TP 14375E

Winter Weather Impact on Holdover Time Table Format (1995-2004)

Prepared by

APS Aviation Inc.

Prepared for
Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

December 2004
Final Version 1.0

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By:

Nicoara Moc

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Program Manager

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Date

Un sommaire français se trouve avant la table des matières.

PREFACE

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

- To develop holdover time data for all newly-qualified de/anti-icing fluids;
- To evaluate weather data from previous winters to establish a range of conditions suitable for the evaluation of holdover time limits;
- To compare endurance times from natural snow with those generated from simulations of laboratory snow;
- To compare fluid endurance time, holdover time and protection time;
- To compare snowfall rates obtained with a real-time snow precipitation gauge with rates obtained using rate pans;
- To further develop and to assist with the commercialization of Type III fluids;
- To develop a test procedure for evaluating forced-air assist systems;
- To conduct general and exploratory de/anti-icing research; and
- To evaluate the possibility of using a fluid failure sensor in holdover time testing.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2003-04 are documented in nine reports. The titles of the reports are as follows:

- TP 14374E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2003-04 Winter;
- TP 14375E Winter Weather Impact on Holdover Time Table Format (1995-2004);
- TP 14376E Endurance Time Testing in Snow: Comparison of Indoor and Outdoor Data for 2003-04;
- TP 14377E Adhesion of Aircraft Anti-Icing Fluids on Aluminum Surfaces: Phase II;
- TP 14378E Evaluation of a Real-Time Snow Precipitation Gauge for Aircraft Deicing Operations (2003-04);
- TP 14379E Development of Holdover Time Guidelines for Type III Fluids;
- TP 14380E A Protocol for Testing Fluids Applied with Forced Air Systems;
- TP 14381E Aircraft Ground Icing General and Exploratory Research Activities for the 2003-04 Winter; and
- TP 14382E A Sensor for Detecting Anti-Icing Fluid Failure: Phase I.

In addition, an interim report entitled *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions* (TP 14383E) has been drafted.

This report, TP 14375E, has the following objective:

- To review the Holdover Time Table format using Winter Weather Data.

This objective was met by acquiring and analysing winter weather data from six meteorological stations in Quebec, Canada, along with the findings from a survey of deicing operations from several major airports across the world. This information was used to review and assess the format of the holdover time tables.

ACKNOWLEDGEMENTS

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

APS would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Stephanie Bendickson, Nicolas Blais, Richard Campbell, Michael Chaput, Sami Chebil, John D'Avirro, Peter Dawson, Marco Di Zazzo, Miljana Horvat, Mark Mayodon, Chris McCormack, Nicoara Moc, Catalin Palamaru, Filomeno Pepe, Marco Ruggi, Joey Tiano, Kim Vepsa, and David Youssef.

Special thanks are extended to Barry Myers, Frank Eyre and Yagusha Bodnar, who on behalf of the Transportation Development Centre, have participated, contributed and provided guidance in the preparation of these documents.

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Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre (TDC). Nine reports (including this one) were produced as part of this winter's research program. Their subject matter is outlined in the preface.

16. Abstract

This study examines the frequency of occurrence of the various winter weather conditions experienced during ground deicing of aircraft with a view to recommending and supporting immediate and future changes to the format of the holdover time tables for SAE Type I, II and IV anti-icing fluids.

Data were acquired from Meteorological Service of Canada (MSC) for six automated weather stations in the province of Quebec, Canada. A total of 5 635 hours of snowstorm data recorded between 1995-96 and 2003-04 and 428 hours of freezing rain and freezing drizzle data were analysed. The data set included 796 hours of snowstorm data from the 2003-04 winter.

In addition, data from surveys of winter operations conducted at several international airports over a three-year period was used to report the frequency of snow, frost, freezing fog, freezing rain/drizzle and cold-soak wing de/anti-icing occurrences during actual deicing operations.

This report contains recommendations to continue the surveys.

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Plusieurs rapports de recherche d'années antérieures sur les essais de technologies de dégivrage et d'antigivrage ont été produits pour le compte de Transports Canada. Ils sont disponibles du Centre de développement des transports (CDT). Le programme de la saison hivernale a donné lieu à neuf rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports.

16. Résumé

La présente étude examine la fréquence des différents événements météorologiques hivernaux qui se produisent durant le dégivrage d'aéronefs au sol, dans le but de recommander et d'appuyer des changements immédiats et futurs au format des tableaux d'efficacité des liquides d'antigivrage de types I, II et IV de la SAE.

Les données, obtenues auprès du Service météorologique du Canada (SMC), provenaient de six stations météorologiques automatisées situées au Québec, Canada. Un total de 5 635 heures de données de précipitations neigeuses, enregistrées entre 1995-96 et 2003-04, et plus de 428 heures de données de pluie verglaçante, ont été analysées. Sont comprises dans l'ensemble de données plus de 796 heures de données de précipitations neigeuses recueillies au cours de l'hiver 2003-04.

De plus, les données des études sur les opérations hivernales menées à plusieurs aéroports internationaux sur une période de trois ans ont servi à signaler la fréquence d'événements de dégivrage ou d'antigivrage dans la neige, le givre, le brouillard verglaçant, la pluie ou la bruine verglaçantes et dans le cas d'aile imprégnée de froid.

Ce rapport comprend des recommandations afin de faire suite aux enquêtes.

17. Mots clés Neige naturelle, taux de précipitation, données météorologiques, tableau de durées d'efficacité, fréquence et répartition des opérations de dégivrage.	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre (TDC) of Transport Canada (TC), APS Aviation Inc. (APS) undertook a study to evaluate precipitation data (precipitation rate/temperature data) from several winters to confirm the suitability of precipitation rate ranges used for holdover time evaluation.

In addition, information collected from other research that relates to winter weather data has been compiled and is included in this report.

The information contained in this report can be used to further evaluate potential refinements to the format of the holdover time (HOT) tables.

Description and Processing of Data

A total of 5 635 hours of storm data points was developed from precipitation gauge logs for natural snow, including 796 hours from the 2003-04 data. Freezing rain/drizzle precipitation events were used to develop 428 hours of data. Data were acquired from Meteorological Service of Canada (MSC) from instruments located at Montreal's Trudeau Airport and five other stations in the province of Quebec, Canada. The data were collected mostly from the winters of 1997-98 to 2003-04.

In addition, the results from a survey of deicing operations at worldwide airports were analysed and used to recommend improvements to the HOT tables.

Results and Conclusions

The weather database gathered over eight years from six sites in Quebec showed that current snow precipitation rate limits of 10 and 25 g/dm^2/h are valid for moderate snow. The data analysis concluded that the column representing moderate snow in the HOT table encompasses only 24 percent of all snow events. This supports earlier data that led to the introduction of a light snow column in the Type I HOT table for precipitation rates of 4 to 10 g/dm^2/h. This column was used during the 2002-03 and 2003-04 winter seasons.

Most snowfall events occur at rates less than 4 g/dm^2/h. In order to use longer holdover times in the light snow column, and because snow comprises 56 percent of all deicing operations, further introduction of a very light snow column in the HOT table was recommended and accepted at the 2003 SAE G-12 meeting.

At the meeting, it was concluded for the Type I HOT table that the temperature row of *-3 to -10°C* should be replaced by two new temperature bands, *below -3 to -6ºC* and *below -6 to -10°C*. Selection of -6ºC as the temperature break was found to be the most operationally advantageous. The format of the Type II/IV HOT tables should be examined to integrate the Type I table changes, including removal of the above 0ºC row and introduction of additional snow columns for precipitation rates lower than 10 g/dm²/h.

The survey of actual winter operations showed that the HOT table columns for snow are given the most frequent use, and thus deserve a corresponding degree of attention. Development of snowmakers to allow snow endurance time testing in controlled laboratory conditions is an important part of this effort.

Frost is the second most frequent type of deicing condition, and sufficient attention should be given to investigating and substantiating frost holdover times, particularly for Type I fluids.

The limited database for freezing rain and drizzle indicates that the current temperature and rate limits for those conditions are valid. However, the database for these conditions is small and additional data would be useful.

The freezing fog columns in the HOT table are used less than 3 percent of the time. Modifying the HOT table column for freezing fog to a single value rather than a range would be justified, based on lengthy endurance times and infrequency of use.

Recommendations

The weather data survey and the winter operations survey have provided useful information and should be continued to generate more data, and expanded to include more cities worldwide. A workgroup should be assembled to examine and formulate the optimum format for HOT tables and to document a generic HOT table format in an Aerospace Standard as discussed at the SAE G-12 HOT Committee.

SOMMAIRE

En vertu d'un contrat avec le Centre de développement des transports (TDC) de Transports Canada (TC), APS Aviation Inc. (APS) a entrepris une étude pour évaluer les données de précipitation (données sur les taux et températures des précipitations) de plusieurs hivers, afin de confirmer la pertinence des plages de taux de précipitation utilisées pour l'évaluation des durées d'efficacité.

De plus, le présent rapport englobe aussi des données colligées à l'occasion d'autres recherches connexes.

L'information contenue dans ce rapport peut servir à évaluer la pertinence d'améliorations possibles à la présentation des tableaux des durées d'efficacité.

Description et traitement des données

Des points de données de précipitations neigeuses ont été établis à partir de relevés nivométriques couvrant un total de 5 635 heures, dont 796 heures pendant l'hiver 2003-04. Des périodes de précipitation de pluie/bruine verglaçante ont servi à générer des points de données couvrant plus de 428 heures. Ces données, obtenues auprès du Service météorologique du Canada (SMC), provenaient d'instruments situés à l'Aéroport Pierre-Elliott-Trudeau, Montréal et de cinq autres stations du Québec, Canada. Les données ne couvraient que les hivers 1997-1998 à 2003-04.

De plus, les résultats d'une enquête sur les opérations de dégivrage à des aéroports à travers le monde ont été analysés et ont servi à recommander des améliorations aux tableaux de durées d'efficacité.

Résultats et conclusions

La base de données météorologiques recueillie au cours de huit ans sur six emplacements du Québec a démontré que les limites actuelles de taux de précipitation de neige de 10 et 25 g/dm^2/h sont valides dans le cas de neige modérée. L'analyse des données a conclu que la colonne du tableau actuel de durées d'efficacité qui illustre la neige modérée ne couvre que 24 pourcent de tous les événements de neige. Cette analyse confirme les données précédentes qui ont mené à l'introduction d'une colonne de neige légère dans le tableau de durées d'efficacité des liquides de type I, pour les taux de précipitation de 4 à 10 g/dm^2/h. Cette colonne a servi durant les hivers 2002-03 et 2003-04.

La plupart des chutes de neige se produisent à un taux inférieur à 4 g/dm^2/h. Afin d'utiliser des durées d'efficacité plus longues dans la colonne de neige légère et parce que la neige compte pour 56 pourcent de toutes les opérations de dégivrage, l'introduction additionnelle d'une colonne de neige très légère au tableau des durées d'efficacité a été recommandée et acceptée à la réunion de 2003 du G–12 de la SAE.

À cette rencontre, l'analyse a conclu que, pour le tableau de durées d'efficacité des liquides de type I, la rangée des températures de *-3 à -10ºC* devrait être retirée et remplacée par deux nouvelles rangées, *au-dessous de -3 à -6ºC* et *au-dessous de -6 à -10ºC*. Le choix de -6ºC comme température limite produit le mélange de durées d'efficacité le plus avantageux du point de vue opérationnel. Le format des tableaux de durées d'efficacité des liquides de types II et IV devrait être examiné en vue d'y intégrer les changements au tableau de type I, y compris le retrait de la rangée de températures au-dessus de 0ºC et l'introduction de colonnes de neige additionnelles pour les taux de précipitation inférieurs à 10 g/dm^2/h.

L'enquête sur les opérations hivernales réelles a démontré que le tableau de durées d'efficacité applicable à la neige est le plus utilisé et, en conséquence, mérite une attention équivalente. Le développement de canon à neige qui permet des essais de durée d'efficacité dans la neige dans des conditions contrôlées en laboratoire, représente une partie importante de cet effort.

Le givre est deuxième en importance parmi les conditions de dégivrage et suffisamment d'attention devrait être portée à l'étude et à la justification des durées d'efficacité dans le givre, en particulier pour les liquides de type I.

La base de données limitée sur la pluie et la bruine verglaçantes démontre que les limites actuelles de température et de taux sont valides dans ces conditions. Cependant, cette base de données est petite et des données additionnelles seraient utiles.

Les colonnes de brouillard verglaçant du tableau de durées d'efficacité ne sont utilisées que moins de 3 pourcent du temps. La modification pour une seule valeur plutôt que pour plusieurs de la colonne du tableau de durées d'efficacité applicable au brouillard verglaçant serait justifiée, étant donné les longues durées d'efficacité et l'usage peu fréquent.

Recommandations

L'étude sur les données météorologiques et l'étude sur les opérations hivernales ont produit de l'information utile et devraient être poursuivies pour générer davantage de données. Elles devraient aussi être étendues à plus de villes à l'international. Un groupe de travail devrait être créé pour examiner et élaborer le format optimal des tableaux de durées d'efficacités, ainsi que pour documenter un format de tableau générique de durées d'efficacité sous forme de Standard aéronautique, tel que discuté au comité G–12 de la SAE sur les durées d'efficacité.

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GLOSSARY

ADM	Aéroports de Montréal
APS	APS Aviation Inc.
FAA	Federal Aviation Administration
HOT	Holdover Time
MSC	Meteorological Service of Canada
OAT	Outside Air Temperature
READAC	Remote Environmental Automatic Data Acquisition Concept
RH	Relative Humidity
TC	Transport Canada
TDC	Transportation Development Centre

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1. INTRODUCTION

Under contract to the Transportation Development Centre (TDC) of Transport Canada (TC), APS Aviation Inc. (APS) undertook a study to advance de/anti-icing technology. This report contains the results of an analysis conducted by APS between 1995-96 and 2003-04 on the evaluation of precipitation rate data. It also encompasses all the data presented in the 2002-03 TC report, TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, (1). This study formed part of the 2003-04 winter research program on deicing. The project is described in the work statement presented as Appendix A.

Holdover time (HOT) tables are developed as guidelines to be used by pilots in aircraft departure planning under different winter weather conditions. Each HOT table is composed of cells, with each cell containing a holdover time range for a specific temperature range and category of precipitation. The time range in each cell is defined by a "lower" time and an "upper" time; these values represent the failure time of the fluid at the upper and lower precipitation rate range, respectively.

There are three standard types of fluid: Type I, Type II, and Type IV. A Type III de/anti-icing fluid designed for aircraft with lower rotation speeds and shorter takeoff rolls has been developed but has yet to be tested for endurance times. Aircraft are deiced using heated Type I fluids. Type II and Type IV fluids are anti-icing fluids that are applied following aircraft deicing, with Type II fluids being thicker and more viscous than Type I fluids. Type IV fluids are designed to provide the utmost in holdover time protection.

The Type I and Type II/IV HOT table formats have undergone significant change since the early 1990s. While the changes have been made primarily to improve and address safety concerns of many individuals and organizations involved in the deicing industry, a structured approach has not been taken for implementing changes. In fact, many of the changes have been made on a year-by-year basis at industry meetings. These changes were typically minor in nature, but after nearly ten years, the impact on the HOTs is more significant. More recently, several changes have been made to improve and simplify the tables, while simultaneously ensuring that a high level of safety is maintained when the tables are put to use. Proposals for changes to the HOT tables have been made by TC, and these include new temperature breakdowns to better reflect winter precipitation conditions, expansion of the snow column to reflect its high usage, and removal of unnecessary HOT ranges in certain columns to result in a single value. To substantiate these changes, a survey of airlines at several international airports was conducted. The survey provided information relating to the frequency of deicing operations as a function of weather condition and temperature.

Several years ago, holdover times for snow were evaluated or developed using lower and upper precipitation rates of 10 and 25 g/dm²/h for all air temperatures (0, -3, -14 and -25°C). Initially it was believed that precipitation rates of 10 to 25 g/dm²/h do not occur below -14°C. The data collected demonstrated that such high precipitation rates, although they do exist, are less frequent at these lower temperatures. As a result, it was concluded that the holdover time rate limits of 10 and 25 g/dm²/h are representative of natural snow conditions and need to be maintained.

Between 2000-01 and 2001-02, a winter operations survey conducted by TC concluded that, for the reporting centres, the distribution of types of deicing operations was:

a) Snow 52 percent;
b) Frost 38 percent; and
c) Other 10 percent.

The *other* category consisted of freezing rain, freezing drizzle, freezing fog, cold-soaked wing and rime ice.

The main purposes of this study were to:

a) Further evaluate weather precipitation data (precipitation rate/temperature data) over several recent winters and substantiate the suitability of proposed data ranges for the evaluation of upper and lower holdover time limits; and
b) Review the surveys of winter weather data and apply them to evaluate the format of the HOT tables.

The following section of this report (Section 2) analyses the natural snow and freezing rain/drizzle data collected in 2003-04 from six stations in Quebec and provides, in conjunction with data from eight previous winter seasons, a distribution of precipitation events by temperature and precipitation rate. Section 3 reviews the operations survey data collected in 2000-01, 2001-02 and 2002-03, and presents an allocation of deicing operations worldwide based on 3 years of observation. Section 4 refers to an analysis done in 2003 to substantiate the current and proposed changes to the format of the HOT tables. Section 5 presents a brief summary of the frost deposition rates measured in natural conditions. The conclusions and recommendations are presented in Sections 6 and 7 of this report.

1.1 Special Credits and Acknowledgements

The author of this report would like to acknowledge and thank the Meteorological Service of Canada (MSC) for their diligence and commitment in providing all weather data required for this project.

The author would also like to acknowledge and thank all participating deicing service providers and airlines that provided information with respect to the survey of operations over the last three years.

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2. DESCRIPTION AND ANALYSIS OF NATURAL SNOW AND FREEZING RAIN/DRIZZLE DATA

2.1 Methodology

This section describes the methods used to evaluate weather data that were collected to study the occurrence of high precipitation rates at low temperatures for natural snow and freezing rain/drizzle.

2.1.1 Sources of Data and Test Sites

The precipitation rates analysed in this report were extracted from the following:

a) The Dorval Remote Environmental Automatic Data Acquisition Concept (READAC) log for the years 1995 to 1999;
b) The data logs from 1998 to 2004 for the three CR21X stations at Rouyn, Pointe-au-Père (Mont-Joli), and Ancienne Lorette (Quebec City);
c) The data log from the Trudeau Airport CR21X station from 1998 to 2004; and
d) The data logs for 2000 to 2004 from two additional stations located in High Falls (near Ottawa, Ontario) and Frelighsburg (in Quebec's Eastern Townships).

The data collected by APS from various sources extending back to the 1991-92 winter season, using different precipitation gauges, are shown in Table 2.1. Each site is identified on a map of Quebec, shown in Figure 2.1. The data, starting with the 1995-96 winter season, analysed and sorted by temperature ranges, are included in Appendix B.

Two similar studies were conducted. One study was conducted by APS in the 1993-94 to 1994-95 winters using data collected from three weather stations located around Montreal. Meteorological Service of Canada (MSC) carried out a similar study in 1995 using data collected at the Lester B. Pearson International Airport in Toronto. Overall, the datasets from MSC and APS were found to be similar enough to merit a comparison for temperature ranges above -7°C. Below that temperature, the MSC data contains no high rate precipitation points. These two studies can be found in Appendices C and D of TC report TP 13993E*, Impact of Winter Weather on Holdover Time Table Format (1995-2002)*, (2).

Table 2.1: Summary of Winter Weather Data

PROJECT #	YEAR	PLATE PAN	READAC YUL	CR21X						CITY OF MONTREAL (Fisher/Porter)	OMBROMETER THIES	TIPPING BUCKET	YYZ
				WUY (Rouyn)	WTQ (Dorval)	WQB (Québec)	WYQ (Pointe-au-Père)	WFQ (Frelighsburg)	XHF (High Falls)				
	1990/91	Test period										X(3)	
	1991/92	Test period								X(6)	X(3)		
	1992/93	Test period								X(6)	X(3)		
C1171	1993/94	Test period								X(1) (Three stations)	X(3) (Shielded)		
CM1222	1994/95	Test period	X(1)										
CM1283	1995/96	15 min	X(2)										X(4)
CM1338	1996/97	15 min	X(2)		X(5)								X(4)
CM1380	1997/98	5-15 min	X(2)	X(2)	X(2)	X(2)	X(2)						
CM1514	1998/99	5-15 min	X(2)	X(2)	X(2)	X(2)	X(2)						
CM1589	1999/00	5-15 min		X(2)	X(5)	X(2)	X(2)	X(2)	X(2)				
CM1680	2000/01	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1680(01-02)	2001/02	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1747	2002/03	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				
CM1892	2003/04	5-15 min		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)				

(1) Data analysed for Transport Canada in 1996.

(2) Data used for this report.

(3) Unusable data - precipitation rate determined by this gauge was always lower than other instruments.

(4) Analysis completed by AES at YYZ.

(5) Unusable data - scattered data (gauge was not shielded).

(6) Data archived.

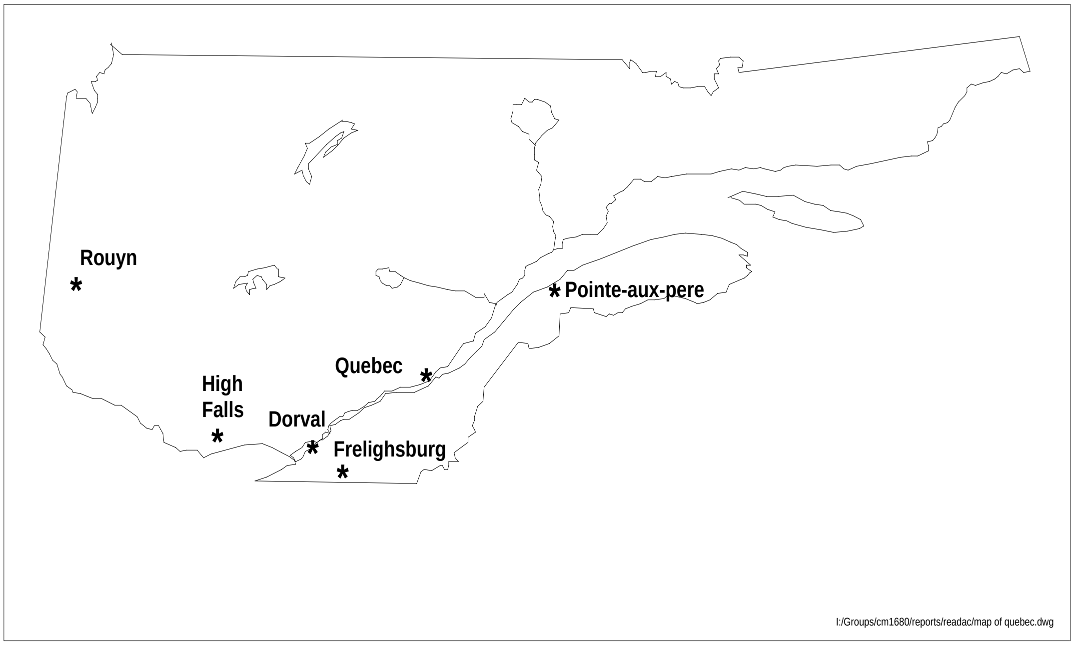

Figure 2.1: Map of Precipitation Gauge Locations

2.1.2 Equipment

Over the years, both the READAC and CR21X stations were used to measure precipitation rates. Starting with the 2003-04 winter, the use of the READAC equipment at Trudeau Airport was discontinued by MSC. The READAC precipitation gauge consists of a bucket partially filled with an antifreeze compound so that it effectively captures snow. A weighing transducer shaft provides instantaneous displacement values of the bucket in terms of millimetres of precipitation. This shaft displacement is transmitted every 2.5 seconds and averaged every minute in an attempt to eliminate spurious data caused by gusts of wind and temperature-induced contraction and expansion of the sensor. The READAC instrument has a resolution of 0.5 mm (5 g/dm²).

The CR21X station operates on the same principle as the READAC station and has an accuracy of 0.1 mm (1 g/dm²). The station measures precipitation with a Fisher Porter precipitation gauge and the readings are logged with a CR21X data logger. A more detailed description of the CR21X equipment can be found in Appendix C.

Precipitation rates tend to fluctuate rapidly during snowstorms. The weight resolution of the READAC stations is less accurate in measuring rapid changes compared to the CR21X station. The data from the CR21X station therefore required less smoothing before it could be interpreted. The increased resolution of the CR21X weighing transducer allows better observation of short periods with heavy precipitation.

For this project, the measuring instruments used to record weather precipitation data were owned and operated by MSC, and these instruments were calibrated according to their standards. The data were acquired for the purpose of this project.

2.1.3 Description of Analytical Methods

Precipitation rate data were averaged at intervals that correspond to three specified periods typically used in the HOT tables: 6 minutes for Type I fluids, 20 minutes for Type II fluids, and 35 minutes for Type IV fluids. For natural snow, data were classified into four temperature ranges: *above 0°C*, *0 to -3°C*, *-3 to -14°C* and *-14 to -25°C*. For freezing rain/drizzle, data were classified into two ranges: *0 to -3°C* and *-3 to -10°C*.

Snowfalls at Dorval were tracked from 1995 to 2004 using the Monthly Meteorological Data Summary provided by MSC. This summary includes meteorological data such as temperature, wind speed and direction, dew point temperature, and humidity on an hourly basis, and precipitation type and total accumulation on a daily basis. An example of the Monthly Meteorological Summary for Montreal is included in Appendix D. The last page of the summary (D-6) states whether it snowed on a particular day and the first page (D-1) provides the total snow accumulation for each day. Based on this information, the precipitation and temperature data were extracted from READAC logs on a minute-by-minute basis and added to a database. The CR21X data were treated in a similar way.

Periods of snowfall were identified using Environment Canada summaries and snow accumulation data were added to the database along with ambient air temperatures. The six CR21X data loggers (at Rouyn, Pointe-au-Père, Ancienne Lorette, Dorval, High Falls, and Frelighsburg) provided temperatures on an hourly basis. The temperatures were then linearly interpolated throughout the hour on a minute-by-minute basis.

2.1.4 Linearization of Cumulative Snow Weight Data

Precipitation rates were calculated in a two-step procedure.

First, using an algorithm developed by APS, the total precipitation for each snowfall was linearized to produce a smooth curve. Figure 2.2 shows an example of linearized values for total snow accumulation.

Secondly, precipitation rates were calculated according to the linearized total snow accumulation values and the time between readings. This procedure is described in Section 2.3.

Using an algorithm developed by APS, the total precipitation for each snowfall was linearized to produce a smooth curve. Table 2.2 shows an example of how the algorithm linearizes data. Figure 2.2 shows an output from the CR21X data logger recording the output from the precipitation gauges and the linearized data for a typical snowfall. The precipitation gauge output, sensitive to 1 g/dm², is plotted versus time to establish the periods of snowfalls.

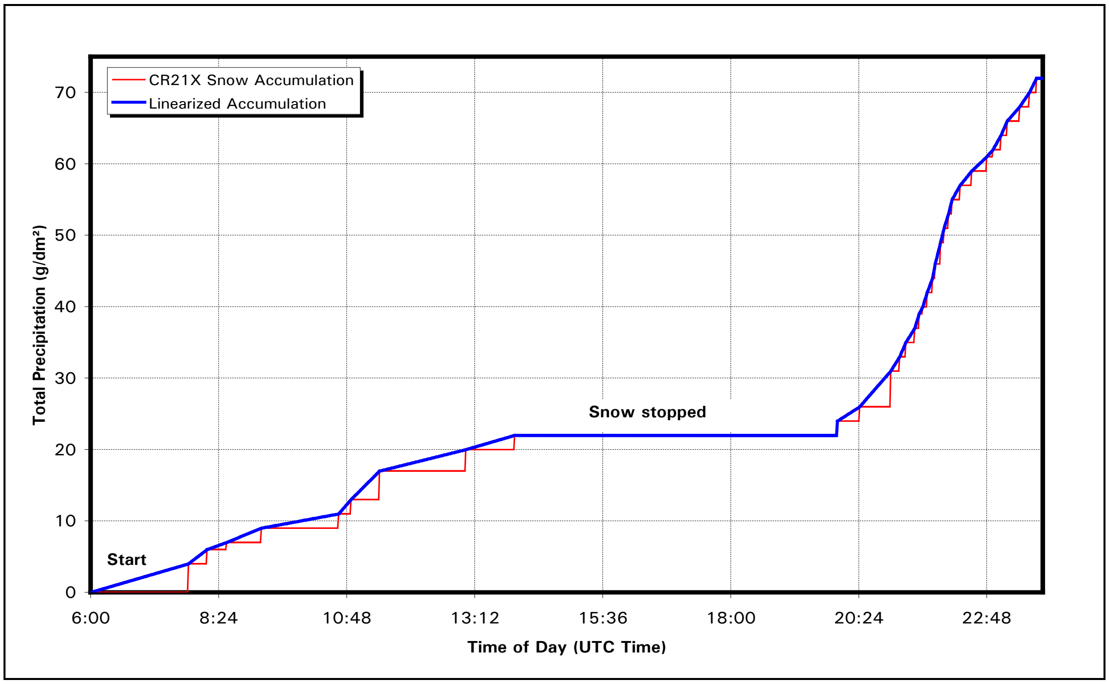

Figure 2.2: CR21X Precipitation Gauge Cumulative and Linearized Precipitation

As seen in Figure 2.2, intervals when snowfalls were interrupted for long periods of time were excluded from the analysis. Subsequent snowfalls were treated in a similar manner. The first and last indications of snowfall (first and last 1 g/dm²) were excluded due to uncertainty about the precise start and end time of the snowfall.

Table 2.2: Sample of Linearized READAC Data

Location	Date	UTC Time	Temp (°C)	Type of Precip.	Total Snow Accumulation (g/dm²)	Linearized Total Snow Accumulation (g/dm²)
YUL	14/12/1995	21:16	-11.8	S-	**40**	**40**
YUL	14/12/1995	21:17	-11.7	S-	**40**	**40.16**
YUL	14/12/1995	21:18	-11.6	S-	**40**	**40.31**
YUL	14/12/1995	21:19	-11.6	S-	**40**	**40.47**
YUL	14/12/1995	21:20	-11.6	S-	**40**	**40.63**
YUL	14/12/1995	21:21	-11.6	S-	**40**	**40.78**
YUL	14/12/1995	21:22	-11.6	S-	**40**	**40.94**
YUL	14/12/1995	21:23	-11.5	S-	**40**	**41.09**
YUL	14/12/1995	21:24	-11.6	S-	**40**	**41.25**
YUL	14/12/1995	21:25	-11.6	S-	**40**	**41.41**
YUL	14/12/1995	21:26	-11.4	S-	**40**	**41.56**
YUL	14/12/1995	21:27	-11.4	S-	**40**	**41.72**
YUL	14/12/1995	21:28	-11.5	S-	**40**	**41.88**
YUL	14/12/1995	21:29	-11.5	S-	**40**	**42.03**
YUL	14/12/1995	21:30	-11.4	S-	**40**	**42.19**
YUL	14/12/1995	21:31	-11.4	S-	**40**	**42.34**
YUL	14/12/1995	21:32	-11.4	S-	**40**	**42.50**
YUL	14/12/1995	21:33	-11.4	S-	**40**	**42.66**
YUL	14/12/1995	21:34	-11.4	S-	**40**	**42.81**
YUL	14/12/1995	21:35	-11.4	S-	**40**	**42.97**
YUL	14/12/1995	21:36	-11.3	S-	**40**	**43.13**
YUL	14/12/1995	21:37	-11.3	S-	**40**	**43.28**
YUL	14/12/1995	21:38	-11.4	S-	**40**	**43.44**
YUL	14/12/1995	21:39	-11.4	S-	**40**	**43.59**
YUL	14/12/1995	21:40	-11.3	S-	**40**	**43.75**
YUL	14/12/1995	21:41	-11.3	S-	**40**	**43.91**
YUL	14/12/1995	21:42	-11.3	S-	**40**	**44.06**
YUL	14/12/1995	21:43	-11.3	S-	**40**	**44.22**
YUL	14/12/1995	21:44	-11.2	S-	**40**	**44.38**
YUL	14/12/1995	21:45	-11.2	S-	**40**	**44.53**
YUL	14/12/1995	21:46	-11.2	S-	**40**	**44.69**
YUL	14/12/1995	21:47	-11.2	S-	**40**	**44.84**
YUL	14/12/1995	21:48	-11.2	S-	**45**	**45.00**
YUL	14/12/1995	21:49	-11.2	S-	**45**	**45.29**
YUL	14/12/1995	21:50	-11.2	S-	**45**	**45.59**
YUL	14/12/1995	21:51	-11.2	S-	**45**	**45.88**
YUL	14/12/1995	21:52	-11.1	S-	**45**	**46.18**
YUL	14/12/1995	21:53	-11.1	S-	**45**	**46.47**
YUL	14/12/1995	21:54	-11.1	S-	**45**	**46.76**
YUL	14/12/1995	21:55	-11.1	S-	**45**	**47.06**
YUL	14/12/1995	21:56	-11.1	S-	**45**	**47.35**
YUL	14/12/1995	21:57	-11.1	S-	**45**	**47.65**
YUL	14/12/1995	21:58	-11.1	S-	**45**	**47.94**
YUL	14/12/1995	21:59	-11.0	S-	**45**	**48.24**
YUL	14/12/1995	22:00	-11.0	S-	**45**	**48.53**
YUL	14/12/1995	22:01	-11.0	S-	**45**	**48.82**
YUL	14/12/1995	22:02	-11.0	S-	**45**	**49.12**
YUL	14/12/1995	22:03	-11.0	S-	**45**	**49.41**
YUL	14/12/1995	22:04	-10.9	S-	**45**	**49.71**
YUL	14/12/1995	22:05	-10.8	S-	**50**	**50.00**

2.2 Description and Processing of Natural Snow and Freezing Rain/Drizzle Data

2.2.1 Natural Snow

Using the information provided in the monthly meteorological summaries by MSC for each of the six weather stations across Quebec, the amount of snow during the 2003-04 winter was compared with Quebec's accumulation over the last 30 years. The period of time used to evaluate the quantity of snow precipitation was from November 2003 to April 2004. It was concluded that the 2003-04 winter had, on average, snow accumulation lower than Quebec's average over the last 30 years. For the six monitored meteorological stations in Quebec, the quantity of snow in cm/year is shown in Table 2.3.

Table 2.3: Snow Accumulation

	WEATHER STATION					
	Frelighsburg	**Quebec City**	**Montreal**	**Rouyn Noranda**	**Mont-Joli**	**High Falls**
Average Snow Accumulation (cm/year)	–	353	220	–	355	231
2003-04 Winter Snow Accumulation (cm)	–	284	154	228	276	168

During the 2003-04 winter season, 47 779 data points were collected for natural snow conditions at six stations in Quebec. These represent 796 hours of snowfall and an average of approximately 133 hours of snowfall at each station. More data were usable from 2003-04 winter than in past winters due to improvements in the CR21X stations.

The distribution of the 2003-04 data points across the six meteorological stations is summarized in Table 2.4.

Table 2.4: Distribution of 2003-04 Snow Data Points by Station

Station	# of Data Points	%
Frelighsburg	7 941	17
Quebec	7 470	16
Montreal	5 331	11
Rouyn Noranda	10 879	22
Mont-Joli	9 485	20
High Falls	6 673	14
Total	**47 779**	**100**

The distribution of new data points from all stations, sorted by temperature, is listed in Table 2.5.

The distribution of data points for 2003-04, by temperature and in histogram format is shown in Figure 2.3.

Table 2.5: Distribution of 2003-04 Snow Data Points by Temperature

Temperature Range	# of Data Points
Above 0°C	8 202
Between 0 and -3°C	13 326
Between -3 and -6°C	11 241
Between -6 and -10°C	94 28
Between -10 and -14°C	3 408
Between -14 and -25°C	2 174
Total	**47 779**

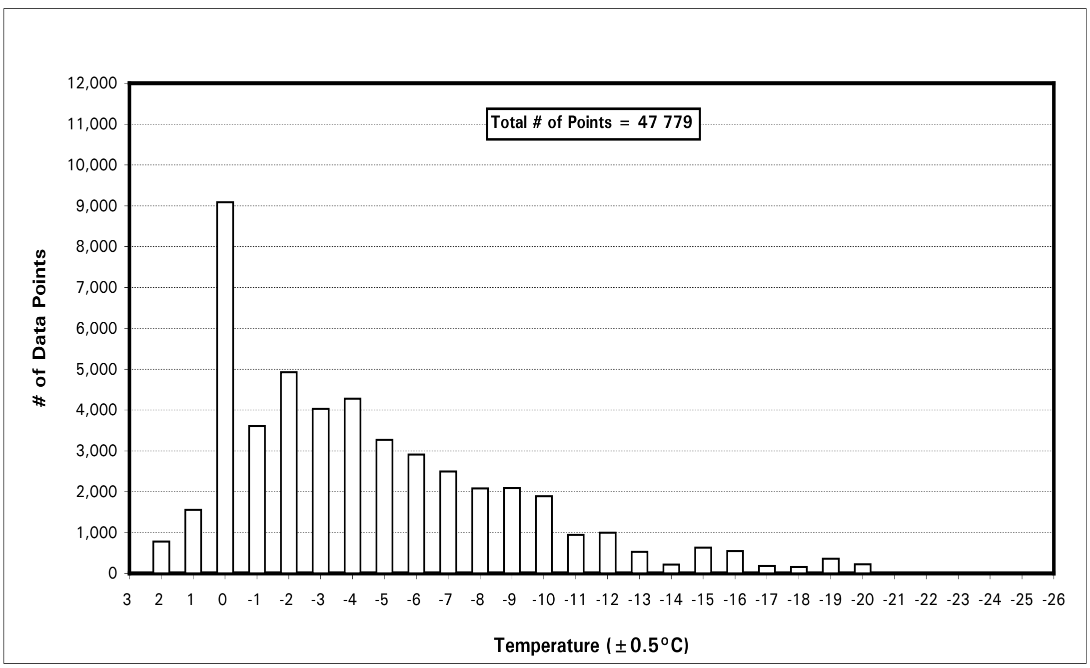

Figure 2.3: Temperature Distribution for 2003-04 Winter – Natural Snow

The following observations should be noted:

a) 17.2 percent of the snowfalls occurred at temperatures above 0°C;

b) 27.9 percent of the snowfalls occurred within the range of 0 to -3°C;

c) 23.5 percent occurred between -3 and -6°C;

d) 19.7 percent occurred between -6 and -10°C;

e) 7.1 percent occurred between -10 and -14°C; and

f) 4.6 percent occurred between -14 and -25°C.

