feb-25	9:10:09 AM	9:21:40 AM	17.71	-1.50	NA	363	YES	N/A
27-Feb-25	9:21:49 AM	9:31:18 AM	14.47	-1.29	NA	482	YES	N/A
27-Feb-25	9:31:27 AM	9:41:25 AM	20.94	0.00	NA	342	YES	N/A
27-Feb-25	9:41:34 AM	9:51:26 AM	21.20	0.00	NA	384	YES	N/A
27-Feb-25	9:51:35 AM	10:02:54 AM	15.74	0.00	NA	598	YES	N/A
27-Feb-25	10:03:03 AM	10:21:00 AM	11.47	0.00	NA	1001	YES	N/A
27-Feb-25	10:21:09 AM	10:28:49 AM	3.80	0.00	NA	1690	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
27-Feb-25	10:28:58 AM	10:40:12 AM	1.21	0.36	NA	5223	YES	N/A
27-Feb-25	10:40:21 AM	10:52:07 AM	1.56	0.40	NA	8036	YES	N/A
27-Feb-25	10:52:16 AM	11:23:32 AM	0.20	0.40	NA	9999	NO	Unusable Rate
27-Feb-25	11:23:41 AM	12:19:47 PM	0.60	-1.02	NA	9095	YES	N/A
27-Feb-25	12:19:56 PM	12:30:52 PM	2.06	-1.21	NA	4011	YES	N/A
27-Feb-25	12:31:01 PM	12:39:37 PM	0.49	-1.30	NA	9999	NO	Unusable Rate
27-Feb-25	12:39:46 PM	12:49:34 PM	0.10	-1.30	NA	9999	NO	Unusable Rate
27-Feb-25	12:49:43 PM	1:01:55 PM	0.50	-1.30	NA	9999	YES	N/A
27-Feb-25	1:02:04 PM	1:12:45 PM	1.72	-1.30	NA	9999	NO	Suspected Mixed Conditions
27-Feb-25	1:12:54 PM	1:22:52 PM	1.65	-1.30	NA	9935	NO	Suspected Mixed Conditions
27-Feb-25	1:23:01 PM	2:00:39 PM	1.14	-1.54	NA	9999	NO	Suspected Mixed Conditions
4-Mar-25	11:04:26 AM	12:38:28 PM	0.00	2.92	NA	9812	NO	Unusable Rate
4-Mar-25	12:38:37 PM	12:40:11 PM	2.70	1.50	NA	5542	NO	Unusable Rate
4-Mar-25	12:40:20 PM	12:55:29 PM	1.89	1.50	NA	6236	YES	N/A
4-Mar-25	12:55:38 PM	1:01:45 PM	4.76	1.50	NA	1949	YES	N/A
4-Mar-25	1:01:54 PM	1:12:48 PM	6.21	1.50	NA	1247	YES	N/A
4-Mar-25	1:12:57 PM	1:21:53 PM	2.42	1.50	NA	2991	YES	N/A
4-Mar-25	1:22:02 PM	1:29:44 PM	2.93	1.50	NA	4669	YES	N/A
4-Mar-25	1:29:53 PM	1:42:37 PM	4.98	0.61	NA	2437	YES	N/A
4-Mar-25	1:42:46 PM	1:53:37 PM	4.64	0.60	NA	2590	YES	N/A
4-Mar-25	1:53:46 PM	2:05:08 PM	2.98	0.60	NA	4142	YES	N/A
4-Mar-25	2:05:17 PM	2:13:44 PM	1.06	0.60	NA	9228	YES	N/A
4-Mar-25	2:13:53 PM	2:25:21 PM	4.26	0.60	NA	5957	YES	N/A
4-Mar-25	2:25:30 PM	2:36:44 PM	5.23	0.54	NA	2893	YES	N/A
4-Mar-25	2:36:53 PM	2:46:06 PM	2.80	0.50	NA	3494	YES	N/A
4-Mar-25	2:46:15 PM	2:55:00 PM	6.45	0.50	NA	2008	YES	N/A

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
4-Mar-25	2:55:09 PM	3:03:04 PM	15.50	0.50	NA	656	YES	N/A
4-Mar-25	3:03:13 PM	3:22:05 PM	22.52	0.50	NA	511	YES	N/A
4-Mar-25	3:22:14 PM	3:28:13 PM	20.74	0.50	NA	450	YES	N/A
4-Mar-25	3:28:22 PM	3:39:55 PM	20.55	0.41	NA	486	YES	N/A
4-Mar-25	3:40:04 PM	4:05:11 PM	14.39	0.40	NA	655	YES	N/A
4-Mar-25	4:05:20 PM	4:20:59 PM	12.79	0.40	NA	673	YES	N/A
4-Mar-25	4:21:08 PM	4:31:09 PM	10.51	0.34	NA	1108	YES	N/A
4-Mar-25	4:31:18 PM	4:42:11 PM	9.98	-0.10	NA	1359	YES	N/A
4-Mar-25	4:52:04 PM	5:01:18 PM	3.72	-0.10	NA	2574	YES	N/A
4-Mar-25	5:01:27 PM	5:33:13 PM	7.13	-0.11	NA	2213	YES	N/A
4-Mar-25	5:46:06 PM	5:59:50 PM	8.69	-0.20	NA	2169	YES	N/A
4-Mar-25	5:59:59 PM	6:15:37 PM	8.99	-0.20	NA	1714	YES	N/A
4-Mar-25	6:15:46 PM	6:32:31 PM	8.45	-0.17	NA	1627	YES	N/A
4-Mar-25	6:32:40 PM	6:37:04 PM	7.37	0.00	NA	1443	YES	N/A
4-Mar-25	6:37:13 PM	6:47:55 PM	3.95	0.00	NA	2394	YES	N/A
24-Mar-25	7:52:13 AM	7:59:20 AM	18.56	-3.10	NA	639	YES	N/A
24-Mar-25	7:59:29 AM	8:08:24 AM	16.87	-3.10	848	589	YES	N/A
24-Mar-25	8:08:33 AM	8:17:55 AM	21.12	-3.10	661	533	YES	N/A
24-Mar-25	8:18:04 AM	8:28:18 AM	16.17	-3.10	934	806	YES	N/A
24-Mar-25	8:28:27 AM	8:37:49 AM	19.92	-2.60	1037	903	YES	N/A
24-Mar-25	8:37:58 AM	8:46:14 AM	28.09	-2.50	1252	988	NO	Unacceptable Weather
24-Mar-25	8:46:23 AM	8:56:06 AM	6.68	-2.50	2944	2442	NO	Unacceptable Weather
24-Mar-25	8:56:15 AM	9:07:35 AM	8.71	-2.50	2878	2535	NO	Unacceptable Weather
24-Mar-25	9:07:44 AM	9:18:10 AM	11.80	-2.50	1194	882	NO	Unacceptable Weather
24-Mar-25	9:18:30 AM	9:30:44 AM	16.79	-2.44	729	661	NO	Unacceptable Weather
24-Mar-25	9:30:53 AM	9:45:22 AM	15.97	-1.50	1296	1016	NO	Unacceptable Weather

Log of Visibility Testing Conducted for Testing Season 2024-25 (cont'd)

DATE (YUL TIME)	TIME BEFORE (YUL TIME)	TIME AFTER (YUL TIME)	RATE (g/dm ² /h)	TEMP. (°C)	APS Visibility (m)	NCAR Visibility (m)	Included in Cleaned Database?	Removal Justification
24-Mar-25	9:45:31 AM	9:55:16 AM	13.11	-1.50	1484	1302	NO	Unacceptable Weather
24-Mar-25	9:55:25 AM	10:07:17 AM	27.29	-1.50	961	769	NO	Unacceptable Weather
24-Mar-25	10:07:26 AM	10:25:39 AM	13.88	-1.50	1436	1144	NO	Unacceptable Weather
24-Mar-25	10:25:48 AM	10:34:59 AM	14.64	-0.09	1636	1544	NO	Unacceptable Weather
24-Mar-25	10:35:08 AM	10:46:09 AM	18.86	1.10	1703	1382	NO	Unacceptable Weather
24-Mar-25	10:46:18 AM	10:56:38 AM	15.10	1.10	3105	2130	NO	Unacceptable Weather
24-Mar-25	10:56:47 AM	11:06:41 AM	2.85	1.10	16424	9149	YES	N/A
24-Mar-25	11:06:50 AM	11:17:24 AM	1.20	1.10	19147	9999	YES	N/A
24-Mar-25	11:17:33 AM	11:27:15 AM	0.48	1.10	19950	9999	NO	Unusable Rate

APPENDIX C

ANALYSIS REPORT: INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

300293

ANALYSIS REPORT:
**INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO
DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER
WEATHER TYPE**

Winter 2020-21

This document was prepared for internal purposes to guide the research planning
and preparation.

Prepared by: Ian Wittmeyer

Reviewed by: Marco Ruggi



November 29, 2021
Final Version 1.1

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Winter 2020-21

1. OVERVIEW

The goal of this study is to characterize the occurrence of cold weather fog and mist at Montreal Trudeau airport (CYUL) when no other weather type is reported. This study is in support of testing activities planned at CYUL for the winter of 2020-21.

2. ANALYSIS METHODOLOGY

METAR data used in this study were sourced from the GTA Surface METAR Data (METAR format) website (<https://data.eol.ucar.edu/dataset/100.013>) made available by the University Corporation for Atmospheric Research (UCAR) and the National Center for Atmospheric Research (NCAR).

Data was subsetted for the cold season months of November through April, from 2009 through 2019. Observations were excluded from the study when the temperature was 2°C or higher. Periods of fog and mist were noted by start and end times to determine length of events when no other precipitation or obscuration was present.

Frequency of occurrence of fog and mist is reported by year, month of year, time of day, temperature, and length of event (see all data in Subsection 4.1 for mist and Subsection 4.2 for fog). In addition, the number of events and total event hours are shown in tables for all months in the study and 11 year "climatological" sums are presented by year and month of year.

3. ANALYSIS

3.1 Mist

The frequency of mist at CYUL is quite variable from year to year. See Subsection 4.1 below for total number of METAR observations by year, which range from 25 to 92. There is no obvious trend in the yearly data. Observations by

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

month are highest in December when frequent weather systems occur, and lowest in April when temperatures are more consistently above 1°C. There is a trend toward fewer mist observations at lower temperatures. A large percentage of mist observations are at the warm end, from 1°C to -1°C. There is a general diurnal cycle in frequency with a peak occurrence in the pre-dawn and early morning hours. Most mist events are relatively short lived as the highest frequency of events is less than just a few hours with a peak duration of 1 to 1.5 hours.

Monthly frequency of total event hours is widely variable from month to month and year to year. December sees the greatest number of mist events, as well as total summed hours of mist from all events per month. The highest yearly total frequency was in 2012, while 2011 had the fewest. The characterization of total number of monthly events largely mimics the number of total event hours, with December seeing the highest monthly frequency, and the highest yearly frequency in 2012.

3.2 Fog

There are relatively few observations of fog when no other weather type or obscuration is also reported (see Subsection 4.2 below for all fog data). As with mist, the frequency of fog is highly variable year-to-year and was most prevalent in 2012 and least in 2011 and 2018. Each of those two years saw no events. Fog observations were most frequent in March, and in warmer temperatures, peaking at 1°C. As expected, fog observations also exhibit a diurnal cycle with the highest frequency in the early pre-dawn hours and early morning.

The relatively few fog events were relatively short lived, with almost all events lasting under 90 minutes. There were many cold season months during the 11-year study period with no fog-only events.

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

4. DATA

4.1 Mist

Table 4.1: Mist – Total Observations by Year (CYUL)

Total Observations by Year	
2009	63
2010	87
2011	25
2012	92
2013	70
2014	65
2015	43
2016	74
2017	89
2018	74
2019	38

Table 4.2: Mist – Total Observations by Month (CYUL)

Total Observations by Month	
11	148
12	214
01	156
02	82
03	106
04	14

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.3: Mist – Total Observations by Temperature (CYUL)

Total Observations by Temperature	
1	225
0	111
-1	81
-2	41
-3	32
-4	42
-5	35
-6	28
-7	11
-8	7
-9	17
-10	16
-11	17
-12	11
-13	5
-14	7
-15	7
-16	2
-17	1
-18	2
-19	2
-20	1
-21	2
-22	4
-23	5
-24	3
-25	4
-26	1

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INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.4: Mist – Total Observations by Hour of the Day (UTC) (CYUL)

Total Observations by Hour of the Day (UTC)	
00	8
01	13
02	20
03	36
04	39
05	35
06	37
07	43
08	53
09	57
10	50
11	49
12	60
13	44
14	38
15	27
16	19
17	13
18	19
19	17
20	9
21	7
22	14
23	13

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INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.5: Mist – Number of Events by Duration of Event (Hours) (CYUL)

# of Events by Duration of Event (Hours)	
0-0.33	31
0.33-0.66	30
0.66-1	17
1-1.5	32
1.5-2	21
2-3	23
3-4	9
4-5	8
5-6	11
6-7	3
7-8	3
8-9	1
9-10	3
10-12	2
12-18	
18-24	1
24-100	

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.6: Mist – Number of Event Hours, All Months (CYUL)

# of Event Hours, All Months							
	Nov	Dec	Jan	Feb	Mar	Apr	Total
2009	14.56	15.56	0.2	0	0.23	0	30.56
2010	0.38	23.78	12.48	0	11	0	47.65
2011	0	10.51	0.83	4.26	0	0	15.61
2012	9	15.63	13.51	9.65	7.91	2.18	57.9
2013	4.36	29.35	5	6.65	0.21	0	45.58
2014	0	23.96	4.66	1.78	6	0	36.41
2015	0	2.08	4.06	0	8.96	5	20.11
2016	28.31	2.53	4	2.13	2.2	0	39.18
2017	0	9.55	19.73	2.16	3.2	0	34.65
2018	14.03	1.55	22.4	5.28	2.2	0	45.46
2019	6.26	0	1.13	8.48	9.05	0	24.93
Total	76.93	134.53	88.03	40.41	50.98	7.18	398.08

Table 4.7: Mist – Number of Events, All Months (CYUL)

# of Events, All Months							
	Nov	Dec	Jan	Feb	Mar	Apr	Total
2009	9	3	1	0	1	0	14
2010	1	15	8	0	1	0	25
2011	0	5	1	2	0	0	8
2012	1	6	4	7	7	2	27
2013	2	7	1	3	2	0	15
2014	0	12	4	3	1	0	20
2015	0	1	6	0	4	2	13
2016	8	1	1	4	2	0	16
2017	0	6	11	2	3	0	22
2018	4	1	9	5	2	0	21
2019	2	0	2	3	4	0	11
Total	27	57	48	29	27	4	192

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Final Version 1.1, November 21

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

4.2 FOG

Table 4.8: Fog – Total Observations by Year (CYUL)

Total Observations by Year	
2009	11
2010	9
2011	0
2012	24
2013	9
2014	1
2015	11
2016	11
2017	21
2018	0
2019	2

Table 4.9: Fog – Total Observations by Month (CYUL)

Total Observations by Month	
11	20
12	9
01	5
02	16
03	42
04	7

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.10: Fog – Total Observations by Temperature (CYUL)

Total Observations by Temperature	
1	23
0	8
-1	15
-2	5
-3	5
-4	7
-5	5
-6	5
-7	2
-8	4
-9	3
-10	2
-11	6
-12	3
-13	1
-14	1
-15	2
-16	
-17	
-18	1
-19	1
-20	
-21	
-22	
-23	
-24	
-25	
-26	

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Final Version 1.1, November 21

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.11: Fog – Total Observations by Hour of the Day (UTC) (CYUL)

Total Observations by Hour of the Day (UTC)	
00	
01	
02	1
03	2
04	2
05	3
06	7
07	14
08	13
09	11
10	15
11	11
12	8
13	5
14	4
15	3
16	
17	
18	
19	
20	
21	
22	
23	

APS/Library/Projects/300293 (TC Deicing 2020-21)/Analysis/MIST/Frequency of Fog and Mist (Final Version 1.1).docx
Final Version 1.1, November 21

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE**Table 4.12: Fog – Number of Events by Duration of Event (Hours) (CYUL)**

# of Events by Duration of Event (Hours)	
0-0.33	2
0.33-0.66	5
0.66-1	
1-1.5	2
1.5-2	
2-3	1
3-4	
4-5	
5-6	1
6-7	
7-8	
8-9	
9-10	
10-12	
12-18	
18-24	
24-100	

INVESTIGATION OF HISTORICAL METAR REPORTS AT CYUL TO DETERMINE FREQUENCY OF FOG AND MIST WITH NO OTHER WEATHER TYPE

Table 4.13: Fog – Number of Event Hours, All Months (CYUL)

# of Event Hours, All Months							
	Nov	Dec	Jan	Feb	Mar	Apr	Total
2009	0.55	0	0	0	0.21	0	0.76
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	7.46	0	7.46
2013	0	0	0	0	0.43	0	0.43
2014	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2016	3.26	0	0	0	0.46	0	3.73
2017	0	0	0	0	0.58	0	0.58
2018	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0
Total	3.81	0	0	0	9.16	0	12.98

Table 4.14: Fog – Number of Events, All Months (CYUL)

# of Events, All Months							
	Nov	Dec	Jan	Feb	Mar	Apr	Total
2009	1	0	0	0	1	0	2
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	3	0	3
2013	0	0	0	0	1	0	1
2014	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2016	3	0	0	0	1	0	4
2017	0	0	0	0	1	0	1
2018	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0
Total	4	0	0	0	7	0	11

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Final Version 1.1, November 21

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APPENDIX D

PROCEDURE:

**SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO
INVESTIGATE THE DEPOSITION RATE OF MIST
AND SUBSTANTIATION OF FREEZING FOG**

300293

PROCEDURE:
**SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO
INVESTIGATE THE DEPOSITION RATE OF MIST AND
SUBSTANTIATION OF FREEZING FOG**

Winter 2021-22

Prepared for:

**Transport Canada
Innovation Centre**

In cooperation with:

**Federal Aviation Administration
William J. Hughes Technical Center**

**Transport Canada
Civil Aviation**

**Federal Aviation Administration
Flight Standards – Air Carrier Operations**

Prepared by: Dany Posteraro



Reviewed by: Marco Ruggi



December 15, 2021
Final Version 1.0

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

Winter 2021-22

1. BACKGROUND

Mist (METAR code BR) is a commonly reported weather phenomenon. Mist is considered an obscuration rather than a precipitation type and can be reported alone or in conjunction with other weather conditions such as snow, freezing rain, et cetera. In terms of visibility, mist can reduce visibility to between 0.6 and 1.2 miles (1 - 2 km), while fog reduces it to less than 0.6 miles (1 km).

Mist is similar to freezing fog (METAR code FZFG) as they are both considered obscurations. Historical research simulating an aircraft taxi in freezing fog indicated that the deposition rates can increase significantly when in motion; consequently, simulated freezing fog rates of 2 to 5 g/dm²/h were selected for developing holdover times (HOTs).

The deposition rates for mist, however, were first quantified in the 2020-21 testing season. The results of these tests showed that the rate can range between 0 and 0.4 g/dm²/h; subsequently, freezing mist was defined and the HOT guidelines were updated. Further research is now required to substantiate the results and determine if other factors/parameters affect the deposition rate. Freezing fog will also be included in this research to substantiate historical freezing fog rates.

2. OBJECTIVE

The objective of this study is to substantiate the range of deposition rates that occur naturally in mist and freezing fog.

3. TEST PLAN

The collection of mist and freezing fog deposition rates will be done in natural occurring conditions below, or close to freezing temperatures. A total of approximately 12 (8 mist and 4 freezing fog) testing events are planned for the winter of 2021-22. Additional tests may be considered only if the data collected during certain events is not adequate (i.e., mist or fog did not occur, mixed precipitation, et cetera).

APS/Library/Projects/300293 (TC Deicing 2021-22)/Procedures/Mist/Final Version 1.0/Mist and Freezing Fog Final Version 1.0.docx
Final Version 1.0, December 21

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

4. MIST AND FREEZING FOG FORECASTING

The following list of elements can be considered when trying to forecast mist or freezing fog conditions.

1. Mist: Surface visibility greater than or equal to 5/8 mile (≈ 1 km) and less than 7 miles (≈ 11 km).
Freezing Fog: Surface visibility less than 5/8 mile (≈ 1 km).
2. Outside air temperature (OAT) $< 2^{\circ}\text{C}$. Most mist and freezing fog observations are at temperatures above -4°C with many occurring near 0°C . Mist and freezing fog are also infrequently reported at temperatures colder than -4°C .
3. High relative humidity $> 90\%$, best if closer to 100% .
4. Overcast sky cover. Low ceiling suggests more robust mist or freezing fog (800 feet i.e., ≈ 240 m or below).
5. No precipitation concurrent with mist or freezing fog (for the purpose of this research).
6. Sustained wind speed < 9 knots (≈ 15 km/h).
7. It is helpful if precipitation occurs before the expected period of mist.

An analysis of historical METAR reports from CYUL was conducted to determine the ideal time for the occurrence of mist or fog alone. It was found that the beginning of winter, early mornings, and temperatures around the freeze point (0°C) are the most favourable.

Note: When there is a forecast for mist or freezing fog conditions, start watching the CYUL TAF the day before and check for low wind speeds, overcast sky cover, low ceiling, and duration of potential mist or freezing fog with no precipitation falling. Keep in mind that forecasting may be difficult to predict (similar to frost testing) but can occur at any time of day. Consideration should, therefore, be made to test for extended periods to increase the chances of successful data collection.

5. TESTING PROCEDURE

The following section details the test procedure to be followed.

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG**5.1 Procedural Updates for Winter 2021-22**

The results of the 2020-21 testing were presented to the G-12 HOT Committee at the May 2021 conference, and the stakeholders recommended the following changes/additions to the testing procedure:

- Addition of dry rate pans to determine if mist or freezing fog accretion rates are similar when comparing a dry wing to a fluid covered wing (wet wing);
- Addition of temperature loggers to determine freezing or non-freezing conditions; and
- Substantiation of freezing fog deposition rates to provide an intensity comparison to mist.

The above changes have therefore been implemented in this procedure and will be reflected in the 2021-22 testing season.

Tests will be carried out at the APS Aviation Inc. (APS) test facility in Montreal and/or surrounding areas i.e., Mont Saint-Sauveur, Mont-Tremblant, et cetera. Testing in the surrounding areas will only be considered if weather conditions at the APS test facility prove insufficient. Mist or freezing fog deposition rates are to be captured using two measurement methods. The first and second methods will simulate a taxiing and stationed aircraft, respectively. It should be noted that since this study is comparative research, both measurement methods should be conducted simultaneously.

5.2 Measurement Method 1: Simulation of a Taxiing Aircraft Using a Test Vehicle

The following is the procedure to be followed for testing with Photo 5.1 provided for illustration purposes:

- a) Ensure active mist or freezing fog conditions (to be confirmed visually and using the standard rate measurement method) and record meteorological conditions;
- b) Take a picture of a nearby lamp post with sufficient lighting to document the visual confirmation in a);
- c) Using two standard precipitation collection pans (rate pans), ensure an iButton is placed on both pans and properly recording for temperature data collection (temperature sample rate should be set to minimum of 1 data point every 30 seconds);
- d) Pour approximately $\frac{1}{4}$ to $\frac{1}{2}$ liter of rate fluid into one of the pans and record the measured weight (in grams) and test start time (hh:mm:ss) in the electronic

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

- rate form. Coordinate the start time of the taxi test with the stationed aircraft test. To ensure that the rate pan is tempered, it should be left outside and covered for at least 15 minutes prior to the start of measurements;
- e) Using the second clean and dry rate pan, record the measured weight (in grams) and test start time (hh:mm:ss) in the electronic rate form. Coordinate the start time of the taxi test with the stationed aircraft test. To ensure that the rate pan is tempered, it should be left outside and covered for at least 15 minutes prior to the start of measurements;
 - f) Take a picture of the rate pans to ensure no dew or frost is present;
 - g) Mount both rate pans on the roof of the test vehicle at a 10° angle as seen in Photo 5.1. Ensure the heating is off and the car is not left running when not in use to prevent air flow disruptions (by a change in air density of the surrounding environment) and in turn, freezing fog or mist deposition;
 - h) Bring the odometer of the test vehicle to zero;
 - i) Drive the test vehicle to simulate a typical aircraft taxi, i.e., travel time of approximately 30 minutes at no more than 30 km/h (≈15 km) with appropriate hold periods to simulate a typical taxi. Plan the route as a round trip which ends at the testing station for measuring the rates post test;
 - j) Determine the visibility using a stationary object i.e., lamp post, et cetera. This is done by determining the distance (using the odometer of the vehicle) of the object when it becomes visible;
 - k) Document the end time of the test run;
 - l) Take note of distance travelled on the odometer;
 - m) Re-weigh both rate pans;
 - n) Take a picture of the rate pans to confirm the presence of dew or frost;
 - o) Retake a picture of the nearby lamp post with sufficient lighting to document the visual confirmation of freezing fog or mist as done in b);
 - p) Document the trajectory and speed of the test vehicle (iPad™ or iPhone™ GPS™ tracking apps can be useful for this). If no app is available, calculate the average velocity during the test by using the distance travelled during the test and the test end time;
 - q) Repeat test if required and if conditions are still appropriate; and
 - r) Download the iButton temperature data at the end of the testing session.

Important: Due to evaporation of the precipitation in the rate pans, it is important to minimize the amount of time the rate pans are indoors during weighing. Care should be taken to weigh the rate pans and return them outdoors quickly. Also, ensure the scale reads zero (tared) before any measurements are taken.

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

Photo 5.1: Example of Rate Pans Installed on a Test Vehicle



5.3 Measurement Method 2: Simulation of a Stationed Aircraft Using the Standard Rate Measurement Method

The following is the procedure to be followed for testing:

Repeat steps a) through f) from method 1 above. For steps d) and e), coordinate the start time of the stationed test with the taxi simulation test.