This is a consolidated report, encompassing all the data presented in TC report TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003),* (1). A total of 338 151 data points were collected for natural snow conditions from 1995-96 to 2003-04. On average, this represented over 100 hours of snowfall per year for each of the six stations in Quebec.

The distribution of snow data points over the nine years of observation is illustrated in Table 2.6.

The distribution of data points by temperature range is listed in Table 2.7.

Table 2.6: Distribution of Snow Data Points (1995-96 to 2003-04)

Year	# of Data Points	%
1995-98	39 426	11.7
1998-99	37 272	11.0
1999-00	43 927	13.0
2000-01	57 280	16.9
2001-02	55 026	16.3
2002-03	57 441	17.0
2003-04	47 779	14.1
Total	**338 151**	**100**

Table 2.7: Temperature Distribution (1995-06 to 2003-04)

Temperature Range	# of Data Points
Above 0°C	39 396
Between 0 and -3°C	93 010
Between -3 and -6°C	82 589
Between -6 and -10°C	71 648
Between -10 and -14°C	33 902
Between -14 and -25°C	17 606
Total	**338 151**

Figure 2.4 shows the temperature breakdown of all data points collected from the winters of 1995-96 to 2003-04 for natural snow. The following observations should be noted:

a) 11.6 percent of the snowfalls occurred at temperatures above 0°C;

b) 27.5 percent of the snowfalls occurred within the range of 0 to -3°C;

c) 24.4 percent occurred between -3 and -6°C;

d) 21.2 percent occurred between -6 and -10°C;

e) 10.0 percent occurred between -10 and -14°C; and

f) 5.3 percent occurred between -14 and -25°C.

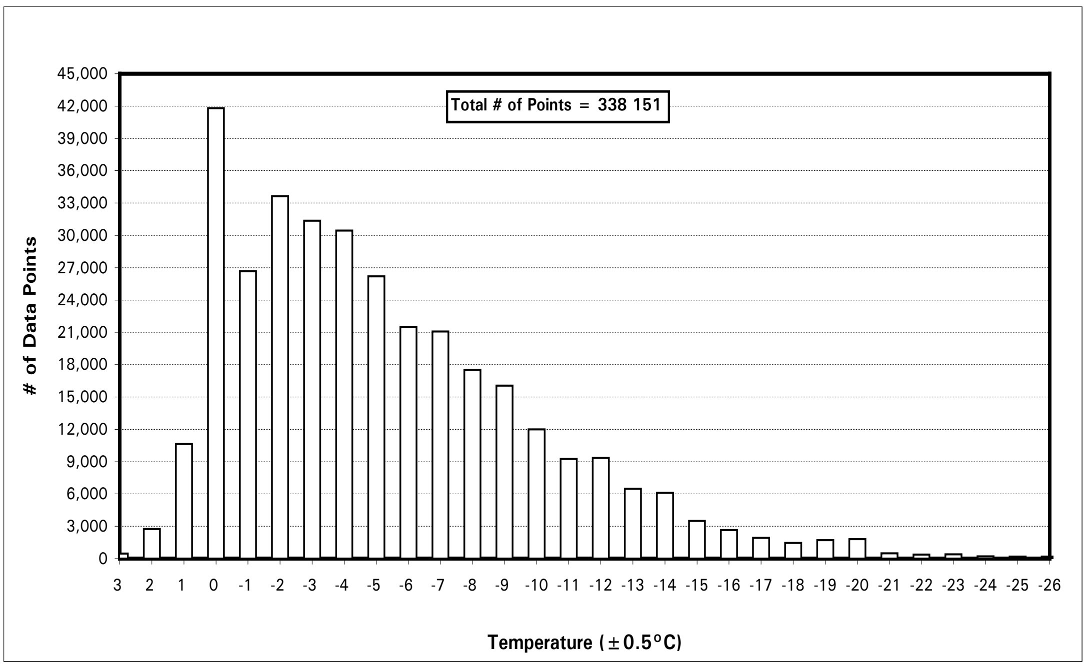

Figure 2.4: Temperature Distribution for the 1996-04 Winters – Natural Snow

2.2.2 Freezing Rain/Drizzle

During the 2003-04 winter, 2 229 data points were collected for Montreal and five other Quebec stations. These represent approximately 37 hours of freezing rain/drizzle data. The distribution of the data by temperature range is shown in Figure 2.5.

The distribution of the 2003-04 data points by temperature range is listed in Table 2.8.

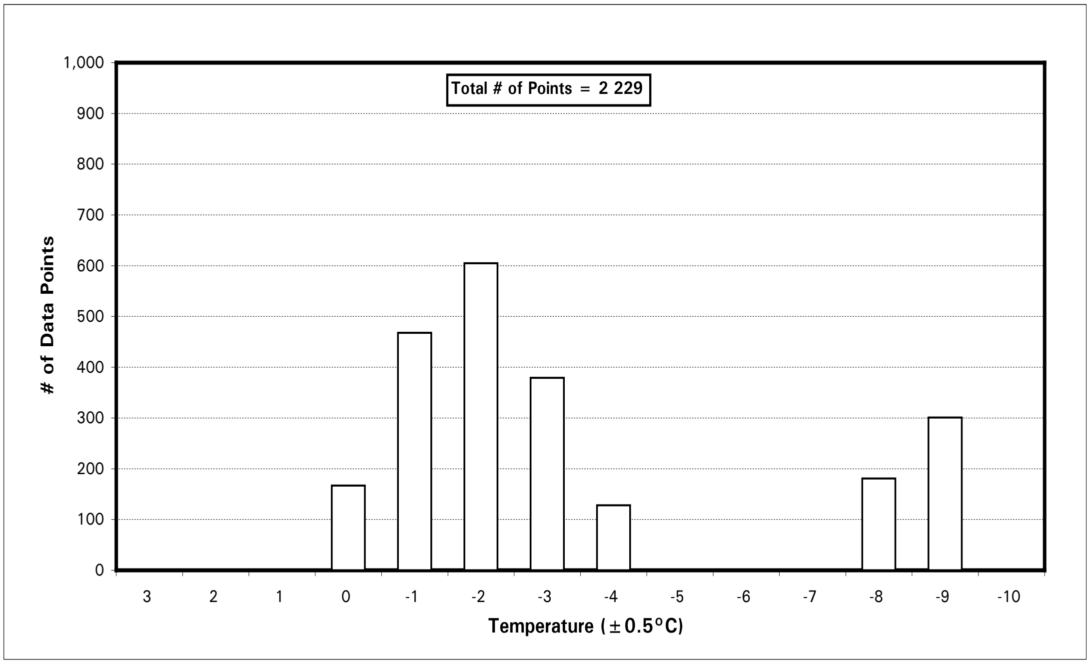

Figure 2.5: Temperature Distribution for 2003-04 – Freezing Rain/Drizzle

Table 2.8: Distribution of 2003-04 Freezing Rain/Drizzle Data Points by Temperature

Temperature Range	# of Data Points
Above 0ºC	0
Between 0 and -3°C	1 450
Between -3 and -6°C	297
Between -6 and -10°C	482
Total	**2 229**

Freezing precipitation data were not collected in the first year, therefore, starting from 1996-97 to 2003-04, a total of 25 719 data points were collected for freezing rain/drizzle conditions. These represent approximately 428 hours of light freezing rain/drizzle data. Freezing rain/drizzle data were developed from CR21X and READAC logs. The 1998 ice storm data is included in this dataset.

The distribution of these data points over the eight years of observation is illustrated in Table 2.9. The distribution of data points by temperature range is listed in the Table 2.10. The distribution of these data points by temperature range is also shown in Figure 2.6.

It should be noted that freezing rain/drizzle did not occur at temperatures below -10°C.

Table 2.9: Distribution of Freezing Rain/Drizzle Data Points over the Last Eight Winters (1996-97 to 2003-04)

Year	# of Data Points	%
1996-00	13 381	52.0
2000-01	785	3.1
2001-02	5 465	21.2
2002-03	3 859	15.0
2003-04	2 229	8.7
Total	**25 719**	**100**

Table 2.10: Distribution of 1996-97 to 2003-04 Freezing Rain/Drizzle Data Points by Temperature

Temperature Range	# of Data Points
Above 0ºC	5 348
Between 0 and -3°C	10 049
Between -3 and -6°C	8 028
Between -6 and -10°C	2 294
Total	**25 719**

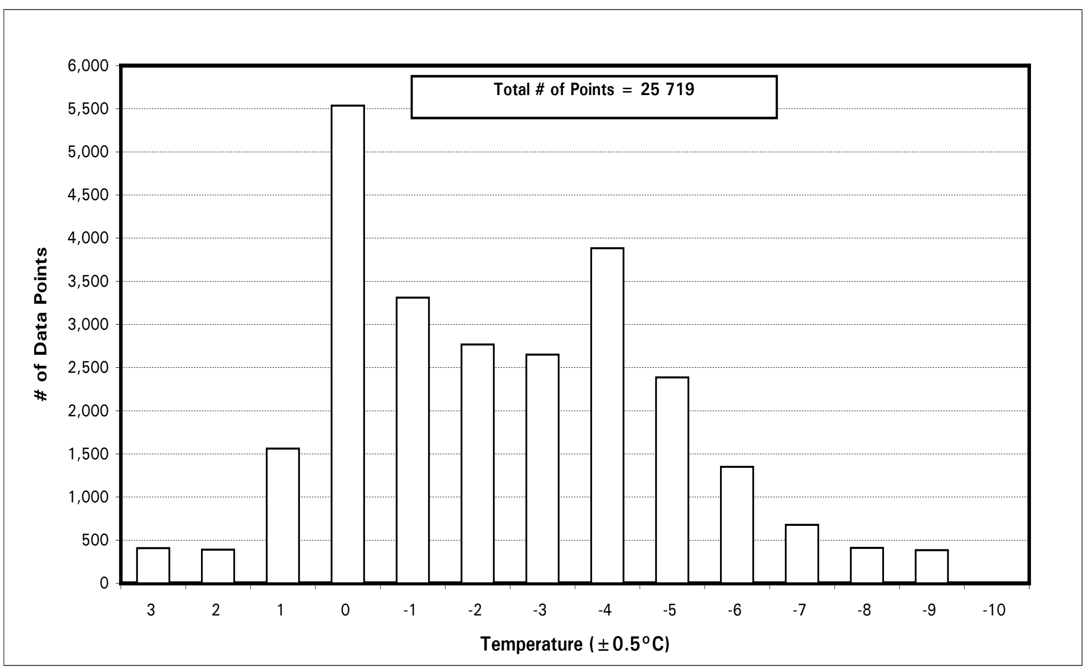

Figure 2.6: Temperature Distribution for Freezing Rain/Drizzle 1996-97 to 2003-04

2.2.3 Validity of Gauges for Recording Precipitation Data

The objective of this section is to evaluate and compare precipitation rates measured with the automated gauge used for this study to rates from the plate pans used for measuring rates for endurance times.

Figure 2.7 shows a comparison of precipitation rates of the READAC gauge and the plate pans (described below) for a storm on January 15, 1999. Figure 2.8 illustrates another comparison during the same storm, this time using the CR21X gauge.

Figure 2.7 and Figure 2.8 show the precipitation rate over a 24-hour period. The 6 minute moving average rates calculated from the CR21X data show much more detail than the READAC. Higher rates were detected from this station because the smoothed data from the lower-resolution READAC station does not allow detection of rapid increases and decreases in rates.

Plate pan data collected from the APS test site located at Trudeau Airport are included in Figure 2.7 and Figure 2.8. The pans were placed at a 10º angle on test stands approximately 30 m away from the precipitation gauge. The rates from the pans are based on the weight of snow that collected in the pans during 10 minute periods. The rates were recorded at the end of each time interval, and each value is based on the average of the two simultaneous pan measurements.

Furthermore, because of questions raised by MSC concerning the accuracy of precipitation gauges, a new analysis has been performed on the 2000-01 winter data. Following the same methodology, the CR21X gauge data were plotted against the plate pan data collected by APS at Trudeau Airport on January 11, 2001. The results are presented in Figure 2.9. At least one verification should be made annually by comparing the rates obtained from the precipitation gauges and the plate pans.

For the 2002-03 winter, the recorded snow event took place on February 22, 2003. The results are presented in Figure 2.10. As can be seen, the data points from the plate pans correlate well with the traces shown in Figure 2.10.

For the 2003-04 winter, the recorded snow event took place on February 22, 2003. The results are presented in Figure 2.11, and as shown, the data points from the plate pans correlate well with the traces. More precipitation accumulates in rate pans during high winds because stands are placed faced into the wind. The differences between the precipitation gauge trace and the plate pan points could be due to the 10ºangle of the test stand. Even so, the CR21X and READAC results are close enough to those of the plate pan collection that they can be used to analyse precipitation data.

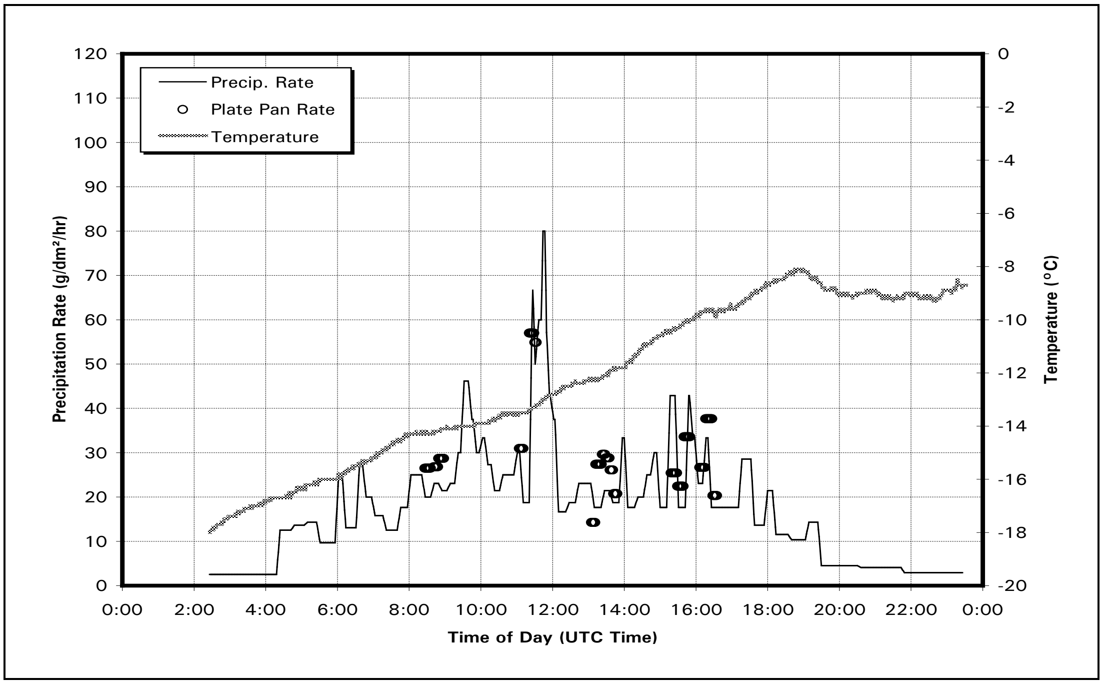

Figure 2.7: READAC Precipitation Rate, January 15, 1999

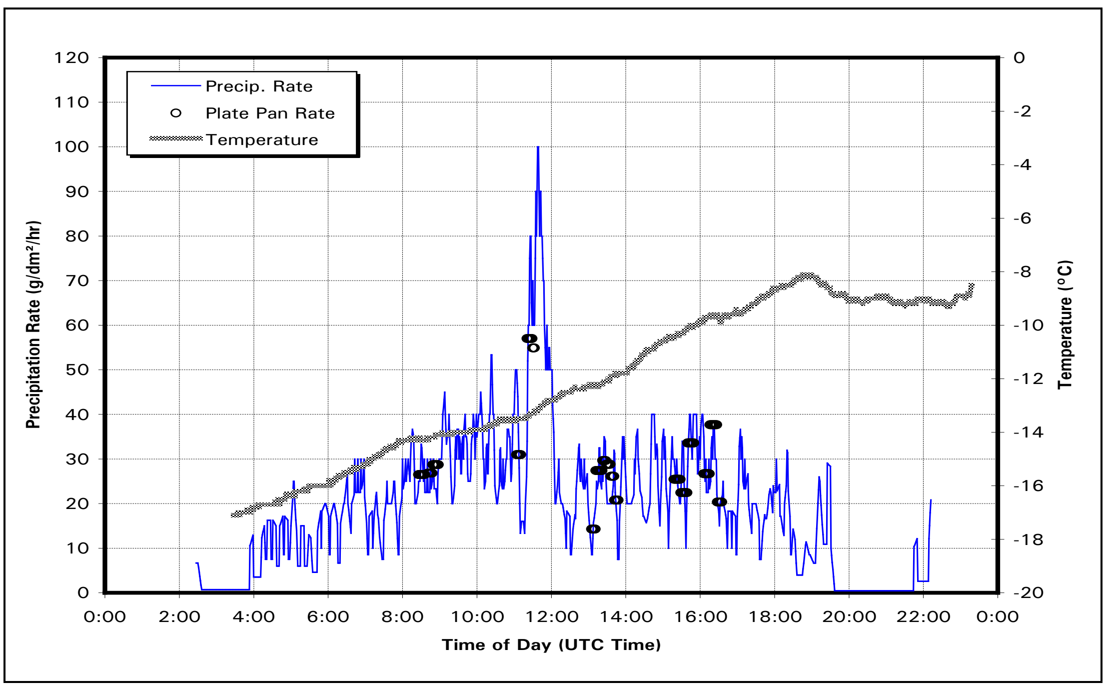

Figure 2.8: CR21X Precipitation Rate, January 15, 1999

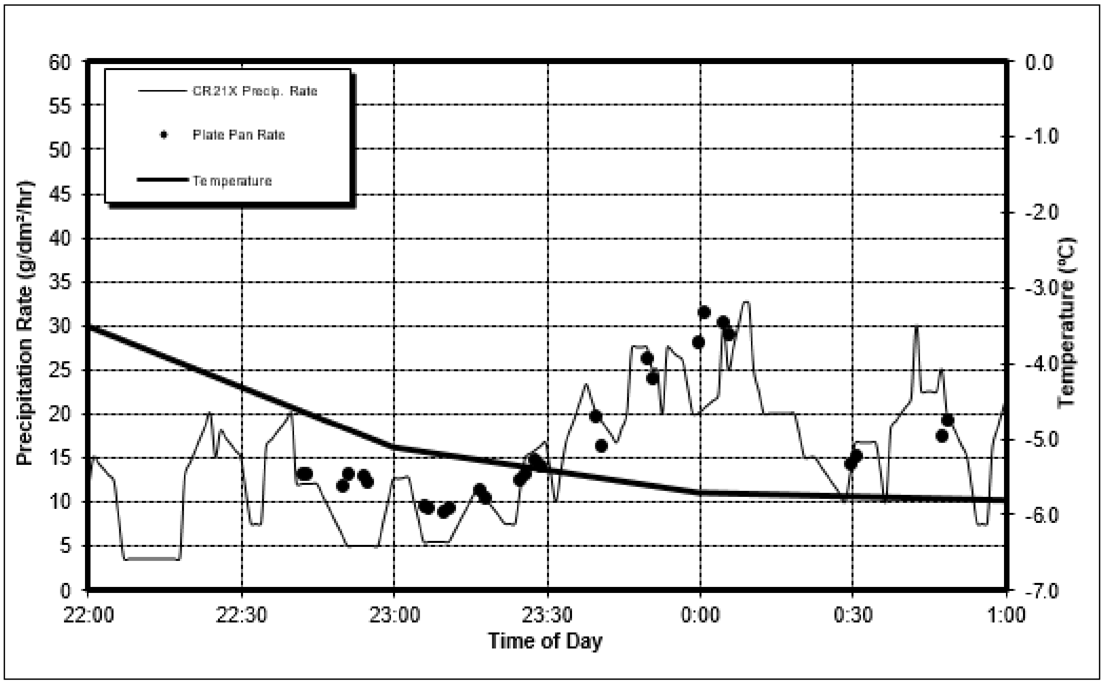

Figure 2.9: CR21X Precipitation Rate, January 11, 2001

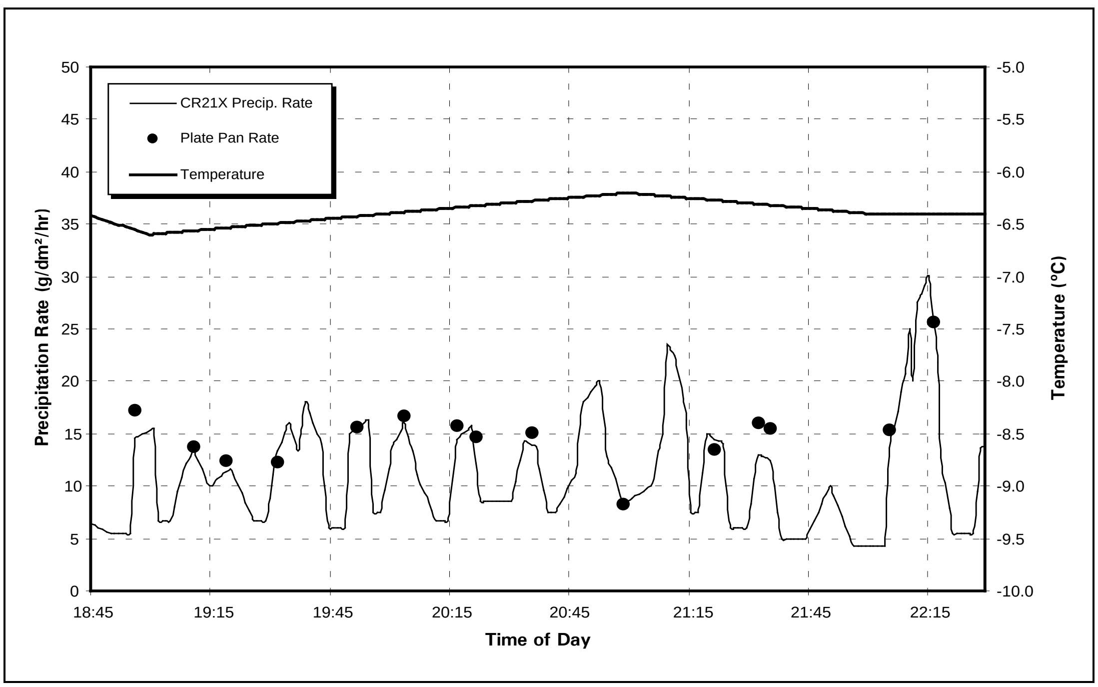

Figure 2.10: CR21X Precipitation Rate, February 22, 2003

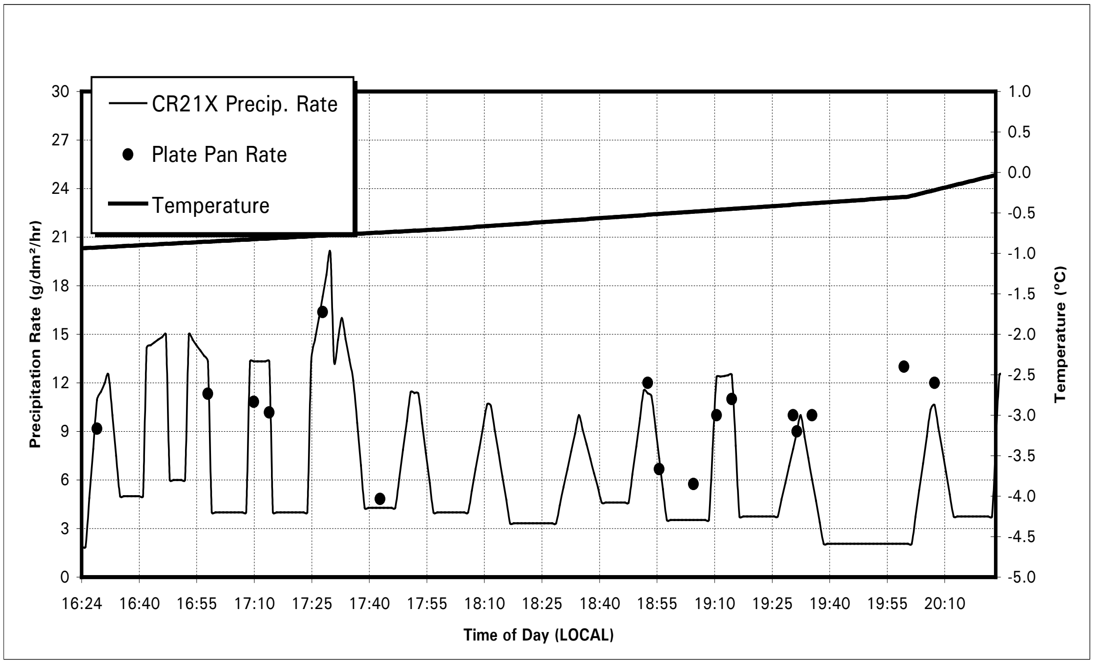

Figure 2.11: CR21X Precipitation Rate, March 20, 2004

2.3 Analysis and Observations for Natural Snow and Freezing Rain/Drizzle

Precipitation rates were calculated from the weather data on a minute-by-minute basis using a moving average based on 6, 20, and 35 minute intervals.

Table 2.11 shows minute-by-minute READAC data at Trudeau Airport for a 49 minute period on December 14, 1995. Also shown are the 6 minute, 20 minute, and 35 minute averages computed using the linearized accumulation. The average snow rates, used as data points, were calculated by taking the snow accumulation during a specific time interval and dividing it by the interval. The three intervals used for this analysis are represented by brackets in the column next to “Linearized Total Snow Accumulation” in Table 2.11. The average snow rate was recalculated every minute by moving the brackets down at one-minute intervals.

For each interval, the rate is calculated every minute using the following method:

$$Rate_i = \frac{W_i - W_{i-1}}{\Delta time}$$

Where:

$Rate_i$ is the rate at a given time;

W_i is the linearized bucket weight at that time;

W_{i-1} is the linearized bucket weight at a one-time interval before the given time; and

$\Delta time$ is the length of the time interval (6, 20, or 35 minutes).

A temperature was associated with the rate, based on the time and day at which the rate was measured. All rate and temperature data were added to a database that contained calculated precipitation rates classified by ambient temperature for all sites included in the study. The database was then sorted by temperature range (*above 0°C*, *0 to -3°C*, *-3 to -14°C*, and *-14 to -25°C*) and the probability for each precipitation rate at each temperature range was calculated using histograms and cumulative percentages.

The snow weather data were graphed in two formats. In one format, the number of snow precipitation events was plotted against the precipitation rates (Figure 2.12). The other format (Figure 2.13) plots the cumulative probability of snow over all possible precipitation rates. The figures shown correspond to the temperature range of -3 to -7ºC for 20 minute rate calculations. Both plots used the corresponding period to calculate average precipitation rates.

The histogram in Figure 2.13 indicates that snow events with low precipitation rates occurred much more frequently than those with high precipitation rates for the temperature range shown.

The cumulative probability in indicates that over 97 percent of all the natural snow events in the data had precipitation rates below 25 g/dm^2/h for 20 minute rate intervals.

A complete set of plots for all temperature ranges and rate durations for natural snow and freezing rain/drizzle is included in Appendix B. As mentioned earlier, this report encompasses all the data presented in TC report TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, (1). For consistency purposes, the data in Appendix B is presented using the same temperature ranges used in the previous versions of this report. Moreover, changing the temperature breakdowns to reflect the values in the TC HOT table for Type I fluids (i.e. change -7°C to -6°C), does not produce a major change in the charts. These temperature ranges will also be used in the remainder of this section.

Table 2.11: Sample READAC Data and Analysis

Location	Date	UTC Time	Temp (°C)	Type of Precip.	Total Snow Accumulation (g/dm²)	Linearized Total Snow Accumulation (g/dm²)		Precipitation Rate (g/dm²/h) Moving Average Intervals 6 min	20 min	35 min
YUL	14/12/1995	21:16	-11.8	S-	40	40.00		(a)	(b)	(c)
YUL	14/12/1995	21:17	-11.7	S-	40	40.16		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:18	-11.6	S-	40	40.31		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:19	-11.6	S-	40	40.47		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:20	-11.6	S-	40	40.63		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:21	-11.6	S-	40	40.78		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:22	-11.6	S-	40	40.94		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:23	-11.5	S-	40	41.09		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:24	-11.6	S-	40	41.25		9.38	[illegible]	[illegible]
YUL	14/12/1995	21:25	-11.6	S-	40	41.41		9.38	9.38	[illegible]
YUL	14/12/1995	21:26	-11.4	S-	40	41.56		9.38	9.38	[illegible]
YUL	14/12/1995	21:27	-11.4	S-	40	41.72		[illegible]	9.38	[illegible]
YUL	14/12/1995	21:28	-11.5	S-	40	41.88		9.38	9.38	[illegible]
YUL	14/12/1995	21:29	-11.5	S-	40	42.03		9.38	9.79	13.16
YUL	14/12/1995	21:30	-11.4	S-	40	42.19		9.38	10.20	13.39
YUL	14/12/1995	21:31	-11.4	S-	40	42.34		9.38	10.62	13.48
YUL	14/12/1995	21:32	-11.4	S-	40	42.50		9.38	11.03	13.57
YUL	14/12/1995	21:33	-11.4	S-	40	42.66		9.38	[illegible]	13.66
YUL	14/12/1995	21:34	-11.4	S-	40	42.81		9.38	[illegible]	13.75
YUL	14/12/1995	21:35	-11.4	S-	40	42.97		[illegible]	12.27	13.84
YUL	14/12/1995	21:36	-11.3	S-	40	43.13		9.38	12.68	13.93
YUL	14/12/1995	21:37	-11.3	S-	40	43.28		9.38	13.10	14.02
YUL	14/12/1995	21:38	-11.4	S-	40	43.44		9.38	13.51	14.11
YUL	14/12/1995	21:39	-11.4	S-	40	43.59		9.38	13.92	14.20
YUL	14/12/1995	21:40	-11.3	S-	40	43.75		9.38	14.34	14.29
YUL	14/12/1995	21:41	-11.3	S-	40	43.91		9.38	14.75	14.38
YUL	14/12/1995	21:42	-11.3	S-	40	44.06		9.38	15.17	14.46
YUL	14/12/1995	21:43	-11.3	S-	40	44.22		10.75	15.58	14.55
YUL	14/12/1995	21:44	-11.2	S-	40	44.38		12.13	15.99	14.64
YUL	14/12/1995	21:45	-11.2	S-	40	44.53		13.51	16.41	14.73
YUL	14/12/1995	21:46	-11.2	S-	40	44.69		14.89	16.56	14.82
YUL	14/12/1995	21:47	-11.2	S-	40	44.84		16.27	16.72	14.91
YUL	14/12/1995	21:48	-11.2	S-	45	45.00		17.65	16.88	15.00
YUL	14/12/1995	21:49	-11.2	S-	45	45.29		17.65	16.62	14.85
YUL	14/12/1995	21:50	-11.2	S-	45	45.59		17.65	16.36	14.71
YUL	14/12/1995	21:51	-11.2	S-	45	45.88		17.65	16.10	14.56
YUL	14/12/1995	21:52	-11.1	S-	45	46.18		17.65	15.85	14.41
YUL	14/12/1995	21:53	-11.1	S-	45	46.47		17.65	15.59	14.26
YUL	14/12/1995	21:54	-11.1	S-	45	46.76		17.65	15.33	14.12
YUL	14/12/1995	21:55	-11.1	S-	45	47.06		17.65	15.07	14.18
YUL	14/12/1995	21:56	-11.1	S-	45	47.35		17.65	14.82	14.25
YUL	14/12/1995	21:57	-11.1	S-	45	47.65		17.65	14.56	14.32
YUL	14/12/1995	21:58	-11.1	S-	45	47.94		17.65	14.30	14.39
YUL	14/12/1995	21:59	-11.0	S-	45	48.24		17.65	14.04	14.45
YUL	14/12/1995	22:00	-11.0	S-	45	48.53		16.79	13.79	14.52
YUL	14/12/1995	22:01	-11.0	S-	45	48.82		15.93	13.53	14.59
YUL	14/12/1995	22:02	-11.0	S-	45	49.12		15.07	13.27	14.66
YUL	14/12/1995	22:03	-11.0	S-	45	49.41		14.22	13.01	14.72
YUL	14/12/1995	22:04	-10.9	S-	45	49.71		13.36	12.76	14.79
YUL	14/12/1995	22:05	-10.8	S-	50	50.00		12.50	12.50	14.86

(a) = (40.94 - 40.00)*60 / 6
(b) = (43.13 - 40.00)*60 / 20
(a) = (45.88 - 40.00)*60 / 35

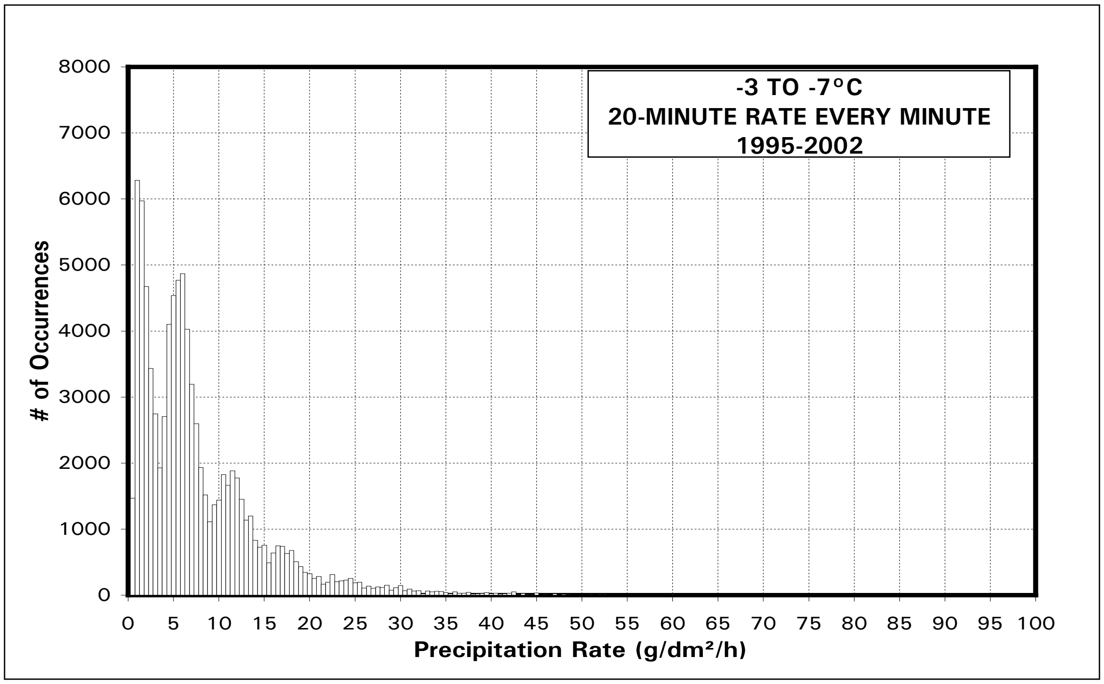

Figure 2.12: READAC and CR21X Analysis – Natural Snow Histogram

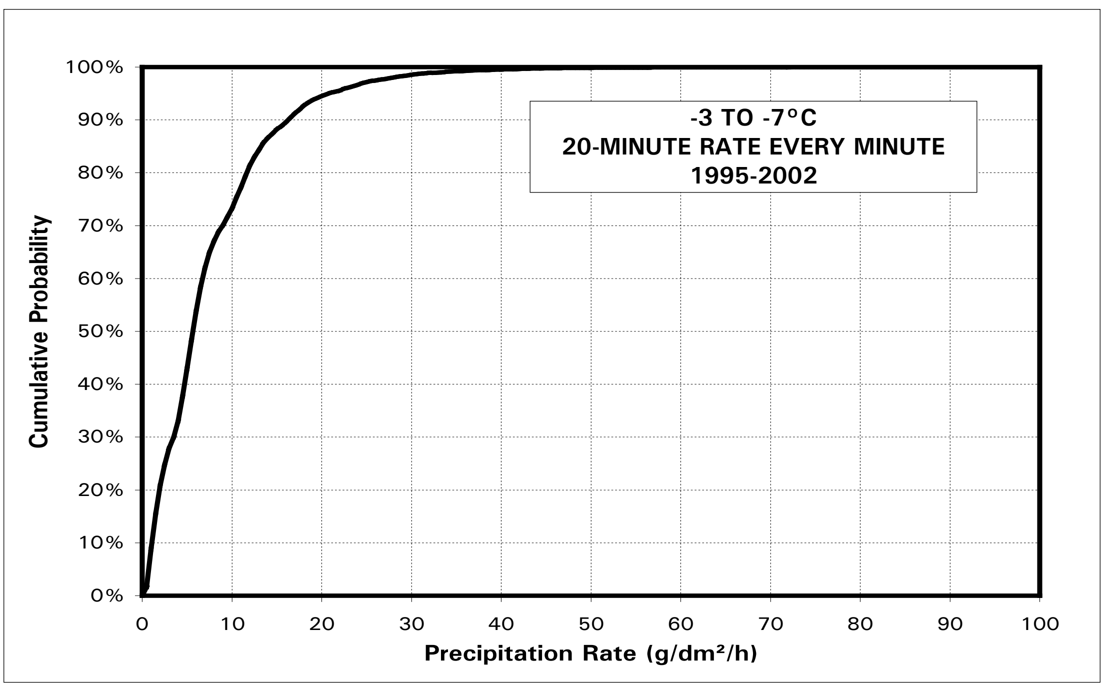

Figure 2.13: READAC and CR21X Analysis – Natural Snow Cumulative Probability

2.3.1 Natural Snow

This analysis takes into account the snow dataset from the last nine winters – the 1995-96 winter to the 2003-04 winter.

The 95th percentiles for several temperature ranges for natural snow conditions are shown in Table 2.12 below.

Table 2.12: 95th Percentile in Each Temperature Range – Natural Snow

Temperature Range	95th Percentile Precipitation Rate (g/dm²/h)		
	6 min	**20 min**	**35 min**
Above 0°C	21	20	20
0°C to -3°C	21	21	21
-3°C to -7°C	22	21	20
-7°C to -14°C	22	22	22
-14°C to -25°C	20	19	19

Each of the rates in this table represents the rate below which 95 percent of all snowfalls occurred in a specific temperature range for a given rate duration. For example, in the temperature range of *-3 to -7°C* for a duration of 20 minutes, the 95th percentile is 21 g/dm^2/h. This indicates that 95 percent of the 20 minute rates recorded between *-3°C to -7°C* were equal to or below 21 g/dm^2/h. Table 2.13 shows the percent of occurrences for precipitation rates above 25 g/dm^2/h for all temperature ranges.

Table 2.13: Percentage of Heavy Snow Occurrences In Each Temperature Range, Natural Snow

Temperature Range	Percent of Occurrences when Rate is above 25 g/dm^2/h		
	6 min	**20 min**	**35 min**
Above 0°C	2.7%	2.7%	2.7%
0°C to -3°C	3.1%	3.0%	2.7%
-3°C to -7°C	3.2%	2.9%	2.7%
-7°C to -14°C	3.3%	3.4%	3.4%
-14°C to -25°C	1.8%	1.6%	1.8%

2.3.2 Natural Snow at Cold Temperatures

The general shape of the curve for the cumulative probability of occurrence at colder temperatures is similar to that of the curves drawn for other temperatures, as shown in Figure 2.14. The chart shows that high precipitation rates occur equally at all temperature breakdowns.

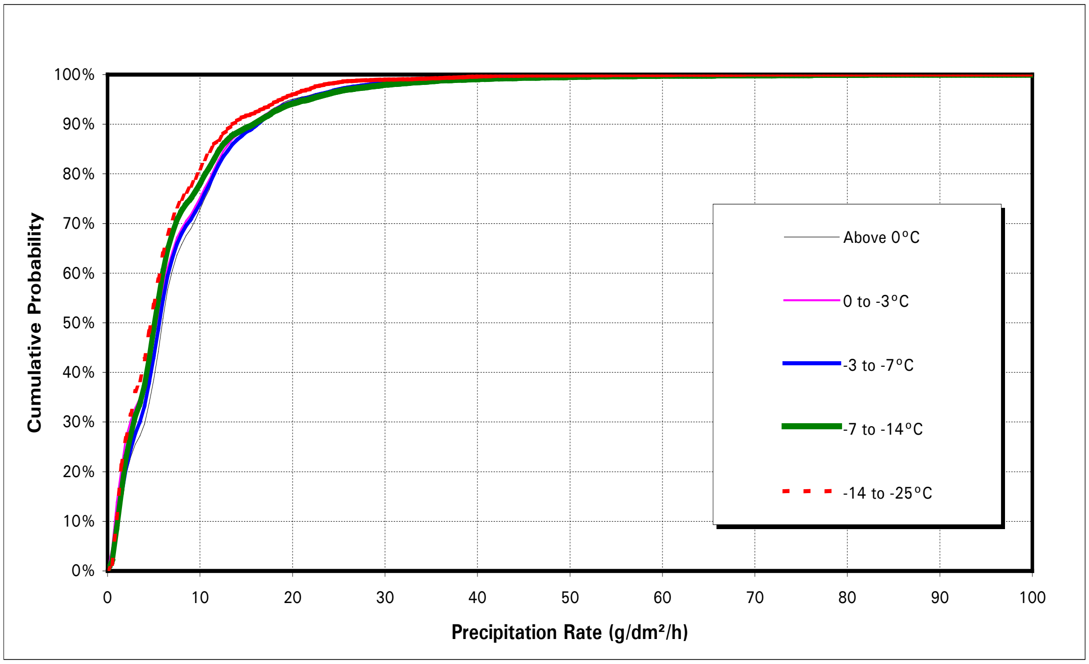

Figure 2.14: 20-Minute Rate Every Minute, All Temperature Ranges

The coldest temperature interval was divided into three smaller intervals (the data are shown in Appendix B):

a) -14 to -18°C;

b) -18 to -22°C; and

c) -22 to -25°C.

High precipitation rates were more common in the *-14 to -18°C* range, but a few high-rate snowfalls were recorded in the other two ranges, as seen in Figure 2.15.

For each cold temperature interval the percentage of occurrences when the precipitation rates were above 25 g/dm^2/h is shown in Table 2.14.

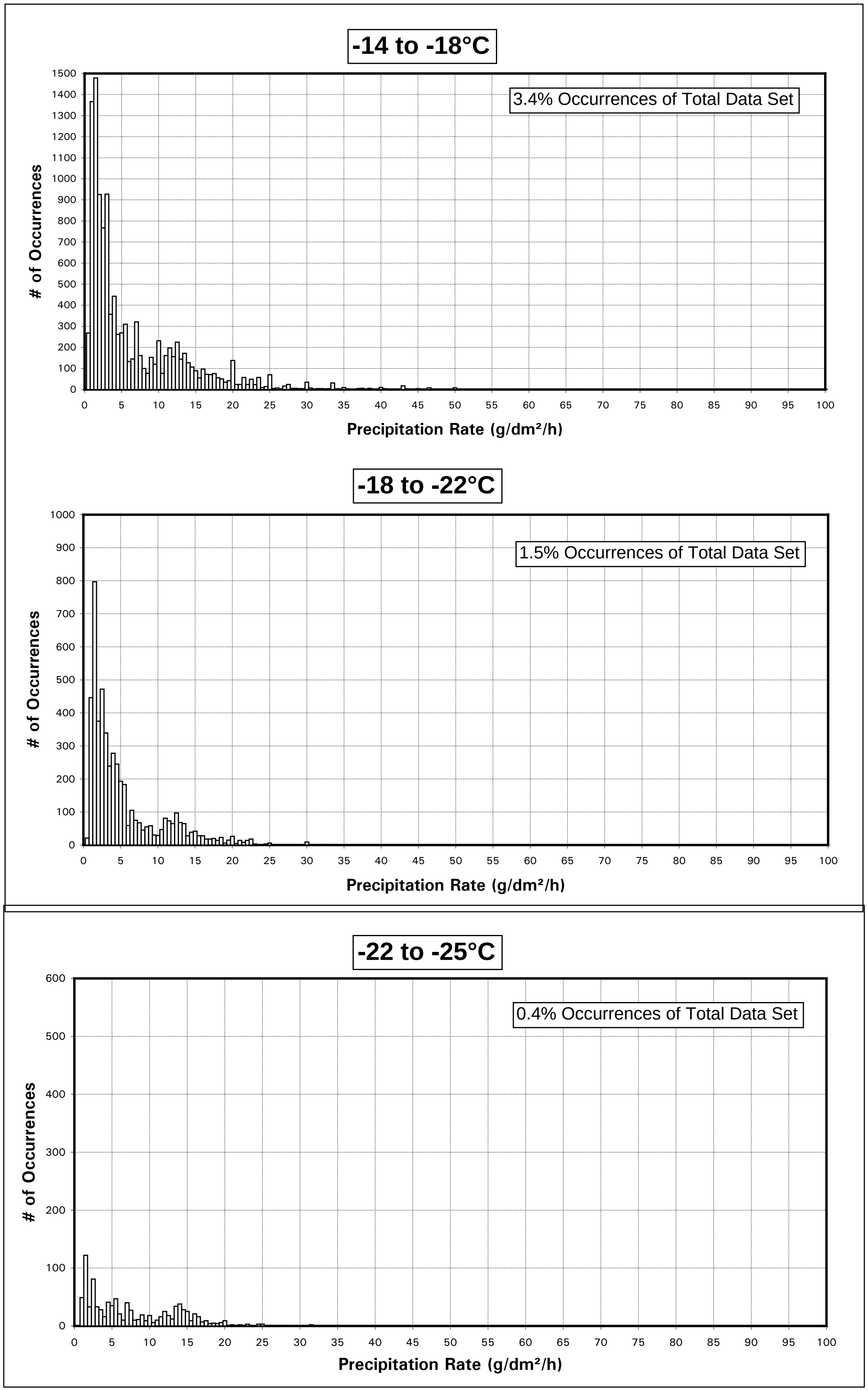

Figure 2.15: Subdivision of -14 to -25ºC – Snow Data

Table 2.14: Percentage of Heavy Snow Occurrences In Cold Temperatures-Natural Snow

Temperature Range	Percent of Occurrences when Rate is above 25 $g/dm^2/h$	Percent of -14 to -25°C Data Points in Each Temperature Range	Percent of Total Data Points in Each Temperature Range
-14 to -18°C	2.4%	64.9%	3.4%
-18 to -22°C	0%	28.2%	1.5%
-22 to -25°C	0.4%	6.9%	0.4%
	Total	**100%**	**5.3%**

Based on these results, consideration should be given to reformatting the HOT tables by dividing the *-14 to -25ºC* interval, as precipitation rates were significantly lower at temperatures below -18ºC and occurrences less frequent. However, the number of potential deicing operations at these lower temperatures needs to be considered.

2.3.3 Probability of Snow Events for Holdover Time Table Temperature Ranges

In an attempt to find the optimum temperature breakdowns for the HOT tables, the snow dataset (338 151 data points) was divided into 1°C intervals. In addition, each temperature range was split into precipitation rate ranges using 1 $g/dm^2/h$ increments. The results were translated into percentages to determine the probability of snow occurrence in each cell of the new table. The outcome is shown in Table 2.15.

The probability of snow event occurrences in each of the holdover time temperature ranges of the HOT tables is shown in Table 2.16 and Table 2.17. Table 2.16 corresponds to the temperature ranges of Type I fluid and Table 2.17 to the ranges of Type II and Type IV fluids. These two tables are determined based on Table 2.15. There were no data available for natural snow conditions below -25°C. In addition, each of the tables provides probability data for snowfall as a function of very light, light, moderate, and heavy snow.

For Type I fluids, over 84 percent of snow events occurred above -10°C, justifying the current temperature break at -6°C. Over 53 percent of the rates were classified as very light snow according to the newly introduced column in the Type I table. The probability of snow events for the Type IV table are 27.5 percent in the range of *0 to -3°C* and nearly 56 percent for the range of *-3 to -14°C*.

The analysis presented in this report is based on data collected over nine years of observation from six meteorological stations across Quebec. A similar weather information database, comprising of hourly measurements over a 12 year period for two stations (Montreal and La Grande), was used for different projects and is discussed in the following subsection. It has been included in this report for documentation purposes.

Table 2.15: Probability (%) of Natural Snow Occurrence – 1995-96 to 2003-04 (Quebec)

TEMP (ºC)	RATE OF PRECIPITATION (g/dm²/h)																											
	0 to 1	*1 to 2*	*2 to 3*	*3 to 4*	*4 to 5*	*5 to 6*	*6 to 7*	*7 to 8*	*8 to 9*	*9 to 10*	*10 to 11*	*11 to 12*	*12 to 13*	*13 to 14*	*14 to 15*	*15 to 16*	*16 to 17*	*17 to 18*	*18 to 19*	*19 to 20*	*20 to 21*	*21 to 22*	*22 to 23*	*23 to 24*	*24 to 25*	*>25*	*Total*	*Cumulative*
above 0	1.47	1.99	1.40	0.98	0.62	0.50	0.44	0.33	0.26	0.19	0.22	0.36	0.47	0.40	0.34	0.30	0.22	0.19	0.17	0.19	0.07	0.07	0.06	0.04	0.06	0.31	**11.7**	**11.7**
0 to -1	1.16	1.73	1.06	0.75	0.47	0.34	0.32	0.20	0.19	0.14	0.17	0.27	0.34	0.29	0.26	0.20	0.15	0.14	0.11	0.10	0.04	0.04	0.03	0.03	0.04	0.21	**8.8**	**20.4**
-1 to -2	1.65	1.41	0.92	0.61	0.53	0.34	0.39	0.24	0.23	0.15	0.16	0.23	0.23	0.23	0.22	0.19	0.16	0.14	0.10	0.12	0.06	0.05	0.05	0.03	0.05	0.28	**8.8**	**29.2**
-2 to -3	1.22	1.84	1.03	0.88	0.57	0.36	0.44	0.29	0.24	0.17	0.19	0.28	0.35	0.34	0.25	0.21	0.17	0.15	0.15	0.13	0.06	0.07	0.06	0.03	0.06	0.38	**9.9**	**39.2**
-3 to -4	1.23	1.60	1.13	0.81	0.55	0.33	0.43	0.30	0.20	0.19	0.16	0.29	0.36	0.28	0.22	0.17	0.13	0.10	0.09	0.11	0.05	0.05	0.04	0.03	0.05	0.30	**9.2**	**48.3**
-4 to -5	0.96	1.30	1.04	0.67	0.44	0.34	0.36	0.24	0.17	0.13	0.16	0.26	0.27	0.27	0.25	0.22	0.15	0.13	0.13	0.15	0.05	0.06	0.04	0.03	0.06	0.31	**8.2**	**56.6**
-5 to -6	1.02	1.16	0.88	0.62	0.42	0.30	0.30	0.19	0.15	0.12	0.15	0.22	0.25	0.18	0.16	0.13	0.12	0.10	0.10	0.11	0.05	0.04	0.03	0.02	0.03	0.18	**7.0**	**63.6**
-6 to -7	0.68	1.29	0.78	0.60	0.35	0.27	0.21	0.14	0.12	0.10	0.11	0.20	0.21	0.19	0.17	0.12	0.10	0.10	0.08	0.08	0.04	0.03	0.03	0.01	0.02	0.17	**6.2**	**69.8**
-7 to -8	0.78	1.25	0.91	0.47	0.37	0.27	0.18	0.11	0.11	0.10	0.10	0.19	0.19	0.17	0.13	0.10	0.07	0.06	0.05	0.06	0.03	0.02	0.02	0.01	0.03	0.25	**6.0**	**75.8**
-8 to -9	0.66	0.85	0.66	0.42	0.27	0.19	0.18	0.11	0.08	0.09	0.11	0.18	0.18	0.15	0.12	0.08	0.07	0.05	0.04	0.03	0.01	0.02	0.01	0.01	0.01	0.08	**4.7**	**80.5**
-9 to -10	0.58	0.71	0.58	0.39	0.25	0.16	0.15	0.10	0.09	0.10	0.08	0.15	0.16	0.14	0.09	0.09	0.07	0.06	0.05	0.06	0.02	0.03	0.02	0.02	0.03	0.11	**4.3**	**84.8**
-10 to -11	0.40	0.69	0.42	0.28	0.14	0.10	0.09	0.06	0.05	0.03	0.04	0.10	0.09	0.06	0.06	0.03	0.05	0.05	0.03	0.05	0.02	0.02	0.01	0.01	0.02	0.08	**3.0**	**87.7**
-11 to -12	0.29	0.63	0.43	0.23	0.14	0.09	0.11	0.05	0.04	0.04	0.04	0.09	0.08	0.05	0.05	0.05	0.04	0.04	0.03	0.05	0.02	0.02	0.02	0.01	0.03	0.08	**2.7**	**90.5**
-12 to -13	0.44	0.46	0.31	0.23	0.13	0.09	0.07	0.04	0.05	0.04	0.03	0.07	0.07	0.08	0.04	0.04	0.03	0.04	0.03	0.03	0.01	0.02	0.01	0.02	0.01	0.08	**2.4**	**92.9**
-13 to -14	0.25	0.43	0.23	0.13	0.10	0.06	0.06	0.05	0.03	0.03	0.03	0.07	0.05	0.04	0.03	0.03	0.03	0.01	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.13	**1.9**	**94.8**
-14 to -15	0.21	0.25	0.17	0.08	0.06	0.05	0.05	0.02	0.02	0.03	0.02	0.04	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.06	**1.3**	**96.1**
-15 to -16	0.16	0.27	0.08	0.06	0.03	0.02	0.04	0.02	0.01	0.05	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.02	**0.9**	**97.1**
-16 to -17	0.18	0.11	0.08	0.03	0.03	0.02	0.02	0.01	0.01	0.04	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.6**	**97.7**
-17 to -18	0.09	0.09	0.12	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.5**	**98.2**
-18 to -19	0.06	0.09	0.09	0.06	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	**0.5**	**98.7**
-19 to -20	0.05	0.12	0.10	0.04	0.04	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.5**	**99.2**
-20 to -21	0.07	0.10	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.3**	**99.5**
-21 to -22	0.03	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.1**	**99.6**
-22 to -23	0.03	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.1**	**99.8**
-23 to -24	0.02	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.1**	**99.9**
-24 to -25	0.04	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.1**	**100.0**
Total	**13.7**	**18.5**	**12.5**	**8.4**	**5.6**	**3.9**	**3.9**	**2.6**	**2.1**	**1.8**	**1.9**	**3.1**	**3.4**	**3.0**	**2.5**	**2.0**	**1.6**	**1.4**	**1.2**	**1.4**	**0.6**	**0.6**	**0.5**	**0.3**	**0.5**	**3.0**		
Cumulative	**13.7**	**32.2**	**44.7**	**53.2**	**58.8**	**62.7**	**66.6**	**69.1**	**71.3**	**73.0**	**74.9**	**78.0**	**81.4**	**84.4**	**86.9**	**88.9**	**90.5**	**91.9**	**93.1**	**94.5**	**95.0**	**95.6**	**96.1**	**96.4**	**97.0**	**100.0**		

Table 2.16: Probability of Snow in Each HOT Table Temperature Range – Type I Fluids

Temperature (°C)	Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	Total
-3 and above	20.1%	8.0%	9.9%	1.2%	**39.2%**
below -3 to -6	12.4%	5.2%	6.1%	0.8%	**24.4%**
below -6 to -10	11.6%	4.1%	4.9%	0.6%	**21.2%**
below -10	9.0%	2.6%	3.1%	0.5%	**15.2%**
Total	**53.2%**	**19.9%**	**24.0%**	**3.0%**	**100.0%**

Table 2.17: Probability of Snow in Each HOT Table Temperature Range – Type II and Type IV Fluids

Temperature (°C)	Very Light Snow	Light Snow	Moderate Snow	Heavy Snow	Total
above 0	5.8%	2.3%	3.2%	0.3%	**11.7%**
0 to -3	14.3%	5.6%	6.7%	0.9%	**27.5%**
below -3 to -14	29.9%	11.0%	13.1%	1.8%	**55.6%**
below -14 to -25	3.2%	0.9%	1.0%	0.1%	**5.2%**
below -25	0.0%	0.0%	0.0%	0.0%	**0.0%**
Total	**53.2%**	**19.9%**	**24.0%**	**3.0%**	**100.0%**

2.3.4 Freezing Rain/Drizzle

The 95th percentile for two temperature ranges is shown in Table 2.18 for freezing rain/drizzle.

In freezing rain/drizzle, the 6 minute 95th percentile was 25 g/dm²/h for the *-3 to -10°C* range and somewhat higher, near 31 g/dm²/h, for the *0 to -3°C* range.

Table 2.18: 95th Percentile in Each Temperature Range – Freezing Rain/Drizzle

Temperature Range	95th Percentile Precipitation Rate (g/dm²/h)		
	6 min	20 min	35 min
0 to -3°C	31	29	27
-3 to -10°C	25	24	24

2.4 Analysis of Freezing Rain and Freezing Drizzle Occurrences

Using the weather dataset provided by MSC, a separate analysis was conducted for freezing rain and freezing drizzle. The freezing rain and freezing drizzle events were tracked from 1997-98 to 2002-03 using the Monthly Meteorological Data Summary provided by MSC.

The analysis methodology was identical with the one described in Sections 2.1.3 and 2.1.4, with one exception, previously it was established as a guideline, that precipitation events with total precipitation of less than 2 cm during 6 hours be excluded. For this analysis, every single freezing rain or freezing drizzle event recorded by the CR21X station was included. However, periods of low-rate precipitation might have been overlooked due to the sensitivity of the recording instrument.

Over six winters, from 1997-98 to 2002-03, 22 freezing drizzle events and 44 freezing rain events were identified. On average, the event duration for freezing rain was about double the event duration of freezing drizzle. Figure 2.16 and Figure 2.17 illustrate the distribution of event duration for freezing rain and freezing drizzle.

Using the minute-by-minute temperature data from the CR21X file, the distribution of data points was calculated and is presented in Figure 2.18 and Figure 2.19 for freezing rain and freezing drizzle. For both weather conditions, the majority of events occurred within the 0 to -3°C temperature range.

Similar to the analysis presented earlier in this section, precipitation rates were calculated from the weather data in 6 minute intervals using a moving average calculated on a minute-by-minute basis.

The freezing rain and freezing drizzle weather data were graphed in two formats. In one format, the number of precipitation events was plotted against the precipitation rates (Figure 2.20 and Figure 2.22). The other format (Figure 2.21 and Figure 2.23) plots the cumulative probability of precipitation over all possible precipitation rates.

2.5 Weather Information Database – La Grande and Montreal

The extensive dataset was acquired by APS from MSC. The hourly data contains weather observations for two meteorological stations in Quebec, located in Montreal and La Grande. The observation period is from January 1, 1990 to December 31, 2001. The data contains observations of the following parameters: visibility, wind speed, wind direction, dew point, relative humidity, atmospheric pressure, cloud opacity, cloud amount and weather condition.

This dataset of weather information was used for different projects. Initially, it was used to evaluate historical relative humidity values during conditions typical of frost, and is therefore presented in Section 4 of TC report, TP 14145E, *Laboratory Test Parameters for Frost Endurance Time Tests* (3). The objective of this study was to examine the range of relative humidity that exists in the natural environment during periods of frost formation.

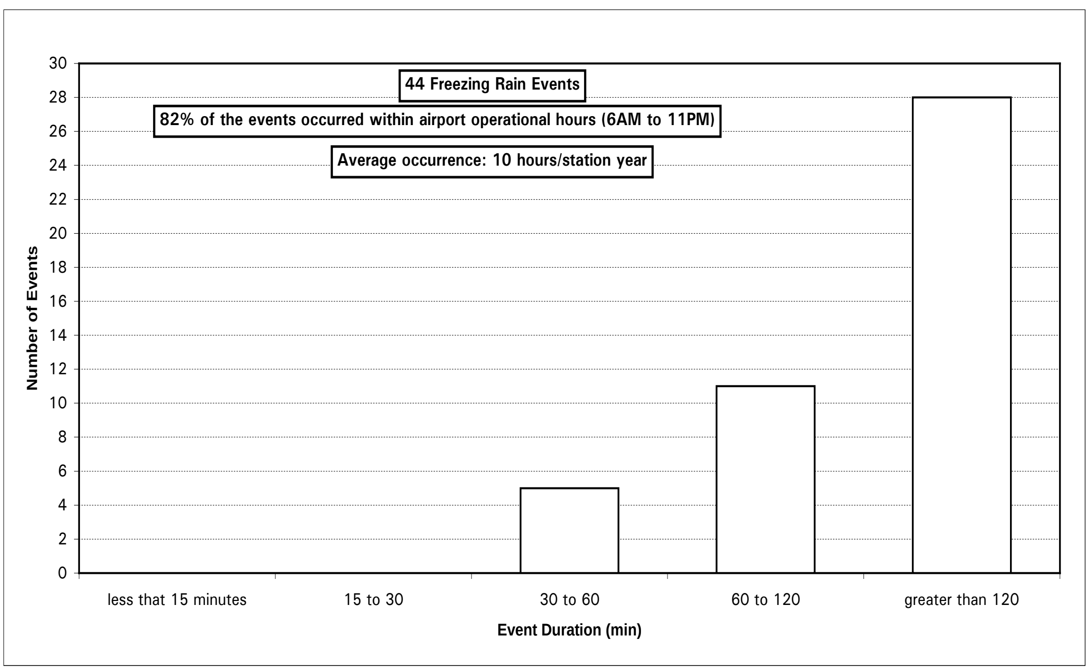

Figure 2.16: Distribution of Event Duration – Freezing Rain

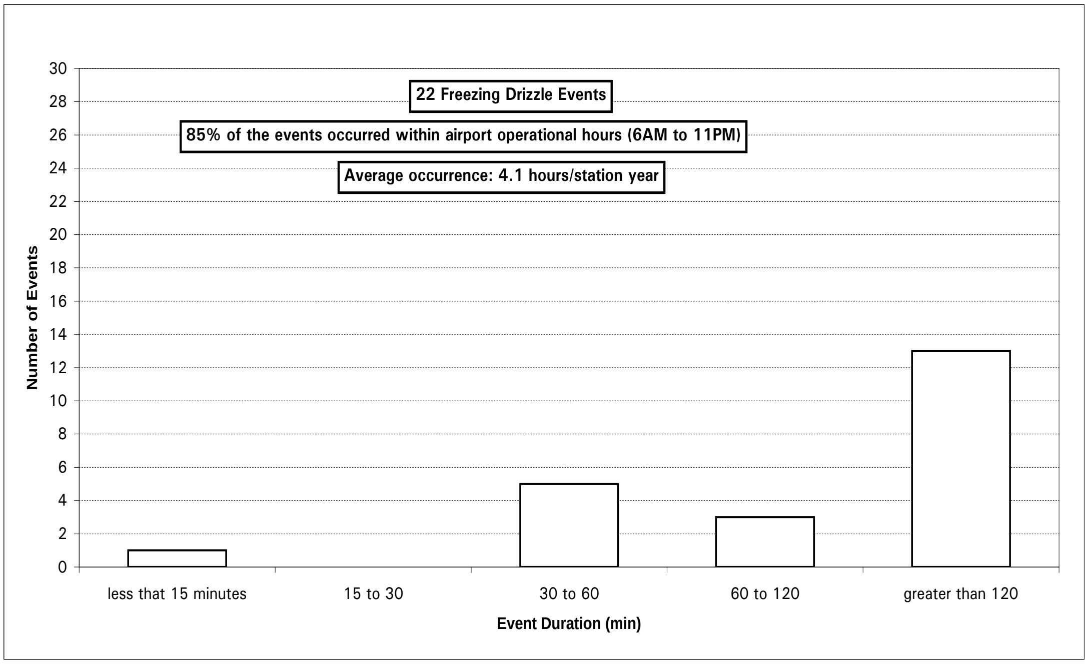

Figure 2.17: Distribution of Event Duration – Freezing Drizzle

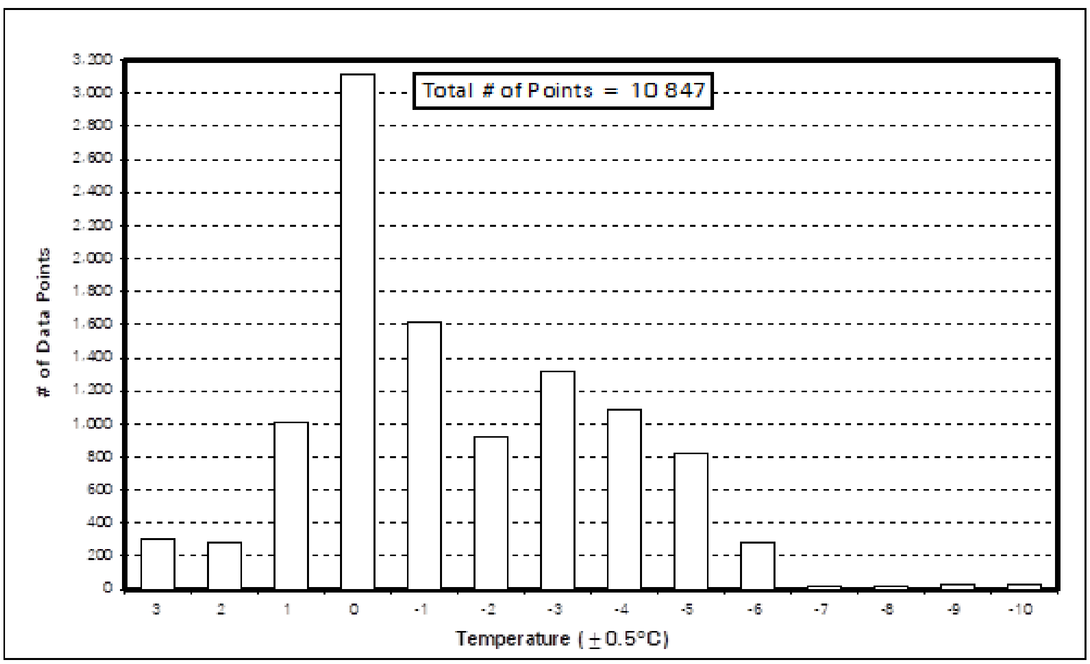

Figure 2.18: Temperature Distribution – Freezing Rain

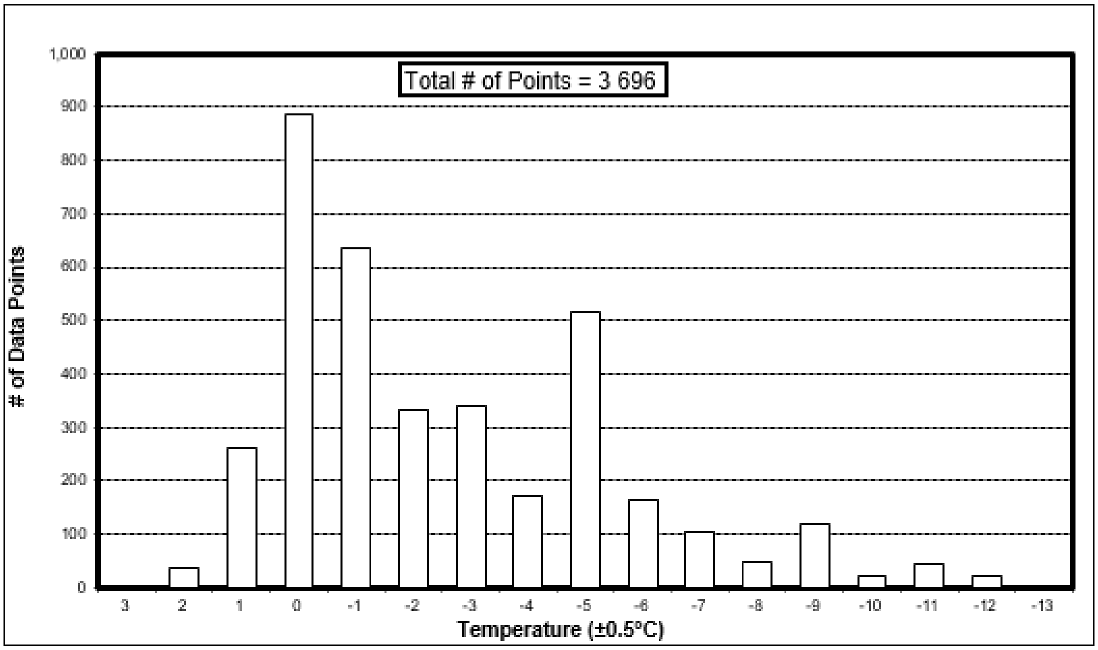

Figure 2.19: Temperature Distribution – Freezing Drizzle

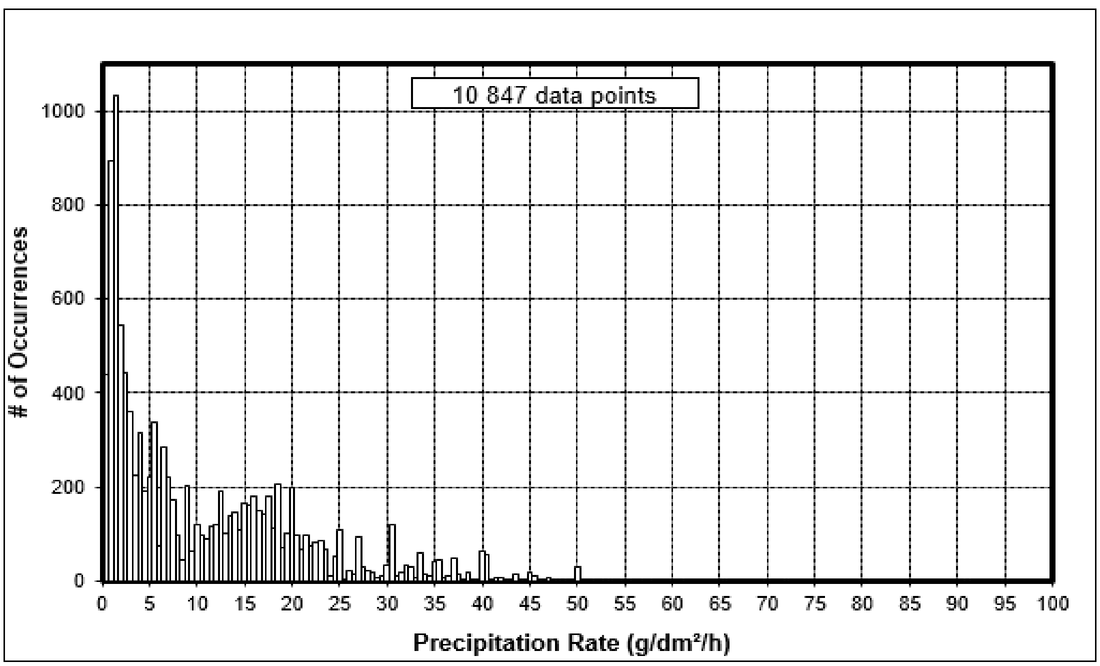

Figure 2.20: Precipitation Rate Analysis – Freezing Rain

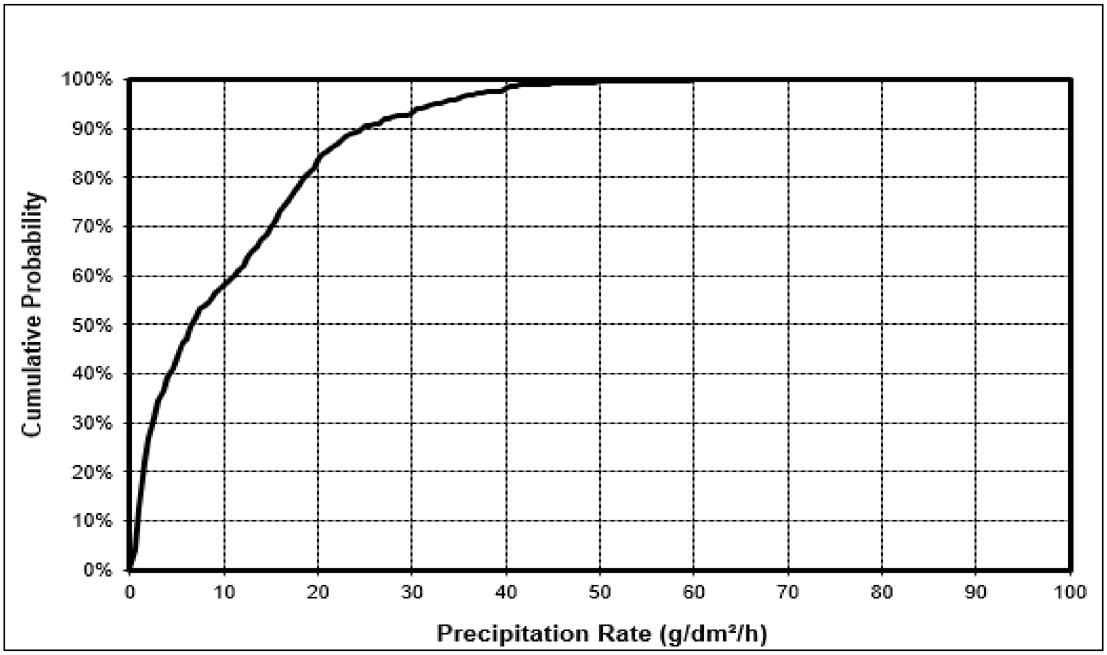

Figure 2.21: Cumulative Precipitation Rate Analysis – Freezing Rain

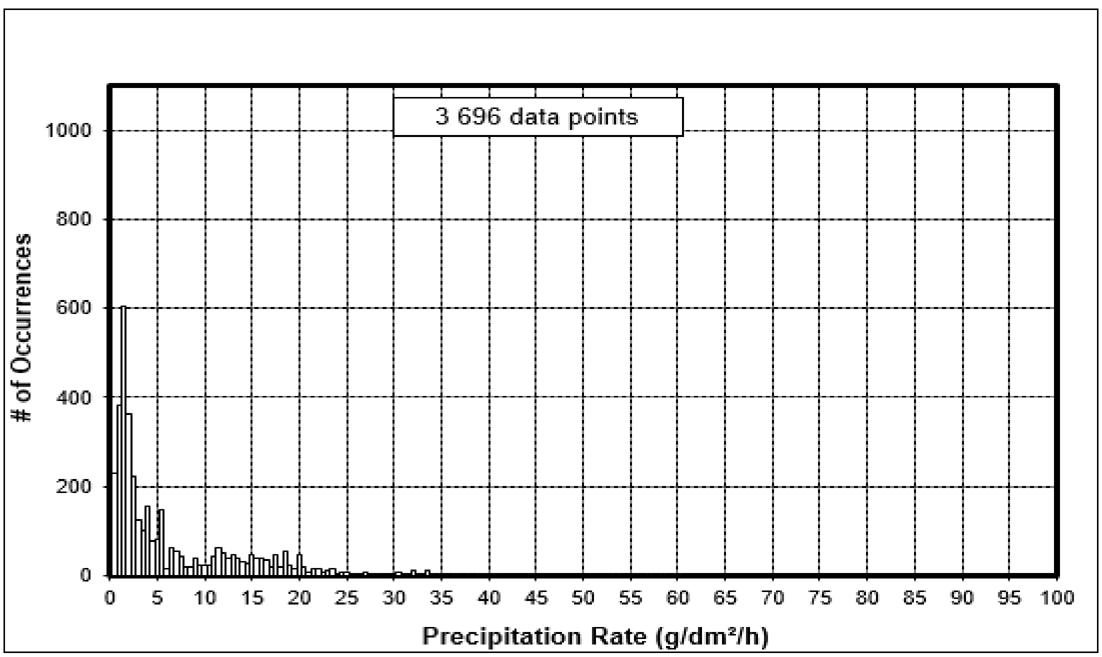

Figure 2.22: Precipitation Rate Analysis – Freezing Drizzle

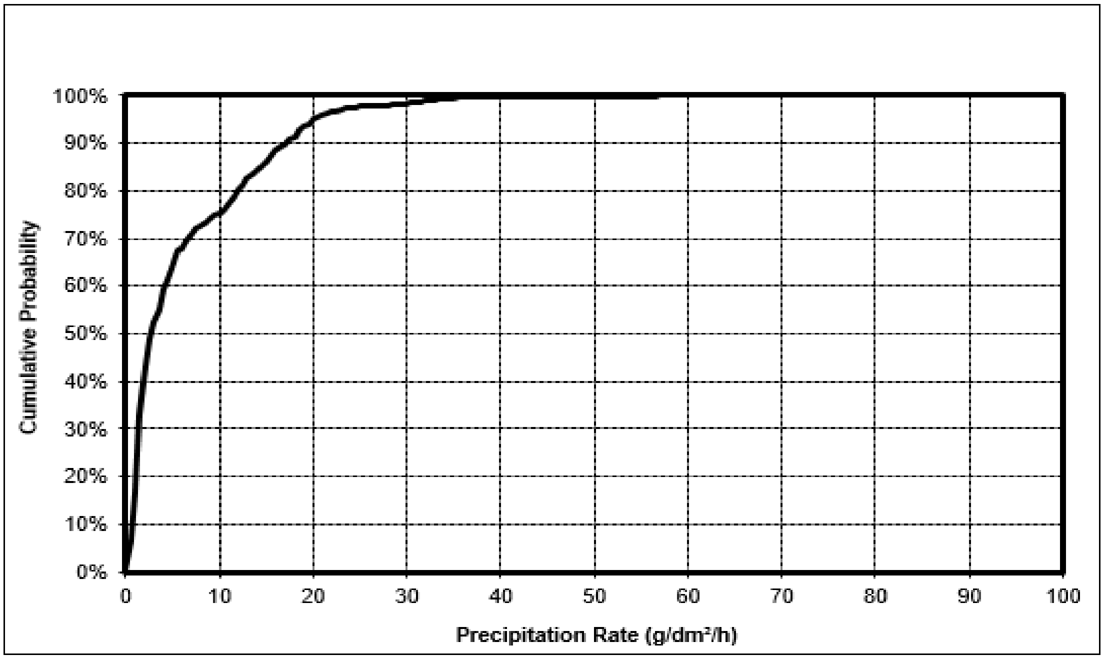

Figure 2.23: Cumulative Precipitation Rate Analysis – Freezing Drizzle

The dataset was filtered by APS by eliminating conditions that were not conducive to frost formation. The resulting database was examined for two ranges of wind below 15 km/h and below 10 km/h.