- g) Place both rate pans on the test stand for a period of approximately 30 minutes. Take note that the duration of freezing fog or mist deposition needs to coincide with the taxi simulation test for comparative purposes;
- h) Take a picture of the rate pans to confirm the presence of dew or frost;
- i) Re-weigh both rate pans and record the time;
- j) Repeat procedure until the end of testing; and
- k) Download the iButton temperature data at the end of the testing session.

Important: Due to evaporation of the precipitation in the rate pans, it is important to minimize the amount of time the rate pans are indoors during weighing. Care should be taken to weigh the rate pans and return them outdoors quickly. Also, ensure the scale reads zero (tared) before any measurements are taken.

6. EQUIPMENT

The following is the equipment required to conduct the simulated aircraft taxi and stationed tests:

- Test vehicle;
- Two (2) position taxi rig;
- Two (2) position test stand;
- Four (4) rate pans;

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

- Weight scale;
- Rate fluid;
- Mounting brackets/bungee cords or tie-downs;
- Data/Rate forms;
- Camera; and
- iPad™ or iPhone™ equipped with GPS™ tracking app (optional).

7. PERSONNEL

One or two people will be required to conduct this test. The simulated aircraft taxi tests will require one person while the stationed tests will require one person as well; however, both activities can be coordinated and be done by one person if required.

8. SAFETY

Personnel must operate in accordance with the “Testing Safety Recommendations” and must follow the protocols for “Extended Work Hours Protocol for APS Personnel.” These documents are included in the “APS Office Policies & Procedures,” which is made available to all APS staff.

9. DATA FORMS AND SOFTWARE

The standard electronic rate file and the general information data form (shown in Figure 9.1) should be used for this study.

When measuring rates, the taxiing pan should be denoted as “Pan 1 – Dry and Pan 2 – Wet” and the stationed pan should be denoted as “Pan 3 – Dry and Pan 4 – Wet.”

SIMULATED TAXIING AND STATIONED AIRCRAFT TESTS TO INVESTIGATE THE DEPOSITION RATE OF MIST AND SUBSTANTIATION OF FREEZING FOG

MIST OR FREEZING FOG - SIMULATED TAXIING AND STATIONED AIRCRAFT TESTING		
DATE: _____	RUN #: _____	
RECORDED BY: _____	SIGNATURE: _____	
APS Data		
<u>Verifications or Actions to be Taken Before Testing (Check when done):</u> • Visual Verification of Mist or Freezing Fog at Start: ☐ Yes ☐ No • Photo confirming mist: ☐ • Photos of both taxi collection pans: ☐ • Photos of both stationed collection pans: ☐ <u>Actions to be Taken on Completion of Testing (Check when done):</u> • Photo confirming mist: ☐ • Photos of both taxi collection pans: ☐ • Photos of both stationed collection pans: ☐ • Temperature data logged (at end of session): ☐		
Simulated Taxi		
DRY PAN Taxi Start (hr:min): _____ Taxi Stop (hr:min): _____ Rate (g/dm ² /h): _____	WET PAN Taxi Start (hr:min): _____ Taxi Stop (hr:min): _____ Rate (g/dm ² /h): _____	ADDITIONAL TEST DATA Visibility (km) : _____ Average Velocity (km/h): _____ Taxi Distance (km) : _____
Simulated Stationed		
DRY PAN Start Time (hr:min): _____ End Time (hr:min): _____ Rate (g/dm ² /h): _____	WET PAN Start Time (hr:min): _____ End Time (hr:min): _____ Rate (g/dm ² /h): _____	
METAR Data		
Observed Weather: _____ Temperature (°C): _____ Relative Humidity (%): _____ Time (hr:min): _____ Wind Speed (km/h): _____		
COMMENTS: _____ _____ _____		

APS/Library/Projects/300293 (TC Deicing 2021-22)/Procedures/Mist Testing/Data Form - Simulated Taxiing and Stationed Aircraft Testing

Figure 9.1: General Information Data Form

APPENDIX E

LOG OF FOG/FREEZING FOG & MIST/FREEZING MIST TESTS 2020-21 THROUGH 2024-25

Table 1: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist Reported by METAR but NOT Visible

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
9	14-Jan-21	Mist	No	Wet	16:35	17:05	15.0	28.0	0.1	16:35	17:05	0.00	0.10	1.0	87	9.7	-	9	YUL	-

Table 2: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist/Freezing Fog/Fog Visible and Reported by METAR

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
18	15-Jan-21	Mist	Yes	Wet	6:15	6:45	15.0	28	0.4	6:15	6:45	0.30	0.10	-4.0	93	4.8	-	14	YUL	-
21	15-Jan-21	Mist	Yes	Wet	-	-	-	-	-	0:10	0:35	0.08	-	0.0	93	4.0	-	6	YOW - M46	-
22	15-Jan-21	Mist	Yes	Wet	-	-	-	-	-	1:08	1:38	0.13	-	-1.0	93	4.8	-	6	YOW - M46	-
23	15-Jan-21	Mist	Yes	Wet	1:58	2:34	13.7	23.3	0.23	2:00	2:34	0.13	0.10	-1.0	93	3.2	-	6	YOW - M46	-
24	15-Jan-21	Mist	Yes	Wet	2:58	3:34	14.1	23.6	0.29	3:00	3:35	0.15	0.15	-1.0	93	4.0	-	6	YOW - M46	-
72	7-Apr-22	Mist	Yes	Wet	-	-	-	-	-	12:30	13:00	0.20	-	2.3	96	-	-	14	YMX (PMG)	Test with fluid. No Pics or temperature log taken.
118	27-Apr-23	Mist	Yes	Dry	4:18	4:47	14	29	0.70	4:17	4:46	0.30	0.40	1.0	100	3.0	0.02	5.5	YUL	-
119	27-Apr-23	Mist	Yes	Wet	4:17	4:46	14	29	2.40	4:17	4:46	0.60	1.80	1.0	100	3.0	0.02	5.5	YUL	-
120	27-Apr-23	Mist	Yes	Dry	4:51	5:20	14	29	0.40	4:50	5:21	0.60	-0.20	1.0	100	3.0	0.02	5.5	YUL	-
121	27-Apr-23	Mist	Yes	Wet	4:51	5:20	14	29	1.80	4:51	5:20	0.20	1.60	1.0	100	3.0	0.02	5.5	YUL	-
122	27-Apr-23	Mist	Yes	Dry	5:26	5:55	14	29	0.50	5:26	5:55	0.10	0.40	2.0	93	1.0	>0.05	7.4	YUL	-
123	27-Apr-23	Mist	Yes	Wet	5:26	5:55	14	29	2.00	5:26	5:55	0.40	1.60	2.0	93	1.0	>0.05	7.4	YUL	-
124	27-Apr-23	Mist	Yes	Dry	5:59	6:29	14	29	0.30	6:00	6:29	0.00	0.30	2.0	93	0.8	>0.05	7.4	YUL	-

Table 2: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist/Freezing Fog/Fog Visible and Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
125	27-Apr-23	Mist	Yes	Wet	5:59	6:29	14	29	1.70	6:00	6:30	0.50	1.20	2.0	93	0.8	>0.05	7.4	YUL	-
42	8-Oct-21	Shallow Fog	Yes	Dry	6:29	7:00	14.2	28	0.00	6:27	7:01	0.00	0.00	8.0	100	16.1	-	0	YUL	-
43	8-Oct-21	Shallow Fog	Yes	Wet	6:29	7:00	14.2	28	1.00	6:28	7:01	0.30	0.70	8.0	100	16.1	-	0	YUL	-
44	8-Oct-21	Shallow Fog/Mist	Yes	Wet	7:33	8:07	21.3	44	1.40	7:33	8:08	0.20	1.20	9.0	100	10.0	-	3.7	YUL	-
45	8-Oct-21	Shallow Fog/Mist	Yes	Dry	7:34	8:07	21.3	44	0.00	7:33	8:07	0.00	0.00	9.0	100	10.0	-	3.7	YUL	-
48	7-Oct-21	Fog/Mist	Yes	Dry	n/a	n/a	n/a	n/a	n/a	5:00	8:00	0.04	n/a	9.6	98	10.5	-	0	Beaconsfield	Surface Test
49	7-Oct-21	Fog/Mist	Yes	Dry	n/a	n/a	n/a	n/a	n/a	5:00	8:00	0.26	n/a	9.6	98	10.5	-	0	Beaconsfield	Surface Test
50	7-Oct-21	Fog	Yes	Dry	n/a	n/a	n/a	n/a	n/a	5:00	8:00	0.42	n/a	7.0	100	38.0	-	4	Laval	Surface Test
61	15-Oct-21	Mist	Yes	Dry	9:13	9:35	6.9	27	0.00	9:12	9:36	0.00	0.00	17.0	94	3.6	-	9	YUL	Began raining during Test. METAR did not change.
62	15-Oct-21	Mist	Yes	Wet	9:14	9:35	6.9	27	0.70	9:13	9:37	0.30	0.40	17.0	94	3.6	-	9	YUL	Began raining during Test. METAR did not change.
63	21-Oct-21	Fog	Yes	Dry	21:30	22:03	14.6	29	0.10	21:29	22:04	0.10	0.00	10.0	100	0.4	-	7	YUL	-
64	21-Oct-21	Fog	Yes	Wet	21:31	22:04	14.6	29	1.30	21:30	22:04	0.50	0.80	10.0	100	0.4	-	7	YUL	-
65	21-Oct-21	Fog	Yes	Dry	22:26	23:03	14.7	28	0.00	22:24	23:03	0.00	0.00	10.0	100	0.6	-	19	YUL	-

Table 2: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist/Freezing Fog/Fog Visible and Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
66	21-Oct-21	Fog	Yes	Wet	22:26	23:02	14.7	28	1.00	22:25	23:03	0.50	0.50	10.0	100	0.6	-	19	YUL	-
67	21-Oct-21	Mist	Yes	Dry	23:19	23:37	6.7	28	0.10	23:20	23:38	0.00	0.10	11.0	100	8.0	-	6	YUL	Began raining during Test. METAR did not change.
68	21-Oct-21	Mist	Yes	Wet	23:19	23:37	6.7	28	0.60	23:20	23:38	0.30	0.30	11.0	100	8.0	-	6	YUL	Began raining during Test. METAR did not change.
69	21-Oct-21	Mist	Yes	Wet	23:54	0:26	14.6	28	0.90	23:53	0:27	0.50	0.40	11.0	100	8.0	-	6	YUL	Began raining during Test. METAR did not change.
70	21-Oct-21	Mist	Yes	Dry	23:53	0:26	14.6	28	0.00	23:52	0:27	0.00	0.00	11.0	100	8.0	-	6	YUL	Began raining during Test. METAR did not change.
104	7-Dec-22	Light Drizzle/ Mist	Yes	Dry	14:03	14:33	14.0	28	0.40	14:02	14:32	0.40	0.00	7.0	100	2.0	850 m	9.26	Senneville	Did not observe any drizzle.
105	7-Dec-22	Light Drizzle/ Mist	Yes	Wet	14:03	14:32	14.0	28	1.40	14:02	14:32	0.50	0.90	7.0	100	2.0	850 m	9.26	Senneville	Did not observe any drizzle.
126	22-Nov-23	Mist	Yes	Dry	7:30	8:00	13.5	27	0.1	7:28	8:01	0.20	-0.10	2.0	99	N/A	1.2	7.0	YUL	-
127	22-Nov-23	Mist	Yes	Wet	7:30	8:00	13.5	27	0.7	7:28	8:01	0.20	0.50	2.0	99	N/A	1.2	7.0	YUL	-
128	22-Nov-23	Mist	Yes	Dry	8:25	8:57	13.7	28	0.1	8:26	8:56	0.10	0.00	2.0	99	N/A	3.5	7.4	YUL	-
129	22-Nov-23	Mist	Yes	Wet	8:26	8:57	13.7	28	0.5	8:27	8:56	0.10	0.40	2.0	99	N/A	3.5	7.4	YUL	-
130	22-Nov-23	Mist	Yes	Dry	21:31	22:01	13.3	27	0.1	21:31	22:01	0.10	0.00	2.0	97	N/A	3.5	7.0	YUL	-
131	22-Nov-23	Mist	Yes	Wet	21:31	22:01	13.3	27	0.7	21:31	22:01	0.20	0.50	2.0	97	N/A	3.5	7.0	YUL	-

Table 2: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist/Freezing Fog/Fog Visible and Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
140	28-Dec-24	Mist	Yes	Dry	21:54	22:26	15.0	30.0	0.03	21:50	22:27	0.08	-0.05	-4.0	93	4.8	> 1	12.9	YUL	No Frost observed / No temp data recorded
141	28-Dec-24	Mist	Yes	Wet	21:54	22:26	15.0	30.0	0.25	21:50	22:27	0.08	0.17	-4.0	93	4.8	> 1	12.9	YUL	No Frost observed / No temp data recorded
142	28-Dec-24	Mist	Yes	Dry	22:43	23:15	15.0	30.0	0.04	22:40	23:17	0.03	0.01	-3.0	93	9.6	> 1	16.6	YUL	No Frost observed / No temp data recorded
143	28-Dec-24	Mist	Yes	Wet	22:43	23:15	15.0	30.0	0.24	22:40	23:17	0.08	0.16	-3.0	93	9.6	> 1	16.6	YUL	No Frost observed / No temp data recorded
144	29-Dec-24	Mist	Yes	Dry	21:10	21:43	15.0	27.0	0.04	21:09	21:45	0.21	-0.17	2.0	100	3.2	700m	14.8	YUL	No Frost observed
145	29-Dec-24	Mist	Yes	Wet	21:11	21:43	15.0	27.0	0.94	21:09	21:45	0.41	0.53	2.0	100	3.2	700m	14.8	YUL	No Frost observed
146	29-Dec-24	Mist	Yes	Dry	22:08	22:41	15.0	28.0	0.03	22:07	22:42	0.19	-0.16	2.0	100	8.0	600m	13.0	YUL	No Frost observed
147	29-Dec-24	Mist	Yes	Wet	22:08	22:41	15.0	28.0	1.17	22:07	22:42	0.43	0.74	2.0	100	8.0	600m	13.0	YUL	No Frost observed
148	29-Dec-24	Mist	Yes	Dry	22:53	23:24	14.6	30.0	0.03	22:51	23:25	0.12	-0.09	2.0	100	16.1	800m	14.8	YUL	No Frost observed
149	29-Dec-24	Mist	Yes	Wet	22:53	23:24	14.6	30.0	0.85	22:51	23:25	0.48	0.37	2.0	100	16.1	800m	14.8	YUL	No Frost observed
150	29-Dec-24	Freezing Fog	Yes	Dry	11:00	11:30	15.0	30.0	0.05	10:57	11:32	0.07	-0.02	0.0	93	0.4	150m-200m	12.9	YUL	No Frost, only Freezing Fog/ No Temp data recorded
151	29-Dec-24	Freezing Fog	Yes	Wet	11:00	11:30	15.0	30.0	0.47	10:57	11:32	0.39	0.08	0.0	93	0.4	150m-200m	12.9	YUL	No Frost, only Freezing Fog/ No Temp data recorded
152	29-Dec-24	Freezing Fog/Fog	Yes	Dry	11:46	12:16	15.0	30.0	0.02	11:45	12:19	0.03	-0.01	0.0	100	0.6	150m-200m	11.1	YUL	No Frost, only Freezing Fog/ No Temp data recorded

Table 2: Log of Data Collected in 2020-21 through 2024-25 – Tests with Mist/Freezing Fog/Fog Visible and Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
153	29-Dec-24	Freezing Fog/Fog	Yes	Wet	11:46	12:16	15.0	30.0	0.49	11:45	12:19	0.36	0.13	0.0	100	0.6	150m-200m	11.1	YUL	No Frost, only Freezing Fog/ No Temp data recorded
154	29-Dec-24	Fog	Yes	Dry	12:30	13:02	15.0	30.0	0.03	12:28	13:05	0.03	0.00	1.0	93	0.4	250m	14.8	YUL	No Frost , Only Fog / No temp data was collected
155	29-Dec-24	Fog	Yes	Wet	12:30	13:02	15.0	30.0	0.52	12:28	13:05	0.27	0.25	1.0	93	0.4	250m	14.8	YUL	No Frost , Only Fog / No temp data was collected
156	3-Feb-25	Mist	Yes	Dry	13:07	13:37	15.0	30.0	0.09	13:07	13:37	0.05	0.04	-5.0	93	4.0	> 1	13.0	YUL	-
157	3-Feb-25	Mist	Yes	Wet	13:07	13:37	15.0	30.0	0.27	13:07	13:37	0.30	-0.03	-5.0	93	4.0	> 1	13.0	YUL	-
164	26-Feb-25	Mist	Yes	Dry	3:02	3:33	14.0	25.0	0.06	3:01	3:33	0.04	0.02	1.0	100	9.7	> 1	14.8	YUL	-
165	26-Feb-25	Mist	Yes	Wet	3:02	3:33	14.0	25.0	1.21	3:02	3:33	0.34	0.87	1.0	100	9.7	> 1	14.8	YUL	-

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
10	14-Jan-21	NIL	Yes	Wet	21:15	21:45	15.0	29	-	21:15	21:45	0.10	-	0.0	93	16.0	-	9	YUL	-
11	14-Jan-21	NIL	Yes	Wet	22:05	22:35	15.0	28	0.3	22:05	22:35	0.10	0.20	0.0	93	16.0	-	11	YUL	-
12	14-Jan-21	NIL	Yes	Wet	23:30	0:03	15.0	28	0.3	23:30	0:03	0.10	0.20	0.0	93	16.0	-	7	YUL	-
13	15-Jan-21	NIL	Yes	Wet	0:45	1:15	14.8	29	0.2	0:45	1:15	0.20	0.00	0.0	93	16.0	-	7	YUL	-
14	15-Jan-21	NIL	Yes	Wet	1:45	2:15	14.8	29	0.2	1:45	2:15	0.30	-0.10	-1.0	93	16.1	-	11	YUL	-
15	15-Jan-21	NIL	Yes	Wet	3:10	3:40	15.0	28	0.2	3:10	3:40	0.20	0.00	-2.0	93	12.9	-	7	YUL	-
16	15-Jan-21	NIL	Yes	Wet	4:15	4:35	15.0	28	0.3	4:15	4:35	0.20	0.10	-2.0	93	12.9	-	11	YUL	-
17	15-Jan-21	NIL	Yes	Wet	5:15	5:45	15.0	29	0.4	5:15	5:45	0.30	0.10	-2.0	100	12.9	-	7	YUL	-
74	8-Apr-22	NIL	Yes	Dry	23:05	23:35	15	30	0.00	23:00	23:30	0.09	-0.09	4.0	93	24.0	-	7.4	YUL	-
75	8-Apr-22	NIL	Yes	Wet	23:05	23:35	15	30	0.51	23:00	23:30	0.24	0.27	4.0	93	24.0	-	7.4	YUL	-
76	9-Apr-22	NIL	Yes	Dry	23:58	0:28	15	30	0.02	23:50	0:30	0.04	-0.02	4.0	100	24.1	-	4	YUL	-
77	9-Apr-22	NIL	Yes	Wet	23:58	0:28	15	30	0.43	23:50	12:30	0.20	0.23	4.0	100	24.1	-	4	YUL	-
78	19-Oct-22	NIL	Yes	Dry	2:54	3:25	14	28	0.10	2:53	3:25	0.00	0.10	4.0	87	24.1	-	0	YUL	Fog patches

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
79	19-Oct-22	NIL	Yes	Wet	2:54	3:26	14	28	0.40	2:53	3:25	0.20	0.20	4.0	87	24.1	-	0	YUL	Fog patches
88	29-Oct-22	NIL	Yes	Dry	2:19	2:51	14	28	0.00	2:20	2:50	-0.06	0.00	4.0	70	24.0	-	6	Senneville	Fog patches
89	29-Oct-22	NIL	Yes	Wet	2:18	2:51	14	28	0.87	2:19	2:50	0.12	0.75	4.0	70	24.0	-	6	Senneville	Fog patches
90	29-Oct-22	NIL	Yes	Dry	2:52	3:24	14	28	0.06	2:53	3:23	0.03	0.03	4.0	70	24.0	-	6	Senneville	-
91	29-Oct-22	NIL	Yes	Wet	2:52	3:24	14	28	1.00	2:53	3:23	0.19	0.81	4.0	70	24.0	-	6	Senneville	-
92	29-Oct-22	NIL	Yes	Dry	3:25	3:57	14	28	0.03	3:26	3:56	0.03	0.00	4.0	70	24.0	-	7	Senneville	Fog patches
93	29-Oct-22	NIL	Yes	Wet	3:25	3:58	14	28	0.91	3:26	3:57	0.28	0.63	4.0	70	24.0	-	7	Senneville	Fog patches
94	29-Oct-22	NIL	Yes	Dry	4:00	4:32	14	28	0.00	4:01	4:33	0.00	0.00	4.0	70	24.0	-	7	Senneville	Fog patches
95	29-Oct-22	NIL	Yes	Wet	3:59	4:31	14	28	0.82	4:00	4:32	0.23	0.59	4.0	70	24.0	-	7	Senneville	Fog patches
96	3-Nov-22	NIL	Yes	Dry	2:07	2:36	14	28	0.40	2:05	2:37	0.10	0.30	3.0	93	24.0	-	3	Senneville	Fog patches
97	3-Nov-22	NIL	Yes	Wet	2:07	2:37	14	28	1.10	2:06	2:37	0.30	0.80	3.0	93	24.0	-	3	Senneville	Fog patches
98	3-Nov-22	NIL	Yes	Dry	2:44	3:13	14	29	0.20	2:43	3:14	0.00	0.20	3.0	93	24.0	-	3	Senneville	-
99	3-Nov-22	NIL	Yes	Wet	2:44	3:14	14	29	0.80	2:43	3:15	0.20	0.60	3.0	93	24.0	-	3	Senneville	-

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
100	3-Nov-22	NIL	Yes	Dry	3:17	3:48	14	28	0.10	3:16	3:44	0.10	0.00	2.0	100	24.0	-	2	Senneville	-
101	3-Nov-22	NIL	Yes	Wet	3:17	3:48	14	28	0.70	3:16	3:44	0.30	0.40	2.0	100	24.0	-	2	Senneville	-
102	3-Nov-22	NIL	Yes	Dry	3:52	4:25	14	28	0.10	3:53	4:26	0.20	-0.10	4.0	81	24.0	-	11	Senneville	-
103	3-Nov-22	NIL	Yes	Wet	3:52	4:25	14	28	0.70	3:53	4:26	0.40	0.30	4.0	81	24.0	-	11	Senneville	-
108	3-Jan-23	NIL	Yes	Dry	18:07	18:39	14	29	0.00	18:08	18:38	0.10	-0.10	2.0	87	24	-	13.0	YUL	-
109	3-Jan-23	NIL	Yes	Wet	18:07	18:38	14	29	0.18	18:08	18:38	0.22	-0.04	2.0	87	24	-	13.0	YUL	-
110	3-Jan-23	NIL	Yes	Dry	19:00	19:29	14	30	0.03	19:01	19:30	0.10	-0.07	2.0	87	24	-	15.0	YUL	-
111	3-Jan-23	NIL	Yes	Wet	19:00	19:29	14	30	0.29	19:01	19:30	0.32	-0.03	2.0	87	24	-	15.0	YUL	-
38	8-Oct-21	NIL	Yes	Wet	4:27	5:01	13.6	27.0	1.10	4:26	5:02	0.40	0.70	11.0	100	24.1	1	5.55	YUL	Fog patches
39	8-Oct-21	NIL	Yes	Dry	4:27	5:01	13.6	27.0	0.10	4:26	5:02	0.10	0.00	11.0	100	24.1	1	5.55	YUL	Fog patches
40	8-Oct-21	NIL	Yes	Dry	5:28	6:02	14.3	29	0.20	5:27	6:02	0.10	0.10	10.0	100	24.1	-	5.55	YUL	Fog Patches
41	8-Oct-21	NIL	Yes	Wet	5:28	6:02	14.3	29	1.30	5:27	6:03	0.30	1.00	10.0	100	24.1	-	5.55	YUL	Fog Patches
51	13-Oct-21	NIL	Yes	Dry	4:53	5:25	14.3	28.0	0.20	4:51	5:26	0.10	0.10	15.0	94	24.1	-	5.5	YUL	-