A second application of this dataset was to assess the wind and ambient temperature distributions during natural freezing precipitation conditions, and is presented in Section 7 of TC report TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (4). The absence of wind appears to have a large influence on Type I fluid endurance times in freezing rain at mild ambient temperatures such as -3°C. It appears that convective heat transfer in calm conditions is unable to remove the heat derived from latent heat of freezing quickly enough to prevent the surface temperature from rising above the ambient temperature. To ascertain typical wind conditions during periods of freezing rain, weather data collected at Montreal and La Grande, Quebec were examined. It was found that about 75 percent of the freezing rain events occurred at -3°C and above, and winds of 11 km/h or above were experienced 90 percent of the time. It was concluded that such wind speeds would be expected to enhance convective heat transfer and counteract the effect of latent heat by rapidly cooling the wing to ambient temperature.

Finally, a study was conducted to identify the worst-case scenario for fluid evaporation (dry-out) following application in expected frost conditions. Among other parameters, the relative humidity was found to play an important role in the process. Subsequently, the historical data were filtered to include only weather conditions facilitating the occurrence of frost, but under all wind speed conditions. The analysis concluded that a relative humidity of 55 to 60 percent adequately represents worst-case real world dry-out conditions, and that this range is valid for wind speeds from 0 to 20 km/h and for temperatures from +2 to -25°C. The outcome from this analysis was presented to the industry at the SAE G-12 Fluids Time Subcommittee meeting, held in Vancouver in May 2003. The presentation can be found in Appendix E of TC report TP 14155E, *Aircraft Ground Icing Research Support Activities for the 2002-03 Winter* (5).

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3. WINTER OPERATIONS SURVEY

During the last three years, an annual survey was conducted by APS on behalf of TC in an attempt to collect data on actual deicing operations at several worldwide stations.

TC was seeking this information in support of a review of the HOT table temperature and weather condition breakdowns such that the research and development emphasis could be aimed at conditions where an important number of operations occur worldwide. In addition, the intent was to identify where improvements could be made to the HOT table format.

This section consists of an introduction, methodology, description and processing of data, analysis, and future survey requirements.

3.1 Introduction

Several years ago, an estimate of the number of deicing operations as a function of precipitation condition for Trudeau Airport was carried out and is presented in Figure 3.1.

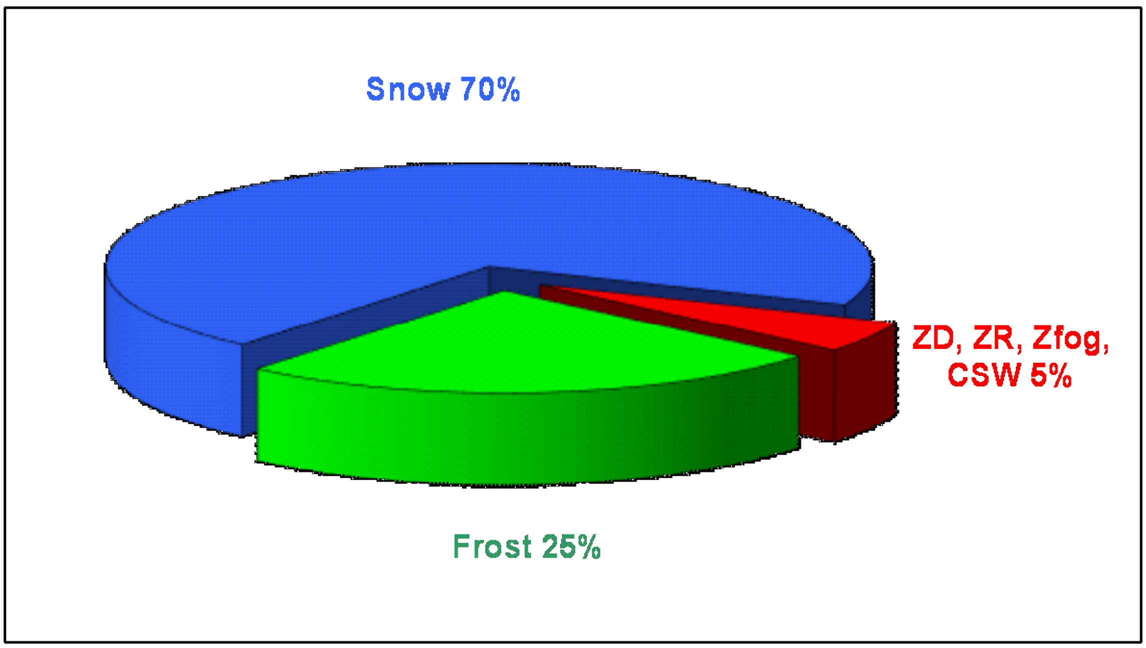

Figure 3.1: Previous Estimate of Frequency of Deicing Operations as a Function of Weather Condition at Trudeau Airport

This study was based on data from hourly weather observations recorded over 30 years at Trudeau Airport and on data related to aircraft deicing events taken from airport deicing logs. The distribution in Figure 3.1 was obtained according to the following steps:

Step I) Aéroports de Montréal (ADM) authorities provided the deicing operation log from a year prior to when Aeromag began operating the deicing centre. The deicing operations were separated into two categories: frost-related deicing and precipitation-related deicing;

Step II) Data from the 1999-00 winter season was averaged with the data collected over the previous 30 years. It was estimated that frost accounted for 25 percent of the deicing operations;

Step III) 75 percent of the deicing operations were due to freezing precipitation, of which 94 percent was in the form of snow, and 6 percent in the form of freezing drizzle, freezing rain, freezing fog and cold-soak wing; and

Step IV) It was established that 70 percent of all deicing operations were due to snow, 25 percent were due to frost, and 5 percent were due to freezing precipitation.

These estimates were reported in the TC report TP 13830E, *Winter Weather Data Evaluation (1995-2001),* (6), and also in the TC report TP 13665E, *Snow Weather Data Evaluation (1995-2000),* (7).

To substantiate these findings, and to evaluate the consistency of the results with other worldwide stations, TC initiated a survey (Appendix E) of airlines from several international airports. The findings from this survey are described and analysed later in this section.

3.2 Methodology

To acquire a worldwide representation of deicing operations, TC distributed the survey to a number of international airlines. The information obtained will be used to support a review of the HOT table temperature and weather condition breakdowns so that the fluid research can be aimed at conditions where an important number of operations occur worldwide. These results will also help in identifying where improvements can be made to the current HOT format.

The survey distributed to the airlines included four tables (see Appendix E). The first two tables were for participants to complete: Table 1 for Type I operations and Table 2 for Type II and/or Type IV operations. The last two tables (Tables 3 and 4) served as examples; these tables showed the combined results from the

2000-01 and 2001-02 surveys of information on deicing operations. The surveyed airlines were given the option to provide data in the form of percentages or numerical values. If separate data for Type I operations was not available, information for all fluids was provided in Table 2.

To receive the maximum number of responses, the survey was distributed to the SAE G-12 Committee participants. A summary of who was polled and who replied in 2000-01, 2001-02, and 2002-03 is presented in Subsection 3.3.

3.3 Description and Processing of Data

The feedback from the 2000-01 survey resulted in four tables for Type I fluids and seven tables for Type II/IV fluids, while the feedback from the 2001-02 survey produced twelve tables for Type I fluids and fifteen tables for Type II/IV fluids. This year, the feedback from the 2002-03 survey resulted in eight tables for Type I fluids and nine tables for Type II/IV fluids. The 2002-03 survey tables are included in Appendix E. Some responses were submitted with the actual number of deicing operations in each cell of the HOT table, while some were submitted with a total number of deicing operations and percentages in each cell of the HOT table. To facilitate the analysis of the data collected, all of the data were converted to the same units. The collaborated results from the three surveys conducted provided data for 112 535 deicing operations (Type I Table) and 86 853 anti-icing operations (Type II/IV Table).

A summary of the deicing operators polled is presented in Table 3.1. In 2000-01, seven of the twenty-one deicing operators replied to the survey, a response rate of 33 percent. In 2001-02, fifteen of the twenty-five deicing operators replied to the survey, a response rate of 60 percent, which is almost twice that of the previous year. This year, eight of the twenty-nine operators replied to the survey, which resulted in a response rate of 28 percent; the lowest in the last three years.

The worldwide distribution of the fifteen airlines and deicing firms that have contributed data for this survey is presented in Figure 3.2.

Table 3.2 and Table 3.3 show the total number of Type I deicing operations as a function of location, year, and precipitation condition. The deicing operations were sorted by weather condition: frost, freezing fog, snow, freezing drizzle, light freezing rain, and other (snow pellets, snow grain, ice pellets, rime ice).

Table 3.1: Summary of Deicing Operators Surveyed

DEICING OPERATOR	CITY	RESPONSE 2000-01	RESPONSE 2001-02	RESPONSE 2002-03
Alaska Air	Alaska	N/A	N/A	
Aeroflot	Moscow	N/A	N/A	
Aero–Mag	Montreal	X	X	X
Aéroports de Paris	Paris (CDG)	N/A	X	
Air Canada/ GlobeGround	Toronto	X	X	X
Air France	Paris (Orly)	X	X	
Air New Zealand	New Zealand	N/A	N/A	
All Nippon Airways	Tokyo			
American Airlines	Chicago			
American Eagle Airlines	Chicago		X	X
British Airways	Heathrow	X	X	
Continental	Newark	N/A	X	
Delta	Boston			
FedEx	Memphis			
Finnair	Helsinki		X	X
Japan Airlines	Sapporo	X		N/A
JAS	Tokyo	N/A		
KLM	Amsterdam	X	X	X
Lufthansa	Munich, Frankfurt	N/A	X	X
Northwest	Detroit			
SAS	Stockholm, Oslo			
Swissair	Zurich			X
United Airlines	Denver, Chicago		X	X
UPS	Louisville		X	
US Airways	Pittsburgh	X	X	X
Vienna Airport	Vienna	N/A	N/A	
West Jet	Calgary / Edmonton	N/A	N/A	

N/A – Survey responses not received.

Figure 3.2: Worldwide Distribution of Responses to the 2000-03 Survey

Table 3.2: Type I Deicing Data 2000 to 2003

	FROST	FRZ. FOG	SNOW	FRZ. DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER	Total
AMSTERDAM (00-01)	0	0	0	0	0	0	0	0
AMSTERDAM (01-02)	0	0	0	0	0	0	0	0
AMSTERDAM (02-03)	0	0	0	0	0	0	0	0
CHICAGO AE (01-02)	50	0	2200	50	200	0	0	2500
CHICAGO AE (02-03)	350	0	1618	80	0	0	0	2048
CHICAGO United (01-02)	3510	0	0	0	0	0	0	3510
CHICAGO United (02-03)	2146	32	2637	25	31	0	0	4871
DENVER (01-02)	104	3	50	4	0	0	0	161
FRANKFURT (01-02)	0	0	0	0	0	0	0	0
FRANKFURT (02-03)	0	0	0	0	0	0	0	0
HELSINKI (01-02)	5129	103	4443	298	55	35	0	10063
HELSINKI (02-03)	2700	100	9194	200	200	250	0	12644
LONDON LGW (01-02)	0	0	0	0	0	0	0	0
LONDON LHR (01-02)	0	0	0	0	0	0	0	0
LOUISVILLE (01-02)	0	0	600	250	150	0	0	1000
MONTREAL (00-01)	2541	0	4611	152	161	65	0	7530
MONTREAL (01-02)	2124	0	2477	112	283	22	67	5085
MONTREAL (02-03)	3016	0	2687	77	108	110	113	6111
MUNICH (01-02)	2562	34	192	0	0	0	0	2788
MUNICH (02-03)	2886	15	72	0	0	0	0	2973
NEWARK (01-02)	44	0	224	0	67	8	0	343
PARIS CDG (01-02)	985	0	315	0	0	0	0	1300
PARIS ORLY (00-01)	0	0	0	0	0	0	0	0
PARIS ORLY (01-02)	428	0	226	0	0	0	0	654
PITTSBURGH (00-01)	78	0	6417	78	1252	0	0	7825
PITTSBURGH (01-02)	282	0	2311	39	85	0	525	3242
PITTSBURGH (02-03)	237	0	4930	136	341	0	0	5644
SAPPORO (00-01)	327	0	363	0	0	0	0	690
TORONTO (00-01)	2868	0	5452	146	117	224	947	9754
TORONTO (01-02)	2300	0	3669	0	0	14	463	6446
TORONTO (02-03)	3658	0	5667	700	0	1	3465	13491
ZURICH (02-03)	745	0	931	0	0	0	186	1862
Total	39070	287	61286	2347	3050	729	5766	112535

Table 3.3: Type II/IV Deicing Data 2000 to 2003

	FROST	FRZ. FOG	SNOW	FRZ. DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER:	Total
AMSTERDAM (00-01)	3300	192	1869	73	38	28	0	5500
AMSTERDAM (01-02)	1980	328	553	77	0	22	0	2960
AMSTERDAM (02-03)	1710	142	798	142	57	0	0	2849
CHICAGO AE (01-02)	0	0	2200	100	200	0	0	2500
CHICAGO AE (02-03)	0	0	1755	80	0	0	0	1835
CHICAGO United (01-02)	0	300	1880	95	150	0	0	2425
CHICAGO United (02-03)	31	0	2901	0	227	0	0	3159
DENVER (01-02)	0	0	0	0	0	0	0	0
FRANKFURT (01-02)	2059	0	1967	46	123	279	0	4474
FRANKFURT (02-03)	2103	0	2229	0	39	0	0	4371
HELSINKI (01-02)	2773	105	4508	298	55	2	0	7741
HELSINKI (02-03)	1900	100	4850	200	200	250	0	7500
LONDON LGW-LHR (00-01)	1800	100	100	0	0	0	0	2000
LONDON LGW (01-02)	1421	0	0	0	0	0	0	1421
LONDON LHR (01-02)	2053	0	0	0	0	0	0	2053
LOUISVILLE (01-02)	4031	0	600	250	150	0	0	5031
MONTREAL (00-01)	81	0	2594	88	132	32	0	2927
MONTREAL (01-02)	45	0	1330	48	213	4	32	1672
MONTREAL (02-03)	57	0	1544	67	85	72	92	1917
MUNICH (01-02)	114	483	1810	12	3	17	0	2439
MUNICH (02-03)	97	502	2389	6	12	109	0	3115
NEWARK (01-02)	44	0	232	0	67	0	0	343
PARIS CDG (01-02)	0	0	100	50	0	0	0	150
PARIS ORLY (00-01)	522	0	25	0	3	0	0	550
PARIS ORLY (01-02)	449	0	224	0	0	0	0	673
PITTSBURGH (00-01)	0	0	1735	328	282	0	0	2345
PITTSBURGH (01-02)	0	0	638	39	85	0	0	762
PITTSBURGH (02-03)	0	0	1298	190	220	0	0	1708
SAPPORO (00-01)	0	0	485	0	0	0	0	485
TORONTO (00-01)	0	0	3447	98	87	33	45	3710
TORONTO (01-02)	2	0	1462	0	0	2	83	1549
TORONTO (02-03)	8	0	2571	599	0	0	1136	4314
ZURICH (02-03)	950	0	1188	0	0	0	237	2375
Total	27530	2252	49282	2886	2428	850	1625	86853

3.4 Validation of Data

3.4.1 Montreal, Quebec – Trudeau Airport

a) Winter 2000-01: Trudeau Airport reported 7 531 deicing operations and 2 927 anti-icing operations. With the exception of freezing fog, deicing and anti-icing operations took place under all weather conditions. Snow precipitation accounted for the largest number of deicing operations;

b) Winter 2001-02: Trudeau Airport reported consistent results with the previous year. A total number of 5 085 deicing operations and 1 672 anti-icing operations took place. Deicing procedures were most frequent under frost and snow conditions. Anti-icing operations were mostly conducted during snow precipitation; and

c) Winter 2002-03: Trudeau Airport reported 6 111 deicing operations and 1 917 anti-icing operations. Similar to the results obtained during the previous two years, deicing and anti-icing operations took place under all weather conditions with the exception of freezing fog. Snow accounted for the majority of the anti-icing operations.

3.4.2 Pittsburgh, Pennsylvania

a) Winter 2000-01: Pittsburgh Airport reported 7 825 deicing operations and 2 345 anti-icing operations. Approximately 80 percent of these operations were during snow precipitation. Freezing rain and freezing drizzle accounted for 19 percent of the operations while frost accounted for the remaining 1 percent. In comparison to Montreal, the number of deicing operations performed was greater during snow and freezing rain/drizzle and much lower during frost. The warmer average temperature in Pittsburgh can justify these differences;

b) Winter 2001-02: In comparison to the previous year, there was a 60 percent decline in the total number of operations performed during the winter of 2001-02. The Pittsburgh area received less precipitation during the 2001-02 winter. Most operations were performed during snow precipitation; and

c) Winter 2002-03: Pittsburgh Airport reported 5 644 deicing operations and 1 708 anti-icing operations. These results were similar to those provided in the 2000-01 survey. Snow accounted for the majority of the de/anti-icing operations. There were no anti-icing operations performed due to frost.

3.4.3 Sapporo, Japan

Winter 2000-01: Sapporo Airport performed 690 deicing operations, of which 53 percent were during snow precipitation and 47 percent during frost, 485 anti-icing operations were performed during snow precipitation.

3.4.4 Chicago, Illinois

a) Winter 2001-02: American Eagle Airlines and United Airlines provided data for the Chicago Airport. The results obtained were in the same magnitude with one exception. United Airlines reported that all of their Type I operations (3 510) were due to frost precipitation. American Eagle Airlines reported that only 2 percent of the Type I operations were due to frost precipitation. United Airlines did not distinguish between Type I and Type II/IV operations on the returned survey, which may have led to the difference in results. The proper distribution of operations performed by United Airlines was not available; and

b) Winter 2002-03: American Eagle Airlines and United Airlines provided data for the Chicago Airport. American Eagle reported 2 048 deicing operations and 1 835 anti-icing operations, while United Airlines reported 4 871 deicing operations and 3 159 anti-icing operations. Both airlines reported that the majority of the deicing operations were performed during snow conditions, however United Airlines reported 44 percent due to frost while American Eagle Airlines only reported 17 percent due to frost.

3.4.5 Denver, Colorado

Winter 2001-02: United Airlines provided data for the Denver Airport. A total of 161 Type I procedures were reported, of which 64 percent were during frost precipitation. No data were obtained for anti-icing operations.

3.4.6 Toronto, Ontario – Pearson Airport

a) Winter 2000-01: Pearson Airport presents a particularity in that two different companies manage the airport's deicing operations. GlobeGround is responsible for the majority of deicing operations under all weather conditions. During frost conditions, Air Canada does most of its deicing operations independently at the gates. Both firms replied to the survey. Air Canada provided their data for frost together with the GlobeGround deicing operations of Air Canada aircrafts. GlobeGround's electronic database collects data in a somewhat different manner than the format requested. They categorize the weather conditions as rime ice, light snow, medium snow, or clear ice, among others. In addition, their database does not make a distinction between Type I operations and Type II/IV operations. To facilitate a global analysis, all tables were to be in the same format, so the total number of operations from GlobeGround were compiled with Air Canada's distribution of deicing operations. The final table shows that anti-icing operations as a result of snow account for almost 93 percent of the cases (just 56 percent for deicing operations). With the exception of freezing fog, deicing operations took place under all weather conditions, including a substantial amount (10 percent) for rime ice. Air Canada reported that rime ice occurs primarily from landing aircraft that accrete ice on the leading edge;

b) Winter 2001-02: The values provided for Toronto were a combination of GlobeGround's data along with Air Canada's data. GlobeGround data were incorporated into Air Canada's results by distributing the data based on Air Canada's operation ratios. Toronto reported a large amount of rime ice, (about 7 percent), but the majority of the precipitation was snow. It should be noted that the values for snow operations include procedures done for "Layover Ice" and "Pre-treating"; and

c) Winter 2002-03: Globe ground provided information for the Toronto Airport. A total of 13 491 deicing operations and 4 314 anti-icing operations were reported; more than twice the number of operations performed during the winter of 2001-02. GlobeGround provided additional deicing data for heavy snow. This data were added to the moderate snow column to be consistent with the HOT table format. Forty-six percent of the total operations performed were due to snow conditions. More than a quarter of the total operations were due to Layover Ice and Rime Ice.

3.4.7 Paris, France – Charles de Gaulle Airport

Winter 2001-02: Aéroports de Paris reported having only three snow-days, with a minimum temperature of -5.9°C. They received just over half the amount of rain received the previous year. It should also be noted that no deicing operations took place after January 17, 2002.

3.4.8 Newark, New Jersey

Winter 2001-02: Continental Airlines provided data for the Newark International Airport, but did not record precise data during the winter of 2001-02. However, they estimated that roughly 70 percent of all their deicing and anti-icing operations were due to snow precipitation.

3.4.9 Helsinki, Finland

a) Winter 2001-02: A total of 10 063 deicing and anti-icing operations were reported. Type I followed by Type IV fluid operations were performed 7 741 times, leaving 2 322 deicing operations that were not followed by anti-icing operations. Frost and snow were the predominant type of precipitation; and

b) Winter 2002-03: A total of 12 644 deicing and anti-icing operations were reported. Type I followed by Type IV fluid operations were performed 7 500 times, leaving 5 144 deicing operations that were not followed by anti-icing operations. Frost and snow were again the predominant type of precipitation. In comparison to the previous year, there was a 28 percent increase in the number of Type I deicing operations performed during snow conditions, and a 30 percent decrease in the number of Type I deicing operations performed during frost conditions.

3.4.10 Louisville, Kentucky

Winter 2001-02: The original data sent from Louisville Airport were given in number of days of de/anti-icing activity. These figures were converted into a number of operations with the help of a Louisville representative via telephone. It was estimated that roughly 80 percent of the Type II/IV operations were due to frost. All Type I operations were followed by Type II/IV operations. The number of deicing operations due to snow, ZD and ZR were the same for both tables. For the Type II/IV table, the numbers were split between the 0°C to -3°C and -3°C to -14°C using Federal Aviation Administration (FAA) worldwide data (1982-97).

3.4.11 Munich, Germany

a) Winter 2001-02: Lufthansa reported 2 788 Type I operations for Munich. Over 85 percent of the Type I operations were followed by Type IV anti-icing operations. Approximately 92 percent of the Type I operations were performed during frost precipitation, while 75 percent of the Type IV operations were performed during natural snow conditions; and

b) Winter 2002-03: The Type I data table submitted by Lufthansa was submitted using the 2001-02 Type I HOT table format. The data were also submitted in the form of percentages, which was then converted to obtain the actual number of deicing operations in each condition. As per Section 2 of the TC report, TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003),* (1), the data were then redistributed according to Quebec's probability of precipitation for each HOT table temperature range to obtain the proper temperature breakdown.

Lufthansa reported 2 973 Type I operations for Munich. Approximately 97 percent of the Type I operations were performed during frost precipitation, while 77 percent of the Type IV operations were performed under natural snow conditions.

3.4.12 Frankfurt, Germany

a) Winter 2001-02: Lufthansa supplied data collected for Frankfurt Germany, but only Type II/IV data were returned. The concentration of fluid dilution used was neat, 75/25, or 50/50. All data collected were taken above -14°C. Snow and frost accounted for most of the precipitation; and

b) Winter 2002-03: Lufthansa returned data for Type IV operations only. The concentration of fluid dilution used was neat, and 50/50. No anti-icing operations were performed below -14°C. Snow and frost accounted for more than 99 percent of the total operations.

3.4.13 London, England

a) Winter 2000-01: At Heathrow International Airport the de/anti-icing operations were conducted using exclusively Type II fluid at a dilution of 75/25. 2 000 deicing operations were performed during the winter of 2001-02. The deicing log showed that frost contamination occurred in 90 percent of the situations. This could be explained by the high relative humidity of the region combined with moderately low temperatures over the winter; and

b) Winter 2001-02: Data were collected from London Heathrow Airport and London Gatwick Airport. Only Type II/IV results were provided in their reply. At both airports, anti-icing operations were performed solely during frost precipitation. Approximately 75 percent of these procedures took place in the temperature range of *0°C to -3°C.*

3.4.14 Amsterdam, Netherlands – Schiphol Airport

a) Winter 2000-01: Deicing operations at Schiphol Airport were reported during all weather conditions in the HOT table. The largest volume is represented by snow precipitation conditions (60 percent). Of the 5 500 deicing operations, approximately 30 percent were classified as "preventive anti-icing operations";

b) Winter 2001-02: Only anti-icing data were provided. The state of the fluid dilution varied from neat to 75/25 to 50/50, depending on the specific step in the procedure. Frost precipitation accounted for about 66 percent of anti-icing procedures; and

c) Winter 2002-03: KLM provided data for anti-icing operations only. All fluid dilutions were used. Frost accounted for more than 60 percent of the total anti-icing operations, while snow accounted for only 28 percent.

3.4.15 Paris, France – Orly Airport

a) Winter 2000-01: Of the 550 deicing operations, 95 percent took place during frost precipitation and only 4.5 percent were performed during snow precipitation. Only Type II/IV fluids were used for the deicing operations; and

b) Winter 2001-02: The data provided by Air France was not divided into temperature ranges. Only the total number of operations for each precipitation condition was provided. In order to make these data compatible with the rest of the survey, actual numbers had to be allocated to each temperature range. Using the ratios from the 2000-01 survey for this airport, the maximum number of operations was divided appropriately to assign a number to each cell of the table.

3.4.16 Zurich, Switzerland

a) Winter 2002-03: Swissair was only able to provide the total number of deicing and anti-icing operations performed; 1 862 and 2 375 respectively. Swissair estimated that 52 percent of the total de/anti-icing operations were performed during snow, and 38 percent were performed during frost. The data were redistributed according to Quebec's probability of precipitation in each HOT table temperature range (Section 2 of TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, (1)) to estimate the number of de/anti-icing operations in each weather condition. Swissair also stated that they underwent a relatively mild winter, and that the figures provided were slightly below average.

3.5 Analysis and Observations

3.5.1 2000 to 2003 Survey Results

Based on the total number of operations reported in the 2000-01, 2001-02, and 2002-03 surveys, a weighted average was calculated. The results from the survey are provided in both actual number of operations and percentages shown in Table 3.4 to Table 3.7.

Table 3.4: 2000-03 Winter Deicing Operations Survey Results for Type I Fluids (Operations)

112 535 Deicing Operations

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	14115	270	9306	7041	5231	1194	2106	724	2668	42655
-3 to -6	27 to 21	10575	8	7132	6556	4730	1147	886	0	1620	32654
-6 to -10	21 to 14	7496	8	5730	4811	3765	43	50	0	1125	23028
below -10	below 14	6876	0	3842	1943	1177	0	0	0	360	14198
	Total	39062	286	26010	20351	14903	2384	3042	724	5773	112535

Table 3.5: 2000-03 Winter Deicing Operations Survey Results for Type I Fluids (Percentages)

112 535 Deicing Operations

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	12.6%	0.2%	8.3%	6.3%	4.7%	1.1%	1.9%	0.6%	2.4%	38.1%
-3 to -6	27 to 21	9.4%	0.0%	6.3%	5.8%	4.2%	1.0%	0.8%	0.0%	1.4%	28.9%
-6 to -10	21 to 14	6.7%	0.0%	5.1%	4.3%	3.3%	0.1%	0.0%	0.0%	1.0%	20.5%
below -10	below 14	6.1%	0.0%	3.4%	1.7%	1.0%	0.0%	0.0%	0.0%	0.3%	12.5%
	Total	34.8%	0.2%	23.1%	18.1%	13.2%	2.2%	2.7%	0.6%	5.1%	100.0%

Table 3.6: 2000-03 Winter Deicing Operations Survey Results for Type II/IV Fluids (Operations)

86 853 Anti-Icing Operations

OAT °C	OAT °F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0°	above 32	6088	478	10564	490	796	845	212	19473
0 to -3	32 to 27	14664	917	20765	1559	897	0	531	39333
-3 to -14	27 to 7	6376	861	16672	833	727	0	859	26328
-14 to -25	7 to -13	408	2	1296	0	0	0	13	1719
below -25	below -13	0	0	0	0	0	0	0	0
	Total	27536	2258	49297	2882	2420	845	1615	86853

Table 3.7: 2000-03 Winter Deicing Operations Survey Results for Type II/IV Fluids (Percentages)

86 853 Anti-Icing Operations

OAT °C	OAT °F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0°	above 32	7.0%	0.5%	12.2%	0.6%	0.9%	1.0%	0.2%	22.4%
0 to -3	32 to 27	16.9%	1.1%	23.9%	1.8%	1.0%	0.0%	0.6%	45.3%
-3 to -14	27 to 7	7.3%	1.0%	19.2%	1.0%	0.8%	0.0%	1.0%	30.3%
-14 to -25	7 to -13	0.5%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	2.0%
below -25	below -13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	31.7%	2.6%	56.8%	3.4%	2.7%	1.0%	1.8%	100.0%

To allow a global analysis, the responses for Type I fluids (24 tables) were compiled with the responses for Type II/IV fluids (32 tables), for a total of 199 388 de/anti-icing operations worldwide. Figure 3.3 graphically shows the distribution of weather conditions grouped in four major categories: snow, frost, ZP (freezing precipitation, which includes freezing fog, freezing drizzle, light freezing rain, and rain on cold-soak wing) and other (i.e. rime ice). Each graph is specific to year and fluid type.

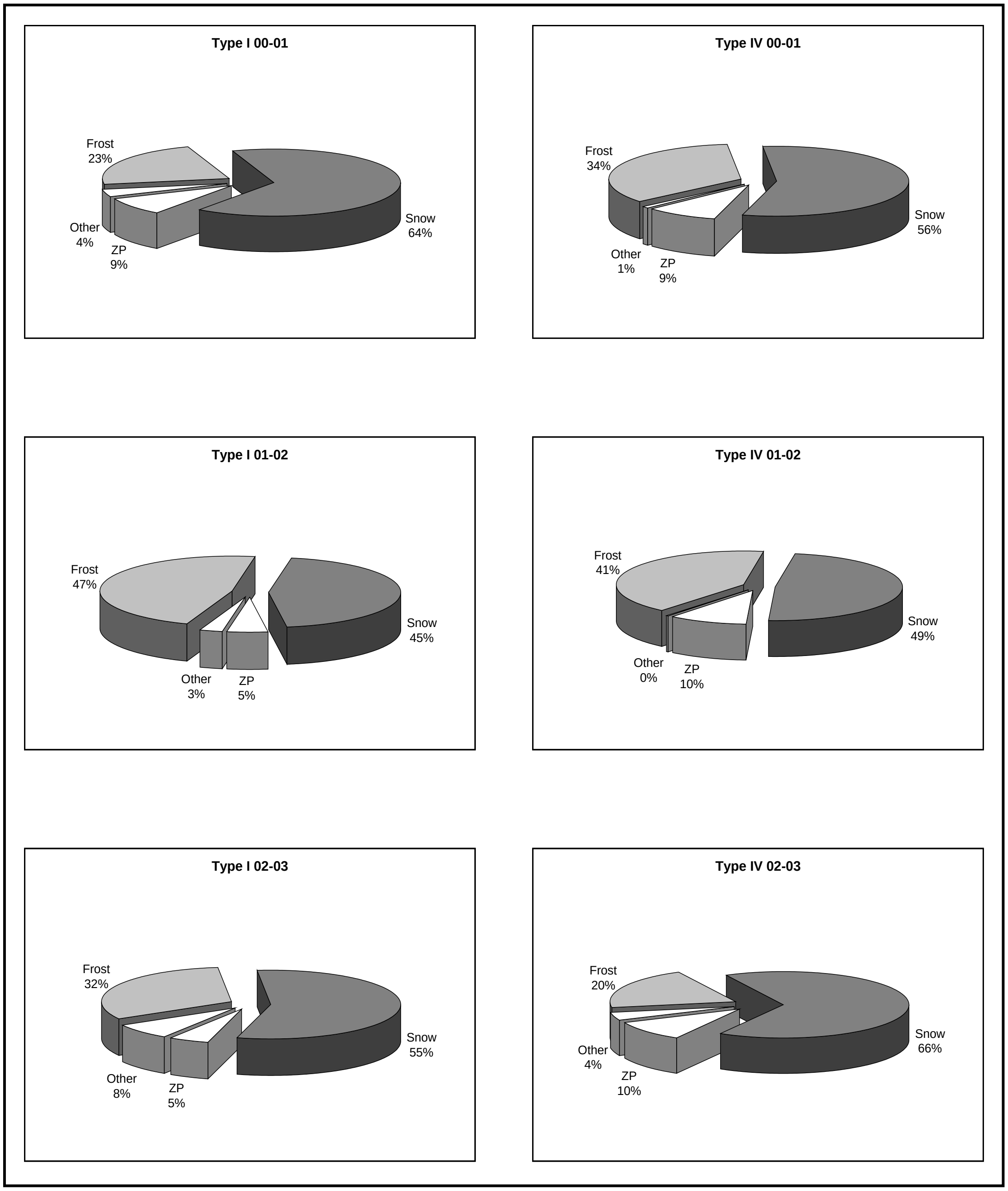

Figure 3.3: Frequency of De/Anti-icing Operations (All Airports) Sorted by Year and Fluid Type – Surveys 2000-03

Figure 3.4 demonstrates the combined results from the 2000-01, 2001-02, and 2002-03 surveys sorted by fluid type. The weather conditions are grouped in four major categories: snow, frost, ZP (freezing precipitation, which includes freezing fog, freezing drizzle, light freezing rain, and rain on cold-soak wing) and other (i.e. rime ice). The distribution of the operations by weather condition is very similar for both Type I fluid operations and Type II/IV operations.

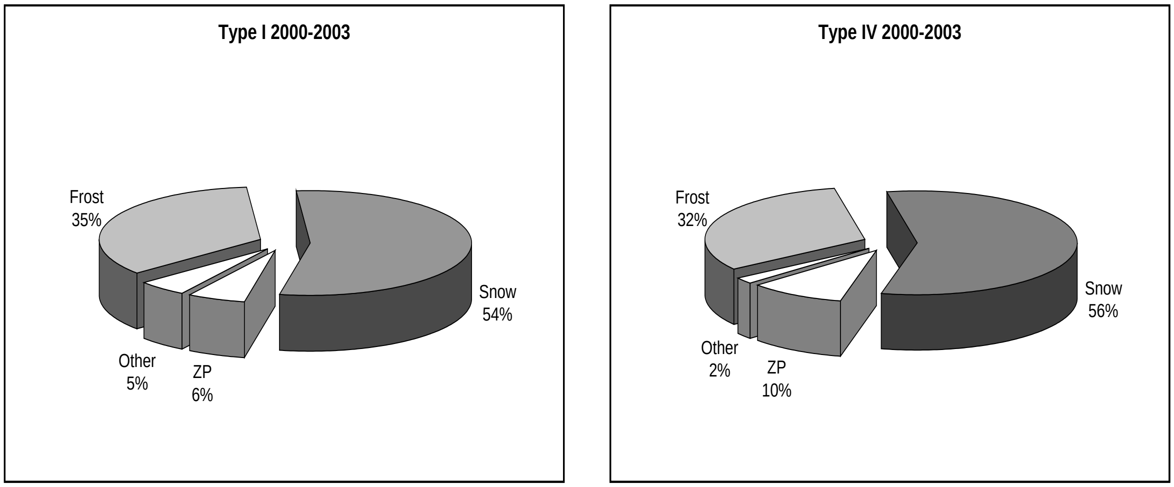

Figure 3.4: Frequency of De/Anti-icing Operations (All Airports) Sorted by Fluid Type – Surveys 2000-03

Figure 3.5 demonstrates the combined results from the 2000-01, 2001-02, and 2002-03 surveys. The number of de/anti-icing operations that occurred under snow precipitation was 55.5 percent, thus substantiating that snow represents the most significant weather condition for deicing operations worldwide. Frost accounted for 33.4 percent of the deicing operations, while 7.4 percent was due to freezing precipitation including freezing fog, freezing drizzle, light freezing rain, and rain on cold-soak wing; the remaining 3.7 percent was due to other forms of freezing precipitation (i.e. rime ice).

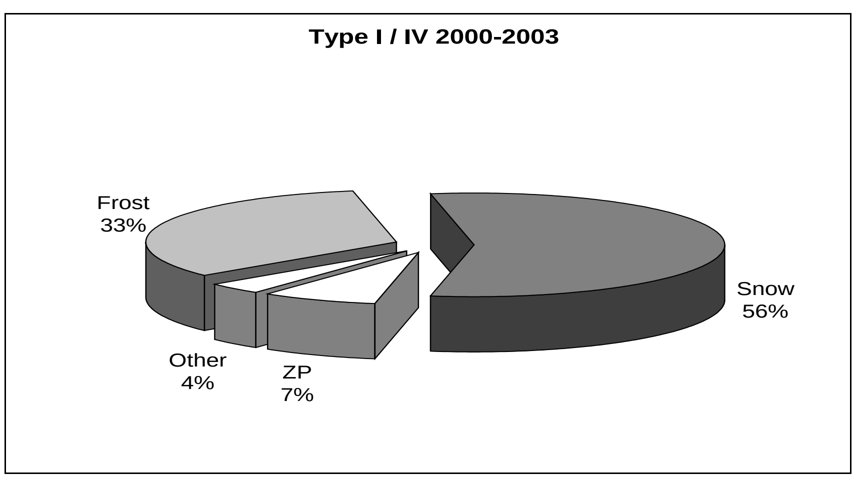

Figure 3.5: Frequency of De/Anti-icing Operations (All Airports) – Surveys 2000-03

The percentages in Figure 3.5 have been rounded to the closest whole number for simplicity.

The results of the 2002-03 survey remained relatively the same in comparison to the two previous years. According to the combined dataset from the 2000-03 surveys, the frequency of de/anti-icing operations due to frost decreased from 37.7 percent to 33.4 percent, while the number of operations due to snow precipitation increased from 52.6 percent to 55.5 percent.

3.5.2 Estimates of Deicing Operations at Trudeau Airport

Table 3.8 shows a complete summary of the data provided by AeroMag and MSC prior to 2001, and also the distribution of deicing operations at Dorval, derived from the last three years of observation.

Table 3.8: Summary of All Results

	FROST [%]	**FRZ. FOG** [%]	**SNOW** [%]	**FRZ. DRIZZLE** [%]	**LIGHT FRZ. RAIN** [%]	**RAIN ON CSW** [%]	**OTHER** [%]
Estimate for Dorval based on MSC and AeroMag Data (Prior to 2001)	25	1	70	1	2	1	0
Estimate for Dorval based on 2000-03 Survey	31.2	0	60.4	2.1	3.9	1.2	1.2
Estimate of all airports 2000-01	26.6	0.7	62.5	2.2	4.8	0.9	2.3
Estimate of all airports 2000-02	37.7	1.4	52.6	2.3	3.4	0.7	1.9
Estimate of all airports 2000-03	33.4	1.3	55.5	2.6	2.7	0.8	3.7

The 2000-03 estimate of all airports illustrated in Figure 3.5 is different from the Dorval allocation over the last three years. At Dorval, snow accounted for 60.4 percent of the deicing operations whereas in the worldwide results from the 2000-01, 2001-02, and 2002-03 surveys, snow accounted for 55.5 percent of the total deicing operations. This variation could be explained by the difference in the average winter temperature between Quebec and the surveyed regions.

Table 3.8 also presents the cumulative results from all three years, from 2001-02 to 2003-04. As observed in this table, the results vary from one year to the other. The survey results are analysed cumulatively, by adding new data to the existing database of results from previous years. As a result, the variation in results will decrease if the number of years of observation increases.

3.6 Future Survey Requirements

Though the culmination of the 2000 to 2003 data were more representative of the different climate conditions, the survey would further benefit if more regions were added; such as Northern Alberta and North-Eastern Europe.

Without the additional data from the areas suggested above, it is impossible to state that the weather conditions during the winters of 2000 to 2003 were typical of those for the past 10 years or of the next 10 years. If funding is available, the analysis should be extended over the next several years, and ideally over 11 years to include the solar cycle; this seems to have a significant effect on the weather cycles.

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4. CHANGES TO THE FORMAT OF THE HOLDOVER TIME TABLES

This section presents a summary of the changes done to the HOT table format over the last three years. The titles of the reports outlining these changes in more detail are in this section. Changes to the table format, agreed upon by the industry members in a certain year, are reflected in the HOT table of the following winter season.

4.1 Changes in 2001-02

In 2001-02, the Type I fluid HOT table format underwent a thorough examination. Research in previous years had indicated a need to make changes to the format. Some of the changes have been presented and accepted by the community, while others have yet to be formally accepted. The two major changes to the format of the Type I fluid HOT table were:

a) Modifying the split point between the two warmest temperature ranges from 0°C to -3°C (temperature ranges change from *above 0°C and 0°C to -10°C to above -3°C and -3°C to -10°C*); and
b) Addition of a column for light snow.

A detailed study providing the reasoning and justification behind those changes was conducted and could be found in Section 6 of TC report, TP 13993E, *Impact of Winter Weather on Holdover Time Table Format (1995-2002)*, (2).

4.2 Changes in 2002-03

In 2002-03 the format of the Type I tables was further reviewed and two new significant changes were implemented:

a) A new temperature breakdown was introduced by splitting the *-3 to -10°C* interval into *below -3 to -6°C* and *below -6 to -10°C* temperature ranges; and
b) Apart from the existing light snow and moderate snow columns, a new column for very light snow was introduced.

A detailed analysis explaining two major changes to the Type I table format was conducted and can be found in Section 4 of TC report TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003)*, (1).

4.3 Changes in 2003-04 and Potential Future Changes

In addition to the changes described in the two aforementioned TC reports, a new Type III generic table was produced in 2003-04 and is described in Section 5 of TC report TP 14374E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2003-04 Winter* (8). Values in the new generic Type III holdover time guidelines were generally based on the holdover times of Clariant Safewing MP III 2031 ECO.

Further potential changes to the holdover time tables are presented in Section 4 of TC report TP 14146E, *Winter Weather Impact on Holdover Time Table Format (1995-2003),* (1).

5. EVALUATION OF FROST AND FOG DEPOSITION RATES IN NATURAL CONDITIONS

This chapter contains an account of the tests conducted over the 2003-04 winter season to collect frost deposition rates in natural conditions. In addition, an account of the freezing fog tests conducted in the previous seasons is also described.

5.1 Measurement of Frost Deposition Rates in Natural Conditions

In the late 1990's, a workgroup of the Society Of Automotive Engineers (SAE) G-12 Fluids Subcommittee was set up to develop the laboratory procedures for endurance time testing. These procedures have been defined in a proposed Aerospace Standard (AS) 5485. For frost, the following parameters were suggested: the plate temperature is 3°C colder than the air temperature in all conditions; and icing intensity ranges from 0.20 g/dm²/h at 0°C to 0.06 g/dm²/h at -25°C.

During the 2000-01 winter, APS conducted laboratory tests to corroborate values for fluid endurance in active frost conditions in current holdover time tables. Simultaneously, the proposed AS5485 procedure for measuring fluid endurance times in frost conditions was evaluated. The times showed an unexpected pattern, with the values at 0 and -25°C being longer than at -10°C. These results also showed that the current holdover time of 45 minutes for frost was not adequate. During the tests, it was also observed that the environmental conditions specified in AS5485 did not produce the desired frost rates at temperatures of -25°C. These results led the experts and regulatory authorities to question the proposed procedure stipulated in AS5485 and to recommend that further work was necessary to validate the proposed parameters in AS5485.

During the 2001-02 and 2002-03 winters, APS conducted tests to establish test parameters that reflect natural environment conditions for active frost. Rates of natural frost accretion were also documented to enable specification of frost intensity for fluid endurance testing. Frost rates were measured over a range of conditions and temperatures. The rates were measured using a painted white aluminum insulated plate that was found to be representative of aircraft wing surfaces.

A field test was also conducted on an operational aircraft in natural frost conditions. The test showed that heated Type I fluids enriched substantially after application on the wing due to the evaporation of water from the water/glycol mix.

The fluid enrichment contributed greatly to the fluid endurance time, and it was concluded that laboratory test procedures needed to account for the enrichment.

As a supplement to this research, endurance times for Type I fluid were measured in natural frost conditions. All of the times measured exceeded the current holdover time values of 45 minutes; this was in contrast to the lower times measured previously in the laboratory.

From the consolidated data collected over the two seasons, a new set of test parameters for Type I fluids was determined. These parameters are described in Table 5.1.

Table 5.1: Recommended Frost Endurance Test Parameters – Type I Fluid

Condition	-3°C and above	Below -3 to -6°C	Below -6 to -10°C	Below -10°C
Air temperature, °C	3	-3	-6	-10
Plate temperature, °C	-3	-9	-12	-16
Icing intensity, g/dm²/h	0.3	0.23	0.2	0.15

Based on the findings of the natural frost endurance tests on SAE Type I fluid, it was recommended to finalize substantiation of the current frost holdover time value (45 minutes).

From the consolidated data collected over the two seasons, a new set of test parameters for Type II, III and IV fluids was determined and is listed in Table 5.2.

Table 5.2: Recommended Frost Endurance Test Parameters – Type II, III and IV Fluids

Condition	Above 0°C	0 to -3°C	Below -3 to -14°C	Below -14 to 25°C
Air temperature, °C	0	-3	-14	-25
Plate temperature, °C	-6	-9	-20	-31
Icing intensity, g/dm²/h	0.20	0.18	0.11	0.05

In order to finalize the test process for Type II, III and IV fluids it was recommended to conduct endurance time testing in frost to substantiate the fluid endurance times in natural conditions.

During the 2003-04 winter, APS conducted frost endurance tests outdoors using insulated white-painted aluminum surfaces. A detailed study documenting these tests was prepared and is presented in the TC Interim report, *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions* (9).

Data collected during 2001-02 and 2002-03 winters, was analysed to determine the temperature differential between the air and plate temperature. This database comprised data measured on white aluminum plates as well as on actual aircraft wing surfaces. The temperature differential that was collected as part of the Type I fluid endurance time testing was superimposed over the historical database, is shown in Figure 5.1.

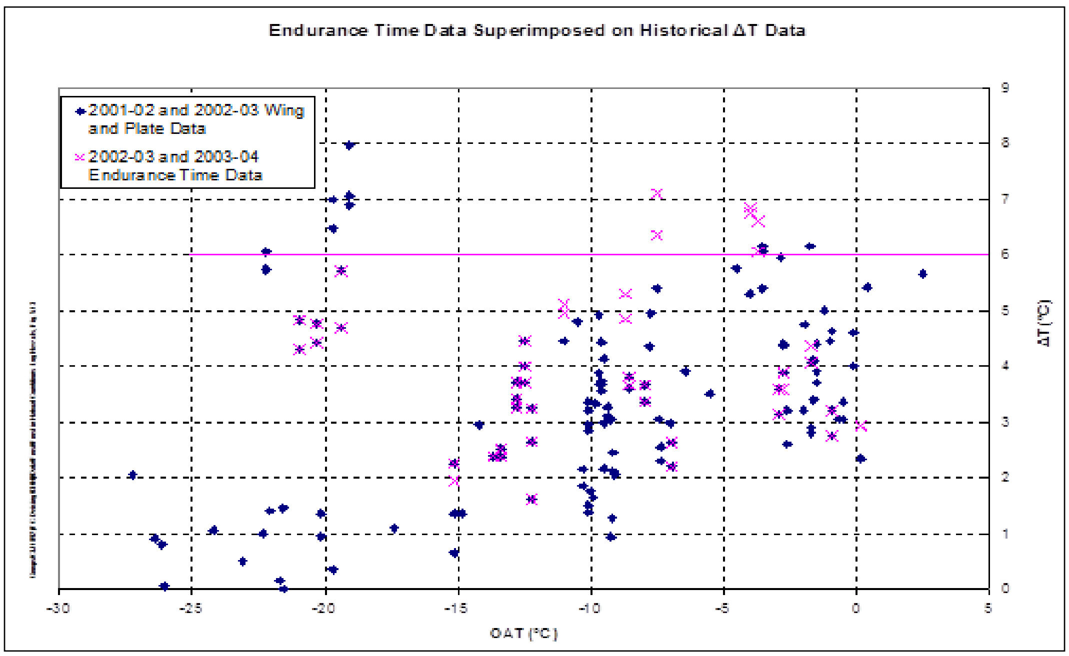

Figure 5.1: Endurance Time Data Superimposed on Historical ΔT Data

The data that was collected demonstrated that the long utilised holdover time of 45 minutes in frost conditions is adequate and should be considered as substantiated. In the event that a new non-glycol freezing point depressant fluid is introduced, the outdoor procedure should be added in the next version of the Aerospace Recommended Practice (ARP 5945) to enable verification of any new Type I products.

Data collected during 2001-02 and 2002-03 winters, was also analysed in an attempt to determine the expected icing intensities in a natural environment. Figure 5.2 shows the icing intensities test points collected in 2003-04 superimposed over the data collected over the two-year period. Examination of

Figure 5.2 suggests that perhaps data is lacking in the Outside Air Temperature (OAT) range of 0°C to +3°C, an important temperature zone that is not only experienced at airports in London and Paris, but also often comes with high Relative Humidity (RH) values.

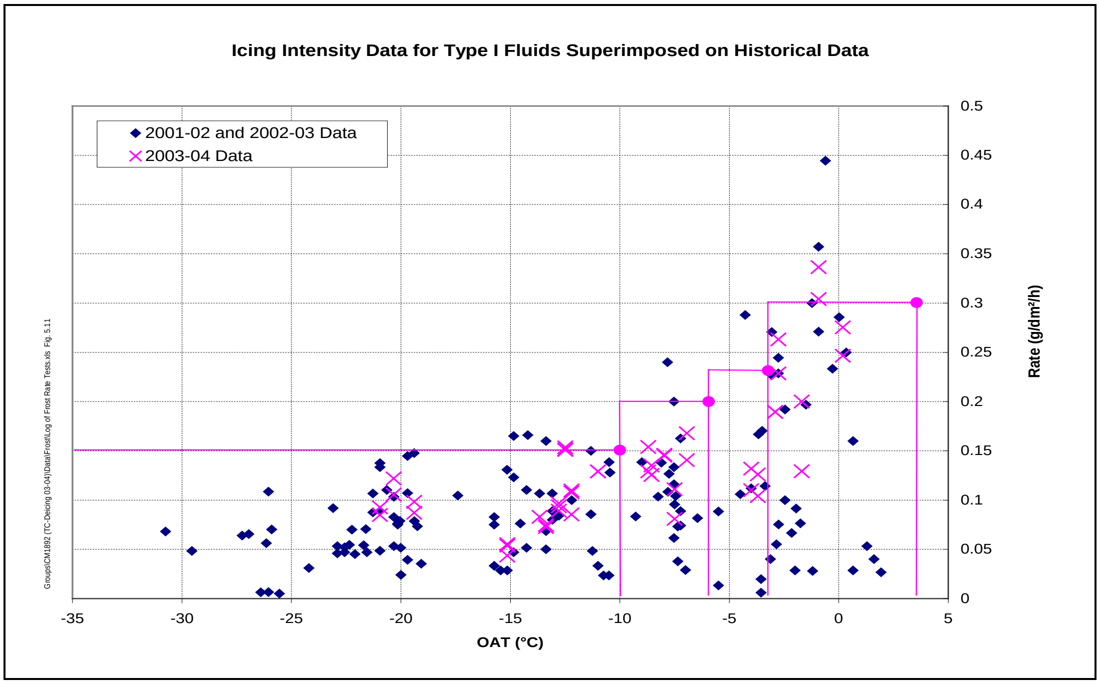

Figure 5.2: Icing Intensity Data for Type I Fluids Superimposed on Historical Data

As the data collected during the winter of 2003-04 does not cover the entire range of conditions in the Type II, III, and IV fluid holdover time tables, it is recommended that testing continue in 2004-05.

5.2 Study to Quantify Freezing Fog Deposition Rates

Natural freezing fog deposition rate measurements were conducted during previous test seasons. It was concluded that current HOT table precipitation rate limits of 2 and 5 g/dm^2/h are conservative, with rates measured during actual fog conditions being closer to 1 g/dm^2/h. For an account of testing from previous years, refer to TC report TP 13993E, *Impact of Winter Weather on Holdover Time Table Format (1995-2002),* (2).

6. CONCLUSIONS

A number of conclusions can be drawn from the various data collected for this report.

6.1 Precipitation Rate Limits for the Moderate Snow Range

Data gathered over nine years from six sites in Quebec form the basis for the winter weather analysis discussed in this report. The data confirms that the long-established HOT table snow precipitation rates of 10 and 25 $g/dm^2/h$ are valid limits at all temperature ranges for the *moderate snow* range. However, the data analysis also emphasizes that this range encompasses only 24 percent of all snow events, and snowfall at rates less than 10 $g/dm^2/h$ accounts for over 73 percent of all snow events. This stimulated the addition of two new snow columns for Type I and Type III fluids.

6.2 Addition of the Light Snow and Very Light Snow Ranges to the Type III HOT Table

Since the majority of all snowfall events occur at rates less than 10 $g/dm^2/h$, and because snow comprises 56 percent of all deicing operations worldwide, two additional columns in the Type III fluid HOT table, for *light snow* (4 to 10 $g/dm^2/h$) and *very light snow* (less than 4 $g/dm^2/h$), were introduced. Such a recommendation was favourably accepted at the 2004 SAE G-12 Frankfurt meeting.

6.3 Frequency Distribution of Types of Deicing Operations

The survey of actual winter operations concluded that, for the reporting centres, the distribution of types of deicing operations was:

a) Snow 56 percent;

b) Frost 33 percent; and

c) Other 11 percent.

The *other* category consisted of freezing rain, freezing drizzle, freezing fog, cold-soaked wing and rime ice.

6.3.1 Snow

This distribution confirms that snow is the most frequently used condition in the HOT table and, therefore, a corresponding degree of attention should be given to further refining it.

6.3.2 Frost

Similarly, this distribution confirms that frost is the second most frequent type of deicing condition, and it is also important that a sufficient degree of attention be given to investigating and substantiating frost holdover times.

6.3.3 Freezing Rain/Freezing Drizzle

Analysis of the winter weather data and survey data concluded that:

a) Freezing rain and drizzle occur in a temperature band with -10ºC as a lower limit; and

b) 91 percent of the time, precipitation rates were found to be less than 25 g/dm^2/h (see Table 2.18).

6.3.4 Freezing Fog

The combined results from the 2000-01, 2001-02, and 2002-03 surveys, presented in Table 3.8, have shown that deicing operations due to freezing fog comprise only around 1.3 percent of all precipitation conditions requiring use of HOT tables.

Based on the survey data and the tests conducted in previous years, it was concluded that:

a) Current HOT table precipitation rate limits of 2 and 5 g/dm^2/h are conservative, with rates measured during actual fog conditions closer to 1 g/dm^2/h; and

b) Modifying the HOT table column for freezing fog to provide a single value rather than a range is justified, based on long endurance times and infrequent use.

7. RECOMMENDATIONS

Recommendations related to specific subjects are offered.

7.1 HOT Table Format

It is recommended that:

- A small workgroup be assembled to examine and formulate the optimum format of the Type II and Type IV fluid HOT guideline tables.

7.2 Weather Data Survey

It is recommended that:

- This survey be continued in order to generate more data, which is particularly needed for relatively infrequent precipitation conditions such as freezing drizzle and rain.

7.3 Winter Operations Survey

As observed in Table 3.8, the results vary from one year to the other. The survey results are analysed cumulatively, by adding new data to the existing database of results from previous years. As a result, the variation in results will decrease if the number of years of observation increases. In addition, the survey would further benefit if more regions were added, such as Northern Alberta and North-Eastern Europe.

If funding is available, it is advisable to continue the survey for the next several winters and expanded to include more cities worldwide. Ideally, the analysis would be extended over 11 years to include the solar cycle.

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9. D'Avirro, J., *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions Frost* (Interim Report), APS Aviation Inc., Transportation Development Centre, Montreal, December 2004.

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING
2003-05

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT
AIRCRAFT & ANTI-ICING FLUID WINTER TESTING
2003-05

5.9 Evaluation of Winter Weather Data

a) Collect more data from the six weather stations in Quebec, with emphasis on freezing drizzle and freezing rain;

b) Continue and expand the operations survey to include more cities worldwide;

c) Analyze the data collected and report the findings; and

d) Provide any resulting recommendations that may have an impact on the HOT table format.

5.6 SAE Standards for Measuring Holdover Times

5.6.3 Short Term Changes to the HOT Tables Proposed by Workgroup

a) Remove the "Above 0°C" row for the Type II/III/IV HOT table guidelines; and make other editorial changes (i.e. removal of abbreviations) as identified by the HOT Working Group;

b) Develop tables of viscosities for the HOT tables, including the viscosities using the AIR method. This will include viscosities of the dilutions. Also measure viscosities using the AIR method of new samples that will be received as part of the NCAR snowmaker round-robin tests; and

c) Prepare presentation of all changes agreed upon by the HOT workgroup meeting and deliver at the SAE G-12 HOT Subcommittee meeting in the spring of 2004.

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APPENDIX B

WINTER WEATHER DATA 1995-96 TO 2003-04

WINTER WEATHER DATA 1995-96 TO 2003-04

The following charts include the complete rate data analysis, subdivided by temperature ranges for both snow and freezing rain. A histogram of points and a cumulative probability chart are included for each rate calculation interval in all temperature ranges.

The lowest holdover time temperature range for snow conditions (-14ºC to -25ºC) was subdivided into three ranges. The charts for this analysis are also included.

INDEX

SNOW

LIGHT FREEZING RAIN / DRIZZLE

COLD SNOW SUBDIVISION

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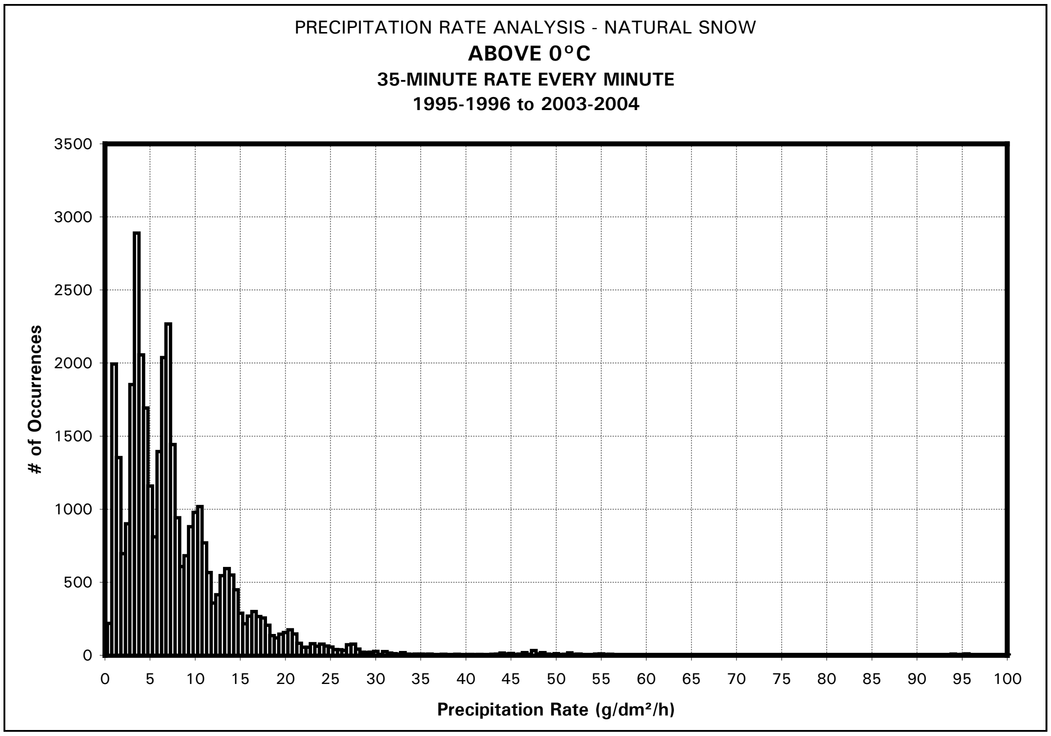
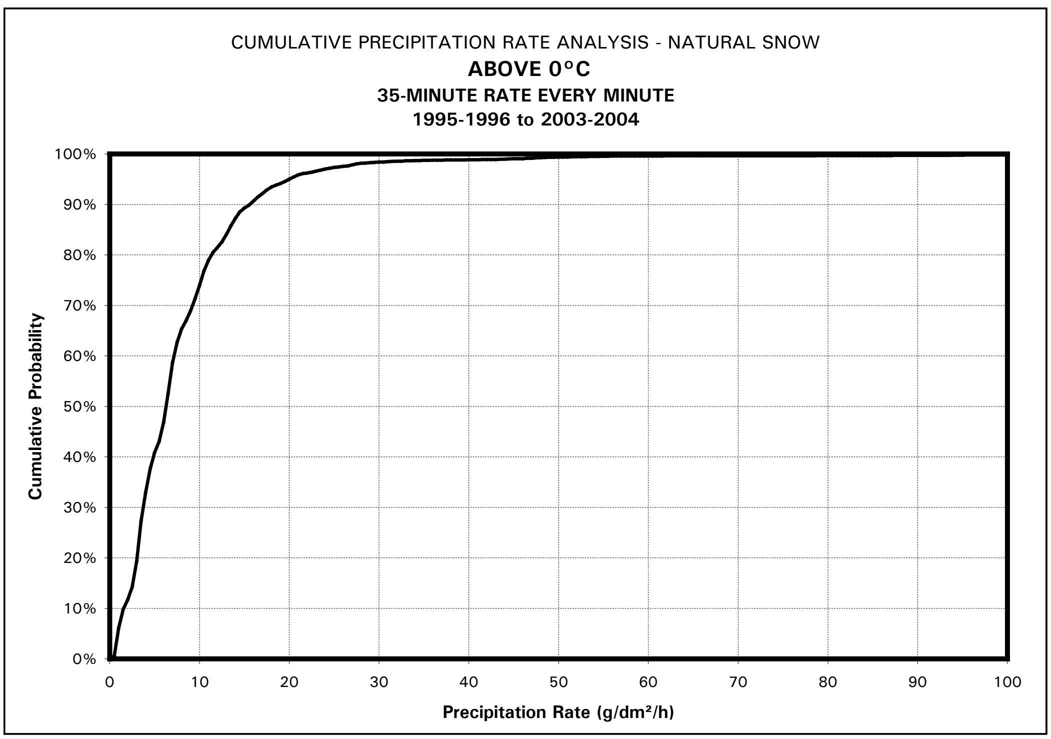

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
500
1000
1500
2000
2500
3000
3500
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
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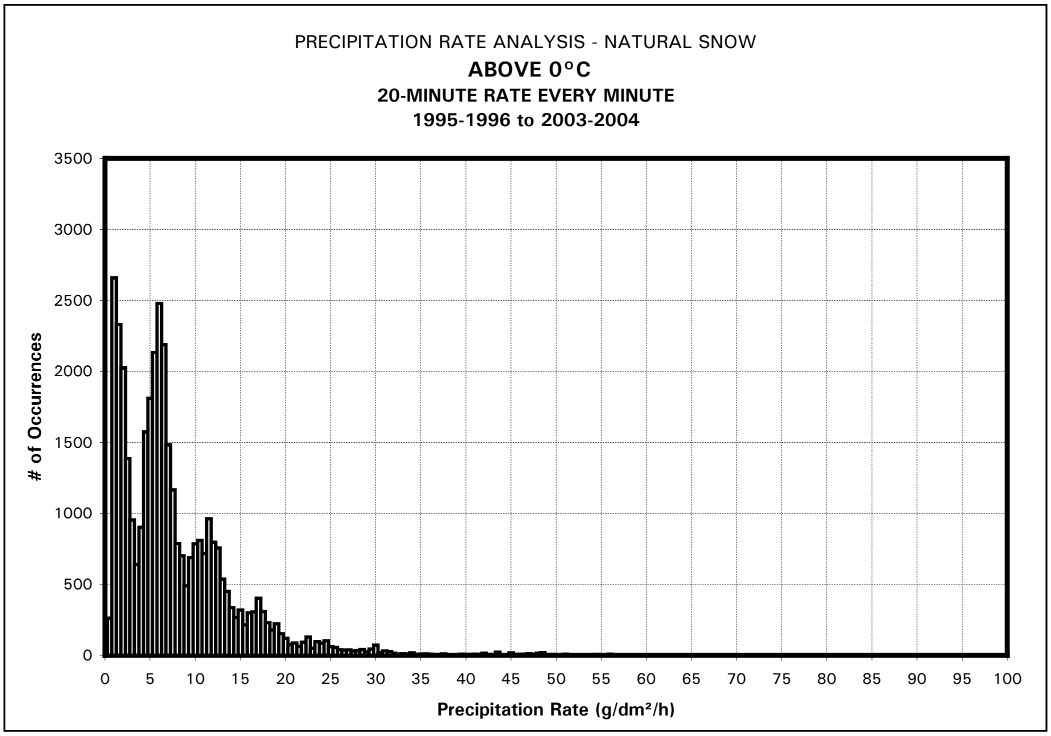
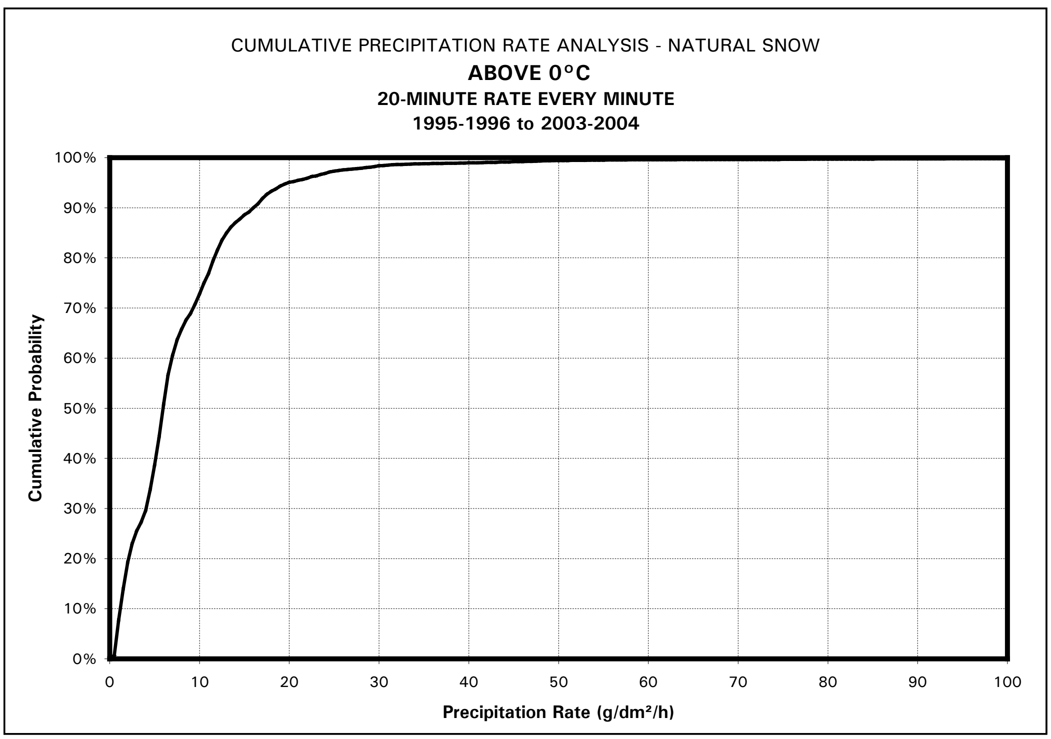
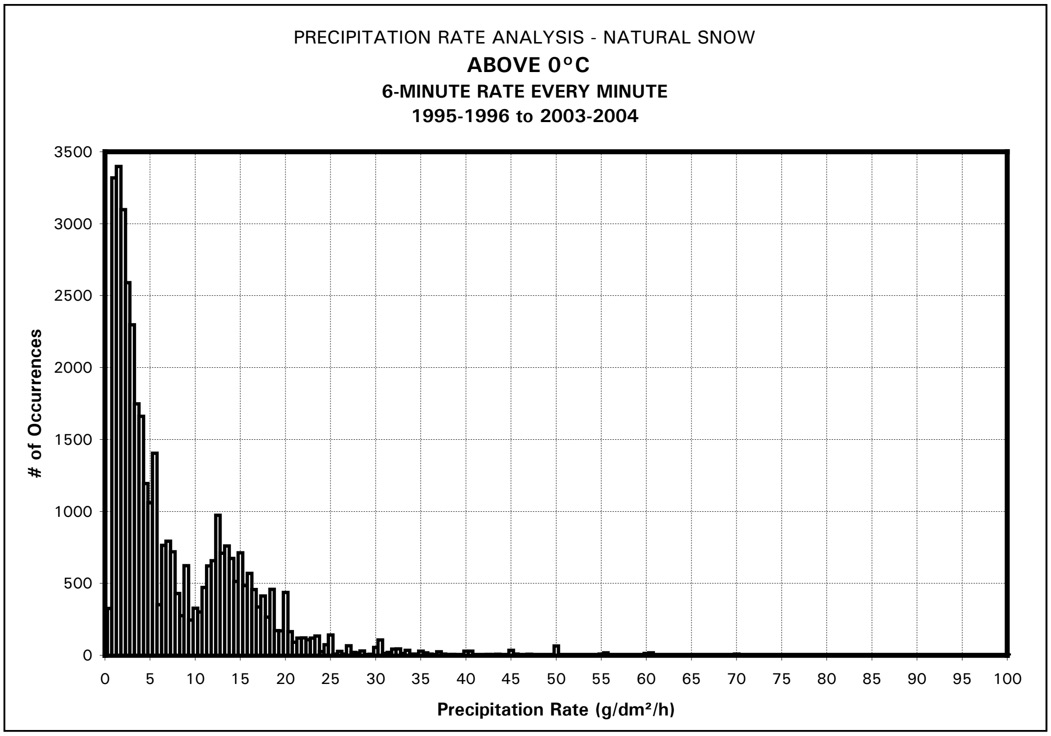
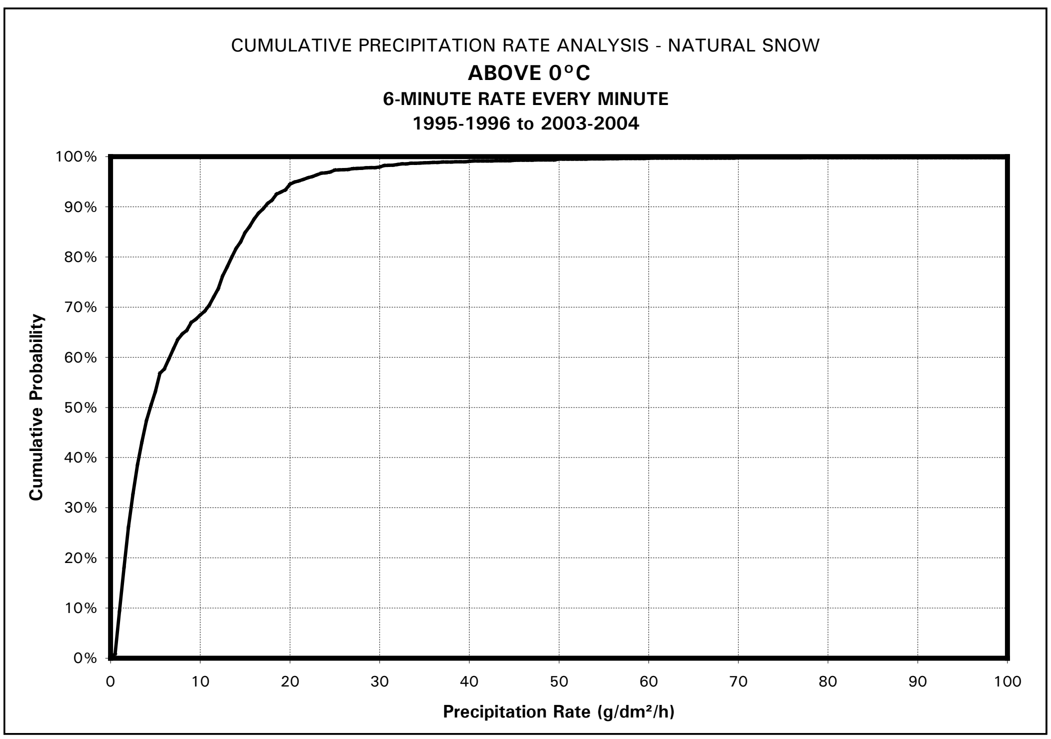
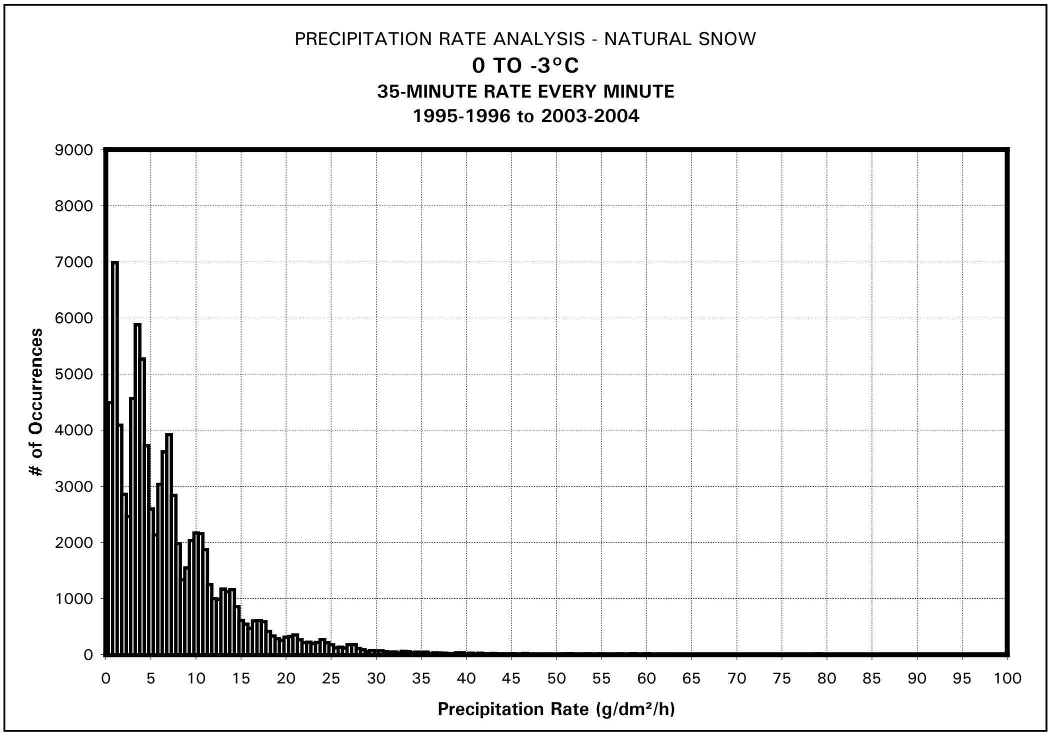
Precipitation Rate (g/dm²/h)