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
52	13-Oct-21	NIL	Yes	Wet	4:52	5:25	14.3	28.0	1.50	4:52	5:26	0.40	1.10	15.0	94	24.1	-	5.5	YUL	-
53	13-Oct-21	NIL	Yes	Dry	5:43	6:16	13.5	25.0	0.00	5:44	6:17	0.10	-0.10	14.0	94	24.1	-	5.5	YUL	-
54	13-Oct-21	NIL	Yes	Wet	5:43	6:16	13.5	25.0	1.20	5:44	6:17	0.40	0.80	14.0	94	24.1	-	5.5	YUL	-
55	13-Oct-21	NIL	Yes	Wet	6:44	7:18	14.8	29.0	0.80	6:43	7:18	0.30	0.50	14.0	100	24.1	-	7	YUL	-
56	13-Oct-21	NIL	Yes	Dry	6:44	7:18	14.8	29.0	0.30	6:44	7:19	0.00	0.30	14.0	100	24.1	-	7	YUL	-
57	13-Oct-21	NIL	Yes	Wet	7:48	8:18	14.7	28.0	N/A	7:45	8:19	0.20	-0.10	15.0	94	48.27	-	7	YUL	Loss of fluid on wet taxi.
58	13-Oct-21	NIL	Yes	Wet	7:45	8:18	14.7	28.0	0.00	7:44	8:19	0.00	0.00	15.0	94	48.27	-	7	YUL	-
80	19-Oct-22	NIL	Yes	Dry	3:54	4:30	14.0	29	0.10	3:54	4:29	0.10	0.00	5.0	81	24.1	-	0	YUL	Confirmed Mist
81	19-Oct-22	NIL	Yes	Wet	3:55	4:31	14.0	29	0.50	3:54	4:29	0.20	0.30	5.0	81	24.1	-	0	YUL	Confirmed Mist
82	25-Oct-22	NIL	Yes	Dry	3:22	3:57	14.0	28	0.10	3:23	3:58	0.10	0.00	14.0	94	56.0	-	11	Senneville	Confirmed Mist
83	25-Oct-22	NIL	Yes	Wet	3:22	3:57	14.0	28	1.30	3:22	3:56	0.30	1.00	14.0	94	56.0	-	11	Senneville	Confirmed Mist
84	25-Oct-22	NIL	Yes	Dry	4:06	4:41	14.0	29	0.00	4:05	4:40	0.03	-0.03	14.0	94	24.5	1.5	11	Senneville	Confirmed Mist
85	25-Oct-22	NIL	Yes	Wet	4:06	4:41	14.0	29	1.17	4:05	4:40	0.27	0.90	14.0	94	24.5	1.5	11	Senneville	Fog Patches

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
86	25-Oct-22	NIL	Yes	Dry	4:51	5:27	14.0	28	0.10	4:52	5:26	0.10	0.00	14.0	94	24.1	1.5	7	Senneville	Fog Patches
87	25-Oct-22	NIL	Yes	Wet	4:52	5:27	14.0	28	1.10	4:52	5:26	0.30	0.80	14.0	94	24.1	1.5	7	Senneville	Fog Patches
106	7-Dec-22	NIL	No	Dry	21:34	22:05	14.5	29.0	0.00	21:35	22:07	-0.10	0.10	6.0	87	24.0	1.5	14.82	Senneville	-
107	7-Dec-22	NIL	No	Wet	21:34	22:06	14.5	29.0	0.90	21:35	22:06	0.30	0.60	6.0	87	24.0	1.5	14.82	Senneville	-
132	25-Jan-24	NIL	Yes	Dry	18:05	18:34	14.0	28	0.00	18:06	18:34	0.00	0.00	0.0	86	16.10	> 1	11.1	YUL	-
133	25-Jan-24	NIL	Yes	Wet	18:06	18:34	14.0	28	0.20	18:06	18:34	0.10	0.10	0.0	86	16.00	> 1	11.1	YUL	-
134	26-Jan-24	NIL	Yes	Dry	17:44	18:14	14.0	28	0.1	17:43	18:13	0.00	0.00	0.0	93	24.00	> 1	22.22	YUL	-
135	26-Jan-24	NIL	Yes	Wet	17:44	18:44	14.0	28	0.9	17:43	18:13	0.10	0.80	0.0	93	24.00	> 1	22.20	YUL	-
136	26-Jan-24	NIL	Yes	Dry	18:34	19:04	14.0	27	0.1	18:33	19:03	0.10	0.00	0.0	93	N/A	> 1	22.20	YUL	-
137	26-Jan-24	NIL	Yes	Wet	18:34	19:04	14.0	27	1.0	18:33	19:03	0.10	0.90	0.0	93	N/A	> 1	22.20	YUL	-
138	26-Jan-24	NIL	Yes	Dry	19:49	20:19	14.0	28	0.1	19:49	20:20	0.10	0.00	0.0	93	24.14	> 1	27.78	YUL	-
139	26-Jan-24	NIL	Yes	Wet	19:49	20:19	14.0	28	0.7	19:49	20:20	0.00	0.70	0.0	93	24.14	> 1	27.78	YUL	-
158	26-Feb-25	NIL	Yes	Dry	0:34	1:03	14.0	28.0	0.05	0:32	1:02	0.15	-0.10	2.0	93	16.1	> 1	17.0	YUL	-

Table 3: Log of Data Collected in 2020-21 through 2024-25 – Tests with Visible Mist and Mist NOT Reported by METAR (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
159	26-Feb-25	NIL	Yes	Wet	0:33	1:03	14.0	28.0	1.47	0:32	1:03	0.44	1.03	2.0	93	16.1	> 1	17.0	YUL	-
160	26-Feb-25	NIL	Yes	Dry	1:44	2:13	14.0	28.0	0.07	1:43	2:13	0.09	-0.02	2.0	93	11.3	> 1	14.8	YUL	-
161	26-Feb-25	NIL	Yes	Wet	1:44	2:13	14.0	28.0	1.65	1:43	2:12	0.32	1.33	2.0	93	11.3	> 1	14.8	YUL	-
162	26-Feb-25	NIL	Yes	Dry	2:20	2:50	14.0	28.0	0.08	2:19	2:51	0.04	0.04	1.0	93	11.3	> 1	11.1	YUL	-
163	26-Feb-25	NIL	Yes	Wet	2:20	2:50	14.0	28.0	1.42	2:19	2:51	0.42	1.00	1.0	93	11.3	> 1	11.1	YUL	-

Table 4: Log of Omitted Data Collected from 2020-21 through 2024-25

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
1	4-Dec-20	-	No	Wet	22:40	23:10	7.5	29	0.1	22:40	23:10	0.10	0.00	2.0	93	24.0	-	13	YUL	-
2	4-Dec-20	-	No	Wet	23:30	0:00	16.0	29	0.1	23:30	0:00	0.10	0.00	2.0	93	24.0	-	16	YUL	-
3	4-Dec-20 - 5-Dec-20	-	No	Wet	1:00	1:30	16.0	29	0.1	1:00	1:30	0.08	0.02	2.2	93	24.0	-	16	YUL	-
4	13-Jan-21	-	No	Wet	2:15	2:45	15.0	29	0.2	2:15	2:45	-0.10	0.30	-1.0	86	24.0	-	11	YUL	-
5	13-Jan-21	-	No	Wet	3:30	4:00	15.0	29	0.1	3:30	4:00	0.00	0.10	-1.0	86	24.0	-	14	YUL	-
6	13-Jan-21	-	No	Wet	5:05	5:35	15.0	29	0.1	5:05	5:35	0.00	0.10	-1.0	86	24.0	-	22	YUL	-
7	13-Jan-21	-	No	Wet	6:05	6:36	15.0	29	0.1	6:05	6:36	0.10	0.00	-1.0	86	24.0	-	15	YUL	-
8	13-Jan-21	-	No	Wet	7:10	7:40	15.0	29	0	7:10	7:40	0.00	0.00	-1.0	86	24.0	-	13	YUL	-
19	15-Jan-21	-	No	Wet	14:45	15:15	15.0	29	0	14:45	15:15	0.00	0.00	3.0	70	12.8	-	15	YUL	-
20	15-Jan-21	-	No	Wet	15:25	15:55	15.0	28	-0.1	15:25	15:55	0.10	-0.20	2.0	69	19.3	-	7	YUL	-
25	10-Mar-21	-	No	Wet	1:15	1:45	14.0	28	0.4	1:15	1:45	0.40	0.00	-2.0	86	24.0	-	6	YUL	-
26	10-Mar-21	-	No	Wet	2:05	2:35	14.0	28	0	2:05	2:35	0.10	-0.10	-2.0	86	24.0	-	2	YUL	-
27	10-Mar-21	-	No	Wet	3:05	3:35	14.0	28	0.2	3:05	3:35	0.10	0.10	-3.0	86	24.0	-	3	YUL	-

Table 4: Log of Omitted Data Collected from 2020-21 through 2024-25 (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
28	10-Mar-21	-	Yes	Wet	4:05	4:35	14.8	28	0.0	4:05	4:35	0.10	-0.10	-3.1	86	24.0	-	7	YUL	METAR is Nil
29	10-Mar-21	-	No	Wet	5:05	5:35	14.8	28	0.1	5:05	5:35	0.10	0.00	-3.0	86	24.0	-	4	YUL	-
30	10-Mar-21	-	No	Wet	6:05	6:35	15.0	28	-0.1	6:05	6:35	0.10	-0.20	-4.0	93	24.0	-	4	YUL	-
31	10-Mar-21	-	No	Wet	7:05	7:35	15.0	28	0.1	7:05	7:35	0.00	0.10	-3.0	86	48.0	-	9	YUL	-
32	21-Mar-21	-	No	Wet	5:09	5:39	15.0	29	0	5:05	5:39	0.00	0.00	0.0	74	40.2	-	11	YMX	-
33	21-Mar-21	-	No	Wet	6:20	6:54	15.0	29	0	6:20	6:54	0.10	-0.10	-1.0	75	40.2	-	9	YMX	-
34	21-Mar-21	-	No	Wet	7:20	7:50	14.7	29	0	7:20	7:50	0.10	-0.10	-1.0	74	48.0	-	7	YMX	-
35	7-Apr-21	-	No	Wet	5:00	5:30	15.0	30	0.1	5:00	5:30	0.00	0.10	6.0	81	24.0	-	11	YUL	-
36	7-Apr-21	-	No	Wet	6:00	6:30	15.0	30	0	6:00	6:30	0.00	0.00	5.0	80	24.0	-	15	YUL	-
37	7-Apr-21	-	No	Wet	7:00	7:30	15.0	30	-0.2	7:00	7:30	-0.20	0.00	6.0	86	48.27	-	17	YUL	-
46	8-Oct-21	Shallow Fog/Mist	Yes	Dry	8:45	9:16	21.0	44	-0.5	8:45	9:16	0.00	-0.50	10.0	100	24.1	-	0	YUL	Tail end of event.
47	8-Oct-21	Shallow Fog/Mist	Yes	Wet	8:45	9:16	21.0	44	0.00	8:45	9:16	0.00	0.00	10.0	100	24.1	-	0	YUL	Tail end of event.
59	13-Oct-21	NIL	No	Dry	8:45	9:19	14.8	28	0.00	8:45	9:20	0.00	0.00	14.0	94	48.27	-	0	YUL	-
60	13-Oct-21	NIL	No	Wet	8:45	9:19	14.8	28	0.00	8:44	9:20	-0.40	0.40	14.0	94	48.27	-	0	YUL	-

Table 4: Log of Omitted Data Collected from 2020-21 through 2024-25 (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
71	25-Mar-22	Mist	Yes	Wet	12:18	12:51	14.9	28	-0.4	12:18	12:51	-0.60	0.20	2.0	93	12.9	-	4	YMX	Tail end of event.
73	7-Apr-23	Mist	Yes	Wet	n/a	n/a	n/a	n/a	n/a	13:00	13:30	0.60	-0.60	2.4	97	n/a	-	13	YMX (PMG)	Weight inaccurate.
114	17-Apr-23	NIL	No	Dry	21:35	22:04	14.0	28.0	0.00	21:36	22:04	0.10	-0.10	8.0	93	24.0	-	5.55	YUL	-
115	17-Apr-23	NIL	No	Wet	21:35	22:04	14.0	28.0	0.30	21:36	22:04	0.30	0.00	8.0	93	24.0	-	5.55	YUL	-
116	17-Apr-23	NIL	No	Dry	22:14	22:43	14.0	29.0	0.03	22:14	22:44	0.13	-0.10	8.0	93	24.0	-	5.5	YUL	-
117	17-Apr-23	NIL	No	Wet	22:14	22:44	14.0	29.0	0.29	22:15	22:44	0.26	0.03	8.0	93	24.0	-	5.5	YUL	-
140	31-Jan-24	NIL	No	Dry	23:46	0:17	14.0	28	0	23:46	0:15	0.00	0.00	0.0	75	24.14	> 1	14.82	YUL	-
141	31-Jan-24	NIL	No	Wet	23:47	0:17	14.0	28	0.3	23:45	0:15	0.10	0.20	0.0	75	24.14	> 1	14.82	YUL	-
142	3-Mar-24	Light Drizzle/ Mist	Yes	Dry	1:36	2:05	14.0	28	0.08	1:35	2:06	0.09	-0.01	2.0	100	4.80	> 1	11.0	YUL	-
143	3-Mar-24	Light Drizzle/ Mist	Yes	Wet	1:36	2:05	14.0	28	1.46	1:35	2:07	0.62	0.84	2.0	100	4.80	> 1	11.0	YUL	-
144	3-Mar-24	Light Drizzle/ Mist	Yes	Dry	2:13	2:44	14.0	28	0	2:13	2:43	0.03	-0.03	2.0	93	9.70	> 1	15.0	YUL	-
145	3-Mar-24	Light Drizzle/ Mist	Yes	Wet	2:13	2:44	14.0	28	1.18	2:13	2:43	0.60	0.58	2.0	93	9.70	> 1	15.0	YUL	-
146	3-Mar-24	Light Drizzle/ Mist	Yes	Dry	2:47	3:15	-	-	0.08	2:46	3:16	0.11	-0.03	2.0	93	9.70	> 1	15.0	YUL	-
147	3-Mar-24	Light Drizzle/ Mist	Yes	Wet	2:46	3:15	-	-	1.53	2:46	3:16	0.71	0.82	2.0	93	9.70	> 1	15.0	YUL	-

Table 4: Log of Omitted Data Collected from 2020-21 through 2024-25 (cont'd)

Test No.	Date	Observed Weather	Visual Verification of Mist at Start (Y/N)	Wet (Fluid) or Dry (No Fluid) Pan	Simulated Taxi Start Time (hh:mm)	Simulated Taxi End Time (hh:mm)	Taxi Distance (km)	Average Taxi Velocity (km/h)	Simulated Taxi Rate (g/dm ² /h)	Simulated Stationed Start Time (hh:mm)	Simulated Stationed End Time (hh:mm)	Simulated Stationed Rate (g/dm ² /h)	Difference in Test Rate (Taxi - Stationary)	OAT (°C)	RH (%)	Reported Visibility (km)	Observed Visibility (km)	Wind Speed (km/h)	Location	Comments
148	3-Mar-24	Light Drizzle/Mist	Yes	Dry	3:25	3:55	14.0	28	0.1	3:25	3:56	0.18	-0.08	2.0	93	4.80	0.1	13.0	YUL	-
149	3-Mar-24	Light Drizzle/Mist	Yes	Wet	3:25	3:55	14.0	28	1.39	3:25	3:56	0.75	0.64	2.0	93	4.80	0.1	13.0	YUL	-

APPENDIX F

THEORETICAL WATER CONTENT IN AIR AT SATURATION AND SUPERSATURATION DURING MIST AND FREEZING FOG TESTING

CALCULATION & COMPARISON OF WATER CONTENT IN AIR FOR RATE PAN

Objective

This describes the methodology used to estimate the water content in the air at various temperatures and relative humidities using rate pan dimensions and a controlled volume of airflow. The goal is to provide both theoretical and estimated values to compare with experimental measurements obtained in Winter 2024-2025.

Parameters & Assumptions

The rate pan used in this analysis has the dimensions of 20 inches by 12 inches. These dimensions are first converted into meters:

$$\text{Length: } 20 \text{ in} = 0.508 \text{ m}$$

$$\text{Width: } 12 \text{ in} = 0.305 \text{ m}$$

The pan opening height is determined by using the rate pan tilt angle of 10° :

$$\text{Height: } \sin(10^\circ) * 0.508 \text{ m} = 0.088 \text{ m}$$

This formula is derived by using trigometric identities such as the following below:

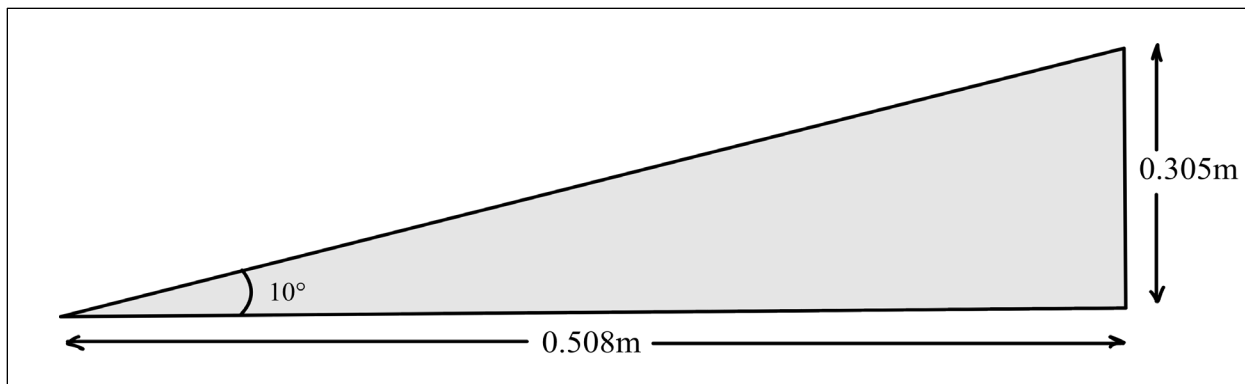


Figure 1: Illustration of Rate Pan Opening

The opening area of the pan is given by:

$$\text{Area: Height} * \text{Width} = 0.088 \text{ m} * 0.305 \text{ m} = 0.02678 \text{ m}^2$$

Assuming that the pan is exposed to airflow over a distance of 30 km (or 30,000 m), the total volume of air interacting with the pan is calculated as:

$$\text{Volume: Area} * \text{Length} = 0.02678 \text{ m}^2 * 30,000 \text{ m} = 804.67 \text{ m}^3$$

The water content (mass) in the air can be calculated using the formula:

$$\text{Mass: Volume} * \text{Water Concentration (g/m}^3\text{)}$$

The pan area is also converted to decimeters squared for further evaporation rate comparison:

$$0.02678 \text{ m}^2 = 2.678 \text{ dm}^2$$

Theoretical Water Content Calculations (100% RH)

Table 1: Theoretical Water Vapor Content at 100% Relative Humidity

Temperature	Water Content (g/m ³)	Total Water (g)	Total Water (kg)	g/dm ² /h
0°C	4.89	3934.84	3.93	1.46
2°C	5.55	4465.93	4.47	1.67
20°C	17.30	13920.82	13.92	5.19

Sample Calculation for the Water Content at 0°C:

$$\text{Volume} * \text{Water per m}^3 = 804.67 \text{ m}^3 * 4.89 \text{ g/m}^3 = 3934 \text{ g} \rightarrow 3.93 \text{ kg}$$

Now, comparing it to experimental values obtained at 0°C while going at constant 30km/h velocity (assumption):

$$\text{Rate} = \frac{\text{mass}}{\text{pan area}} = 1.46 \text{ g/dm}^2/\text{h}$$

Estimated Water Content Calculations (125% RH)

Table 2: Theoretical Water Vapor Content at 125% Relative Humidity

Temperature	Estimated Water Content (g/m ³)	Total Water (g)	Total Water (kg)	g/dm ² /h
0°C	6.08	4892.39	4.89	1.83
2°C	7.00	5632.69	5.63	2.10
20°C	22.20	17863.67	17.86	6.67

Humidity Levels and Corresponding Water Content at 0°C

Table 3: Water Content at 0°C for Various Relative Humidity Levels

Relative Humidity	Water Content (g/m ³)
80%	3.90
90%	4.39
100%	4.89
125%	6.08

Sample Calculation for the Water Content at 0°C:

$$Volume * Water \text{ per } m^3 = 804.67 \text{ m}^3 * 6.08 \text{ g/m}^3 = 4892.39 \text{ g} \rightarrow 4.89 \text{ kg}$$

Now, comparing it to experimental values obtained at 0°C while going at constant 30km/h velocity (assumption):

$$Rate = \frac{mass}{pan \text{ area}} = 1.83 \text{ g/dm}^2/\text{h}$$

Conclusion

The primary objective of this is to evaluate the consistency between theoretical predictions of water vapor content in air and experimental observations obtained under controlled conditions. This involves validating field measurements of water vapor mass using a defined pan geometry and known airflow parameters. The analysis also seeks to compare theoretical water content values, calculated from established psychrometric relationships to empirical data collected during the tests. Additionally, it aims to estimate the maximum potential evaporation rates under both saturated (100% relative humidity) and supersaturated (e.g., 125% relative humidity) atmospheric conditions.

All calculations presented in this report are based on the assumption of laminar and uninterrupted airflow over the pan, with negligible turbulence effects. Relative humidity values exceeding 100 percent are treated as theoretical extensions intended to simulate supersaturation. Furthermore, it is assumed that the rate pan remained fully exposed to ambient airflow along the entire test distance, without any obstructions or shielding that could affect airflow behavior.

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APPENDIX G

NON-STANDARD TEMPERATURE-ENDURANCE TIME RELATIONSHIP ANALYSIS DATABASE

Non-Standard Temperature-Endurance Time Relationship Analysis Database

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	snow	Warm	n/a	0.04591	significant	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	50/50	snow	Warm	n/a	0.07934	not	Equal
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	snow	Warm	n/a	0.61177	not	Equal
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	Snow	Warm	N/A	0.00000	significant	Standard
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	snow	Warm	n/a	0.02849	significant	Equal
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	snow	Warm	n/a	0.08444	not	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	snow	Warm	n/a	0.00000	significant	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	snow	Warm	n/a	0.00557	significant	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	snow	Warm	n/a	0.00139	significant	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	snow	Warm	n/a	0.85618	not	Equal
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	50/50	snow	Warm	n/a	0.00199	significant	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	snow	Warm	n/a	0.43084	not	Equal
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	snow	Warm	n/a	0.08045	not	Equal
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	Snow	Warm	N/A	0.00000	significant	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	snow	Warm	n/a	0.00003	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	50/50	snow	Warm	n/a	0.30120	not	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	snow	Warm	n/a	0.02022	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	snow	Warm	n/a	0.07007	not	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	50/50	snow	Warm	n/a	0.46588	not	Equal
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	snow	Warm	n/a	0.00701	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	snow	Warm	n/a	0.00384	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	50/50	snow	Warm	n/a	0.00227	significant	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	snow	Warm	n/a	0.00001	significant	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	50/50	snow	Warm	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	snow	Warm	n/a	0.00001	significant	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	50/50	snow	Warm	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	snow	Warm	n/a	0.00161	significant	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	snow	Warm	n/a	0.00353	significant	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	snow	Warm	n/a	0.04065	significant	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	snow	Warm	n/a	0.00013	significant	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	Snow	Warm	N/A	0.35673	not	Equal
Kilfrost Limited	ABC-K Plus	2007	II	PG	100/0	snow	Warm	n/a	0.09371	not	Standard
Kilfrost Limited	ABC-K Plus	2007	II	PG	75/25	snow	Warm	n/a	0.71651	not	Equal
Kilfrost Limited	ABC-K Plus	2007	II	PG	50/50	snow	Warm	n/a	0.00000	significant	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	100/0	snow	Warm	n/a	0.02617	significant	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	75/25	snow	Warm	n/a	0.04617	significant	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	50/50	snow	Warm	n/a	0.58706	not	Reversed
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	snow	Warm	n/a	0.00608	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2023	II	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2023	II	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2023	II	PG	50/50	snow	Warm	n/a	0.00147	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	Snow	Warm	N/A	0.00000	significant	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	snow	Warm	n/a	0.00549	significant	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	snow	Warm	n/a	0.00006	significant	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	snow	Warm	n/a	0.00009	significant	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	50/50	snow	Warm	n/a	0.88281	not	Equal

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	snow	Warm	n/a	0.00000	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	snow	Warm	n/a	0.00000	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	50/50	snow	Warm	n/a	0.01843	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	snow	Warm	n/a	0.00019	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	snow	Warm	n/a	0.00000	significant	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	50/50	snow	Warm	n/a	0.07501	not	Equal
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	Snow	Warm	N/A	0.00000	significant	Standard
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	Snow	Cold	N/A	0.02089	significant	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	snow	Cold	n/a	0.00001	significant	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	snow	Cold	n/a	0.00063	significant	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	snow	Cold	n/a	0.00001	significant	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	snow	Cold	n/a	0.00894	significant	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	snow	Cold	n/a	0.00004	significant	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	snow	Cold	n/a	0.33938	not	Equal
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	snow	Cold	n/a	0.00108	significant	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	Snow	Cold	N/A	0.00001	significant	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	snow	Cold	n/a	0.00001	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	snow	Cold	n/a	0.00001	significant	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	snow	Cold	n/a	0.05041	not	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	snow	cold	N/A	0.00048	significant	Standard
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2023	II	PG	100/0	snow	Cold	n/a	0.00000	significant	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	Snow	Cold	N/A	0.06316	not	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	snow	Cold	n/a	0.00001	significant	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	snow	Cold	n/a	0.00456	significant	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	Snow	Cold	N/A	0.00000	significant	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Reversed
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZD	Warm	high	n/a	n/a	Equal
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Equal
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Equal
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZD	Warm	high	n/a	n/a	Equal
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Reversed
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Reversed
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Equal
Kilfrost Limited	ABC-K Plus	2007	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Kilfrost Limited	ABC-K Plus	2007	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Kilfrost Limited	ABC-K Plus	2007	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Kilfrost Limited	ABC-K Plus	2007	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZD	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZD	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZD	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZD	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZD	Warm	low	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZD	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZD	Warm	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZF	Warm	low	n/a	n/a	Reversed
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Equal
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZF	Warm	high	n/a	n/a	Reversed
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Reversed
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZF	Warm	low	n/a	n/a	Equal
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZF	Warm	low	n/a	n/a	Reversed
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Reversed
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Equal
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Reversed
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Reversed
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Kilfroast Limited	Ice Clear II	2021	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Kilfroast Limited	Ice Clear II	2021	II	PG	100/0	ZF	Warm	low	n/a	n/a	Reversed