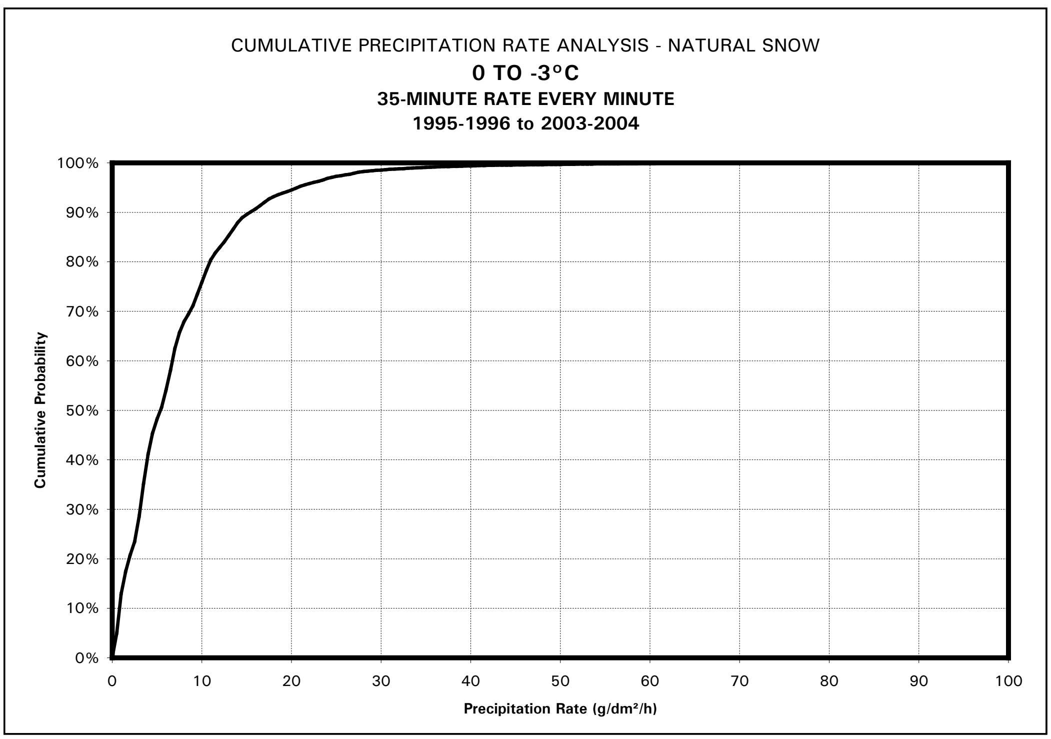

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
500
1000
1500
2000
2500
3000
3500
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

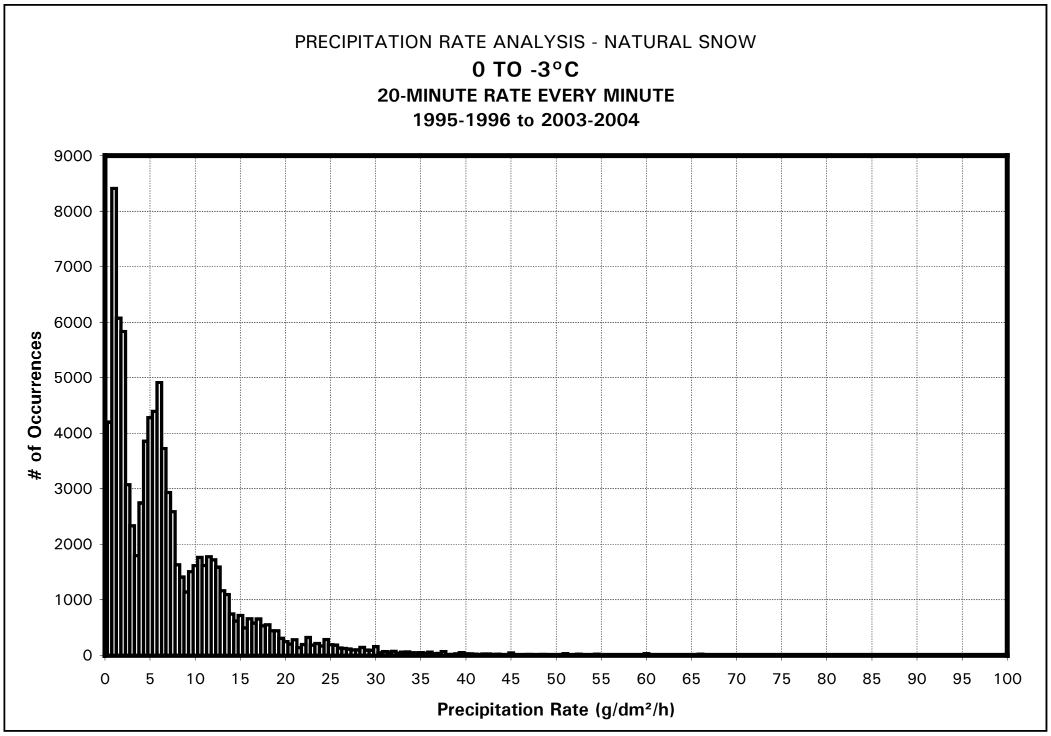

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

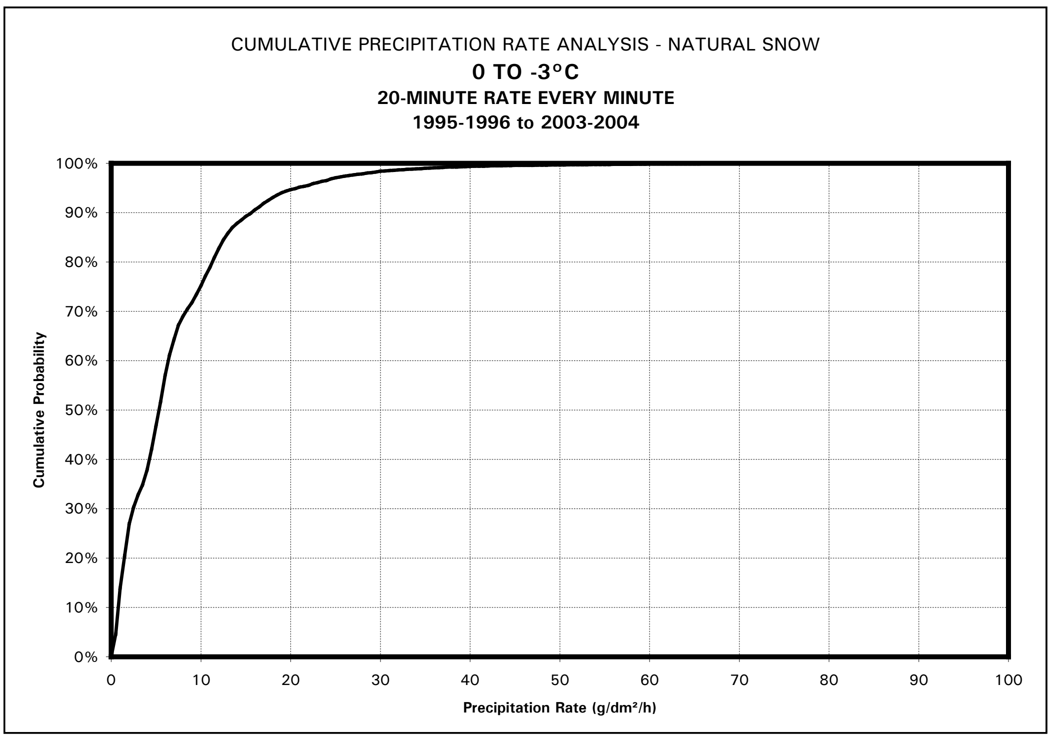

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
3500
3000
2500
2000
1500
1000
500
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

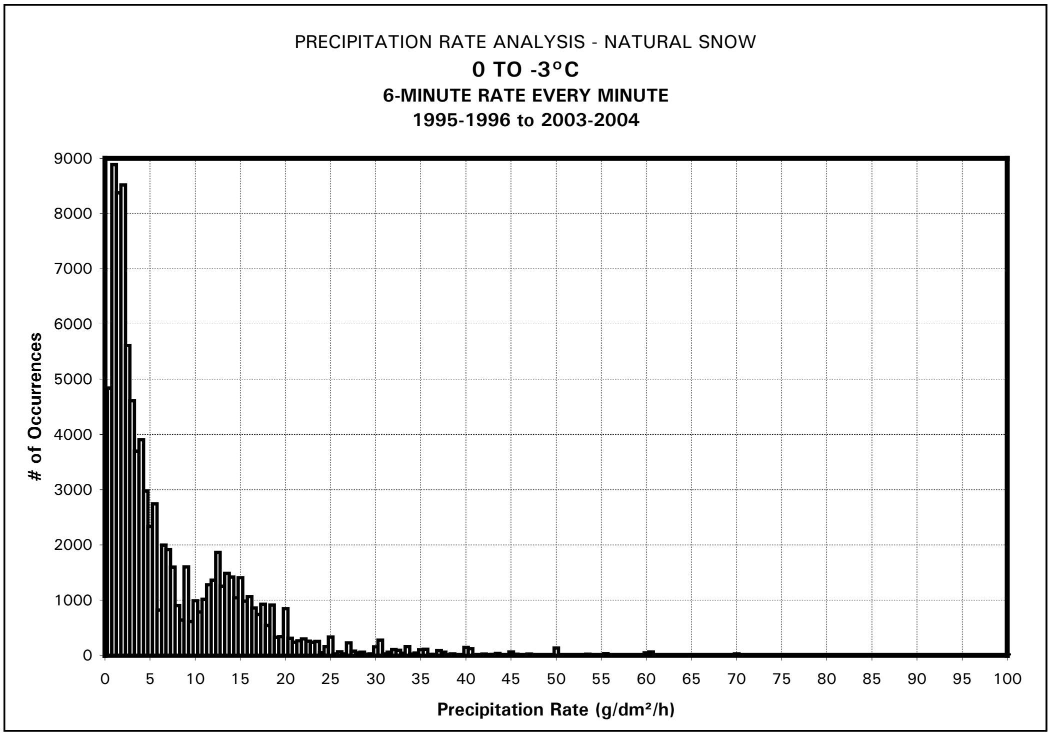

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
ABOVE 0°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

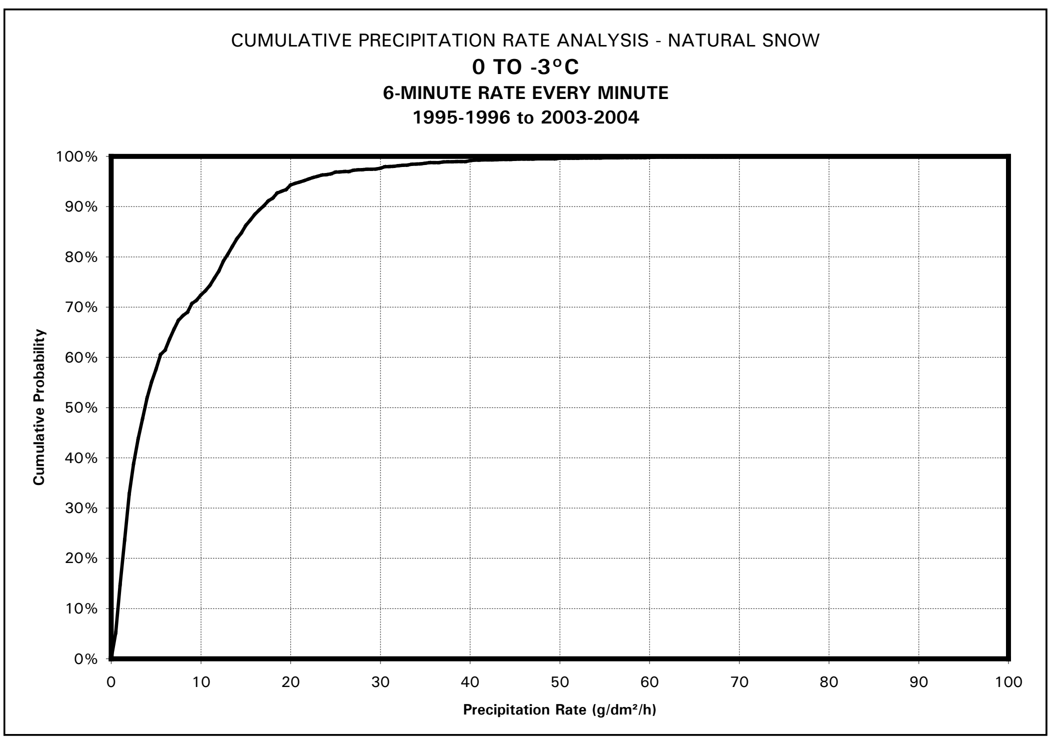

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

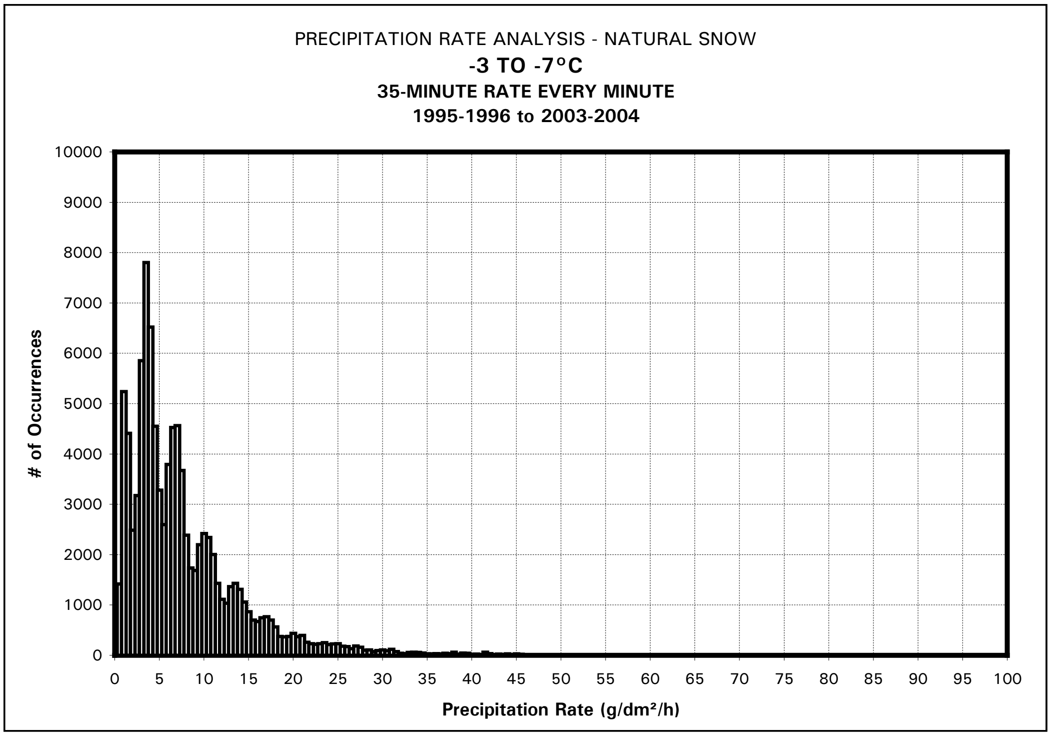

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

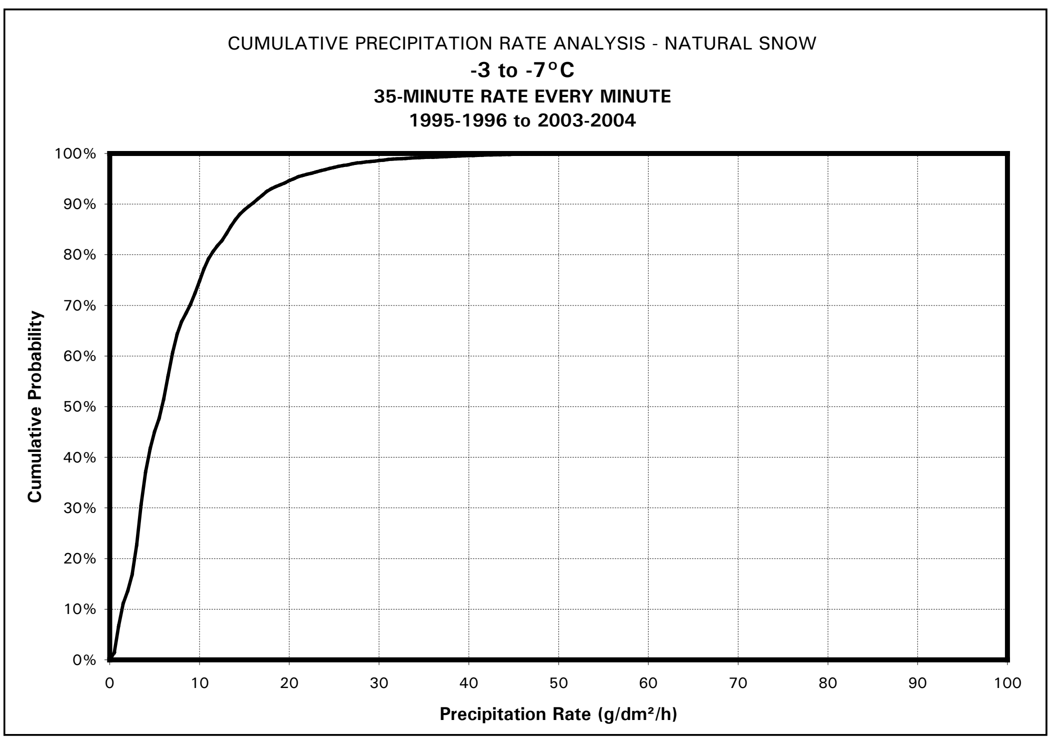

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Precipitation Rate (g/dm²/h)

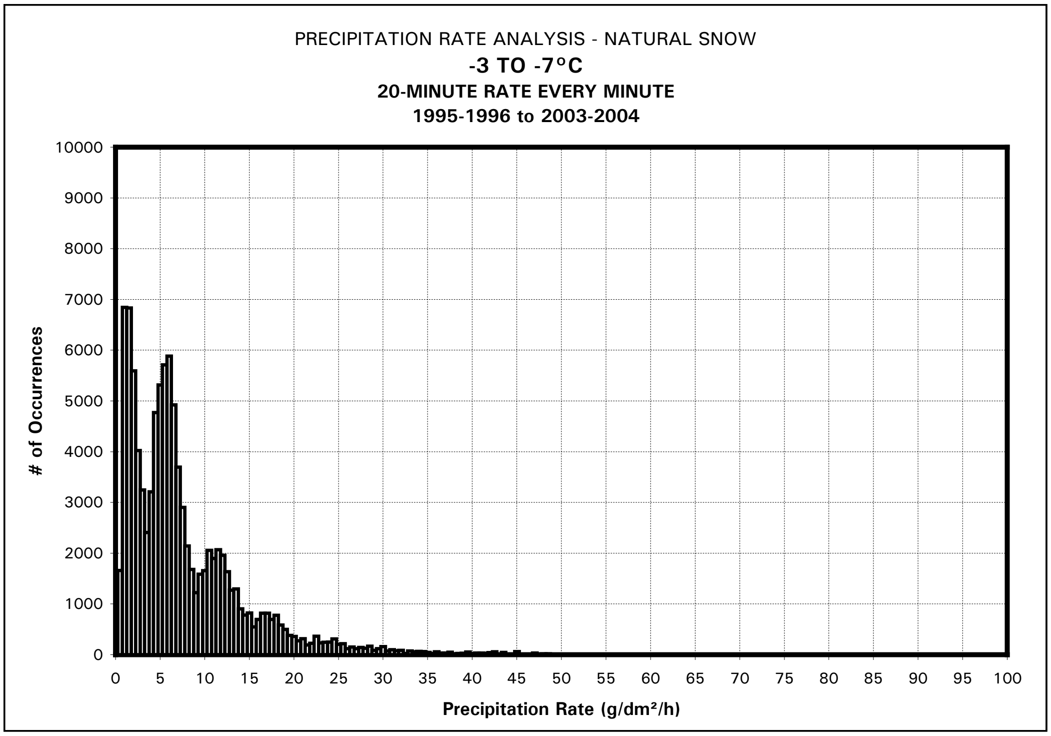

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
90
100
Precipitation Rate (g/dm²/h)

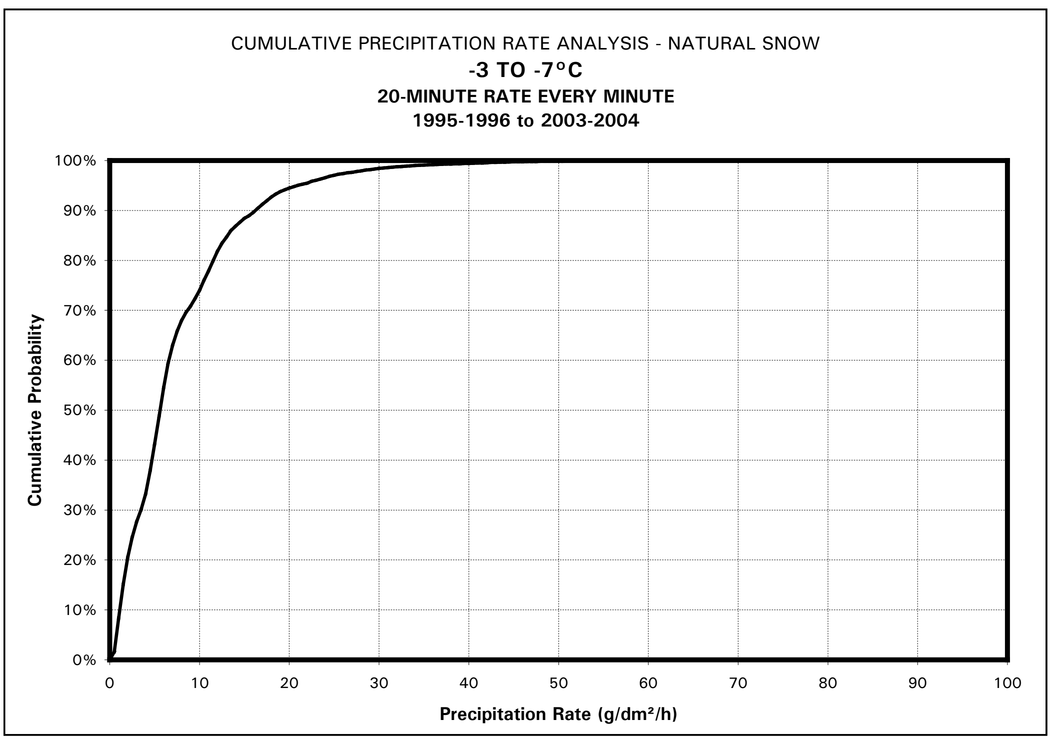

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

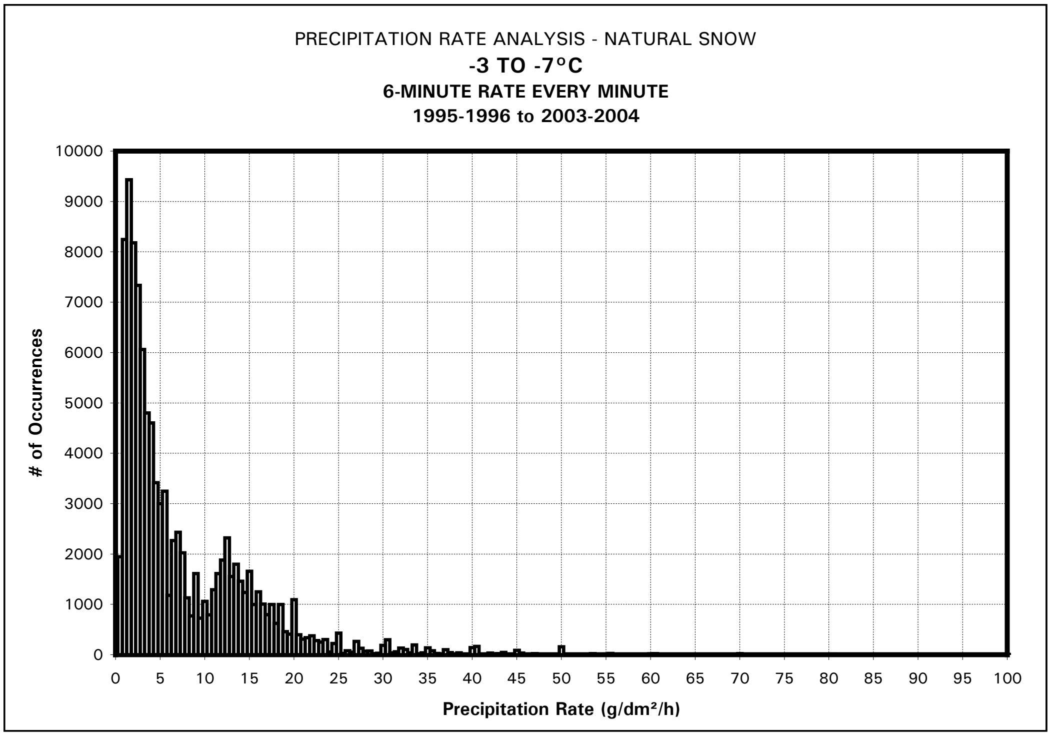

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
0 TO -3°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

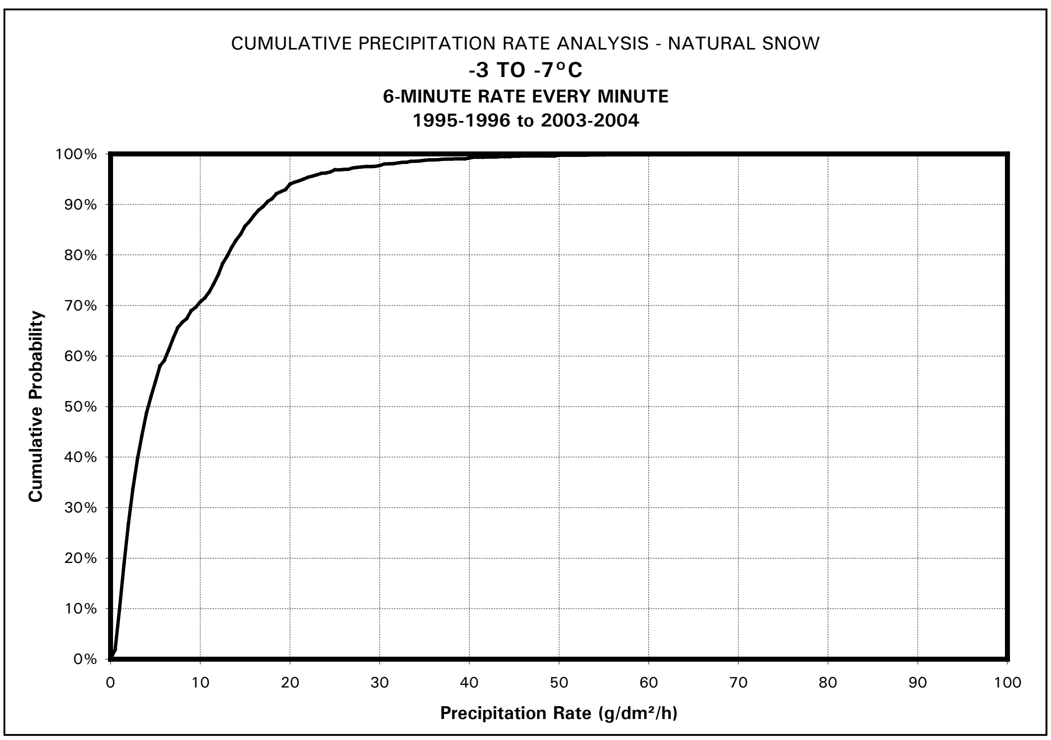

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

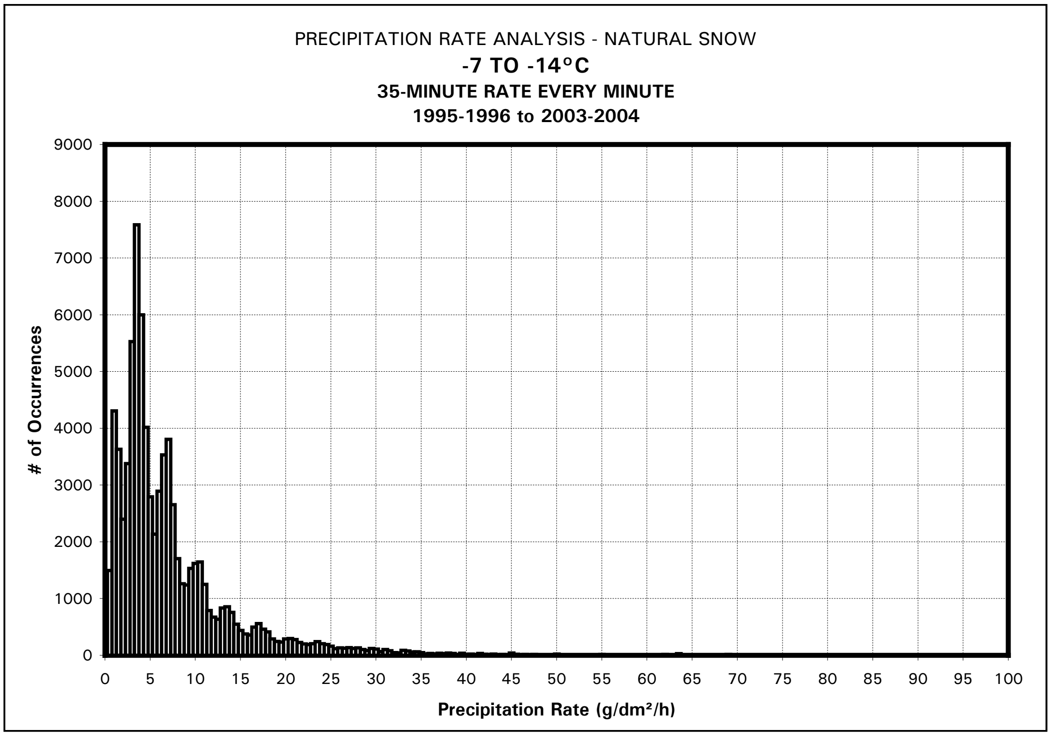

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 to -7°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