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZF	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZF	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZF	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZF	Warm	low	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZF	Warm	high	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZF	Warm	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Reversed
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZF	Cold	low	n/a	n/a	Reversed
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Reversed
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Kilfrost Limited	ABC-K Plus	2007	II	PG	100/0	ZF	Cold	high	n/a	n/a	Equal
Kilfrost Limited	ABC-K Plus	2007	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Kilfrost Limited	ABC-S Plus	2006	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Kilfrost Limited	Ice Clear II	2021	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZF	Cold	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZF	Cold	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZF	Cold	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZF	Cold	high	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZF	Cold	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZR	Warm	high	n/a	n/a	Reversed
ABAX Industries	ECOWING AD-2	2016	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
ABAX Industries	ECOWING AD-2	2016	II	PG	75/25	ZR	Warm	low	n/a	n/a	Reversed
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ABAX Industries	ECOWING AD-49	2008	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
ALAB International	PROFLIGHT EG4	2022	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Reversed
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ALAB International	PROFLIGHT PG4	2023	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZR	Warm	high	n/a	n/a	Equal
AllClear Systems LLC10	AeroClear MAX	2016	III	EG	100/0	ZR	Warm	low	n/a	n/a	Equal
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
AllClear Systems LLC10	ClearWing EG	2018	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Standard
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Equal
ASGlobal	4Flite EG	2020	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Equal

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ASGlobal	4Flite PG	2019	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
AVIAFLUID International Ltd	AVIAFlight EG	2019	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
AVIAFLUID International Ltd	AVIAFlight PG	2019	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZR	Warm	high	n/a	n/a	Equal
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	Cleanwing II	2008	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
CHEMCO Inc.	ChemR EG IV	2016	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Reversed
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Standard
CHEMCO Inc.	ChemR Nordik IV	2019	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Equal
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Standard
Chongqing Joba Chemical Co.	FW-IV	2023	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Reversed
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	2005	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	2005	IV	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	2012	IV	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Advance	2010	IV	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® II	2010	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Cryotech Deicing Technology	Polar Guard® Xtend	2018	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
Dow Chemical Company	UCAR ENDURANCE™ EG106 ADF/AAF	2005	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Dow Chemical Company	UCAR™ FLIGHTGUARD™ AD-49	2008	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Inland Technologies Inc.	ECO-SHIELD®	2015	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
JSC RCP Nordix	Defrost ECO 4	2016	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
JSC RCP Nordix	Defrost NORTH 4	2020	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Reversed
Kilfroast Limited	ABC-K Plus	2007	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-K Plus	2007	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Kilfroast Limited	ABC-S Plus	2006	IV	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Kilfroast Limited	Ice Clear II	2021	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Kilfroast Limited	Ice Clear II	2021	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type II	2021	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
MKS DEVO KIMYA SANAYI TIC AS.	COREICEPHOB Type IV PG	2023	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY 9311	2013	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-2	2006	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZR	Warm	high	n/a	n/a	Reversed
Newave Aerochemical Co. Ltd.	FCY-EGIV	2019	IV	EG	100/0	ZR	Warm	low	n/a	n/a	Equal
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard

Non-Standard Temperature-Endurance Time Relationship Analysis Database (cont'd)

Fluid Manufacturer	Fluid Brand	First Test Year	Type	Glycol	Dilution	Precip.	Temp.	Rate	P-Value of Temp. in Regression	P-Value Significance	Visual Assessment of Relationship
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT NG Type II	2019	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZR	Warm	high	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	100/0	ZR	Warm	low	n/a	n/a	Standard
ROMCHIM PROTECT SRL	ADD-PROTECT Type II	2018	II	PG	75/25	ZR	Warm	low	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZR	Warm	high	n/a	n/a	Standard
Shaanxi Cleanway	Cleansurface IV	2023	IV	PG	100/0	ZR	Warm	low	n/a	n/a	Standard

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APPENDIX H
PRESENTATIONS FOR 2024-25

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
SAE G-12 HOT COMMITTEE: DOCUMENTS UPDATE**

SAE G-12 HOT COMMITTEE: DOCUMENTS UPDATE

SAE G-12 Holdover Time Committee – Montreal – Nov 6, 2024
Presented By: Benjamin Bernier, Committee Secretary, G-12 HOT

G-12 HOT DOCS: STATUS

Published Documents (6)

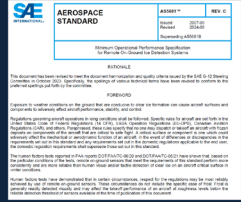
Document	Status	Effective Date
ARP5945A - Endurance Time Test Procedures for SAE Type I Aircraft Deicing/Anti-Icing Fluids	October 13, 2017 - Revised - Free Year Review	
ARP5488B WIP - Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	October 13, 2017 - Revised - Free Year Review	
ARP5488B WIP - Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	October 13, 2017 - Revised - Free Year Review	
ARP5488B WIP - Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	October 13, 2017 - Revised - Free Year Review	
AS5186C - Minimum Operational Performance Specification for Ground Ice Detection Systems	August 28, 2007 - Canceled	
AS5681C - Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems	August 13, 2017 - Revised	
ARP6207 - Qualifications Required for SAE Type I Aircraft Deicing/Anti-Icing Fluids	October 13, 2017 - Issued - Free Year Review	
ARP5718B - Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids	December 7, 2017 - Revised - Free Year Review	

G-12 HOT DOCS: STATUS

- ROGIDS standard (AS5681) – **Revision C Published Aug 2024**
- Endurance time testing standards – **In Committee Ballot**
 - ARP5945 (Type I Fluids)
 - ARP5485 (Type II/III/IV Fluids)
- Fluid qualification standards – **Ballot to follow - Winter 2024/25**
 - ARP6207 (Type I Fluids)
 - ARP5718 (Type II/III/IV Fluids)

AS5681 - REVISION C

- AS5681 (Operational Performance Spec for ROGIDS) – Revision C
- New content:
 - Role of ROGIDS vs. visual/tactile post-deicing checks
 - Additional references (Transportation Safety Board of Canada, Fond-du-Lac accident)
- Editorial changes:
 - Typos
 - Document harmonization



ARP5485 – REVISION C

- New content:**
 - Laboratory snow test conditions for -30C/-25C
 - Data handling for very cold natural snow
- Updates to existing sections:**
 - Clarify WSE1 tests/checks performed
 - Test surface specs
 - Criteria for repeating tests
 - Precipitation rate data targets in snow
 - Maximum freezing precipitation test durations
- Editorial changes:**
 - Updating references
 - Document harmonization
- Full change details in Changes Summary document
 - See WIP on StandardWorks



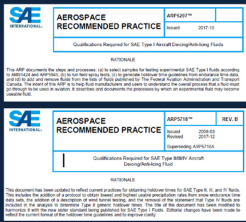
ARP5945 – REVISION B

- Updates to existing sections:**
 - Test surface specs
 - Criteria for repeating tests
- Editorial changes:**
 - Page number fix
 - Document harmonization
- Full change details in Changes Summary document
 - See WIP on StandardWorks



PROPOSED UPDATES: ARP6207/5718

- New sections
 - Flaps-Adjusted HOTs
 - Freezing Mist
 - Middle-speed ramp
- Updates to existing sections
 - Revision to "Role of HOT Committee" statement
 - Active frost HOT table info
 - Update Type I notes and cautions
- Editorial changes:
 - References
 - Typos
 - Document harmonization



PLANNED TIMELINE

- ARP5485/5945 committee ballots ongoing
 - Current participation 16/43 members (more votes needed!)
 - If accepted, revisions **expected to be published in Dec 2024**
- ARP5718/6207 revisions being drafted now
 - Committee ballot planned for **Late 2024/Early 2025**
- Document status to be reviewed at next committee meeting (Malaga – May 2025)

G-12 HOT DOCS: SPONSORS

→ Questions concerning the HOT committee documents? Contact the committee secretary.

Benjamin Bernier
Secretary – G12 HOT
bbernier@apsaviation.ca

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
2024-25 ENDURANCE TIME TESTING PROGRAM**

joint research facility
Transport Canada
Transport Canada
Federal Aviation Administration
Conducted by:
AiPS
Aviation Inc.



2024-25 ENDURANCE TIME TESTING PROGRAM
SAE 12 Holdover Time Committee - Nov 6, 2024
Presented by: Peter Kitchener

ENDURANCE TIME (ET) PROGRAM

APS Aviation is contracted to conduct
HOT Testing on behalf of TC/FAA

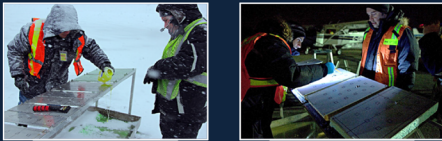


Example of Fluid Failure Example of Fluid Failure

Transport Canada Transport Canada AiPS Federal Aviation Administration

ENDURANCE TIME (ET) PROGRAM

Natural Snow and Natural Frost Testing
APS Test Site (Montreal, Canada)



Natural Snow Natural Frost

Transport Canada Transport Canada AiPS Federal Aviation Administration

ENDURANCE TIME (ET) PROGRAM

Simulated Freezing Precipitation Testing
NRC-CEF (Ottawa, Canada)



Simulated Freezing Precipitation

Transport Canada Transport Canada AiPS Federal Aviation Administration

2024-25 ET Program

→ 2024-25 testing season is **starting soon!**

→ HOT Fluid Request Letter: emailed September 5, 2024

→ Contains info on:

- Types of Testing Offered
- Testing Fees
- Fluid Sample Preparation
- Shipping Details
- Plus: Fluid Submission Forms and FAQ Sheet



Transport Canada Transport Canada AiPS Federal Aviation Administration

Standard HOT Testing

→ Fluid manufacturers: Please advise early if planning to submit fluid samples for testing.

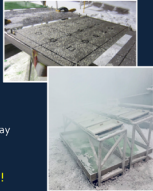
- Earlier notice of fluid submission is helpful for test planning

→ Fluid Receipt Deadline: **Dec. 1, 2024**

- Fluids should be received at APS TEST SITE by this date
- Early fluid submission = more opportunity for data collection
- Testing alternatives may be available (needs TC/FAA approval, may carry added cost)

→ **Reminder: Complete and Send Fluid Submission Form!**

- Send alongside fluid shipment or submit electronically



Transport Canada Transport Canada AiPS Federal Aviation Administration

Very Cold Snow Testing

→ **2024-25 Very Cold Snow Testing**

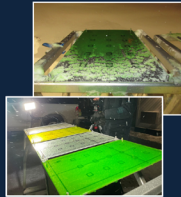
- Testing for new or existing Type II/III/IV fluids.
- Participating fluids will receive fluid-specific HOTs for snow below -14°C .
- Testing generally conducted **every second winter**.
- **Next opportunities expected to be 2026-27 or 2028-29.**

→ **Confirmation Deadline: Nov. 15, 2024**

- Written confirmation of participation needed by this date.

→ **Fluid Receipt Deadline: Dec. 1, 2024**

- Early fluid submission is important due to extensive testing requirements.
- Fluids should be received at APS TEST SITE.



Transport Canada | Transport Canada | APS | Federal Aviation Administration

Fluid Testing with LOU of -29.5°C or Colder

→ **2024-25 Fluid Testing with LOU of -29.5°C or Colder**

- Testing for new Type II/III/IV fluids, or fluids that have been recently published.
- Participating fluids will receive fluid-specific HOTs down to the LOU (if -29.5°C or colder) in conditions of snow, and freezing fog.
- If the LOU is unknown before winter testing and is later found to be -29.5°C or colder, the fluid manufacturer may request to complete the testing the following year, and the HOTs will be included in the guidelines for that year.

→ **Fluid Receipt Deadline: Dec. 1, 2024**

- Fluids should be received at APS TEST SITE.



Transport Canada | Transport Canada | APS | Federal Aviation Administration

Common Questions and Answers

→ Common Questions that APS receives:

- Can you submit multiple samples for research testing, and cancel testing before the end of the testing period? **YES***
- Can you conduct preliminary / limited testing? **YES***
- Can you cancel testing before all tests are completed? **YES***
- Can you only conduct freezing precipitation testing only (no snow)? **YES***
 - Annual freezing precipitation test session scheduled to take place in **March 2024**
 - 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

Transport Canada | Transport Canada | APS | Federal Aviation Administration



AiPS
Aviation Inc.

Questions?
Peter Kitchener
pkitchener@apsinc.com

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
2024-25 WIND TUNNEL TESTING PROGRAM**

Joint research led by:
Transport Canada
Federal Aviation Administration
Conducted by:
AIPS
Aviation INC.

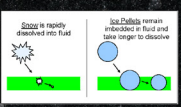


2024-25 WIND TUNNEL TESTING PROGRAM

SAE G32 Holdover Committee, Montreal, November 6, 2024
Peter Kitchener

Background

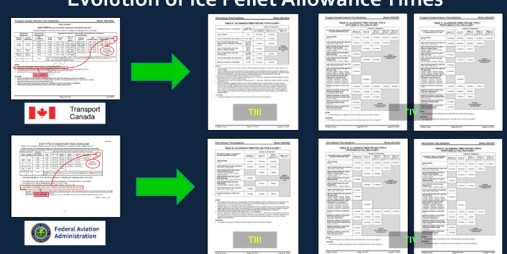
→ Standard HOT testing does not apply to ice pellets due to different failure mechanism



→ Since 2006, aerodynamic testing has been conducted by TC and FAA to develop and validate ice pellet allowance times



Evolution of Ice Pellet Allowance Times



List of Validated Fluids

→ In 2024-25, TC/FAA issued Table 44: list of fluids validated for use with allowance times
– Validated Type III and IV fluids are listed

→ New to market fluids will be granted a grace period to complete validation testing



2024-25 Allowance Time Testing Program

→ Testing is planned for January 2025!

→ Fluid manufacturers (FMs) are required to participate were emailed October 4th, 2024:

- Email Contains Info on:
 - Fluid Sample Preparation
 - Shipping Details
 - Fluid Submission Forms

→ Fluid Receipt Deadline: **Dec. 1, 2024**

FMs: Please advise early if planning to submit fluid samples for testing.

Common Questions and Answers

→ Are there fees associated with this testing?
– Testing is currently supported by TC/FAA. FMs are required to provide the fluid samples.

→ My fluid is not commercialized yet, can I send my fluid for testing?
– Due to associated costs, testing is assigned to commercially available fluids only.

→ What fluid types can be submitted?
– Any fluid type can be submitted, however allowance times currently exist for 100% Type III and Type IV fluids only.

→ If I don't test for allowance times, does this effect my HOT table?
– Allowance time testing is encouraged, but independent to the holdover times.

→ My fluid won't arrive in time, is that ok?
– Efforts will be made to accommodate late submissions if possible, however testing is done during a fixed time window in Jan/Feb.



Reassessing Type II Allowance Times

- Ice Pellet Allowance Times (ATs) were developed for Type III and IV fluids. **Type II ATs were explored but not prioritized because;**
 - In the early 2000s, European operators reported that ice pellets were a rare occurrence;
 - And; Type II fluids are less common in North America and more widely used in Europe.
- Recent work from the MWG, analyzing 20 years of data, has documented over **27,000 reports** of Ice Pellets in Europe, either as a single weather condition or as part of mixed precipitation.
 - This figure represents approximately **25% of all Ice Pellet reports** across Canada, the U.S., and Europe.
- **Reassessing the utility of Type II Allowance Times could be beneficial.**

Transport Canada | Transport Canada | AIPS | Institut de la sécurité de l'aviation

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
MIXED ICING CONDITIONS RESEARCH**

Joint research led by:
 Transport Canada
 Federal Aviation Administration
 Conducted by:
 APS Aviation Inc.



MIXED ICING CONDITIONS RESEARCH
 SAL G-12 HOT Committee, Nov 6th, 2024
 Presented by: Benjamin Bernier, APS Aviation

OUTLINE

- Background and METAR Working Group
- Testing Methodology
- Achievements
- Summary and Way Forward

1 of 16

Background

- When aircraft are operated in adverse winter conditions, the reported METAR weather conditions may not always have a corresponding condition in the HOT guidance to allow for safe departure, especially for mixed conditions.
- TC and FAA, with support of a METAR Working Group, engage in HOT research and development to support operational capabilities in winter mixed conditions.
- This research group continues to make progress by issuing guidance to mixed conditions evaluated through analytical or laboratory-based methods.

→ **GOAL: Provide Holdover/Allowance Times To Support Ground Anti-Icing Operations During Mixed Icing Conditions**

2 of 16

METAR Working Group

- METAR working group (MWG) formed in 2020
 - Includes technical experts and meteorologists
 - TC, FAA, NCAR, APS

MWG Conceptual Representation of Project Process

	Number of Mixed Conditions (METAR codes)	Number of Reports*	% of Total Reports
Completed (Guidance provided)	23	816,773	74.8%
In progress	21	222,725	20.4%
Outstanding	120	52,049	4.8%
Total	164	1,091,547	100%

3 of 16

OUTLINE

- Background and METAR Working Group
- **Testing Methodology**
- Achievements
- Summary and Way Forward

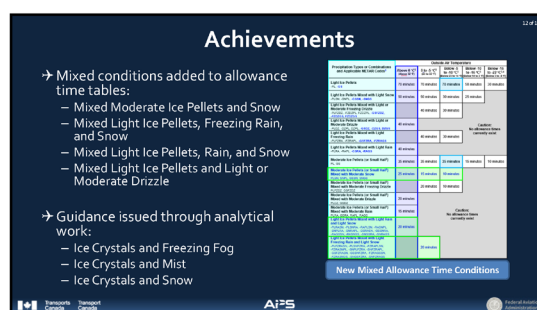
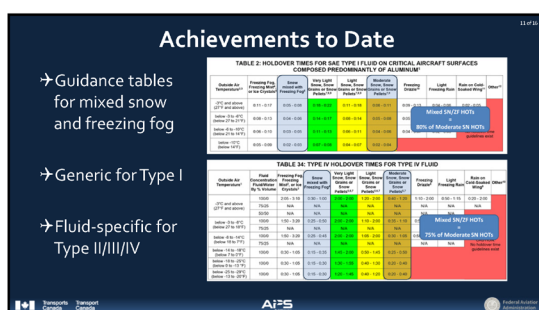
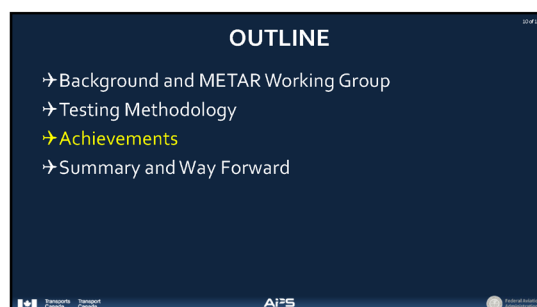
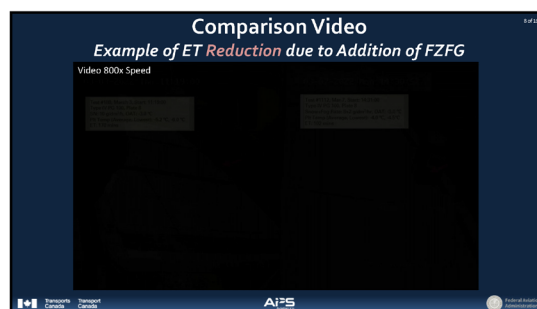
4 of 16

Testing Facilities



NRC Climatic Engineering Facility NRC Icing Wind Tunnel

5 of 16



Mixed Icing Research Benefits

- More mixed conditions covered by HOT guidance
 - Fewer situations where operators grounded due to lack of available guidance
- Continued improvement to the guidance available
 - Better tailored guidance as more data becomes available
 - Longer HOTs provided, better operational windows

11 of 18

Canada Department of Transport **AiPS** National Institute of Aerospace Research

OUTLINE

- Background and METAR Working Group
- Testing Methodology
- Achievements
- **Summary and Way Forward**

14 of 18

Canada Department of Transport **AiPS** National Institute of Aerospace Research

Summary + Way Forward

- Mixed icing conditions remain active area of research
- 2024-25 research expected to focus on:
 - Mixed snow + freezing mist
 - Mixed rain (or drizzle) + snow
 - Mixed snow + freezing fog
- The goal is to continue to expand operational capabilities through guidance supported by research



12 of 18

Canada Department of Transport **AiPS** National Institute of Aerospace Research

Thank you!



Questions?
Benjamin Bernier
bbernier@apsaviation.ca

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**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
DOCUMENTATION OF FLUID FAILURE: REFERENCE GUIDE**



Purpose

→ To advise industry of an available reference document providing examples of de/anti-icing fluid failure.

Outline

- Background
- Document Update and New Content
- Summary and Way Forward

Background – Failure Reference Document

→ APS developed a **reference document** for industry (on behalf of TC/FAA)

→ Material compiled from previous research projects

→ Version 1 available in TC report **TP15559E**

1. BACKGROUND	2
2. PUBLISHED RESOURCES AND OTHER REFERENCE MATERIALS	2
2.1 Fluid Failure Occurrence in Natural Snow (Excerpt from ATP1405)	2
2.2 Appearance of Frozen Contamination (Excerpt from ATP1405)	4
2.3 Published Reports	4
2.4 Q12 Presentation Material	5
3. EXAMPLES OF FAILURE PROGRESSION ON TEST PLATES	6
3.1 Natural Snow	6
3.2 Freezing Temperature	10
3.3 Natural Frost	14
4. EXAMPLES OF FLUID FAILURE ON AIRCRAFT	16
4.1 Anti-Icing Fluid Failure On-Wing in Natural Freezing Rain	16
4.2 Anti-Icing Fluid Failure On-Wing in Natural Snow (from 2012-13 FlightDeck)	24
4.3 Flight Deck 2015-16 Ice Pellets Storm	26
5. EXCEPTIONS AND OUTLIERS	34
5.1 Failure in Cold Temperatures	34
5.2 Mixed Conditions	37
5.3 Contaminated Fuel	37
6. DISCLAIMER	37

Background – Failure Reference Document

→ Reference document contains examples of failed anti-icing fluid on:

- Test surfaces
- Full-scale aircraft

→ Previously presented to committee in November 2023

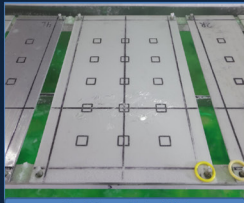
Outline

- Background
- **Document Update and New Content**
- Summary and Way Forward

Update to Reference Guide

→ APS is drafting an updated version of the reference guide

→ Contains additional photography captured during 2023-24 simulated freezing precipitation testing session



New Reference Photos Added

7 of 12

Update to Reference Guide

→ New content includes:

- Examples of same fluids in multiple different conditions
- Type IV EG fluid examples shown below



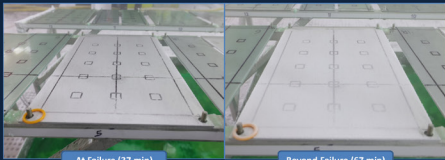
Freezing Drizzle Freezing Rain Freezing Fog

8 of 12

Update to Reference Guide

→ New content includes:

- Examples of fluids going beyond the point of failure
- Type IV PG fluid example below (freezing fog)



At Failure (37 min) Beyond Failure (67 min)

9 of 12

Outline

→ Background

→ Document Update and New Content

→ Summary and Way Forward

10 of 12

SUMMARY AND WAY FORWARD

→ APS developed reference document with examples of fluid failure

- Version 1 published in TC report **TP5559E**

→ Updated version of document to follow in upcoming report **TP5608E**

- Download published reports from www.apsoaviation.ca/reports

→ More full-scale + airfoil model photos desired for future editions

- Photo submissions from industry?
- Opportunities to test full-scale aircraft
- Additional testing with airfoil models



11 of 12



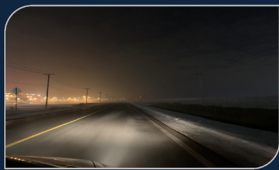
Questions/Comments?

Benjamin Bernier
bbernier@apsoaviation.ca

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
UPDATE: INVESTIGATION OF MIST & FREEZING FOG DEPOSITION RATES**

Joint research led by:
 Transport Canada
 Federal Aviation Administration
 Conducted by:
 AIPS
 Aviation Inc.



UPDATE: INVESTIGATION OF MIST & FREEZING FOG DEPOSITION RATES
 SAE 12 Holdover Time Committee, Montreal, Nov 6, 2024
 Presented by: Dany Posteraro, Eng., M.Eng., PhD

OUTLINE

- Background
- Methodology
- Summary of Data Collected to Date
- Way Forward

OUTLINE

- **Background**
- Methodology
- Summary of Data Collected to Date
- Way Forward

BACKGROUND

- Mist and Freezing Fog are a commonly reported weather phenomenon:
 - Mist is considered an obscuration (small suspended water droplets which can produce a rate)
 - Freezing Fog is a precipitation type
 - Can occur alone or with other conditions i.e. snow, freezing rain, etc
- When mist is combined with other precipitation types, it is still considered an obscuration
- However, HOTs exist for both conditions when occurring alone

BACKGROUND

- Visibility:
 - Mist: between 5/8 and 7 (FMH₁) or 6 (MANOBS) statute miles
 - Fog: <5/8 statute mile
- Historical research simulating an aircraft taxi in freezing fog indicated that the deposition rates can increase significantly when in motion
- The deposition rates for fog were quantified in early 2000's
- The deposition rates of mist was first examined in 2020-21 and continues today

Summary of 2020-21 Mist Rate Evaluation Testing

- Initial testing performed in 2020-21
 - see presentation from May 21 Webex
- Data indicated mist rates were comparable to frost, and less than freezing fog, therefore using Freezing Fog HOTs was considered conservative and acceptable
- Changes were issued in the guidance for 2021-22 and onwards



POTENTIAL CHANGE TO HOT GUIDELINES



OBJECTIVE

- The objective is to investigate the range of deposition rates that occur naturally in mist and freezing fog
- This research is required to further evaluate and possibly update guidance for the appropriate treatment of mist and freezing fog, and in mixed conditions

OUTLINE

- Background
- **Methodology**
- Summary of Data Collected to Date
- Way Forward

METHODOLOGY

- Mist and Freezing Fog typically occur in similar conditions to frost:
 - Calm winds
 - High humidity
 - Overcast sky cover (vs clear skies for frost)
- An analysis of historical CYUL METAR reports found that the beginning of winter, early mornings, and temperatures around the freeze point (0°C) are the most favorable for the occurrence of mist and freezing fog

METHODOLOGY

- Taxiing and stationary mist and freezing fog deposition rates were captured simultaneously using a test vehicle and standard test stand
- The testing methodology was updated in 2021-22 to include both a fluid and a dry medium for capture



Simulated aircraft taxiing setup using vehicle



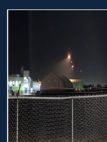
Simulated stationary aircraft setup

METHODOLOGY

- 30-minute rate collection period:
 - Generally done on the hour coordinating with METAR reports
 - Targeted METAR reported mist or freezing fog conditions, however,
 - In some instances, mist/fog was visually observed but not reported by METAR



Mist visible and reported by METAR
Ottawa January 15, 2021



Mist visible, not reported by METAR
Montreal April 8-9, 2022

OUTLINE

- Background
- Methodology
- **Summary of Data Collected to Date**
- Way Forward

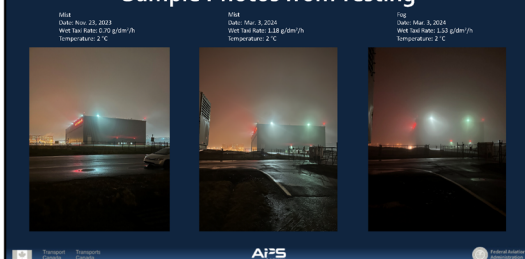
Summary of Data Collected to Date

- Testing has been conducted since 2020-21 and in 2021-02
 - Includes both wet and dry rates
 - Wet pan more conservative than dry pan
 - Taxi rate more conservative than stationary rate
- Freezing Fog
 - A total of 36 fog tests were conducted to date
 - Includes both wet and dry rates
 - Temperature range of data collected: -4°C to 14°C
- Mist
 - A total of 112 mist tests were conducted to date
 - Includes both wet and dry rates
 - Temperature range of data collected: -4°C to 17°C with most above 0°C

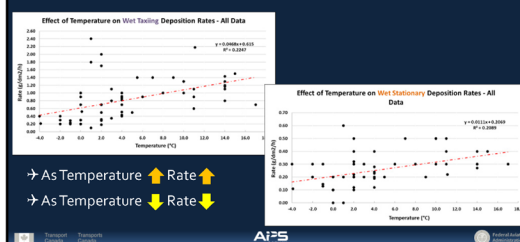
Sample Photos from Testing



Sample Photos from Testing



General Observed Trend



Fog/Freezing Fog Rate Analysis

- 2°C Conservative to mitigate risks and operationally relevant
- Fog could be as high as 2.4 g/dm²/h when taxiing and 0.6 g/dm²/h when stationary
- Only taxi data shown

Fog/Freezing Fog Wet Taxi				
Years 2001-2002 & 2020-2024	Number of Data Points	Average Rate	Rate Range	Rate Standard Deviation
All Data	14	1.34	0.21 - 2.4	0.64
4°C and Cooler	7	1.28	0.21 - 2.4	0.90
2°C and Cooler	6	1.44	0.21 - 2.4	0.87
0°C and Cooler	2	0.37	0.21 - 0.52	0.22

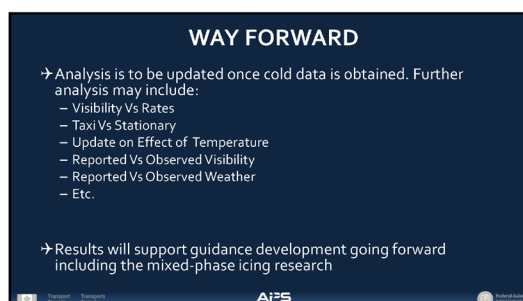
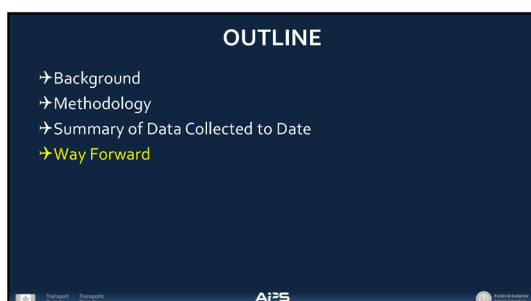
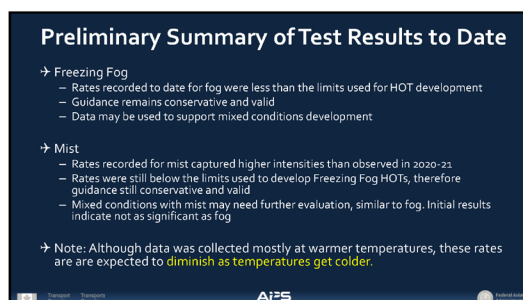
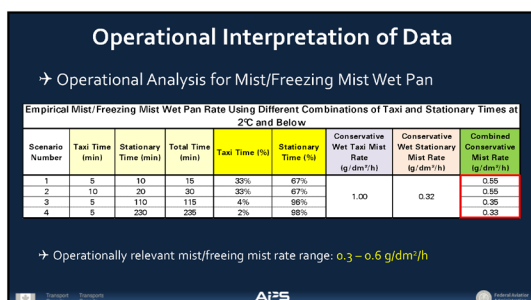
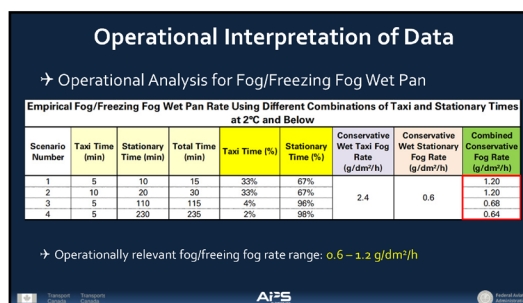
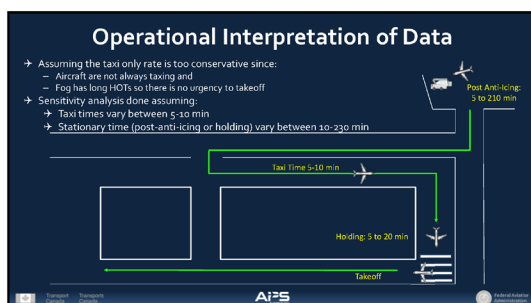
Note: All rates are in units of (g/dm²/h)

Mist/Freezing Mist Rate Analysis

- 2°C Conservative to mitigate risks and operationally relevant
- Mist could be as high as 1 g/dm²/h when taxiing and 0.32 g/dm²/h when stationary
- Only taxi data shown

Mist/Freezing Mist Wet Taxi				
Years 2020-2024	Number of Points	Average Rate	Rate Range	Rate Standard Deviation
All Data	46	0.68	0.1 - 1.5	0.37
4°C and Cooler	32	0.52	0.1 - 1.1	0.29
2°C and Cooler	22	0.41	0.1 - 1.0	0.25
0°C and Cooler	14	0.40	0.2 - 1.0	0.27

Note: All data are in units of (g/dm²/h)





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**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING,
MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
ARTIFICIAL SNOW MACHINES AND ENDURANCE TIME RESEARCH**

Joint research led and co-funded by:

**ARTIFICIAL SNOW MACHINES
 AND ENDURANCE TIME RESEARCH**
 Giza Montreal, November 6th, 2014
 Presented by: Dany Postoraro Eng, PhD
 AiPS Aviation



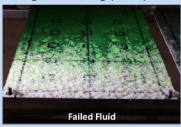
Outline

- **Background**
 - Why develop artificial snow?
- Previous Activities
- Artificial Snow Testing
 - NCAR Snowmachine Testing
 - AMIL Snowmachine Testing
- Preliminary Results
- Next Steps



Background

- New fluids must undergo endurance time (ET) testing to receive fluid-specific holdover times
- Fluid applied to test surface; exposed to precipitation until fluid failure (fluid layer stops absorbing oncoming precipitation)



Failed Fluid



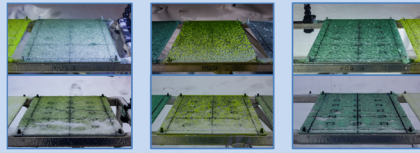
Why Develop Artificial Snow?

- Natural snow testing is a large component of the yearly HOT testing
- Natural snow data must be collected at specific times of the year Dec-April
 - In contrast, simulated precipitation testing can be done at the NRC CEF in Ottawa year round

Parameter	Unit	Natural Conditions		Simulated Conditions	
		Dec	Jan	Dec	Jan
Average Air Temp	°C	-10	-15	-10	-15
Average Precip Rate	mm/hr	1.5	1.5	1.5	1.5
Average Wind Speed	km/h	10	10	10	10
Average Humidity	%	80	80	80	80
Average Cloud Cover	%	80	80	80	80
Average Snow Depth	cm	10	10	10	10
Average Snow Grain Size	mm	1.5	1.5	1.5	1.5
Average Snow Density	kg/m³	100	100	100	100
Average Snow Water Content	%	10	10	10	10
Average Snow Ice Content	%	90	90	90	90
Average Snow Adhesion	N/m²	10	10	10	10
Average Snow Abrasion	N/m²	10	10	10	10
Average Snow Compaction	N/m²	10	10	10	10
Average Snow Melting	°C	-10	-10	-10	-10
Average Snow Freezing	°C	-10	-10	-10	-10
Average Snow Sublimation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Evaporation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Condensation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Deposition	mm/hr	1.5	1.5	1.5	1.5
Average Snow Accumulation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Removal	mm/hr	1.5	1.5	1.5	1.5
Average Snow Clearance	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sweeping	mm/hr	1.5	1.5	1.5	1.5
Average Snow Blowing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Drifting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Settling	mm/hr	1.5	1.5	1.5	1.5
Average Snow Compaction	mm/hr	1.5	1.5	1.5	1.5
Average Snow Melting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Freezing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sublimation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Evaporation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Condensation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Deposition	mm/hr	1.5	1.5	1.5	1.5
Average Snow Accumulation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Removal	mm/hr	1.5	1.5	1.5	1.5
Average Snow Clearance	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sweeping	mm/hr	1.5	1.5	1.5	1.5
Average Snow Blowing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Drifting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Settling	mm/hr	1.5	1.5	1.5	1.5
Average Snow Compaction	mm/hr	1.5	1.5	1.5	1.5
Average Snow Melting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Freezing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sublimation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Evaporation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Condensation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Deposition	mm/hr	1.5	1.5	1.5	1.5
Average Snow Accumulation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Removal	mm/hr	1.5	1.5	1.5	1.5
Average Snow Clearance	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sweeping	mm/hr	1.5	1.5	1.5	1.5
Average Snow Blowing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Drifting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Settling	mm/hr	1.5	1.5	1.5	1.5
Average Snow Compaction	mm/hr	1.5	1.5	1.5	1.5
Average Snow Melting	mm/hr	1.5	1.5	1.5	1.5
Average Snow Freezing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sublimation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Evaporation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Condensation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Deposition	mm/hr	1.5	1.5	1.5	1.5
Average Snow Accumulation	mm/hr	1.5	1.5	1.5	1.5
Average Snow Removal	mm/hr	1.5	1.5	1.5	1.5
Average Snow Clearance	mm/hr	1.5	1.5	1.5	1.5
Average Snow Sweeping	mm/hr	1.5	1.5	1.5	1.5
Average Snow Blowing	mm/hr	1.5	1.5	1.5	1.5
Average Snow Drifting	mm/hr	1.5	1.5	1.5	1.5
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Average Snow Removal	mm/hr	1.5	1.5	1.5	1.5
Average Snow Clearance	mm/hr	1.5	1.5	1.5	1.5

Previous Activities: Characterization Study

→ APS Aviation (APS) conducted a **natural snow characterization study** to identify factors contributing to variance in natural snow test results



Fluid Failure Characterization Photos

→ Precipitation rate and temperature known as primary factors affecting fluid performance
→ Wind speed and snowflake particle size identified as secondary factors contributing to endurance time variance in snow

APS

Previous Activities: Characterization Study

→ Higher winds was associated with longer than expected endurance times
→ Smaller particle size was associated with longer than expected endurance times
→ Magnitude of effects dependent on the fluid being tested
– EG Type III ET performance was not affected by either wind speed or particle size

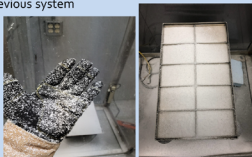
Fluids:	PG Type II	EG Type III	PG Type IV
Significant Variables	Wind Speed	None	Wind Speed Particle Size

APS

Previous Activities: NCAR Machine Development

→ NCAR has been further developing their existing snow machine system
→ New "next-gen" snow machine contains hardware and software improvements intended to address issues seen with previous system

- Better rate control, particle size modulation
- Spatial distribution issues addressed
- Test repeatability improved

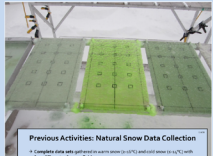


APS

Previous Activities: Natural Snow Data Collection

→ Current research goal is to **evaluate data correlation** of AMIL/NCAR snow machines vs. natural snow data
→ APS collected **natural snow data sets** with reference fluids to use as **evaluation baseline**

- Type II, Type III, and Type IV fluids used
- Ethylene based and propylene based
- Data collected across wide range of rates and temperatures



Previous Activities: Natural Snow Data Collection

APS

Outline

- Background
 - Why develop artificial snow?
- Project Workflow and Previous Activities
- **Artificial Snow Testing**
 - NCAR Snowmachine Testing
 - AMIL Snowmachine Testing
- Preliminary Results
- Next Steps

APS

Artificial Snow: Testing Locations



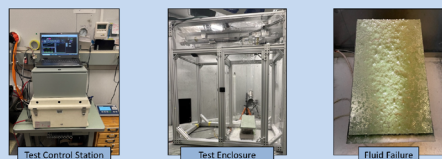
APS

Outline

- Background
 - Why develop artificial snow?
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17 of 31

NCAR Machine Testing: Sample Photos

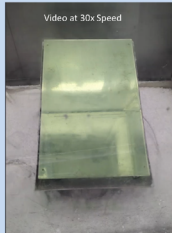


- APS has begun conducting artificial snow tests with the next-gen NCAR snow machine system (with support from NCAR) in Boulder CO.
- Data collection efforts to date
 - 4 Test fluids; more than 100 total tests completed; testing to continue through 2025 and beyond

18 of 31

NCAR Machine Testing: Timelapse Video

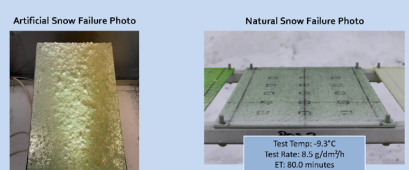
- PG-based Type IV fluid
- Test Temperature: -6.4°C
- Precipitation Rate: 28.1 g/dm²/h
- Test Endurance Time: 30.8 minutes
- Corresponding Natural Snow Test Endurance Time: 28.1 minutes



Video at 30x Speed

19 of 31

NCAR Machine Testing: Sample Comparison



Artificial Snow Failure Photo

Natural Snow Failure Photo

Test Temp: -9.3°C
Test Rate: 8.2 g/dm²/h
ET: 79.8 minutes

Test Temp: -9.3°C
Test Rate: 8.5 g/dm²/h
ET: 80.0 minutes

Visual differences in failure observed with different lighting and angles. New NCAR setup will provide more consistent imaging for comparative analysis.

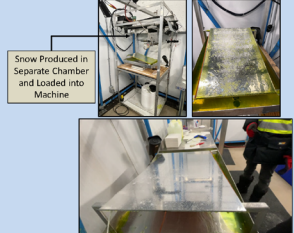
20 of 31

Outline

- Background
 - Why develop artificial snow?
- Previous Activities
- **Artificial Snow Testing**
 - NCAR Snowmachine Testing
 - **AMIL Snowmachine Testing**
- Preliminary Results
- Next Steps

27 of 31

Artificial Snow: AMIL Machine Testing



- AMIL has begun replicating the natural snow data with their snow machine system to evaluate the data output vs. natural snow
- Data collection is currently underway
 - 170+ total tests run to date
 - 4 test fluids
- Testing to continue through 2024 and beyond

28 of 31

Outline

- Background
 - Why develop artificial snow?
- Previous Activities
- Artificial Snow Testing
 - NCAR Snowmachine Testing
 - AMIL Snowmachine Testing
- **Preliminary Results**
- Next Steps



AIPS



Data Collection Status

→ Overall status

Artificial Snow Research Data Counts		Test Location			
Fluid	Data Set	Natural Snow (or Standard Amount)	NCAR	%	AMIL
PG Type II	Warm	57	0	0%	25
	Cold	34	0	0%	13
EG Type III	Warm	63	21	33%	26
	Cold	30	1	3%	13
PG Type IV	Warm	59	59	100%	35
	Cold	34	27	79%	19
EG Type IV	Warm	60	0	0%	30
	Cold	27	0	0%	15
Totals		364	108	30%	176

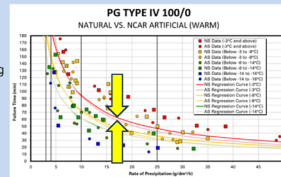


AIPS



Preliminary Results

- Early data analysis has begun with test data collected to date
- Data is compared with corresponding natural snow data regression to provide basis of comparison
- Dark curves = Natural Data
- Lighter curves = Artificial Data



AIPS



PG Type IV – NCAR Data Comparison

HOT Differences NCAR Set vs. Matched Natural Set				
Temp/Rate	25	10	4	3
-3°C and above	-9.2%	-1.6%	6.7%	9.4%
below -3 to -8°C	-11.0%	-3.6%	4.5%	7.1%
below -8 to -14°C	-12.2%	-5.0%	2.9%	5.6%

Average Deviation (Warm): -0.5%
Average Abs. Deviation (Warm): 6.6%

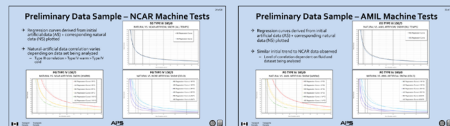


AIPS



Preliminary Results

- Same analytical procedure was conducted with both the NCAR and AMIL data for each of the 4 fluids in warm and cold conditions
- Sample of NCAR and AMIL regressions shown below



AIPS



Preliminary Results

NCAR					
Fluid	Data Set	Number of Data Points (N)	Data Set Completed (%)	Comments on Data set Completion	Average Absolute Deviation (%)
PG Type II	Warm	0 of 57	0%	Need Data	-
PG Type II	Cold	0 of 34	0%	Need Data	-
EG Type III	All Temps	22 of 93	24%	Need More Data	4.2%
PG Type IV	Warm	59 of 59	100%	Complete	6.6%
PG Type IV	Cold	27 of 34	79%	Almost Complete	44.6%
EG Type IV	Warm	0 of 60	0%	Need Data	-
EG Type IV	Cold	0 of 27	0%	Need Data	-



AIPS



Preliminary Results

AMIL

Fluid	Data Set	Number of Data Points (#)	Data Set Completion (%)	Comments on Data set	Average Absolute Deviation (%)	Comments on Data Correlation
PG Type II	Warm	25 of 57	44%	Need Data	7.4%	Promising (Limited Data)
PG Type II	Cold	13 of 34	38%	Need Data	67.4%	Research Needed
EG Type III	All Temps	39 of 93	42%	Need Data	1.8%	Promising
PG Type IV	Warm	35 of 59	59%	Need Data	4.7%	Promising (Limited Data)
PG Type IV	Cold	19 of 34	56%	Need Data	39.5%	Research Needed
EG Type IV	Warm	30 of 60	50%	Need Data	9.9%	Limited Data
EG Type IV	Cold	15 of 27	56%	Need Data	9.9%	Limited Data






Observations

→ More data is needed for most of the data sets to gain better insight when compared to the natural snow data sets

→ With results to data:

- Warm snow seems to correlate compared to the natural snow but should still be improved
- Cold snow results to date not as well correlated compared to the natural snow (lack of data can impact current results)

→ To bridge the gap between artificial snow and natural snow data sets (especially in cold snow):

- Conduct research to improve snow machine (snowflake size, plate heater, etc.)
- Explore impacts of secondary factors to bridge the gap

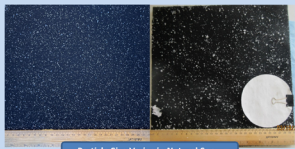





Particle Size Effects

→ Particle size can affect the endurance time. In general,

- Larger particles can shorten the endurance time
- Smaller particles can extend the endurance time

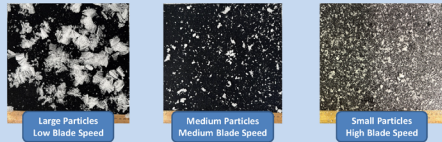


Particle Size Varies in Natural Snow






NCAR Snow Machine
Particle Size Comparison at -3°C



→ New NCAR machine can produce a range of particle sizes

- Different size particles produced by changing blade speed






NCAR Artificial Snow Machine Particle Size Comparison at -23°C



→ Artificial snow particle size also changes when testing temperature is changed

- Colder temperatures produces smaller particles






Artificial Snow vs. Natural Snow at -23°C



→ Standard settings used for cold snow NCAR tests produces very fine particles

- May be finer than natural cold snow (more characterization needed)






Particle Size and Future Research

31 of 33

- Review of preliminary data indicates that level of data correlation varies depending on fluid and temperature category
 - EG Type III showed promising correlation in both NCAR/AMIL data to date
 - EG Type III also most resistant to secondary environmental factors (particle size/wind) in natural snow characterization study
- Recall: PG Type IV cold data set showed weaker correlation
 - PG Type IV more impacted by particle size/wind in natural snow characterization study
 - It may be possible that the correlation can be improved by modulating snowflake size
- Planned research for 2024-25: repeat PG Type IV cold data collection effort with modified blade speed settings
 - Determine if modulating snowflake size produces better correlated artificial snow data
 - Continue characterization of particle size outputs with new NCAR machine






Outline

32 of 33

- Background
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- **Next Steps**






Next Steps

33 of 33

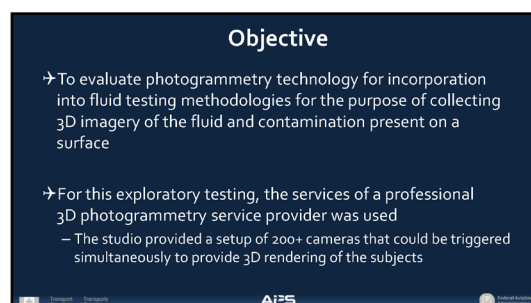
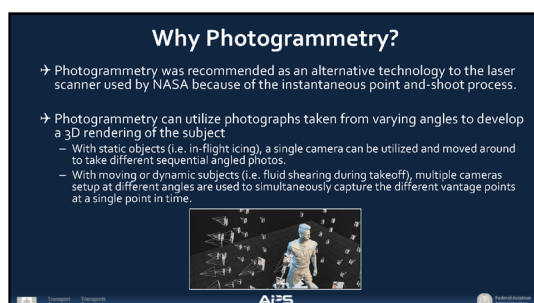
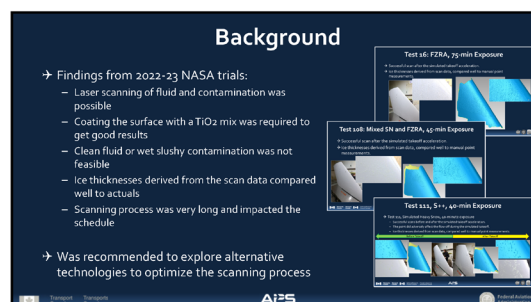
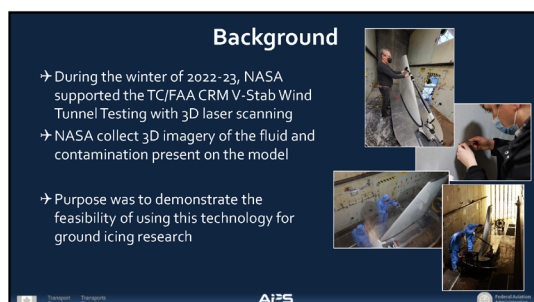
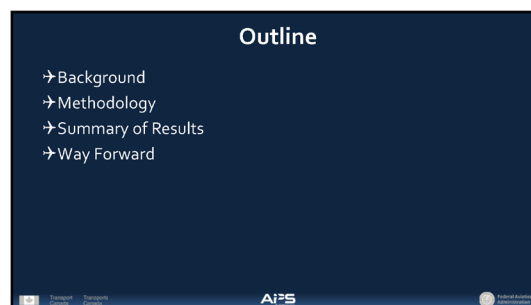
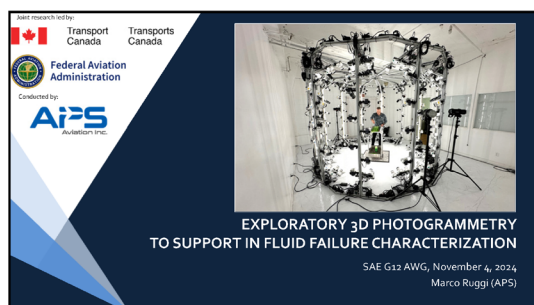
- **Continue Data Collection Efforts**
 - Continue data sets collected with both AMIL/NCAR machines for all four fluids tested
 - Targeted testing to be conducted to evaluate effect on ETs (snowflake size, plate temp, etc.)
- **Continued Analysis of Data Collected to Date**
 - In-depth analysis of individual data sets
 - Detailed evaluation of performance discrepancies + related factors (isolate high wind tests, large snowflake tests, etc)
- **Adaptations to Snowmachines / Testing Processes**
 - Determine if/how to incorporate secondary environmental factors to better attune artificial results to natural results