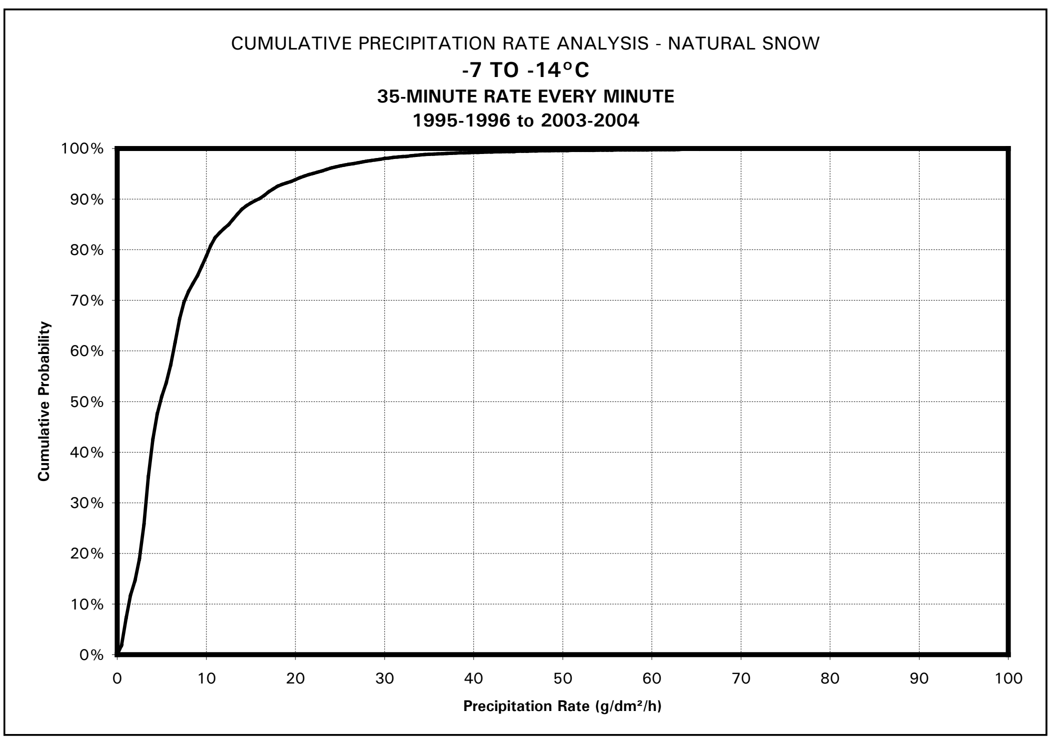

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

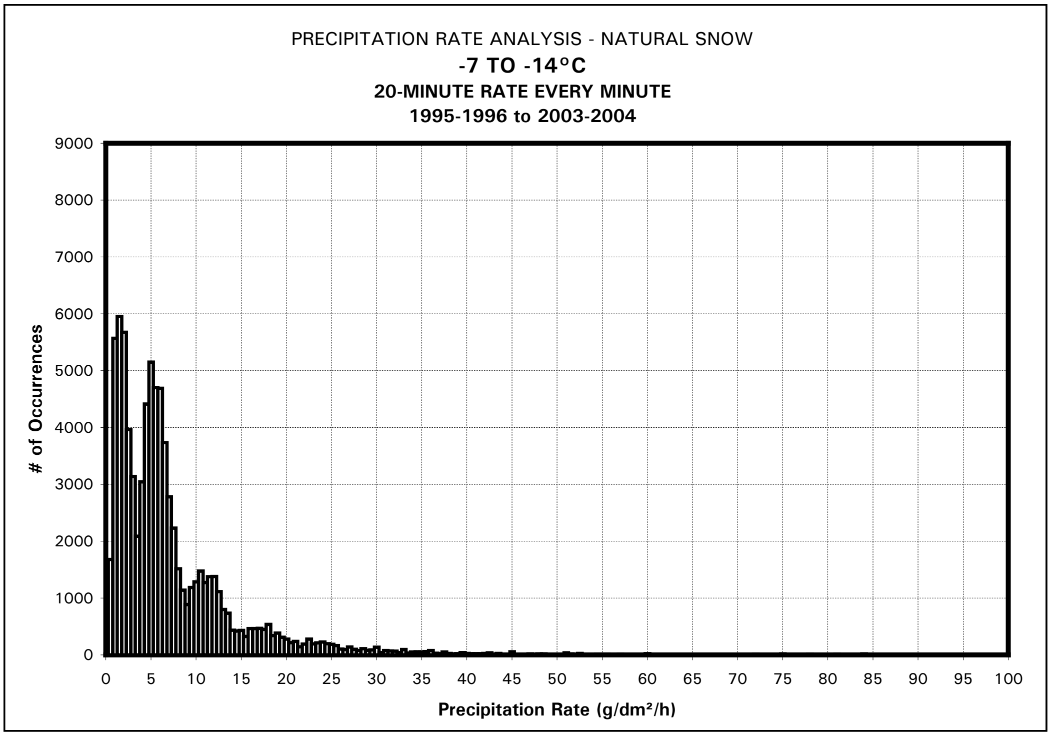

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100

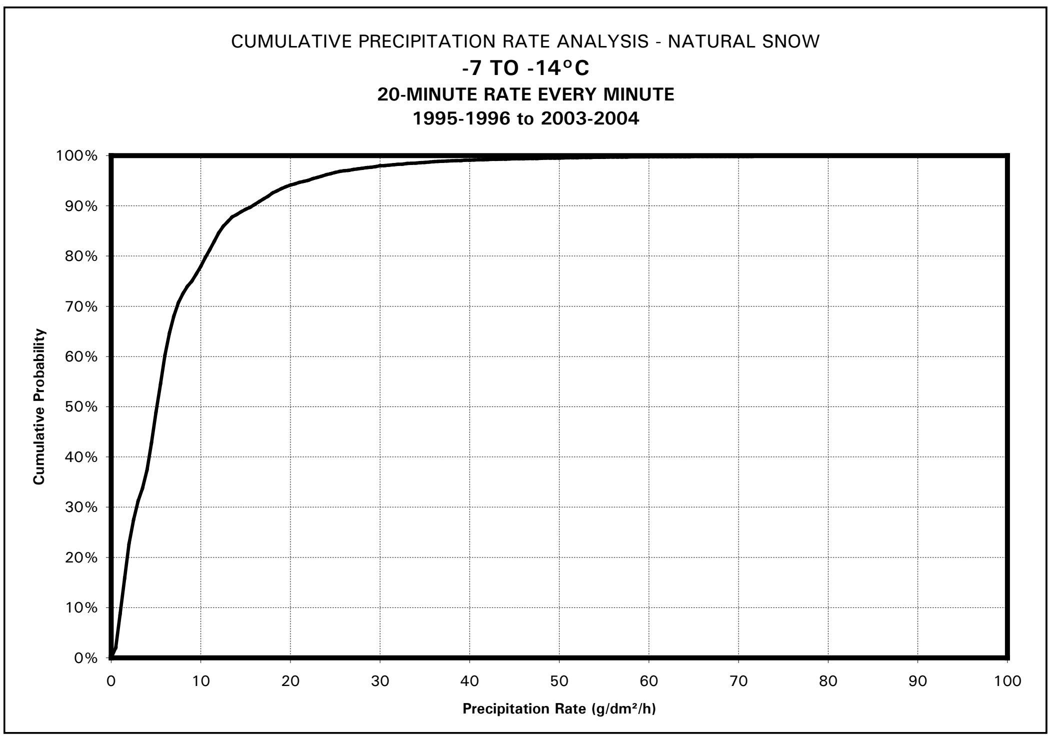

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

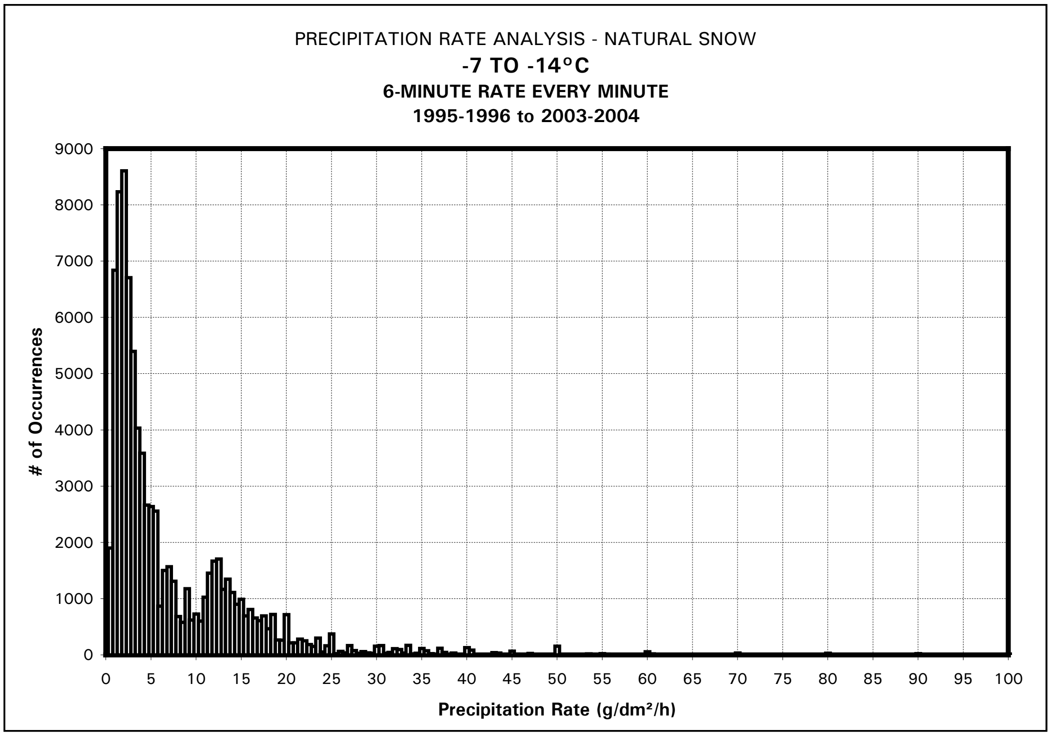

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-3 TO -7°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

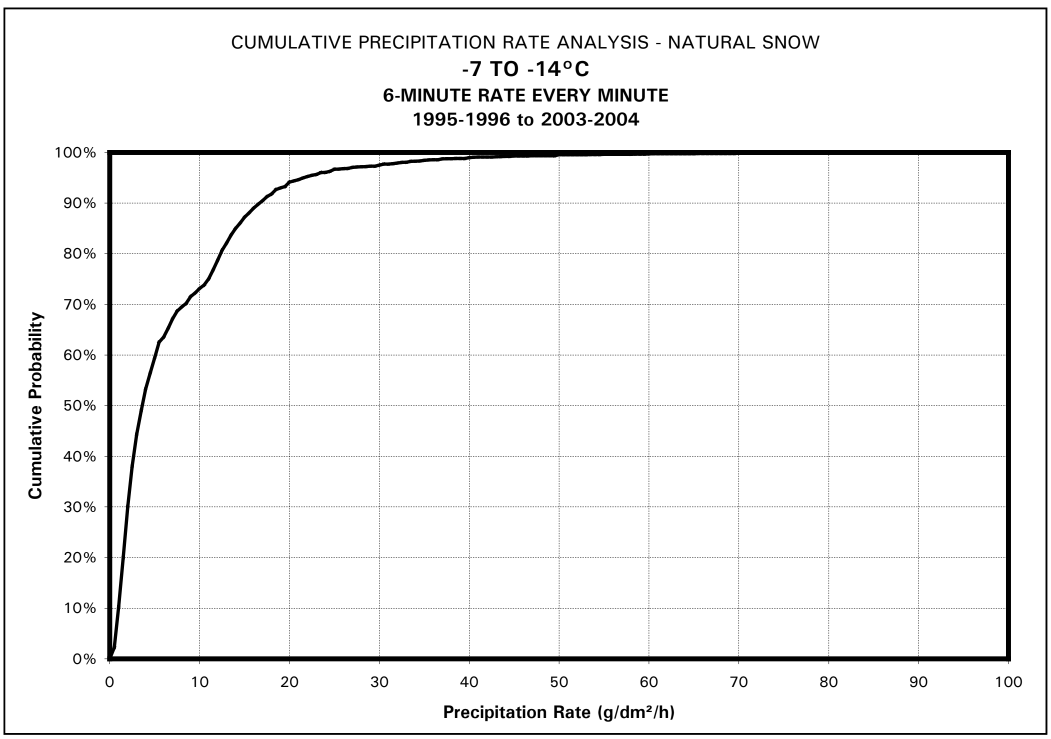

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)

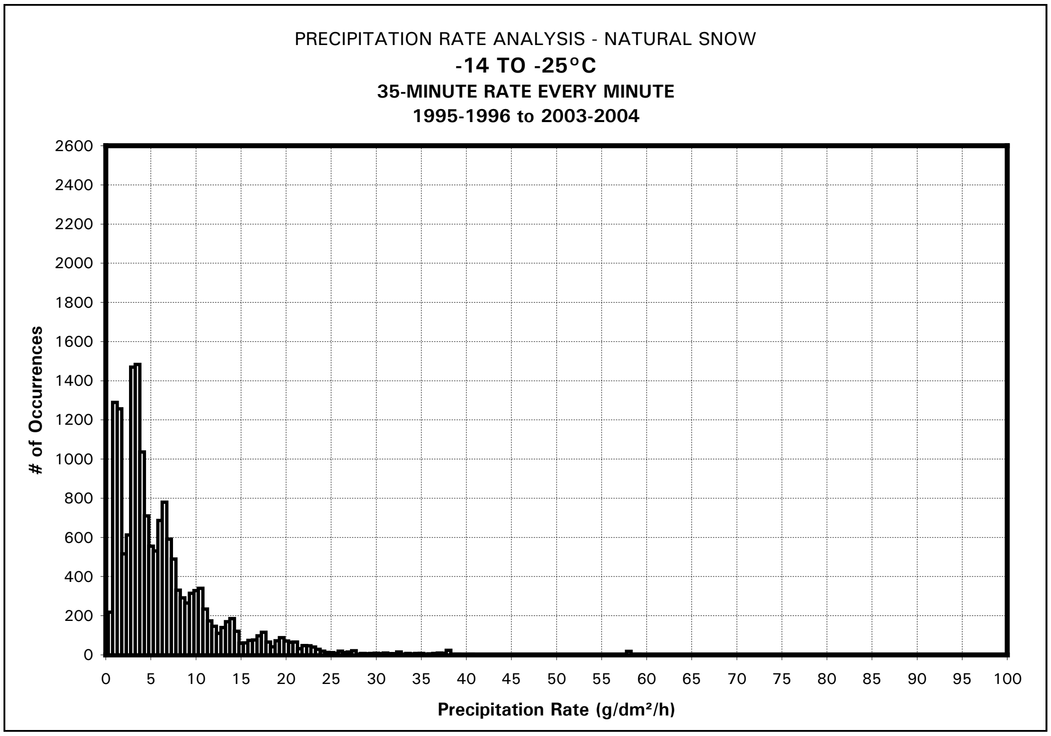

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)

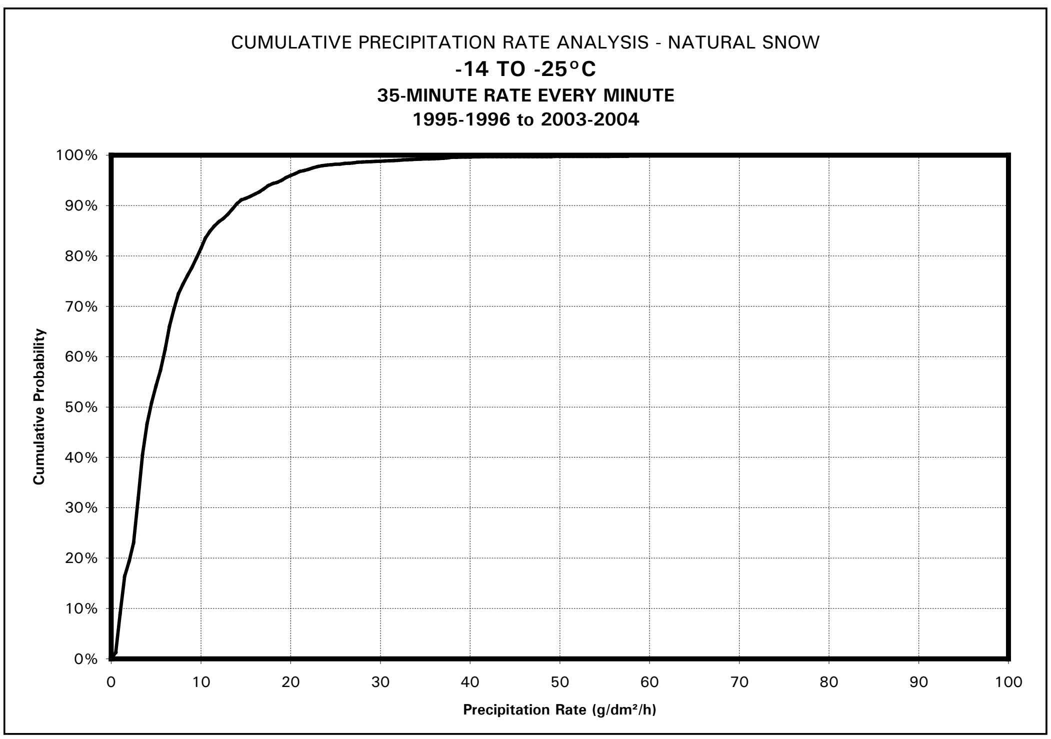

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

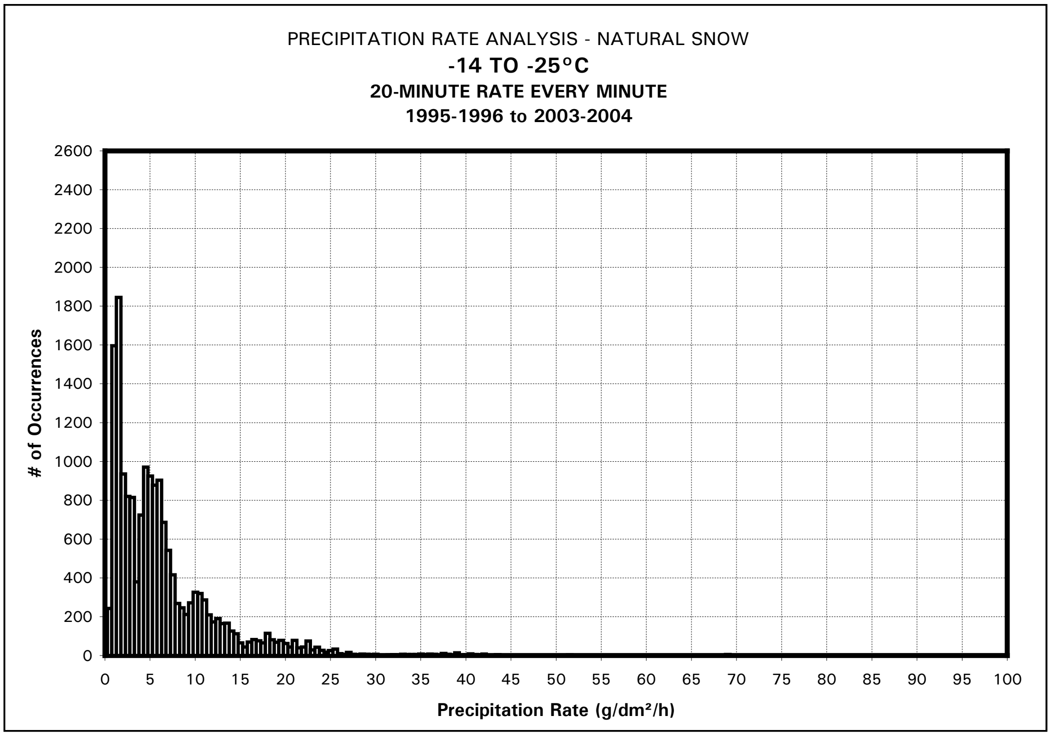

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

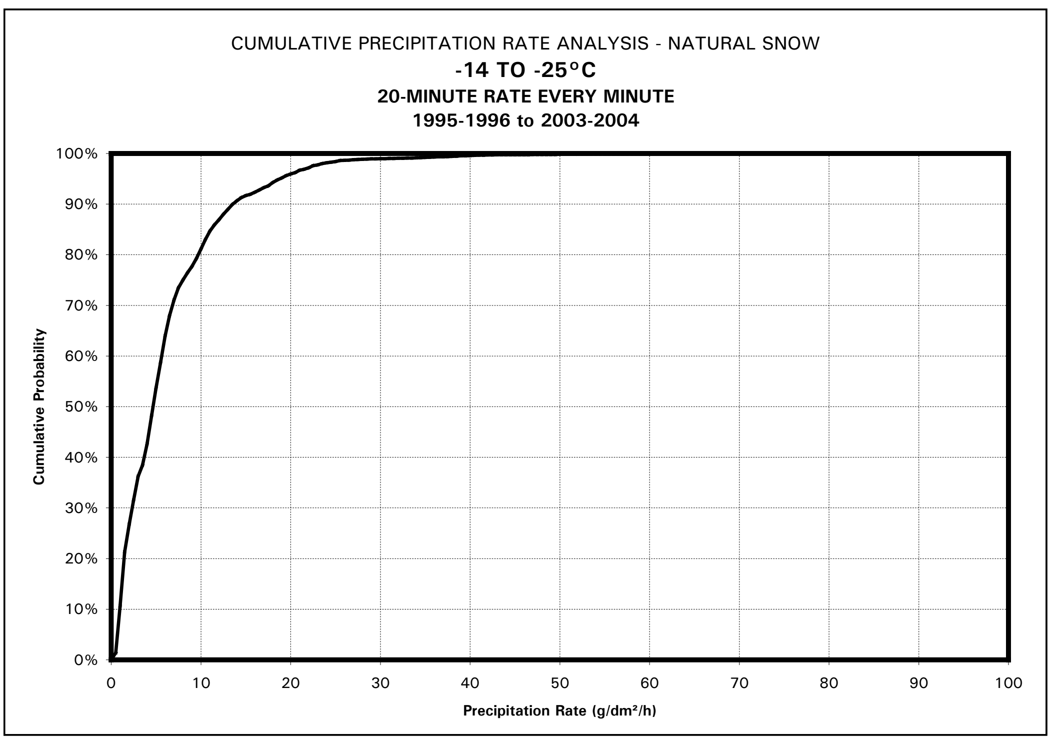

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

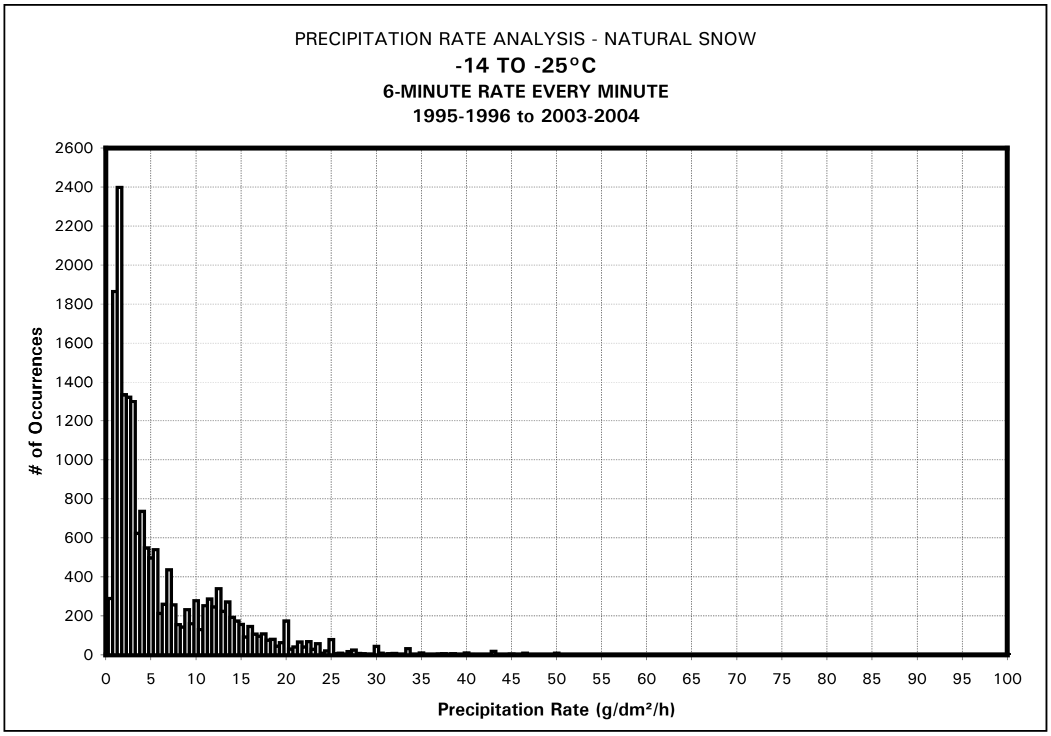

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-7 TO -14°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

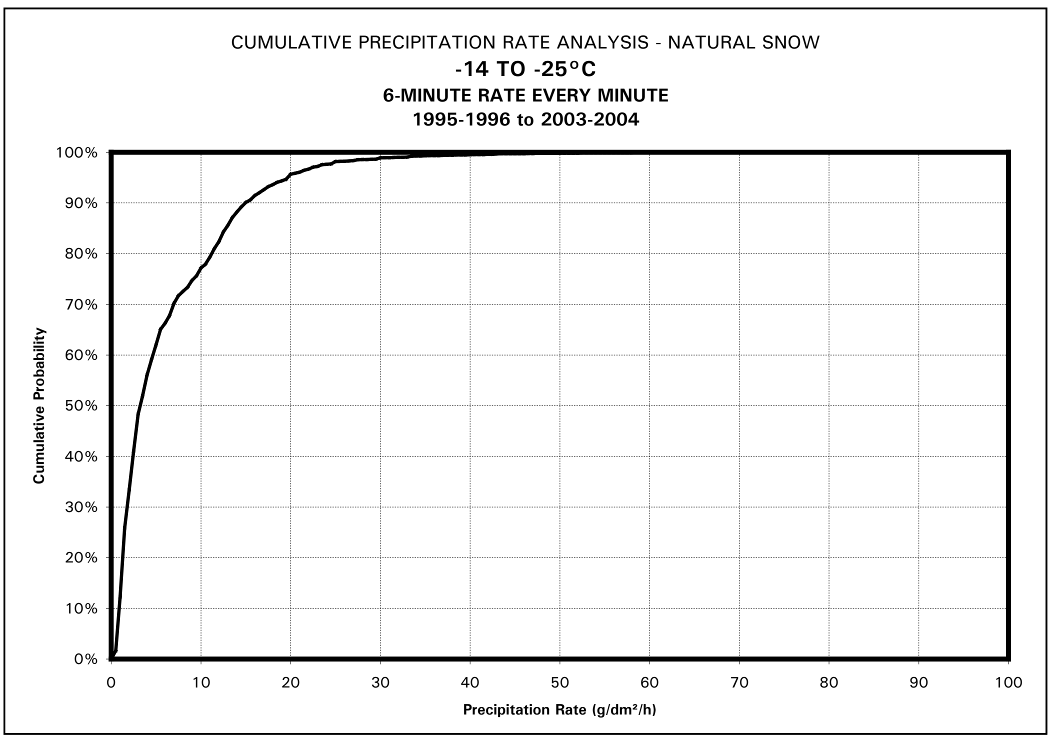

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

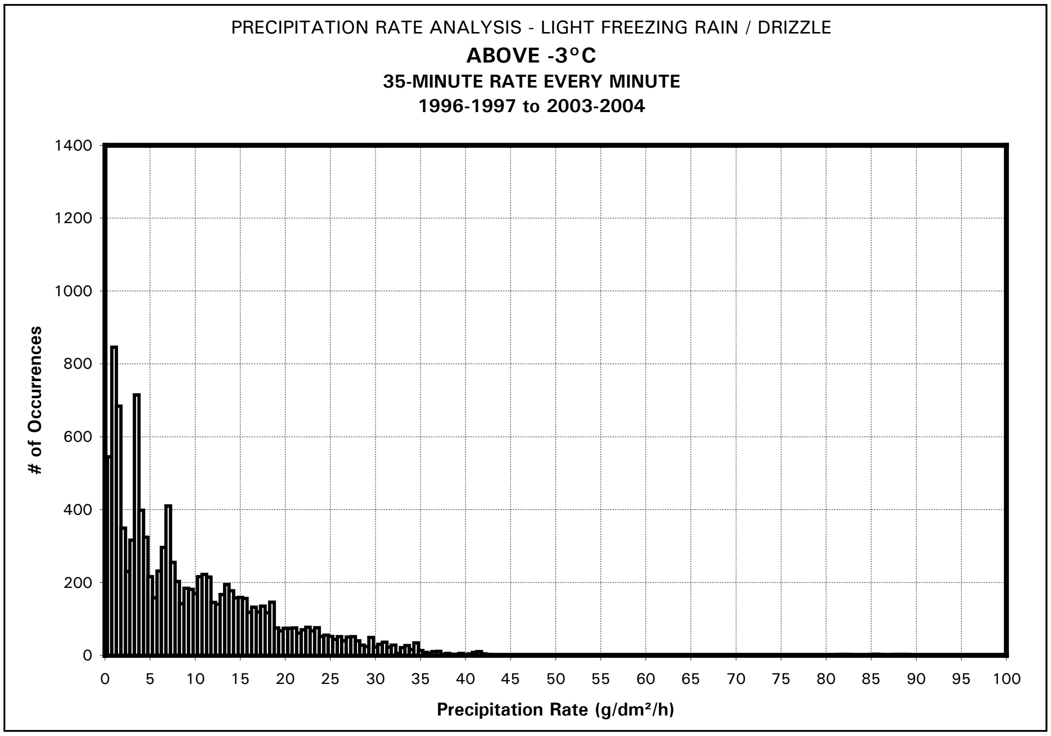

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

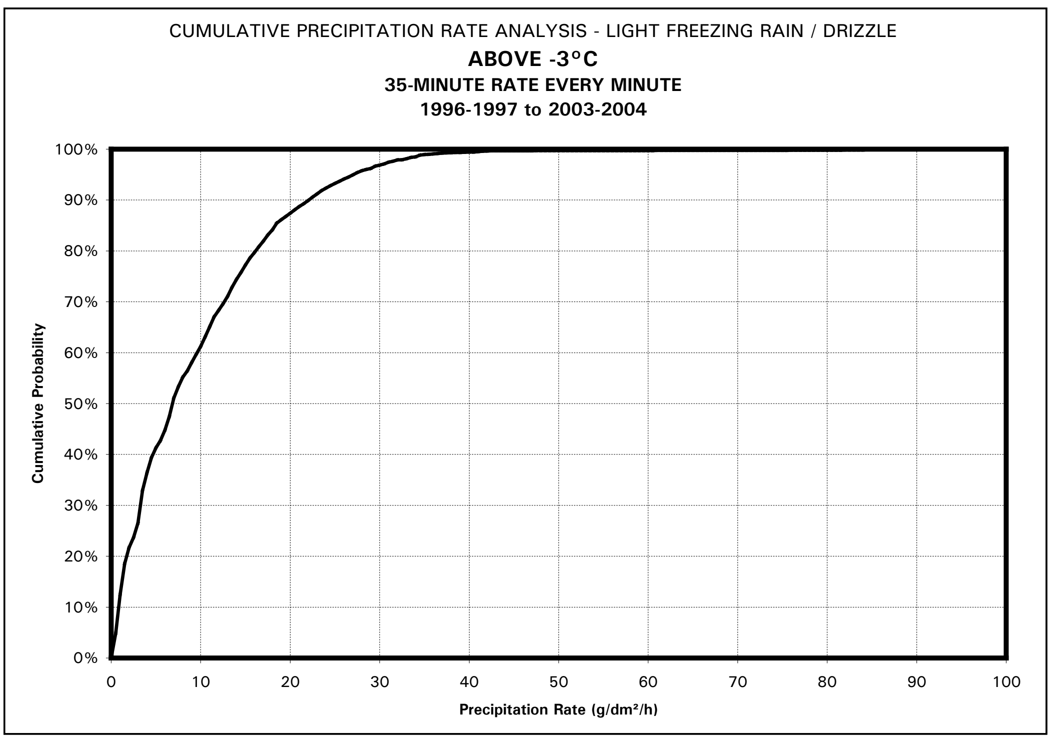

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Precipitation Rate (g/dm²/h)

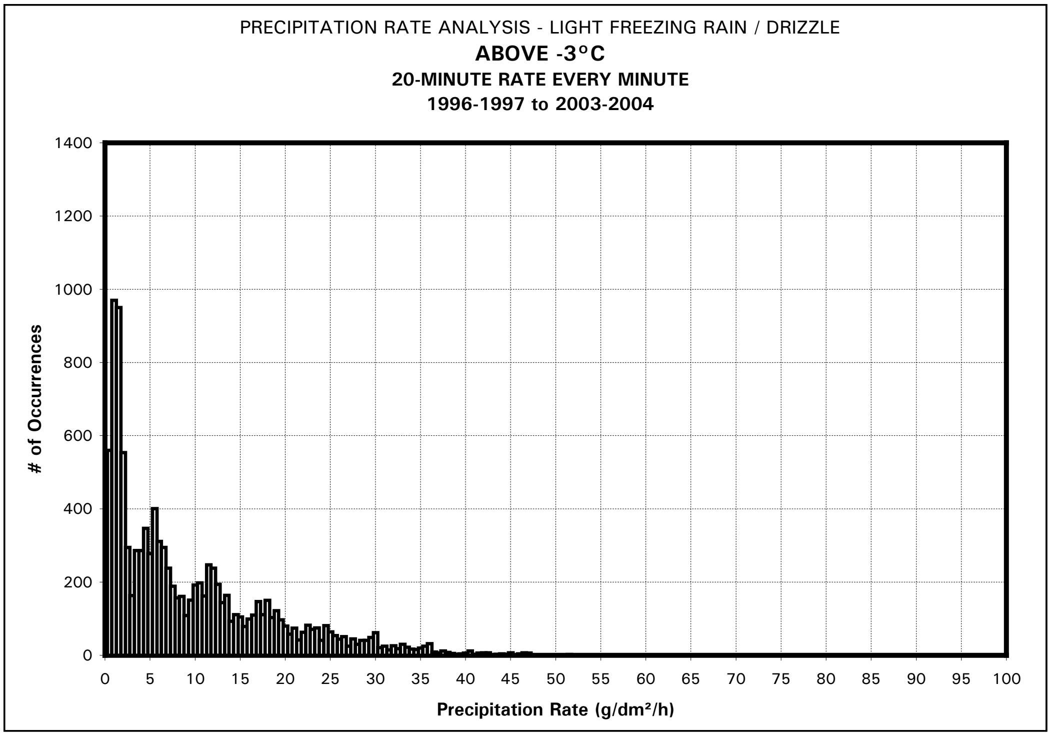

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
10
20
30
40
50
60
70
80
90
100
Precipitation Rate (g/dm²/h)

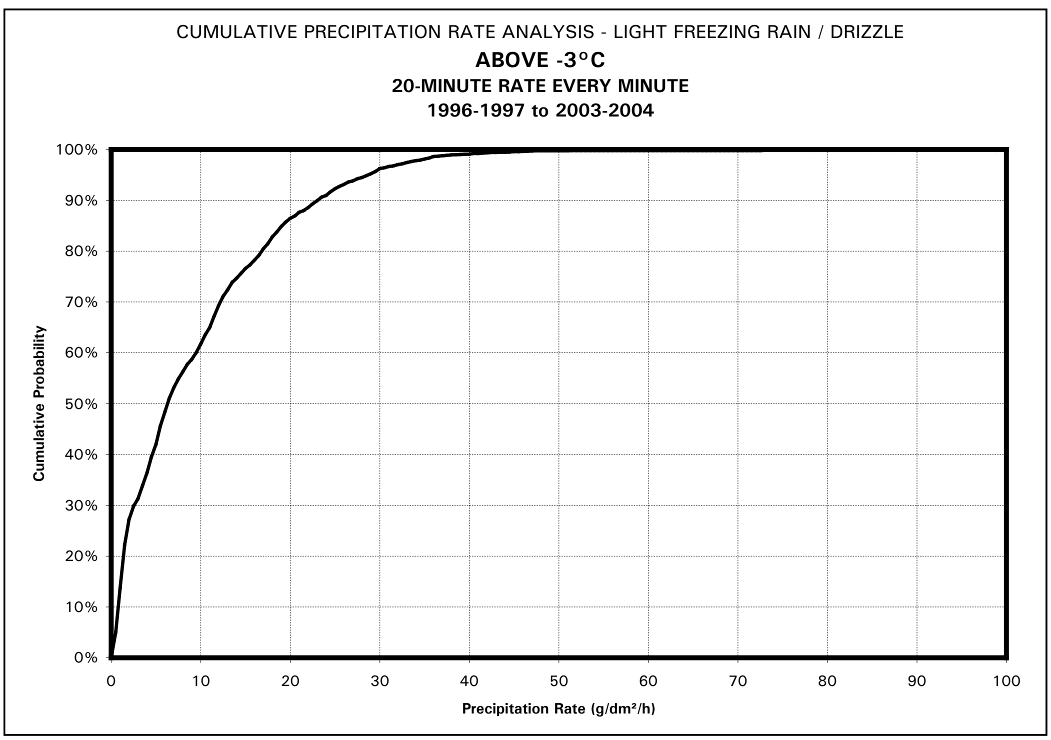

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

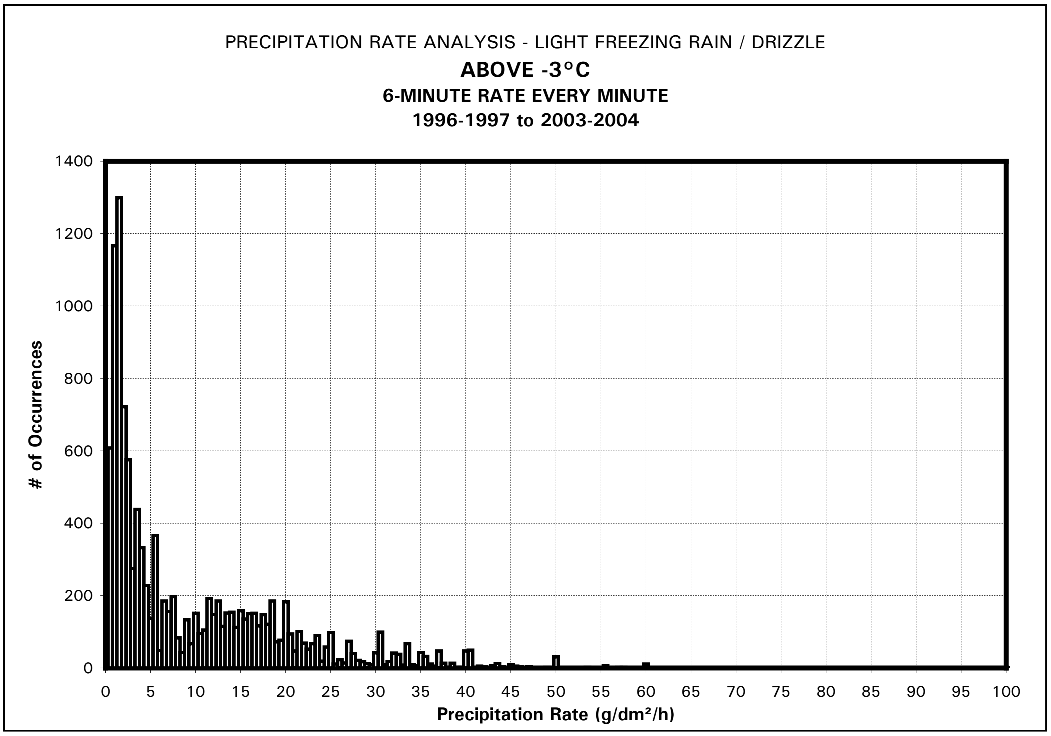

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

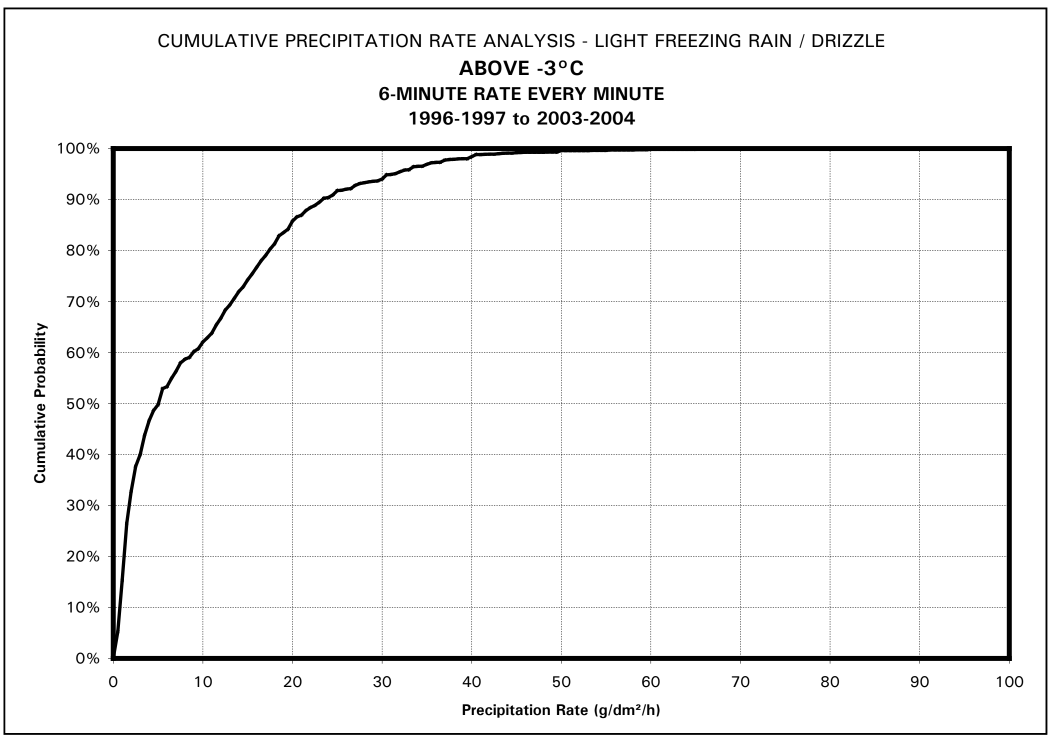

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
1400
1200
1000
800
600
400
200
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