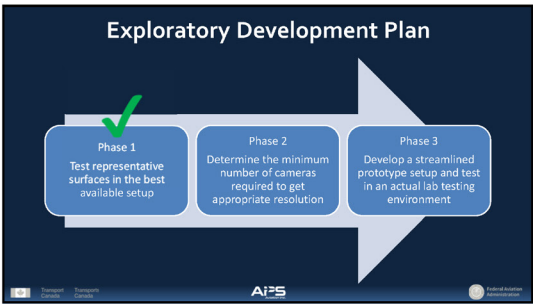





**SAE G-12 AERODYNAMIC WORKING GROUP (AWG) COMMITTEE
MEETING, MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
EXPLORATORY 3D PHOTOGRAMMETRY TO SUPPORT IN FLUID FAILURE
CHARACTERIZATION**

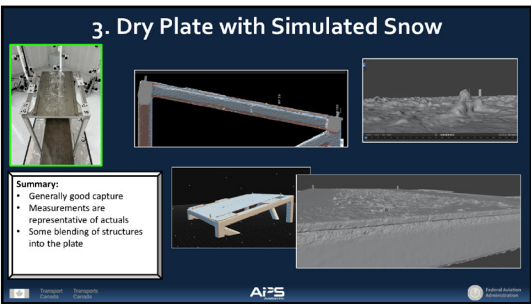
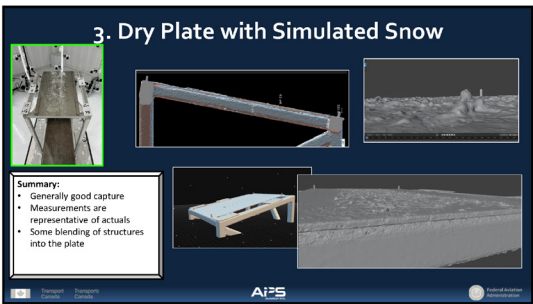
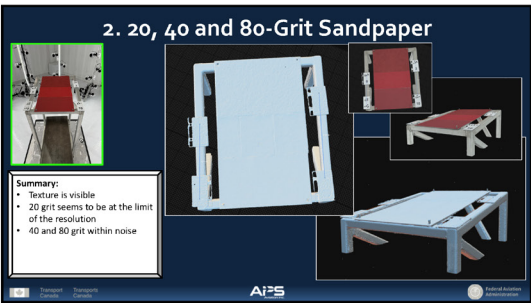
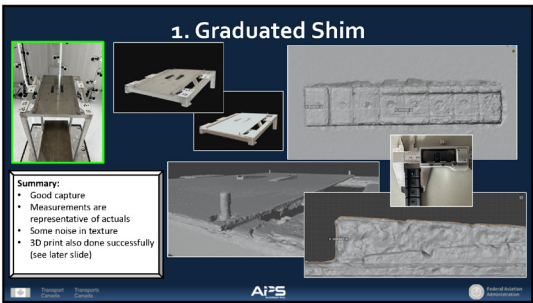


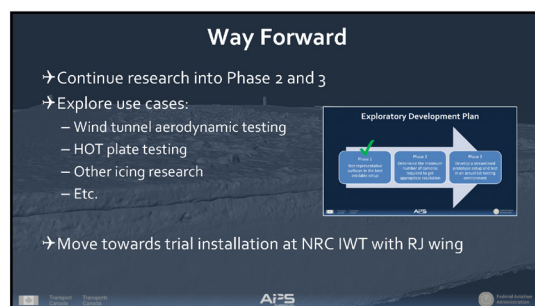
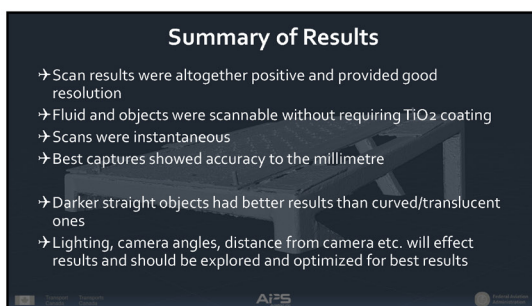
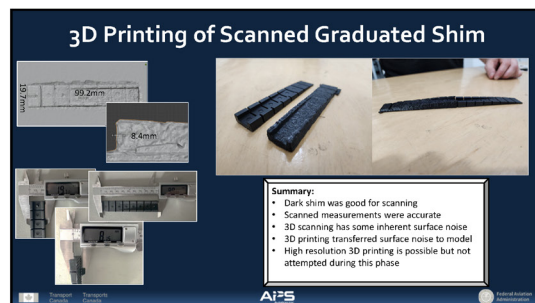
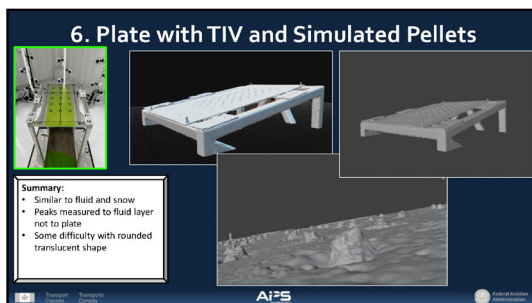
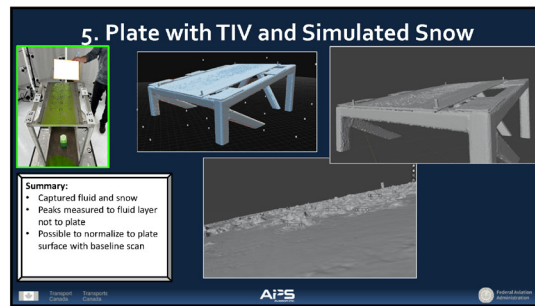
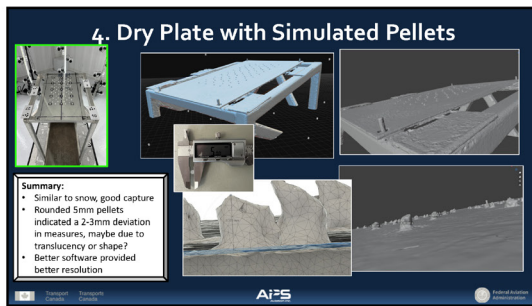


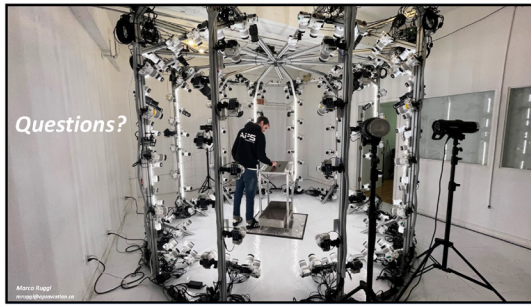
Methodology

→ Testing conducted in non-freezing environment with representative subjects for the trials

Test	Test Subjects
1	Graduated shim x2 in opposite orientations
2	20, 40, an 80-Grit sandpaper overlayed
3	Dry plate with simulated snow
4	Dry Plate with simulated pellets
5	Plate with TIV and simulated snow
6	Plate with TIV and simulated pellets







**SAE G-12 AERODYNAMIC WORKING GROUP (AWG) COMMITTEE
MEETING, MONTREAL, CANADA, NOVEMBER 2024**

**PRESENTATION:
WIND TUNNEL TESTING UPDATE**



Transport Canada



Federal Aviation Administration



APS



National Research Council Canada



NASA



WIND TUNNEL TESTING UPDATE

SAE G12 AWG, November 4, 2024
Marco Ruggi (APS), Peter Forsyth (NRC), and Andy Broeren (NASA)

Outline

→ Background

→ Previous Research

→ Testing Plans for 2024-25

Wind Tunnel Facility

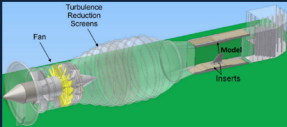
→ NRC 3 m x 6 m Icing Wind Tunnel

– Located in Ottawa, Ontario, Canada

– Open-circuit for naturally cold conditions in winter months

– Test section with inserts: 3 m x 5 m

– Maximum speed on gas turbine drive: 60 m/s (115 kts)





ICE PELLET ALLOWANCE TIME RESEARCH
HISTORICAL PRESENTATIONS

→ The work conducted by FAA/TC has been presented by APS to G-12 AWG and HOT Committee yearly since 2006

– Details of testing methodologies, research objectives, and results.

– All presentations available on the SAE website







→ Additional presentations were given at the AWG in May 2012 and May 2013 by NASA and NRC

– Details of the extensive calibration and characterization work led by Andy Broeren, NASA and Catherine Clark, NRC-CNRC

2023-24 Summary of Test Runs

→ 20 days of RJ wing testing between Jan 14 – Feb 16, 2024

– Original plan was 10 days RJ and 10 days V-stab, but due to technical issues, V-stab testing was cancelled and RJ testing extended

Objective #	Objective	# of Runs
1	Baselines (Dry wing)	43
2	Ice Pellet Allowance Time Validation (New Fluids)	43
3	Allowance Time Expansion	28
4	New Mixed Allowance Time Conditions	35
5	General Exploratory Testing	14
	Total	163

*Some also served as Validation tests

2023-24 Notable Achievements

Validation Testing Results

→ Tested 4 Type IV fluids

→ Allowance times are generic, so systematic "spot checking" was done to identify any potential issues

Fluid	Status
ASGlobal - 4Flite PG	✓ Validated
AVIAFLUID International Ltd - AVIAFLUID EG	✓ Validated
AVIAFLUID International Ltd - AVIAFLUID PG	✓ Validated

APSLibrary/Projects/301351 (TC Deicing 2024-25)/Reports/G & E/Final Version 1.0/Report Components/Appendices/Appendix H/Appendix H.docx
Final Version 1.0, July 26

H-45

	COMBINED COLUMNS	NEW TEMP. COLUMN
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
10	10	10
11	11	11
12	12	12
13	13	13
14	14	14
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99	99	99
100	100	100

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Transport Canada | National Research Council Canada | Conseil national de recherches Canada | AIPS

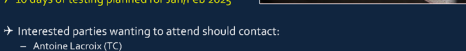
COMBINED COLUMNS, NEW TEMP. COLUMN	
1	2
3	4
5	6
7	8
9	10
11	12
13	14
15	16
17	18
19	20
21	22
23	24
25	26
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95	96
97	98
99	100

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Transport Canada / National Research Council Canada / Conseil national de recherches Canada

- Validation testing for new-to-market fluids will solicit 8 fluids:

- 4 new from 2024-25
 - 1 untested since 2023-24
 - 1 untested since 2023-22
 - 2 previously not commercialized
- Expansion of allowance times
- Longer PG times (work in progress)
 - Longer EG times, especially at colder temps
 - More mixed conditions
- 10 days of testing planned for Jan/Feb 2025
- 



**SAE G-12 EQUIPMENT COMMITTEE MEETING, MONTREAL, CANADA,
NOVEMBER 2024**

**PRESENTATION:
FORCED AIR WORKING GROUP UPDATE**



FORCED AIR WORKING GROUP UPDATE

SAE G12 Equipment, Montreal, November 6, 2024
Presented by: Marco Ruggi (APS)

APS

OUTLINE

- Background
- Working Group Activities
- Overview of Draft AIR
- Ballot Results
- Way Forward

APS

Background

APS

BACKGROUND

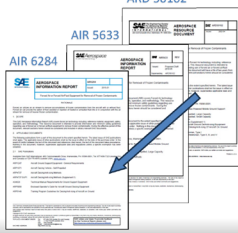
- Forced air systems (FAS) have been in development since the 1990's
- TC and FAA supported research into forced air technology to:
 - identify potential ways that forced air could be used in de/anti-icing operations
 - Identify possible safety issues that could arise from their use
- G-12 Equipment Committee subsequently proposed a working group to focus on issues and develop an AIR



APS

History of Forced Air Standards

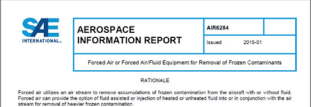
Document	Year	Notable
ARD 50102	2002	Published
AIR 5633	2010	Proposed but never published
AIR 6284	2015	Published
AIR 6284 REV A	2024+	In Progress (details in this presentation)



APS

Status of AIR 6284 (2015 Version)

- Feedback from industry was that:
 - Document is outdated
 - References are old or obsolete
 - Needs a refresh to be better suited to current users



APS

Working Group Activities

AirPS

New Forced Air Working Group

- At the Helsinki G12 Equipment meeting in May 2023, a motion was made to initiate a new working group (WG)
- Objective:
 - To review the AIR and update as required based on industry needs

Current Working Group Members	
David Thornton – UNIFI (AIRS Organizer)	Joe Griffin – Mallagan
Marco Ruggi – APS (Document Sponsor)	John D'Avirro – APS
Anders Larsen – Vestergaard	Josh Watkins – Global
Andrew Hook – IDS	Mark Stevenson – Global
Antoine Lacroix – TC	Michael Halloran – FAA
Chris Ludington – IDS	Richard Benz – Delta
Dany Rostero – APS	Sean Kerrick – FAA
Ed Sachs – JBT	Tim McClain – FAA
Frank Lipinski – FAA	Tim Smith – FAA
Gab Leclerc – Aeromob	Warren Underwood – FAA
Jacques Leroux – Dow	Yvan Chabot – TC
Jason Grove – Global	

AirPS

Summary of Revisions to AIR6284

- Working group identified several areas for improvement

- Re-organization of format
- Updating of references
- Inclusion of new Sections
 - Potential Applications of FAS in Deicing and Anti-Icing Processes
 - Evaluation of FAS Effects on Fluids
 - Characterization of FAS Pressures on Aircraft Surfaces



AirPS

Working Group Activities

- Oct 11, 2023 - Kickoff meeting
- Nov 8, 2023 - G12 Presentation and Discussion
- Jan 30, 2024 - Follow-up WG Meeting
 - Determine AIR update strategy
- Apr 2, 2024 - AIR Progress Review WG Meeting
 - Review AIR Progress and get feedback
- July 9, 2024 - WG Approval to proceed with Ballot
 - Final review of AIR draft



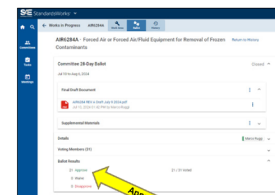
AirPS

AIR6284 Revision A Ballot Results

AirPS

AIR6284 REV A – 1st Ballot

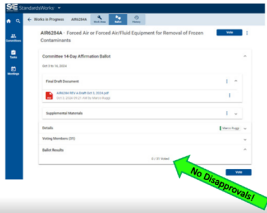
- Draft was submitted for a Committee 28-day Ballot
 - Jul 10 to Aug 6, 2024
- **Ballot was approved!**
- Several editorial comments were received
 - 30+ comments from industry
 - Thank you! Very helpful!



AirPS

AIR6284 REV A – Reaffirmation Ballot

- Updates made to document
 - All comments were responded to and resolved
- Updated Draft submitted for a Committee 14-Day Affirmation Ballot
 - Oct 3 to Oct 16, 2024
- **Document is ready for SAE publishing!!**



AIR8284 REV A - Milestones

Date	Milestone	Status
May 23, 2023	Workgroup formed at G-12 meeting	✓
April 2, 2024	Developed Draft 1.0 based on WG feedback	✓
May 14th, 2024	Presentation to G12 Equipment Committee	✓
May 2024 - August 2024	Update document with feedback from industry	✓
August 2024	Ballot AIR6284 REV A	✓
October 2024	Reaffirmation Ballot for Editorial Changes	✓
October 2024	Document submitted to SAE Council for Publishing	✓

Way Forward

- AIR 6284 REV A will be available online shortly
- The Forced Air Working Group will meet on an as needed basis
 - To address any feedback on REV A
 - To discuss any future improvements to document
- Any interested parties can contact:
 - David Thornton: davidthornton@unifiservice.com
 - Marco Ruggi: mruggi@apsaviation.ca

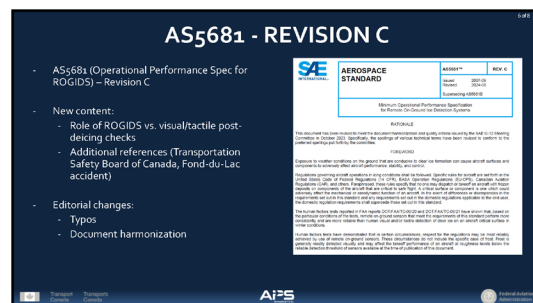
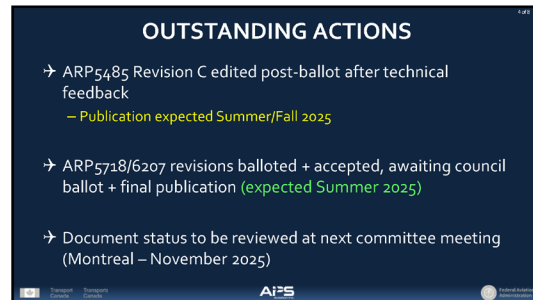
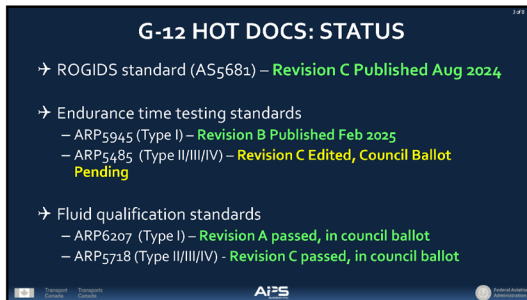
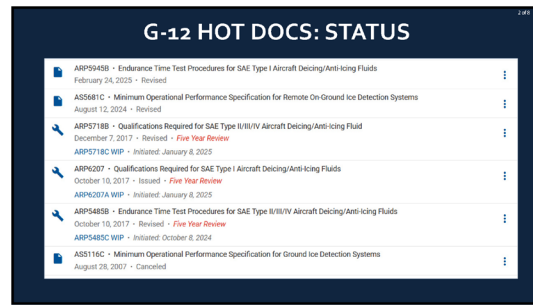




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**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING, MÁLAGA,
SPAIN, MAY 2025**

**PRESENTATION:
SAE G-12 HOT COMMITTEE: DOCUMENTS UPDATE**



ARP5945 – REVISION B

- Updates to existing sections:
 - Test surface specs
 - Criteria for repeating tests
- Editorial changes:
 - Page number fix
 - Document harmonization
- Full change details in Changes Summary document
 - See WIP on StandardWorks

**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING, MÁLAGA,
SPAIN, MAY 2025**

**PRESENTATION:
WINTER 2024-25 ENDURANCE TIME TESTING UPDATE**

Joint research led by:
Transport Canada
Federal Aviation Administration
Conducted by:
AiPS
Aviation Inc.



**WINTER 2024-25
ENDURANCE TIME TESTING UPDATE**

SAE G2: HOT Committee, Malaga, May 20, 2025
Presented by: Peter Kitchener

Purpose

→ To provide an overview of the new fluids tested for inclusion in the HOT guidelines.

Notes:

- HOTs and fluid info are not official until published by TC/FAA
- All fluid data/charts are included in an Appendix.
- Appendix slides will be available on the SAE website but not shown at meeting unless requested.

Outline

→ 2024-25 Testing Overview

- Methodology
- HOT Test Results: 8 Fluids
- Very Cold Snow Test Results Summary: 9 Fluids
- Summary
- Appendix: Detailed Test Results

Testing Overview

→ **1,151** total endurance time (ET) tests were conducted in the winter of 2024-25

→ **8 new fluids** are expected to be added to the HOT Guidelines for the 2025-26 winter season



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	0	0	0	0	0	0	0
	Comp.	0	0	0	0	0	0	0	0
	100/0	138	24	40	18	16	8	12	256
Type II	75/25	36	-	8	8	8	4	3	67
	50/50	31	-	4	4	4	-	2	45
	100/0	0	0	0	0	0	0	0	0
Type III	75/25	0	-	0	0	0	0	0	0
	50/50	0	-	0	0	0	-	0	0
	100/0	482	44	79	48	48	24	58	783
Type IV	75/25	0	-	0	0	0	0	0	0
	50/50	0	-	0	0	0	-	0	0
	Total	687	68	131	78	76	36	75	1,151

New Fluids

ESSPO	ESSPO CHEMICALS D.O.O	Type II	Nordwing PG2
LNT SOLUTIONS	LNT Solutions	Type II	P250
ESSPO	ESSPO CHEMICALS D.O.O	Type IV	Nordwing PG4
No Logo Available	AFLRUS LLC	Type IV	Green Flo Type 4
ALLCLEAR	ALLClear Systems	Type IV	Clear IV Flight
	Newave Aerochemical Co. Ltd.	Type IV	FCY-EGIV PLUS
	Xinjiang Zhongtian Linyang Aviation	Type IV	Clearice-IV
LNT SOLUTIONS	LNT Solutions	Type IV	P450

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APIS

Test Methodology

Endurance Time Testing Standards

ARPS945Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type I

ARPS485Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type II, III, and IV

Test Variables

Precipitation type and rate

Air Temperature

Fluid temperature and application quantity

Test surface
(aluminum, composite, painted, etc.)

APIS

Test Methodology

Outdoor Natural Snow

Natural Frost

Simulated Freezing Precipitation

Fluid Failure

APIS

Analysis Methodology

→ Holdover times are derived using regression analysis that assumes a power law relationship of the raw endurance time data

Endurance Time (min)

Rate (g/dm²/h)

General Form of Equation

Freezing Precipitation: $HOT = 10 \cdot Rate^A$

Snow: $HOT = 10 \cdot Rate^A \cdot (2 \cdot Temp)^B$

(If A, B = coefficients determined by regression analysis)

→ Specific coefficients are developed for each cell of the HOT table

APIS

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 (min)

Rate (g/dm²/h)

Raw HOTs are rounded to the closest 5-mins or 1-min depending on the applicable rounding rules

(i.e. 38 and 32 mins → 35 and 30 min HOT)

Holdover Time Development Standards

ARPS6207Qualification Process for SAE AMS 1428 Type I Fluids

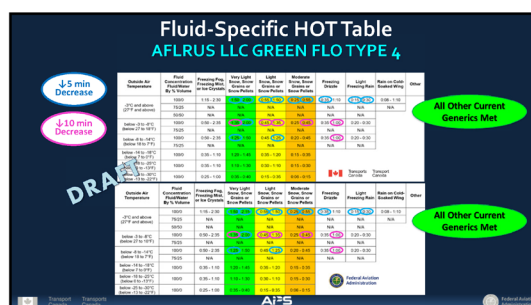
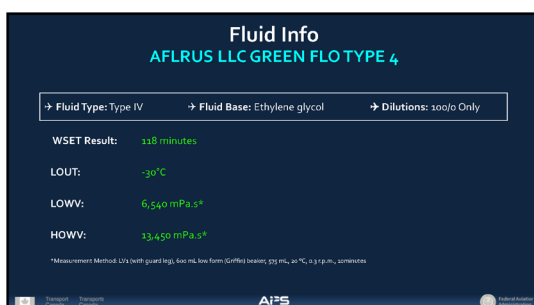
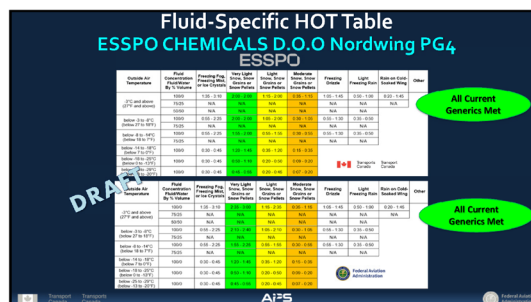
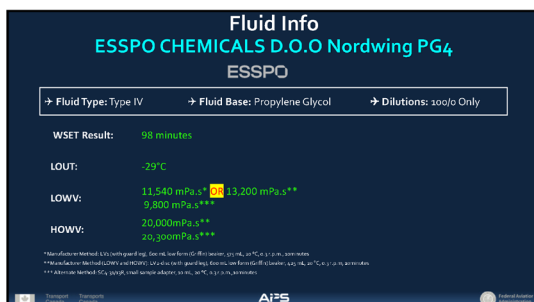
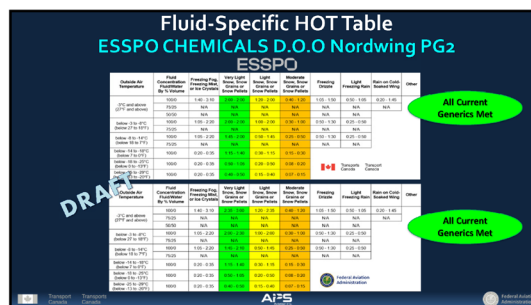
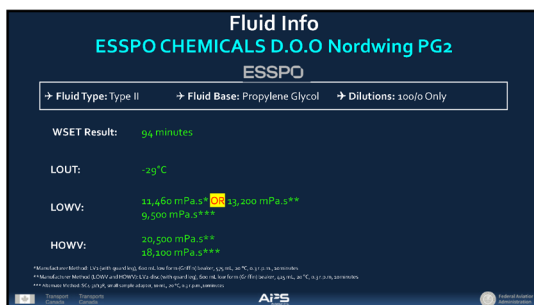
ARPS718Process to Obtain Holdover Times for Aircraft Deicing/Anti-icing Fluids, SAE AMS1428 Types II, III, and IV

APIS

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APIS



Fluid-Specific HOT Table

ALLCLEAR SYSTEMS CLEAR IV FLIGHT

ALLCLEAR

Operating Air Temperature	Fluid Temperature	Pressing Avg. Pressure at 100% Volume	Visc. Light (cP) at 100% Volume	UHMW PE Sliding Friction Coefficient	Wettable Surfaces	Pressing Details	UHMW PE Sliding Friction Coefficient	Roll on 100% Saturated Visc.	Other
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	All Current Generics Met
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	
Below -100 °C and above -100 °C	1000	1.20 - 1.30	1.20 - 1.30	0.20 - 0.25	1.00 - 1.50	1.00 - 1.50	0.20 - 0.10	0.20 - 0.10	

DRAFT

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Outline

- 2024-25 Testing Overview
- Methodology
- HOT Test Results: 8 Fluids
- **Very Cold Snow Test Results Summary: 9 Fluids**
- Summary
- Appendix: Detailed Test Results

Very Cold Snow Testing

- In addition to standard HOT testing, fluids can be submitted for supplemental **very cold snow (VCS) testing**
- Participating fluids receive fluid specific HOTs in snow at temperatures **below -14°C**
 - Non-participating fluids receive generic HOTs in snow below -14°C
- Testing open to new or existing Type II/III/IV fluids, generally offered to industry **every two years**
 - Northern travel required to obtain cold natural snow data, which incurs a greater cost
 - Fluid submitted on time (by December 1st) is imperative to capture the required data

Testing Status – Very Cold Snow

- VCS data sets for **3** 2023-24 fluids are complete
 - Due to late fluid receipt, testing completed over two years
 - All fluid-specific HOTs exceed corresponding generic HOTs
- VCS data sets for **6** 2024-25 fluids are complete
 - All fluid-specific HOTs exceed corresponding generic HOTs
 - Results on upcoming slides

Very Cold Snow HOTs ESSPO CHEMICALS D.O.O Nordwing PG2 ESSPO

Canada		Transport		Transport		Canada		Transport		Transport	
Outside Air Temperature		Fluid Concentration (Equivalent By % Volume)		Freezing Fog (Freezing Mts. 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)	
Below -14 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	

Very Cold Snow HOTs ESSPO CHEMICALS D.O.O Nordwing PG4 ESSPO

Canada		Transport		Transport		Canada		Transport		Transport	
Outside Air Temperature		Fluid Concentration (Equivalent By % Volume)		Freezing Fog (Freezing Mts. 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)	
Below -14 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	

Very Cold Snow HOTs AFLRUS LLC GREEN FLO TYPE 4

Canada		Transport		Transport		Canada		Transport		Transport	
Outside Air Temperature		Fluid Concentration (Equivalent By % Volume)		Freezing Fog (Freezing Mts. 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)	
Below -14 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	

Very Cold Snow HOTs ALLCLEAR SYSTEMS CLEAR IV FLIGHT

Canada		Transport		Transport		Canada		Transport		Transport	
Outside Air Temperature		Fluid Concentration (Equivalent By % Volume)		Freezing Fog (Freezing Mts. 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)	
Below -14 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	
Below -18 to -20°C (Below 7 to 29°F)		1000		0.20 - 0.30		0.15 - 0.18		0.30 - 1.10		0.15 - 0.20	

Very Cold Snow HOTs											
Newave Aerochemical Co. Ltd. FCY-EGIV PLUS											
Transport Canada						Federal Aviation Administration					
Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)	Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)
Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50

Very Cold Snow HOTs											
Xinjiang Zhongtian Liyang Aviation Clearice-IV											
Transport Canada						Federal Aviation Administration					
Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)	Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)
Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50

Very Cold Snow HOTs											
ALAB INTERNATIONAL PROFLIGHT EG 4											
Transport Canada						Federal Aviation Administration					
Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)	Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)
Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50

Very Cold Snow HOTs											
ALAB INTERNATIONAL PROFLIGHT PG 4											
Transport Canada						Federal Aviation Administration					
Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)	Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)
Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -14 to -20°C (Below 7 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -10 to -15°C (Below 14 to 20°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50
Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	Below -5 to -10°C (Below 23 to 27°F)	1000	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50	0.30 - 1.50

Very Cold Snow HOTs											
MKS DEVO KIMYA SANAYI TIC AS. COREICEPHOB TYPE II											
Transport Canada						Federal Aviation Administration					
Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)	Outside Air Temperature	Fluid Concentration (By % Volume)	Freezing Ppt. (By % Volume)	Very Light Snow (By % Volume)	Light Snow (By % Volume)	Moderate Snow (By % Volume)
Below -14 to -20°C (Below 7 to 27°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	Below -14 to -20°C (Below 7 to 27°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25
Below -10 to -15°C (Below 14 to 20°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	Below -10 to -15°C (Below 14 to 20°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25
Below -5 to -10°C (Below 23 to 27°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	Below -5 to -10°C (Below 23 to 27°F)	1000	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25	0.15 - 0.25

Outline											
→ 2023-24 Testing Overview											
→ Methodology											
→ HOT Test Results: 8 Fluids											
→ Very Cold Snow Test Results Summary: 9 Fluids											
→ Summary											
→ Appendix: Detailed Test Results											

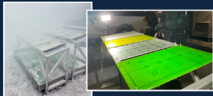
Summary

→ **Fluids Tested:**

- Tests carried out with 8 new fluids

→ **Results:**

- 8 new fluid specific HOT-table
- New fluid-specific VCS HOTs for g new and existing fluids
- Generic Active Frost HOTs substantiated
- No impact to existing generic Type II HOTs
- Moderate impacts to existing generic Type IV HOTs



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Outline

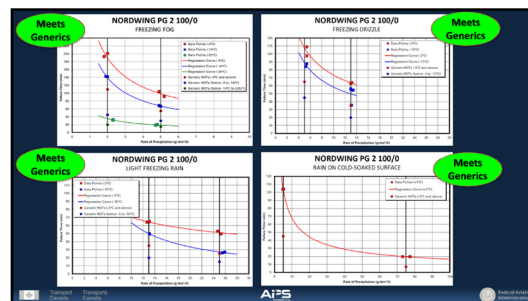
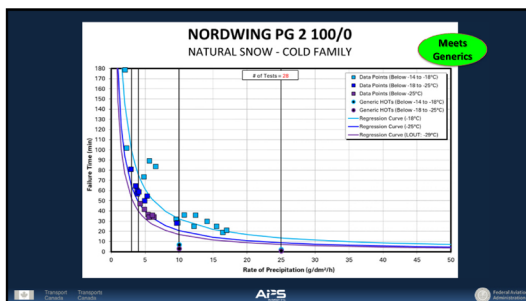
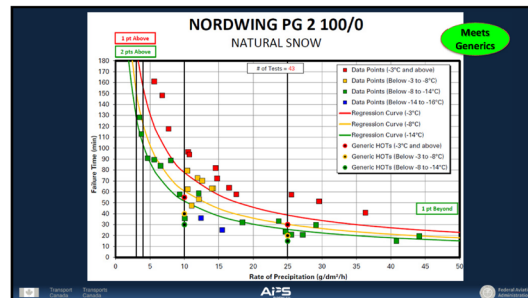
- 2024-25 Testing Overview
- Methodology
- HOT Test Results: 8 Fluids
- Very Cold Snow Test Results Summary: g Fluids
- Summary
- Appendix: Detailed Test Results

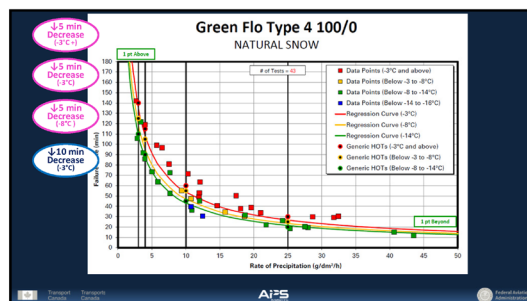
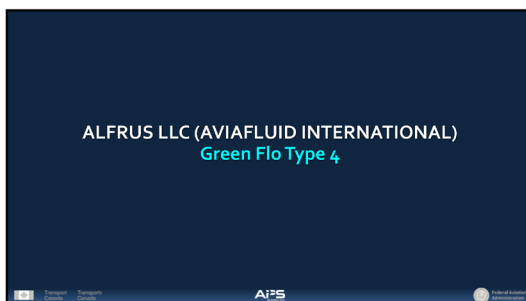
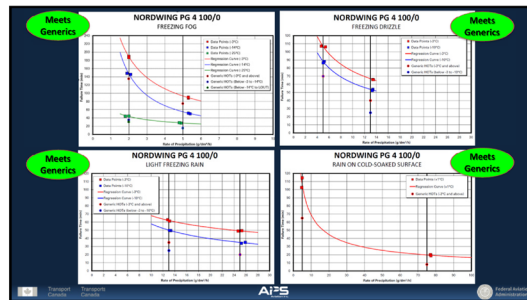
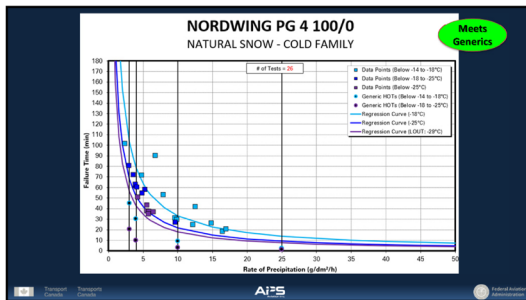
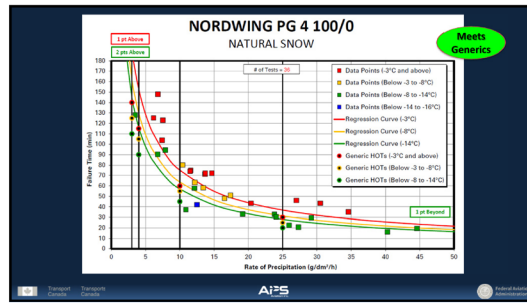
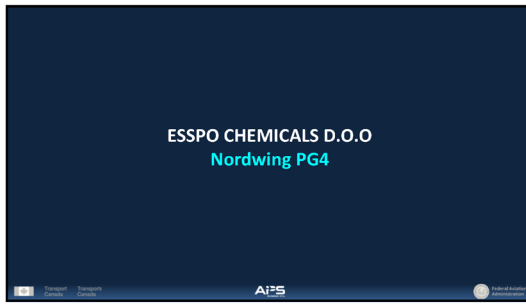
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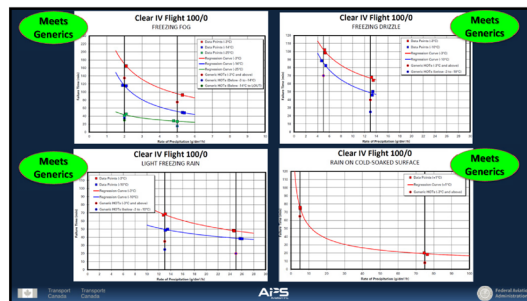
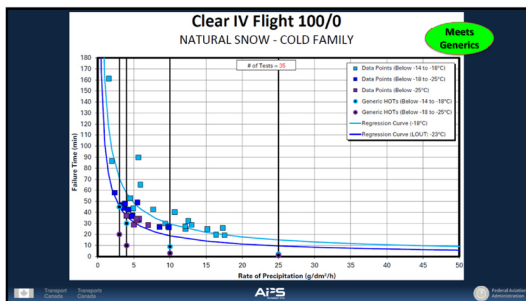
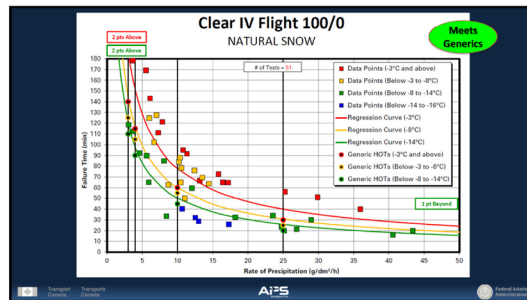
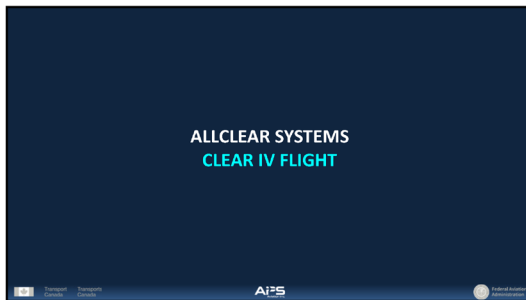
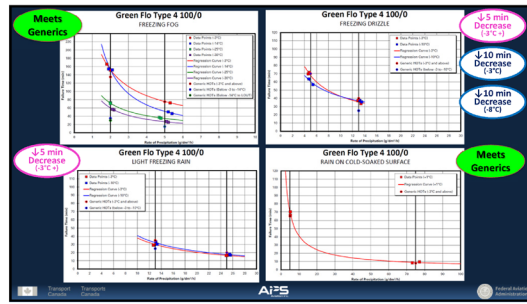
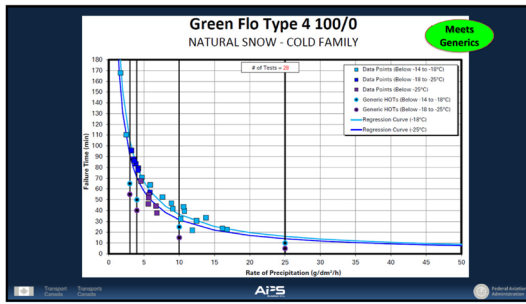
ESSPO CHEMICALS D.O.O

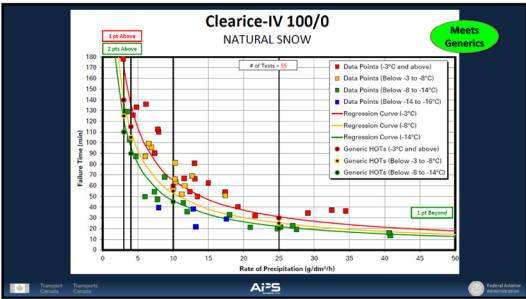
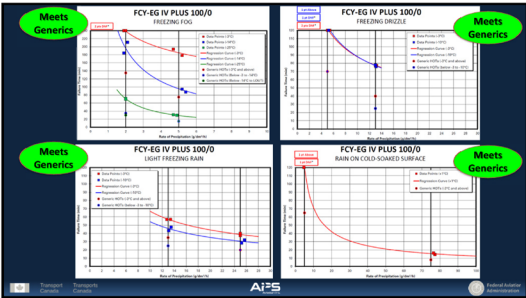
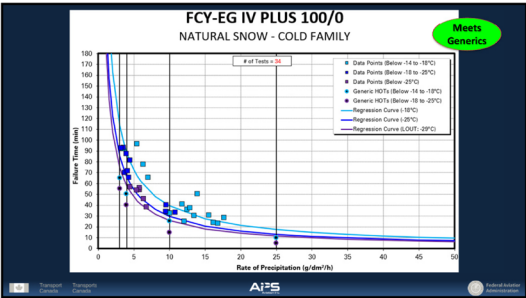
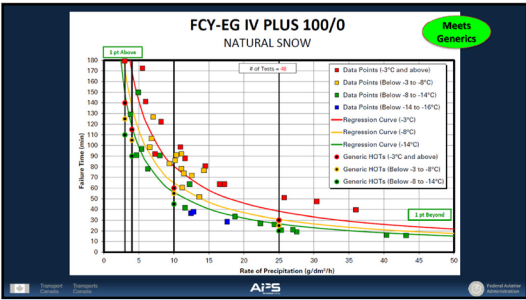
Nordwing PG2

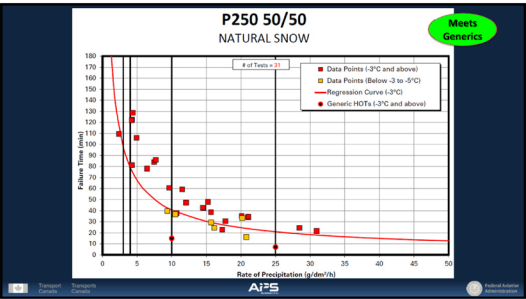
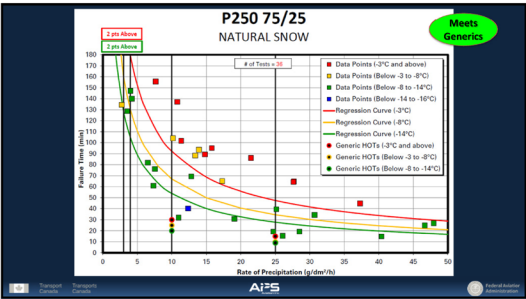
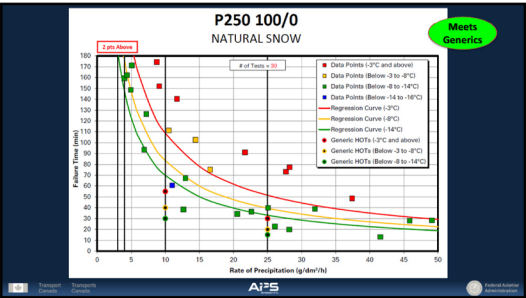
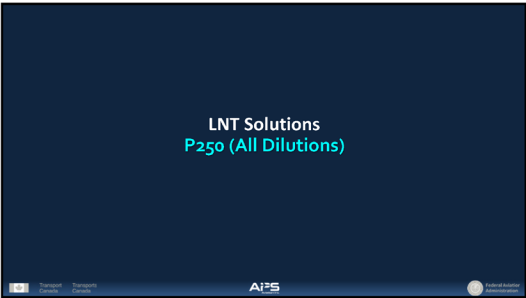
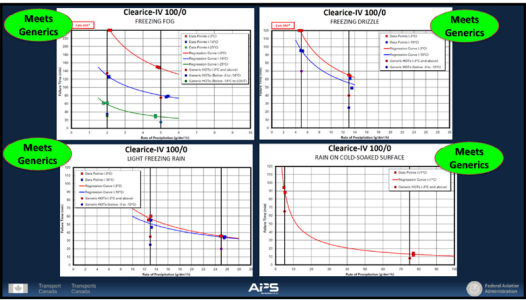
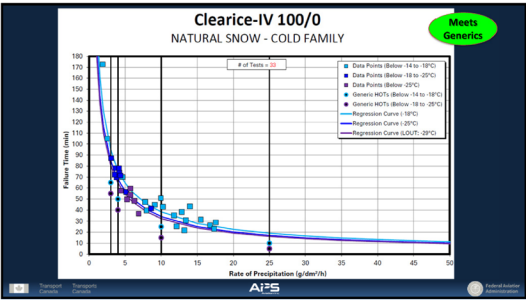
AI²S

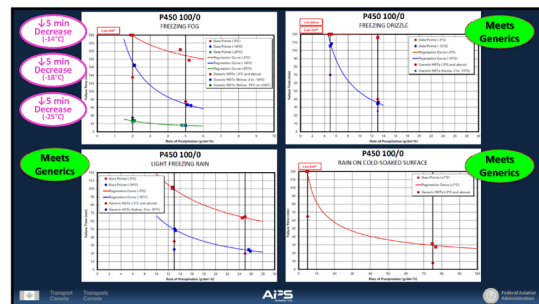
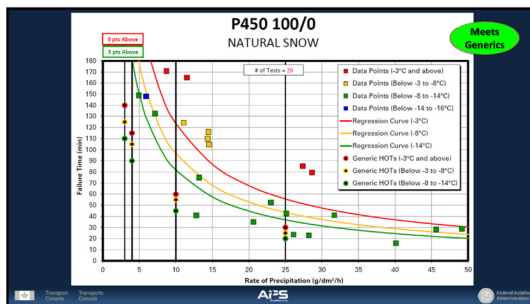
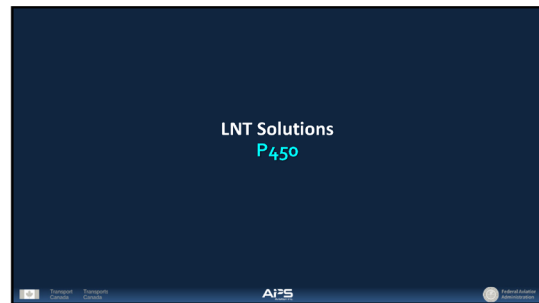
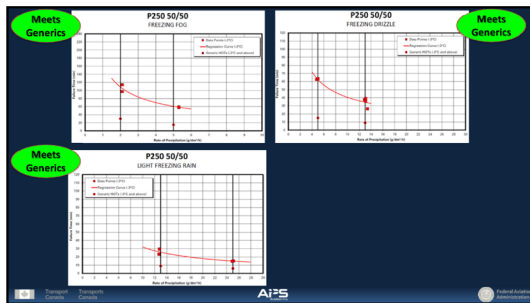
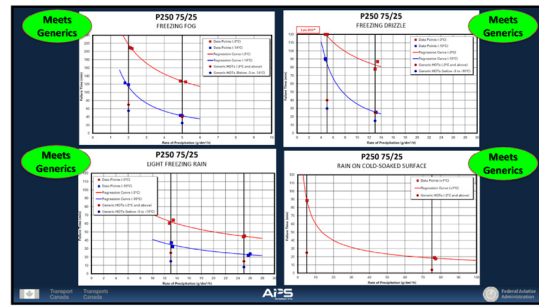
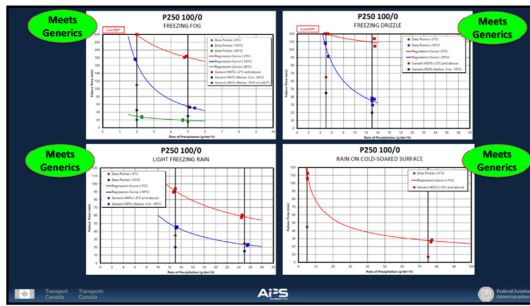


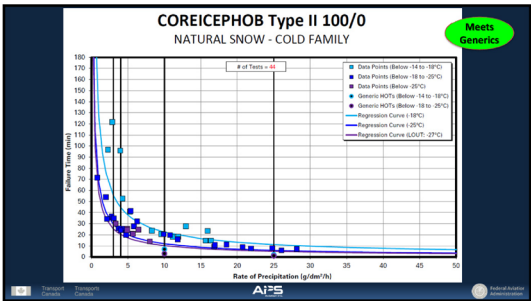
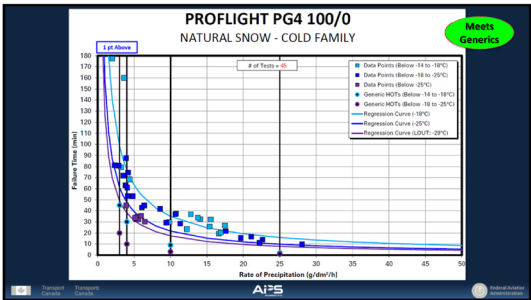
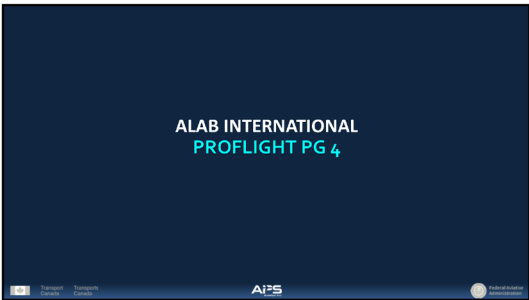
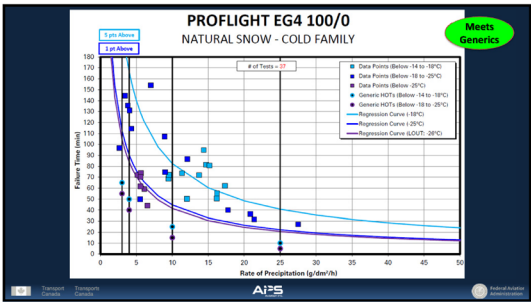
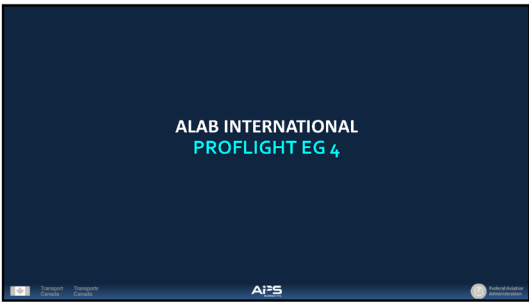














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**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING, MÁLAGA,
SPAIN, MAY 2025**

**PRESENTATION:
2024-25 MIXED PHASE ICING TESTING TO SUPPORT GUIDANCE
DEVELOPMENT**

Joint research led by:
 Transport Canada
 Transports Canada
 Federal Aviation Administration
Conducted by:
 AIPS
Aviation Inc.



**2024-25 MIXED PHASE ICING TESTING
TO SUPPORT GUIDANCE DEVELOPMENT**
SAE G32 Holdover Time Committee, Málaga, May 20, 2025
Presented by: Benjamin Bernier

OUTLINE

- Background and Objective
- Methodology
- Testing Results
 - Moderate Snow mixed with Rain
 - Snow mixed with Mist
 - Snow mixed with Freezing Fog (Type I)
 - Very Light or Light Snow mixed with Rain/Drizzle
- Summary and Way Forward

Background

- Not all METAR reported conditions have corresponding conditions in the HOT guidance to allow for safe departure
 - Especially true for mixed conditions
- TC and FAA, with support of a METAR Working Group, are committed to HOT R&D to support operational capabilities in mixed conditions.
 - Research ongoing since 2021-22
- Laboratory testing was conducted in 2024-25 to support the development of guidance in four mixed conditions.

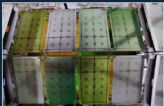
OUTLINE

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- Summary and Way Forward

Test Methodology

- Comparative test methodologies compared mixed icing tests to baseline snow and/or freezing precipitation tests
- Mixed guidance can then be derived from existing HOTs in standard HOT conditions
 - Provides conservative means for accelerated guidance development



Test Methodology

- Standard HOT testing methodology used and modified to incorporate multiple simultaneous icing conditions.
 - Fog, mist, and rain generated by NRC ceiling mounted sprayer system.
 - Snow generated from crushed ice that is sifted and dispensed.



OUTLINE

→Background and Objective

→Methodology

→Testing Results

Moderate Snow mixed with Rain

Snow mixed with Mist

Snow mixed with Freezing Fog (Type I)

Very Light or Light Snow mixed with Rain/Drizzle

→Summary and Way Forward

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Summary of Data Collected at NRC CEF

→9 testing days

→4 mixed icing combinations

→18 different conditions

→148 individual ET tests

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OUTLINE

→Background and Objective

→Methodology

→Testing Results

Moderate Snow mixed with Rain

Snow mixed with Mist

Snow mixed with Freezing Fog (Type I)

Very Light or Light Snow mixed with Rain/Drizzle

→Summary and Way Forward

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Methodology:

Mixed Moderate Rain and Moderate Snow

→No guidance for moderate intensity RASN and SNRA currently exist.

Conditions of RASN and SNRA account for approximately 10% of mixed conditions experienced in ground icing (as identified by MWG)

→Initial work in 2022-23 and 2023-24 explored different mixed conditions ratios of RASN and SNRA

RASN combinations capped at 75 g/dm²/h (based on Moderate Rain upper limit)

SNRA combinations with snow fixed at 25 g/dm²/h (based on Moderate Snow upper limit)

→2024-25 testing evaluated impact of higher rate limits (additive LWE of 100 g/dm²/h)

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Combined Results (Type II/III/IV):
Moderate Snow mixed with Rain

→Two new rate combinations + repeat tests completed in 2024-25

NEW: RA 66 + SN 30 (Heavy Rain)

NEW: RA 75 + SN 35 (Heavy Rain)

REPEATS: RA 66 + SN 30

→Most fluids outperform cold soaked wing (CSW) baseline

→Minimum performance of approx. 75% of CSW HOTs observed at several rate combinations

→Results support guidance based on 75% of a fluid's CSW HOT for Type II/III/IV fluids

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Previous Results (Type I):
Moderate Snow mixed with Rain

→Type I fluids were tested in this condition in 2022-23

→All Type I fluid tests in mixed condition outperformed the CSW baseline

→Results support guidance based on 100% of the generic CSW HOT for Type I fluids

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APSLibrary/Projects/301351 (TC Deicing 2024-25)/Reports/G & E/Final Version 1.0/Report Components/Appendices/Appendix H/Appendix H.docx
Final Version 1.0, July 26

H-78

OUTLINE

- Background and Objective
- Methodology
- **Testing Results**
 - Moderate Snow mixed with Rain
 - **Snow mixed with Mist**
 - Snow mixed with Freezing Fog (Type I)
 - Very Light or Light Snow mixed with Rain/Drizzle
- Summary and Way Forward

Methodology: Snow mixed with Mist

- "Freezing" Mist is not reported by METAR, however it can occur when mist is present at 0 °C and below.
 - No specific guidance currently exists for snow mixed with mist below 0°C
- Preliminary testing was conducted in 2023-24 to evaluate the impact of this mixed icing combination
- Additional data collected in 2024-25 to support guidance development
- Mist simulated by spraying freezing fog at a test rate of **0.4 g/dm²/h**
 - Based on principle that mist is essentially lighter fog with less visibility impact
 - Rate values in line with observations from ongoing research into deposition rates of mist

Results – Snow mixed with Mist

- Test results show that the addition of mist either had no impact or extended fluid protection times when compared to the snow-only baselines.

Temp.	Condition	Data Points	Avg. Ratio	Std. Dev.	1-Sigma	Min. Ratio
-3	SN 10 + BR 0.4	16	125%	25%	100%	100%
	SN 25 + BR 0.4	8	125%	27%	102%	100%
-14	SN 10 + BR 0.4	8	115%	14%	101%	100%
-25	SN 10 + BR 0.4	8	124%	18%	107%	105%
	All	40	124%	22%	102%	100%

Photo Example – Snow + Freezing Mist (Cont'd)

- **Why are we seeing improvements in protection time if the total LWE is higher?**
 - Plate temperature differential
 - Icing combination impacts visual appearance of fluids ("washing" of contamination)



Next Steps – Snow mixed with Mist

- Lack of observed impact on fluid performance supports treatment of freezing mist as an "obscuration" (similar to how mist is currently handled)
- Further research required to better understand reporting of mist before guidance recommendation issued
 - Feedback from MWG raised concerns that METAR reports of BR can potentially include instances of very light drizzle
- Additional analysis of operational context to follow in 2025-26 to support guidance development

OUTLINE

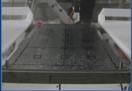
- Background and Objective
- Methodology
- **Testing Results**
 - Moderate Snow mixed with Rain
 - Snow mixed with Mist
 - **Snow mixed with Freezing Fog (Type I)**
 - Very Light or Light Snow mixed with Rain/Drizzle
- Summary and Way Forward

Type I Fluid Testing (Snow + Freezing Fog)

→ Current guidance in SN+ZF for Type I fluids is equivalent to 80% of the moderate snow HOT for Type I fluids

- Test data from previous years shows Type I SN+ZF performance generally equivalent to SN-only, some outliers at 80% of SN-only performance

Temp	Fluid	Data Points	Avg. Ratio	Std. Dev.	1-Sigma	Min. Ratio
0	Type II	2	154%	7%	147%	149%
0	Type III	2	100%	2%	98%	99%
0	Type IV FG	2	109%	2%	107%	107%
0	Type IV PG	2	138%	3%	135%	133%
0	All	8	126%	24%	102%	99%



→ Additional tests conducted in 2024-25 with modified fog rates to further characterize Type I performance

- Fog rate of 1 g/dm²/h (previously 2 g/dm²/h) used in mixed tests

Test Results – Snow + Freezing Fog (Type I)

→ The table below presents SN+ZF data collected in 2022-23, 2023-24, and 2024-25 for Type I fluids.

Temp	Data Points	Avg. Ratio	Min. Ratio	All Year Type I Data			
				Avg. Ratio	Min. Ratio	Avg. Ratio	Min. Ratio
0	24	100%	100%	100%	100%	100%	100%
-10	12	100%	100%	100%	100%	100%	100%
-20	8	100%	100%	100%	100%	100%	100%
-40	44	100%	100%	100%	100%	100%	100%

→ Type I endurance times in mixed SN/ZF are generally equivalent to moderate snow HOTs when using operationally relevant ZF rates.

→ Results support increasing ratio of mixed SN/ZF HOTs to 100% of moderate SN HOTs for Type I fluids.

OUTLINE

- Background and Objective
- Methodology
- Testing Results
 - Moderate Snow mixed with Rain
 - Snow mixed with Mist
 - Snow mixed with Freezing Fog (Type I)
 - Very Light or Light Snow mixed with Rain/Drizzle
- Summary and Way Forward

Test Objective – Very Light or Light Snow + Rain/Drizzle

→ Previous work was completed in 2008-09 for Light Snow and Rain:

- Testing consisted of a combined LWE rate of 25 g/dm²/h (Rain: 13 g/dm²/h - Snow: 12 g/dm²/h)
- Testing -SN RA was completed at +1°C, was compared to -FZRA at -3°C.

→ Guidance Published: After completing this testing, it was agreed that in conditions of light snow and rain, Light Freezing Rain HOTs can be used.

→ Why revisit previous work when the guidance has already been published?

- Recent mixed conditions testing demonstrated varying results moderate rain and snow combinations
- Decision made to repeat historical testing using modern mixed conditions testing methods

Test Results – Very Light or Light Snow + Rain/Drizzle

→ The table below provides a summary of the testing collected in 2024-25.

- Due to time constraints, only one test run was completed

→ The data suggests that use of -FZRA HOTs in conditions of Very Light or Light Snow + Rain/Drizzle is still appropriate.

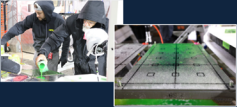
Temp	Fluid	Data Points	Avg. Ratio	Std. Dev.	1-Sigma	Min. Ratio
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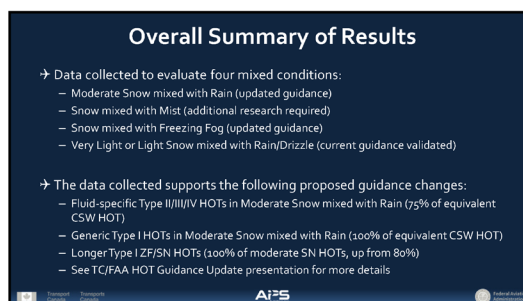
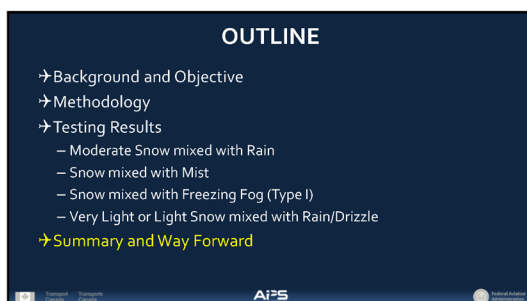
Summary – Very Light or Light Snow + Rain/Drizzle

→ The collected data supports the current guidance published in using -FZRA HOTs in conditions of Very Light or Light Snow + Rain/Drizzle.

→ Additionally, data is beneficial in preparing for future work on Light Snow mixed with Light Freezing Rain

- Currently lacks guidance, to be examined in the coming years.

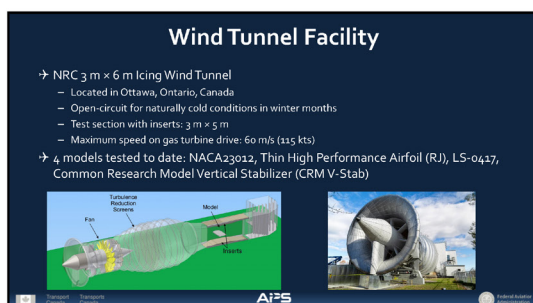
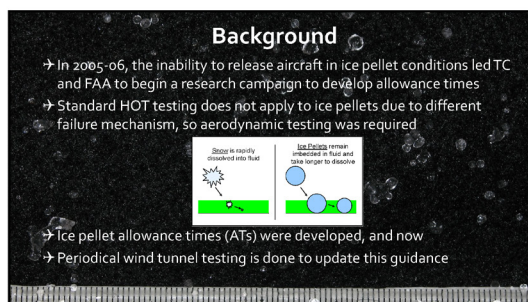
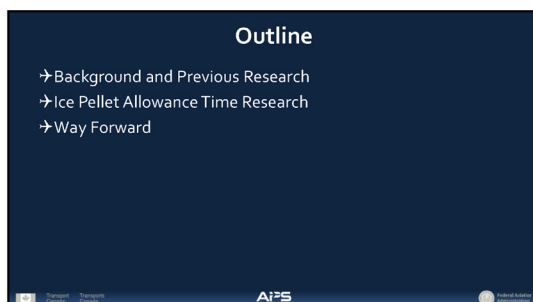
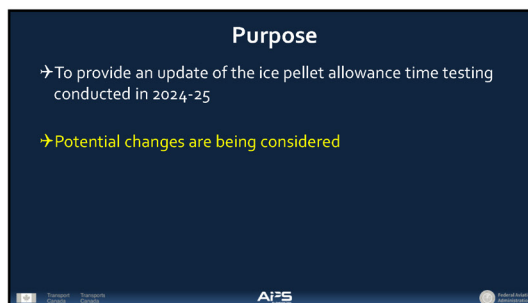
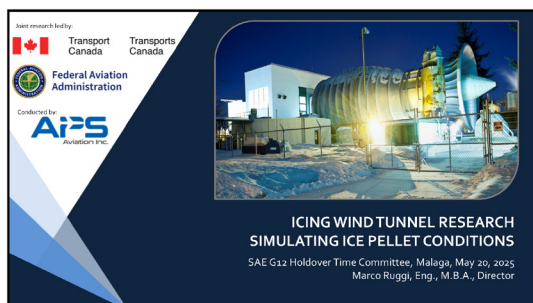


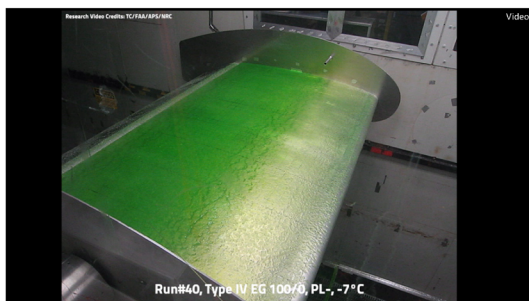


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**SAE G-12 HOLDOVER TIME (HOT) COMMITTEE MEETING, MÁLAGA,
SPAIN, MAY 2025**

**PRESENTATION:
ICING WIND TUNNEL RESEARCH SIMULATING ICE PELLET CONDITIONS**





2024-25 Summary of Test Runs

→ 10 days of RJ wing testing between Jan 12 – Jan 24, 2025

Objective #	Objective	# of Runs
1	Baseline Tests (Dry wing)	20
2	Ice Pellet Allowance Time Validation (New Fluids)	43
3	EG Fluids - Expansion of Allowance Times*	1
4	PG Fluids - Expansion of Allowance Times*	9
8	Other Exploratory Tests	3
	Total	76

*Some also served as Validation tests

APS



Validation Testing

- Ice Pellet Allowance Times are developed by testing commercially available TIII and TIV fluids
- This guidance is generic therefore more conservative to be applicable to all Type III/IV fluids on the market
- As new fluids are developed and become commercially available, they are tested against the existing ATs to validate the guidance.
- A systematic "spot checking" testing is done in order to identify any potential issues

Validation Testing Results

Fluid	Status
Chongqing Joba Chemical Co.,Ltd - FW-IV	✓ Validated
Clariant Produkte GmbH - Safewing MP IV LAUNCH PLUS	✓ Validated

Expansion of Allowance Times

Expansion of EG and PG Allowance Times

- Historically, Type IV EG and PG fluids were grouped together in the allowance time guidance, however,
- Testing indicated that each type of fluid may have longer capacities in specific conditions as compared to the other
- Glycol-specific (EG/PG) Allowance Times were first published in 2021-22
- Since then, efforts have been focused on "expanding" the allowance times in specific cells for both EG and PG fluids
 - Initial expansion was focused on EG fluids
 - Now includes PG fluids as well

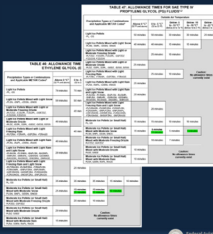
Cells in Development

- Data collected to date indicates potentials in several cells **highlighted**
- Other cells may be feasible, but may not have been tested yet
- Current testing does not target Type III fluids, or Type II (ATs don't exist)
- Testing is conducted as secondary priority, therefore data collection is slower, however
- Testing expected to continue

Other Changes to Allowance Times

Moderate Ice Pellets Mixed with Moderate Snow

- Update to allowance times is required
- New times provide better operational flexibility
- Applies to EG and PG TIV tables



APS

List of Fluids Validated for Use with ATs

- Each year all FMs are contacted for participation in the AT testing program
- The fluids listed in red will have status updated to "Fluid has not been validated"



APS

Way Forward

APS

Wind Tunnel Research Plans for 2025-26

- Ice pellet allowance time research
 - Validation with new fluids (outstanding fluids)
 - Continuation expansion testing
- Testing planned for Jan/Feb 2026



APS



**SAE G-12 AERODYNAMIC WORKING GROUP (AWG) COMMITTEE
MEETING, MÁLAGA, SPAIN, MAY 2025**

**PRESENTATION:
ALLOWANCE TIME VALIDATION TESTING – FLUID SAMPLE IMPACT ON
TEST RESULTS**

Joint research led by:
Transport Canada
Federal Aviation Administration
Conducted by:
AiPS
Aviation Inc.



**ALLOWANCE TIME VALIDATION TESTING –
Fluid Sample Impact on Test Results**

SAE G12 AWG Committee, Malaga, May 18, 2025
Marco Ruggi, Eng., M.B.A., Director

Purpose

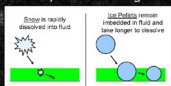
- Informational presentation to solicit some feedback and discussion from aerodynamicists and OEMs

Outline

- Background and Impacts of Research
- Failed Validation Test Results
- Way Forward

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, so aerodynamic testing was required



- Ice pellet allowance times (AT) were developed, and now
- Periodical wind tunnel testing is done to update this guidance

EVOLUTION OF TEST METHODOLOGY



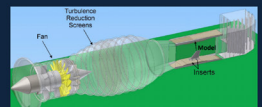
Falcon 20 testing used primarily visual observations to evaluate fluid flow-off




IWT allowed aerodynamic data to be used for evaluating fluid flow-off performance

Wind Tunnel Facility

- NRC 3 m x 6 m Icing Wind Tunnel
 - Located in Ottawa, Ontario, Canada
 - Open-circuit for naturally cold conditions in winter months
 - Test section with inserts: 3 m x 5 m
 - Maximum speed on gas turbine drive: 60 m/s (115 kts)
- 4 models tested to date: NACA 23012, RJ, LS-0417, CRM V-Stab




EVOLUTION OF ICE PELLET ALLOWANCE TIMES

The diagram illustrates the evolution of ice pellet allowance times. It shows a timeline from 2006 to 2024, with key documents and regulatory changes. A circular diagram on the right shows the progression from 10 to 15 minutes.

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

PARTICIPANTS

18 Successful Aerodynamic Testing Campaigns So Far!!!

Notable Changes to Ice Pellet Guidance Directly Resulting from Testing

→ In general, testing results in improvements to guidelines:

- More conditions added, including mixed conditions
- Longer allowance times, especially now with EG and PG tables
- Operational flexibility i.e. 90-minute rule

→ However, in other cases, testing identifies issues and requires adjustments to ensure safety in operations:

- 115 knots requirement below -10°C for PGs
- Revised/reduced allowance times based on specific fluids or types

List of Validated Fluids

→ In 2024-25 published first list of fluid validated for use with allowance times

- Maintains transparency in guidance
- FMs are accountable to have fluids tested

→ Current guidance has "two testing opportunities" grace period that will be removed for 2025-26

- TC/FAA decision to ensure fluids meet requirements
- Prudent based on some recent year results

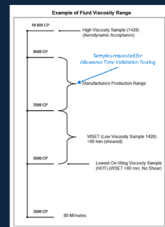
Failed Validation Results

Validating New Fluids for Use with Allowance Times

- Once commercially available, fluids must undergo ice pellet allowance time validation testing to ensure the fluid is safe to use with the published guidelines.
- Testing is conducted in a subset of conditions
 - Typically, 10 or more tests in variety of AT conditions
 - Target variety of temps and conditions (mercy of mother nature)
- The allowance times are generic, so this process is satisfactory
 - provides a “first alert” if a fluid may be underperforming
 - If issues observed, further action and testing would be required

Fluid Samples

- FMs prepare custom samples for testing, however, FMs sell within the “Manufacturers Production Range” (MPR)
 - HOT testing uses LOWV
 - WSET uses low viscosity sample
 - AS5900 Acceptance testing uses HOWV
 - AS5900 Re-Qualification testing uses MPR
 - Allowance Time Validation testing uses MPR



- Qualification and Re-qualification evaluates WSET and Aerodynamics, as a pass/fail, however
- Changes in performance (up or down) may have resulting changes in HOTs and AT

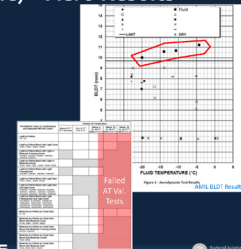
Failed Validation Test Results

- In the history of validation testing there have been 3 instances of failed validation testing
 1. Fluid A (first sample)
 2. Fluid A (second sample) - two years later
 3. Fluid B
- In all three instances, Allowance Time Validation testing (APS) identified issues and were confirmed through Aerodynamic Acceptance Test High Speed Ramp testing (AMIL)
 - These issues may not have been identified through current AMS1428 processes! (i.e. sample preparation, etc.)
 - Summary of data to follow in next slides....

Fluid A (first sample)

Fluid A (First Sample) – Aero Results

- Several WT tests failed evaluation criteria
 - Lift losses exceeded acceptance threshold $< -9^{\circ}\text{C}$
- Fluid subsequently tested for BLDT
- All 4 tests conducted did not pass BLDT
 - Other fluids tested passed
- FM submitted fluid for re-qualification



Fluid A (second sample)

Fluid A (Second Sample) – Aero Results

→ Several WT tests failed evaluation criteria

- Lift losses exceeded acceptance threshold <4°C

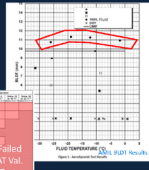
→ Fluid subsequently tested for BLDT

→ All 4 tests conducted did not pass BLDT

- Other fluids tested this year passed

→ MPR viscosity exceeded the HOWV

	Method	Pass or Fail?
Lowest Ice-Wing Viscosity Methods	1	Pass
Highest Ice-Wing Viscosity Methods	2	Fail
	3	Non-Applicable



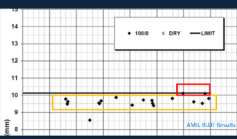


Fluid A (Second Sample) – Re-Qualification

→ Re-qualification of fluid generated results that passed, however

→ All data were very close to BLDT, and

→ 2 data points were at the limit



Fluid B

Fluid B – Aero Results

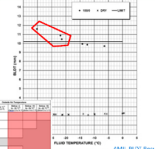
→ Several WT tests failed evaluation criteria

- Lift losses exceeded acceptance threshold <5°C

→ Fluid subsequently tested for BLDT

→ 3 tests conducted <20°C did not pass BLDT

→ Viscosity was acceptable

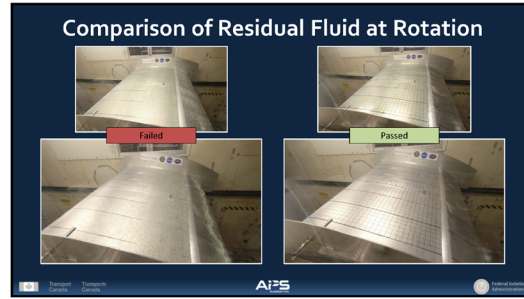
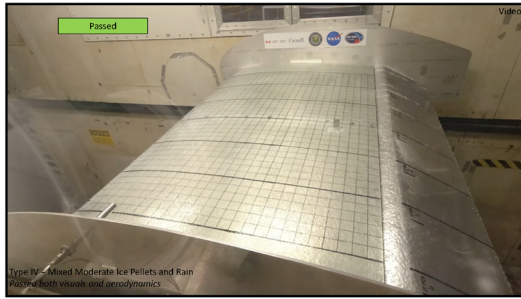






Failed

Type IV – Mixed Moderate Ice Pellets and Freezing Drizzle
Failed aerodynamically, visuals were borderline



TEST PARAMETERS

→ 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_N = Normal coefficient, C_D = Drag coefficient, α = Angle of Attack
 - Contaminated wing performance was compared to dry/clean wing performance

→ Also measured fluid brix, fluid thickness, temperature, etc.

AIPS

VISUAL CONTAMINATION RATINGS

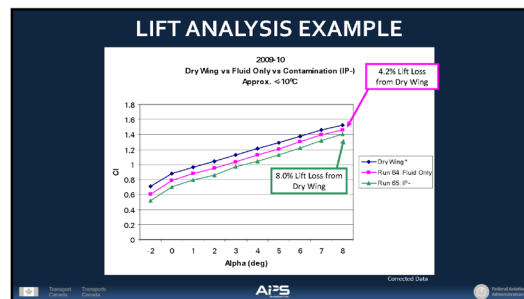
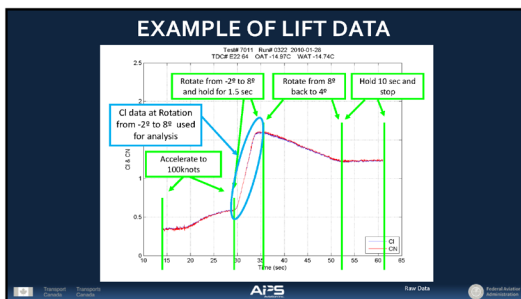
R=1, R=2, R=3, R=4, R=5, R > 1.3

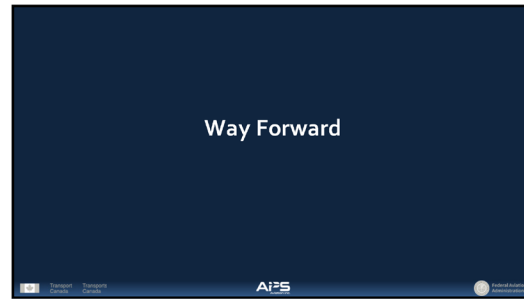
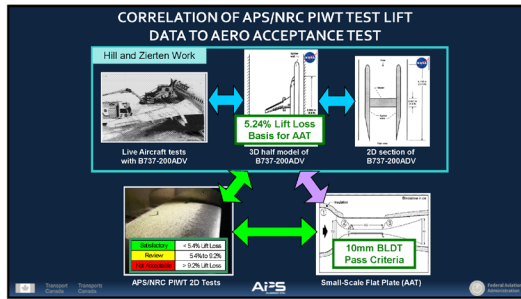
PRIOR TO TAKEOFF

AT ROTATION

Ratings assigned by experienced observers.
Rating system proved to be well repeatable.

AIPS





Status of Fluid A and B

- TC and FAA have been working with FMs to ensure appropriate action is being taken regarding fluids in question
- Fluids A and B were both commercially available at the time of testing

This slide is titled "Status of Fluid A and B" and contains two bullet points. It also features the APS logo at the bottom.

MPR vs. LOWV vs. HOWV

- LOWV and HOWV are typically artificially created samples
- Do the current testing criteria still correctly characterize the fluids performance?
- Open discussion....

This slide is titled "MPR vs. LOWV vs. HOWV" and contains three bullet points. It includes an icon of a person thinking and the APS logo at the bottom.