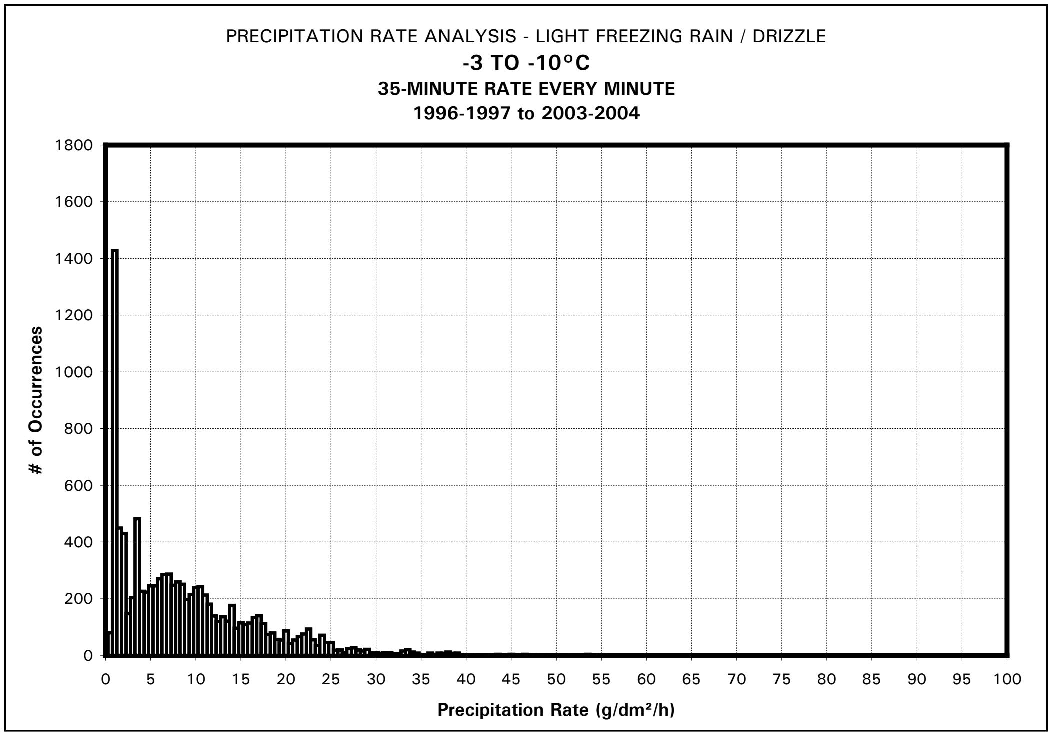

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

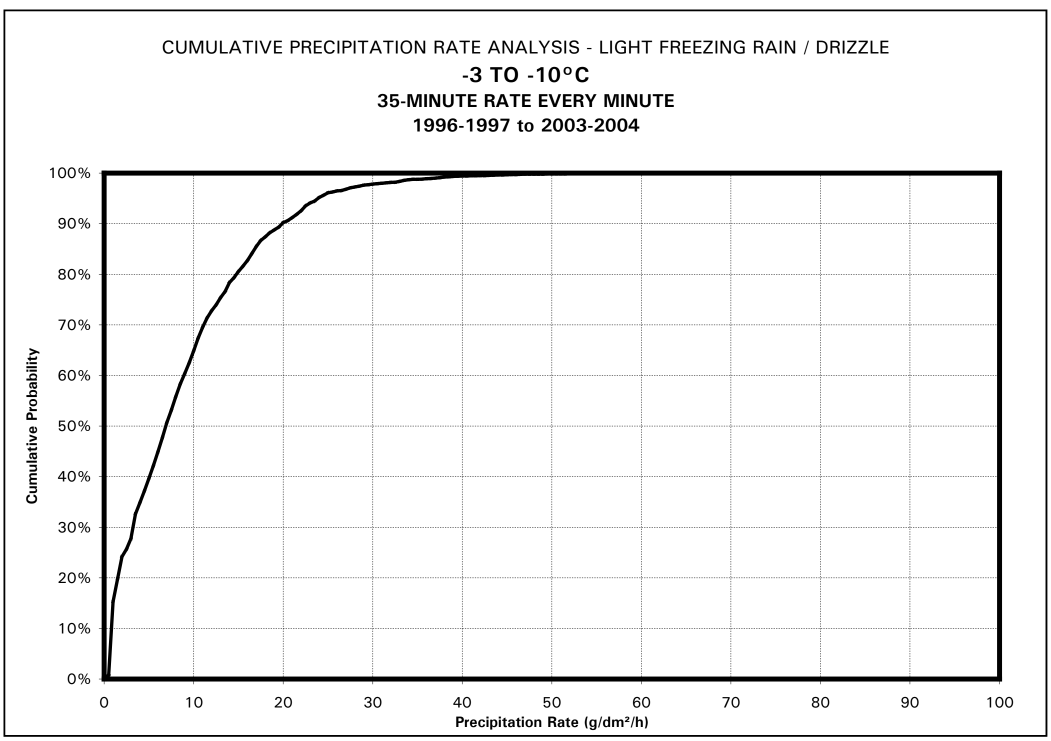

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)
0
200
400
600
800
1000
1200
1400
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

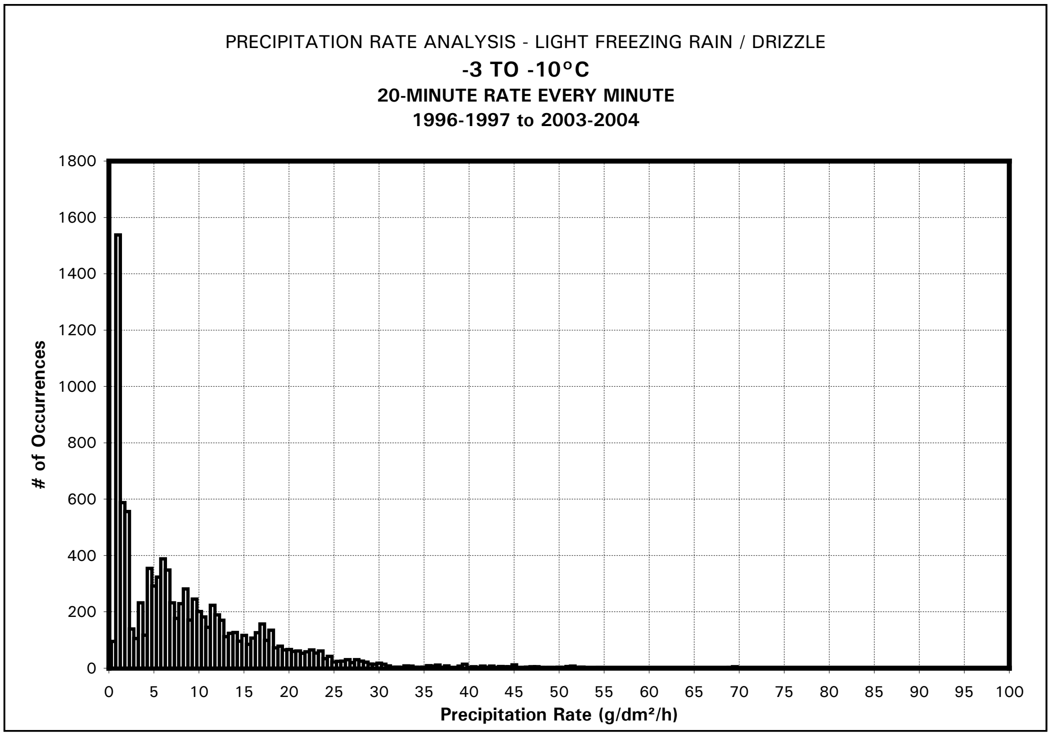

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100

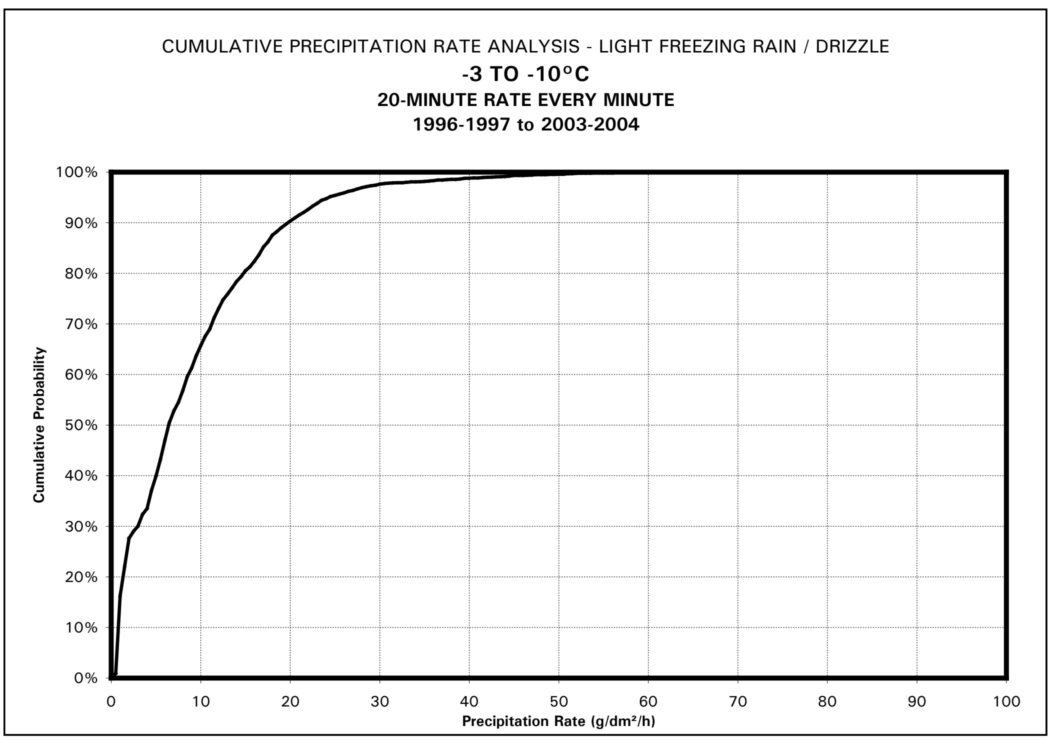

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)

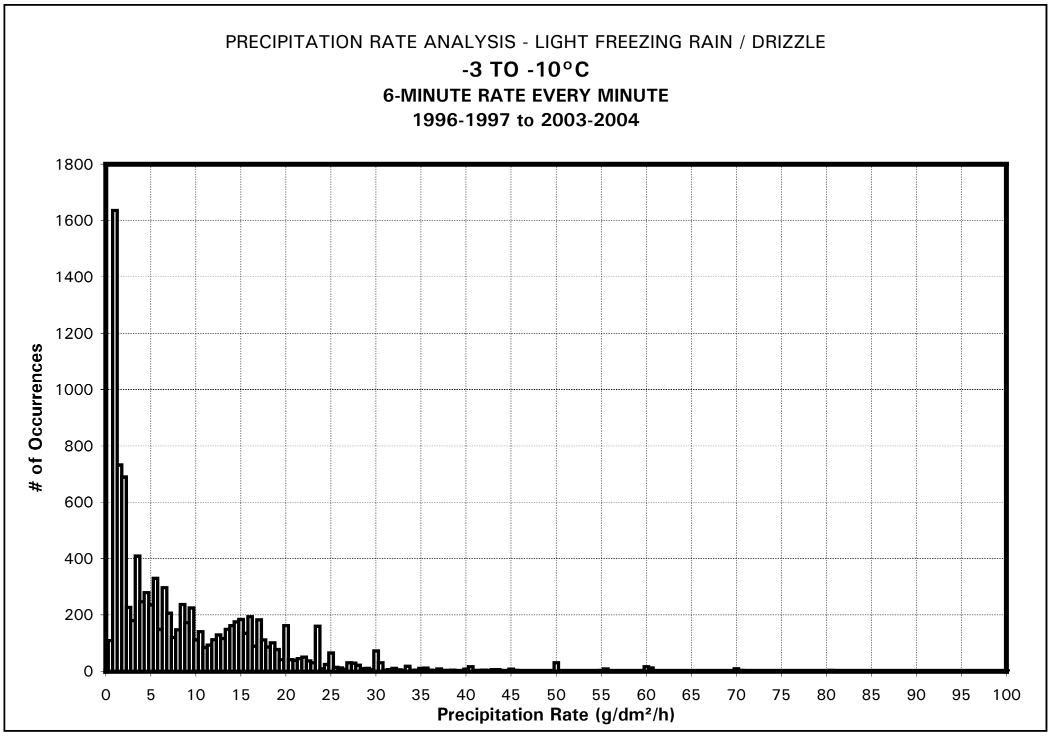

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
ABOVE -3°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)

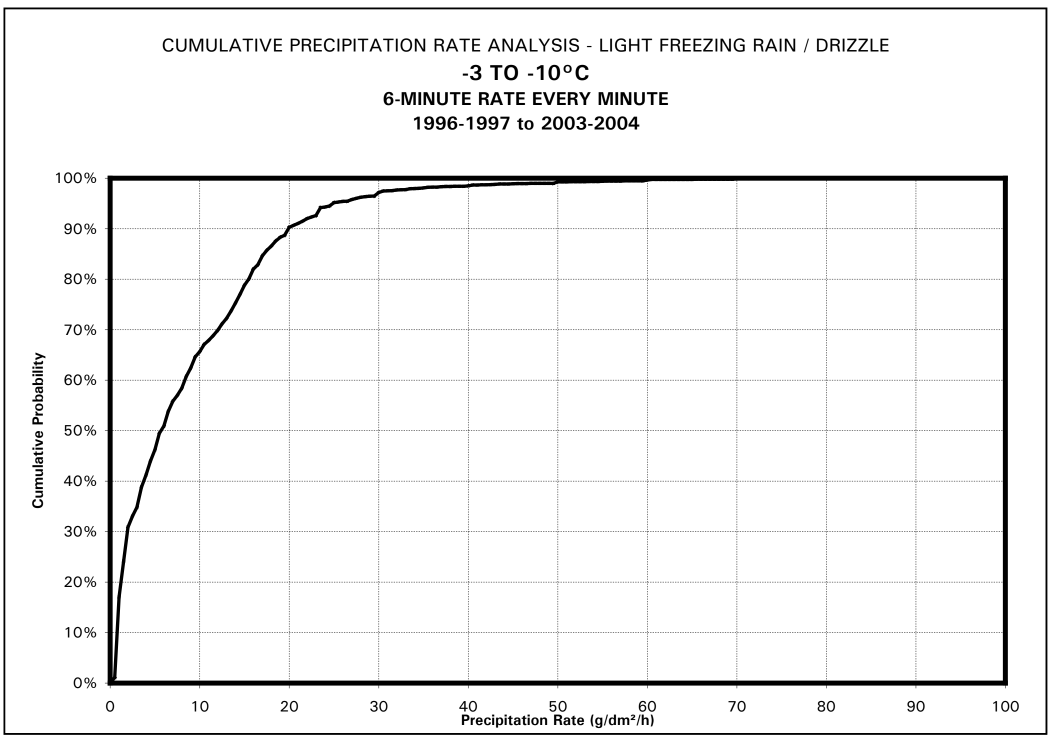

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

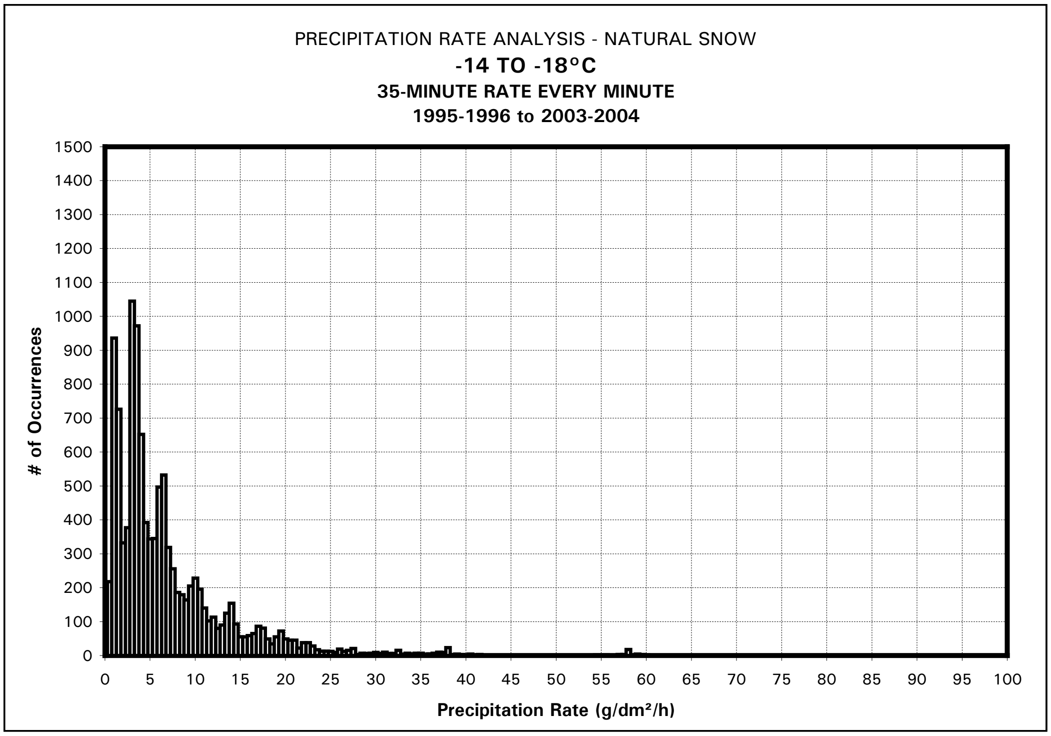

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
35-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

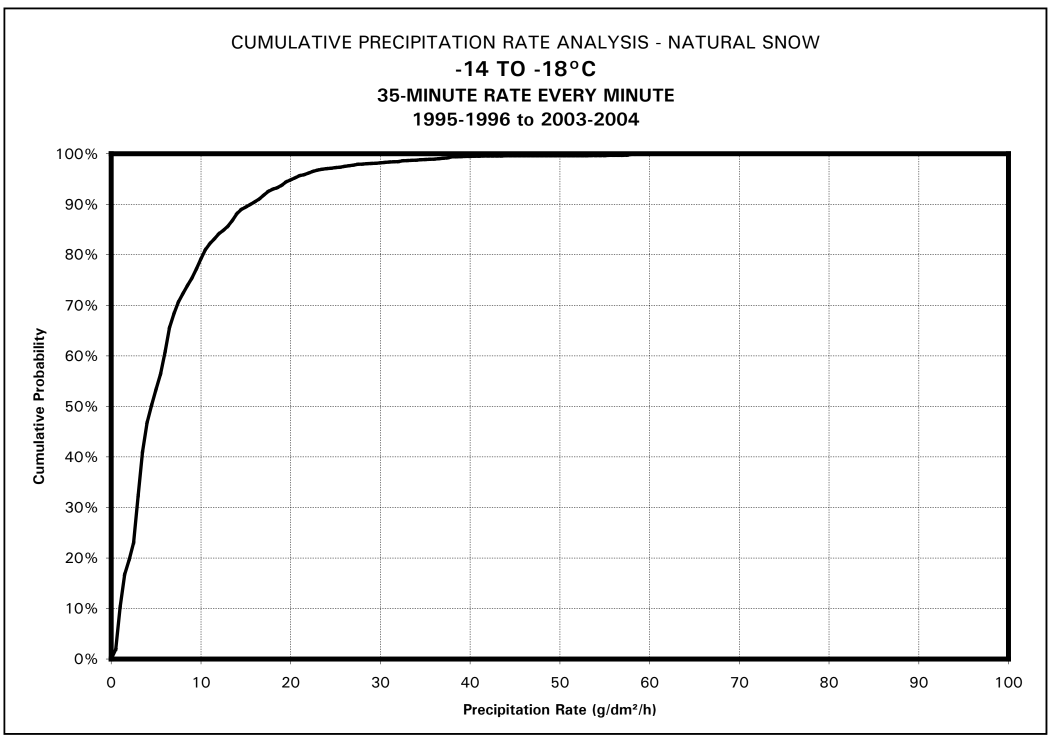

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)

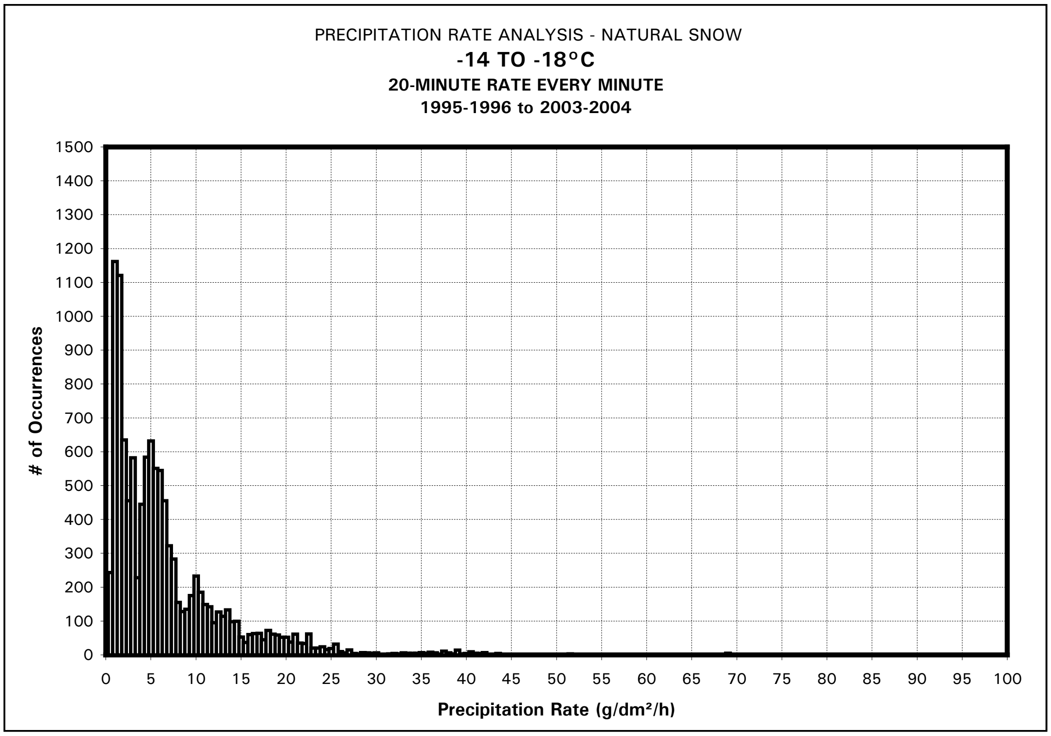

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
20-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)

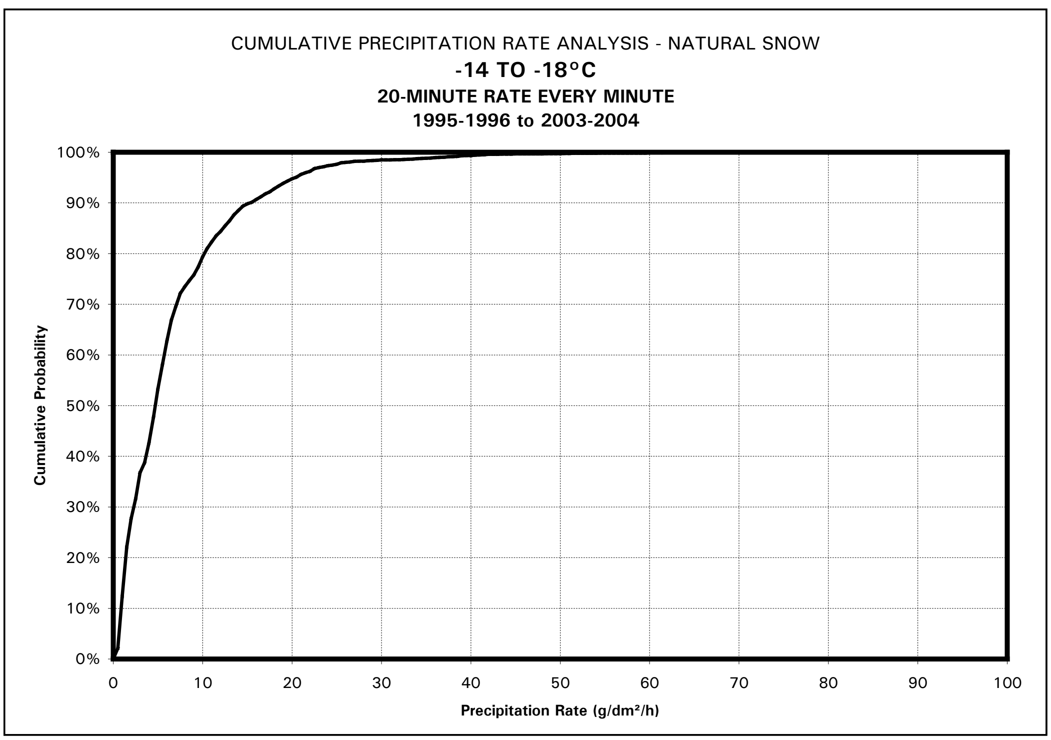

PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
# of Occurrences
0
200
400
600
800
1000
1200
1400
1600
1800
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

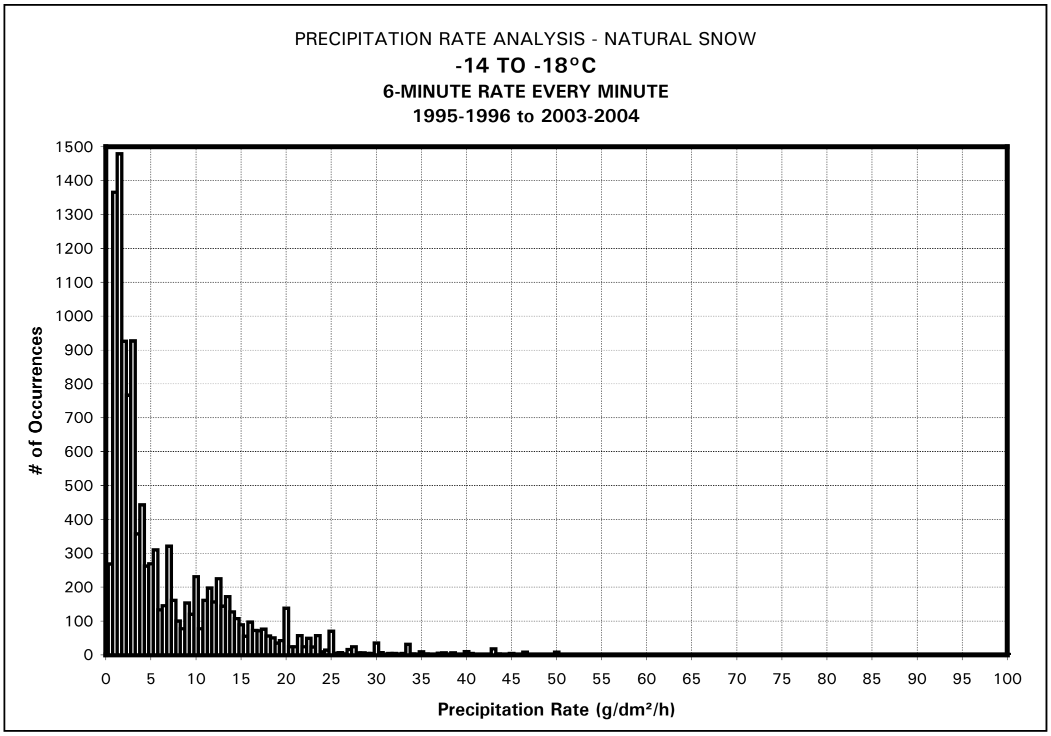

CUMULATIVE PRECIPITATION RATE ANALYSIS - LIGHT FREEZING RAIN / DRIZZLE
-3 TO -10°C
6-MINUTE RATE EVERY MINUTE
1996-1997 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

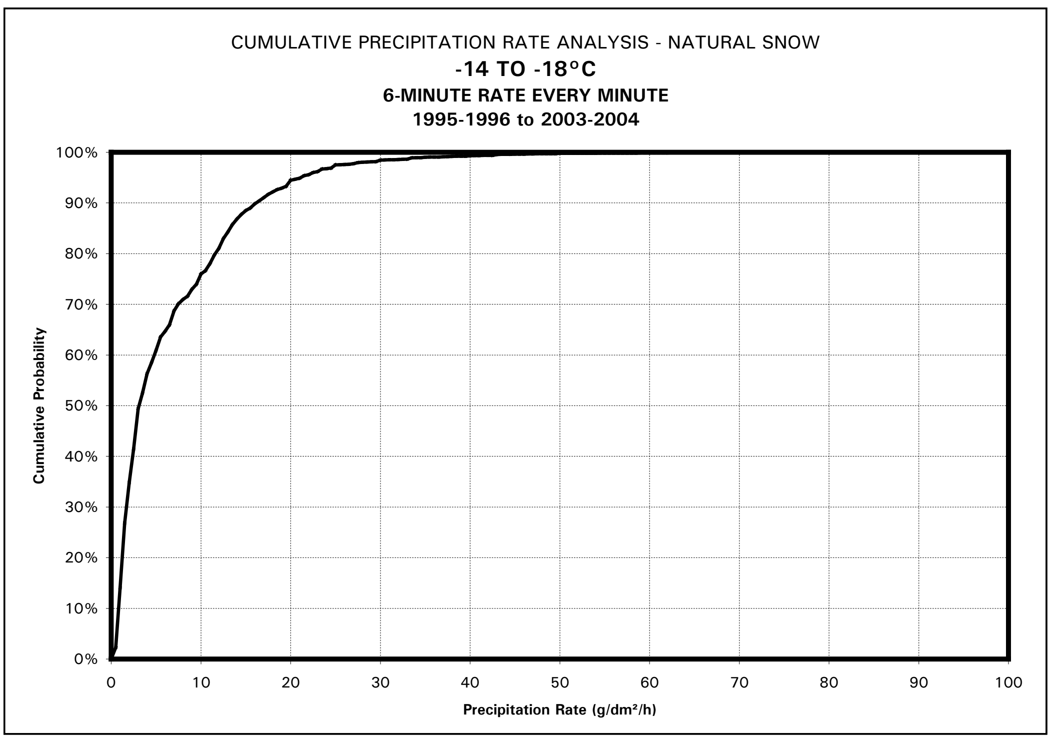

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

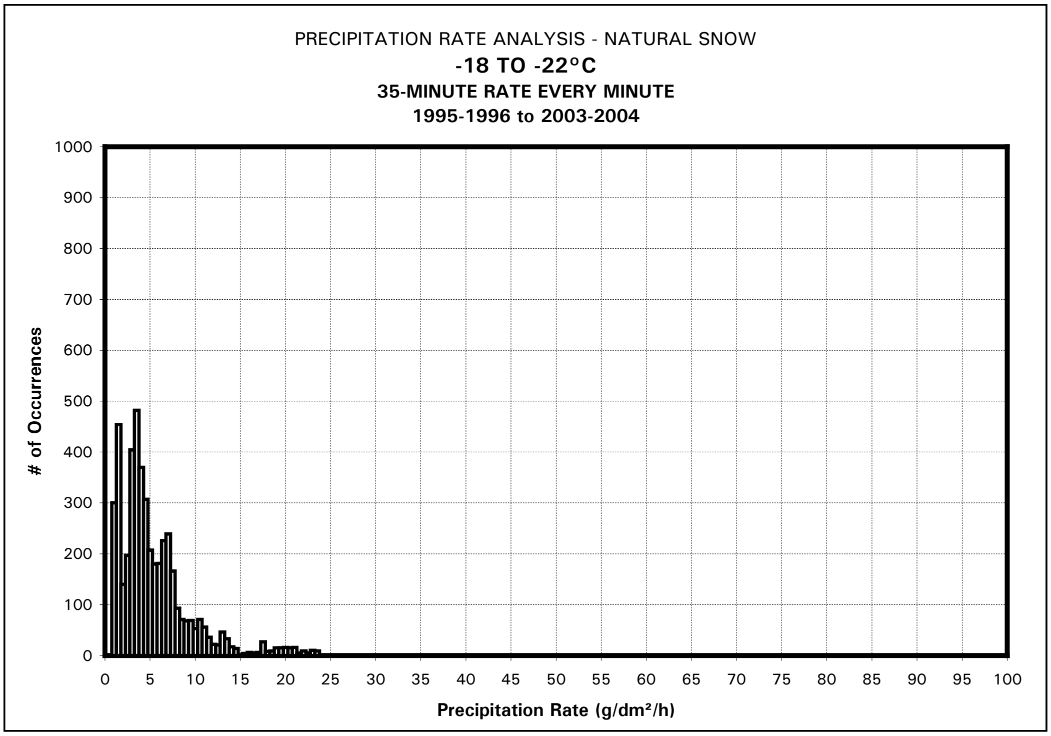

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

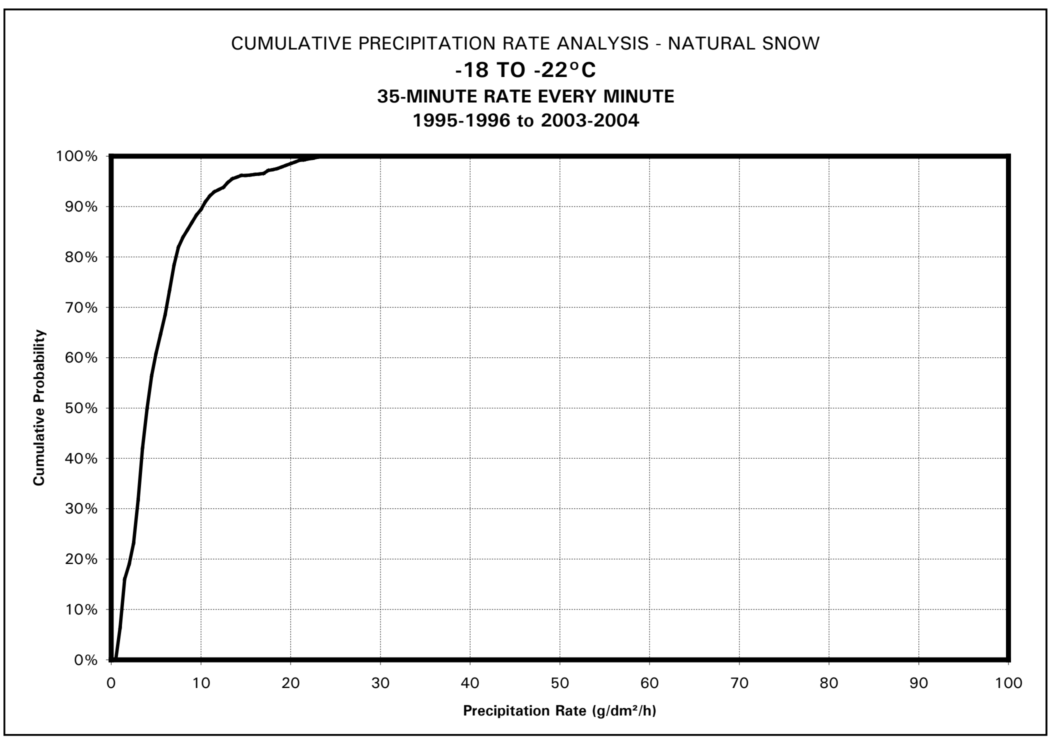

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

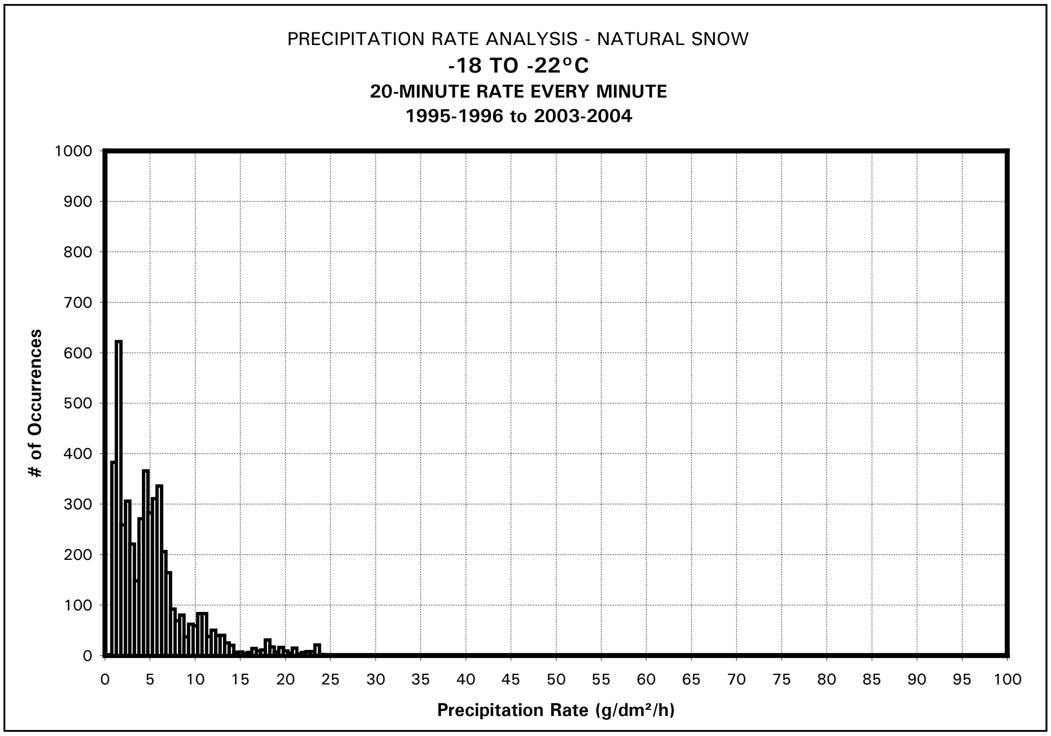

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

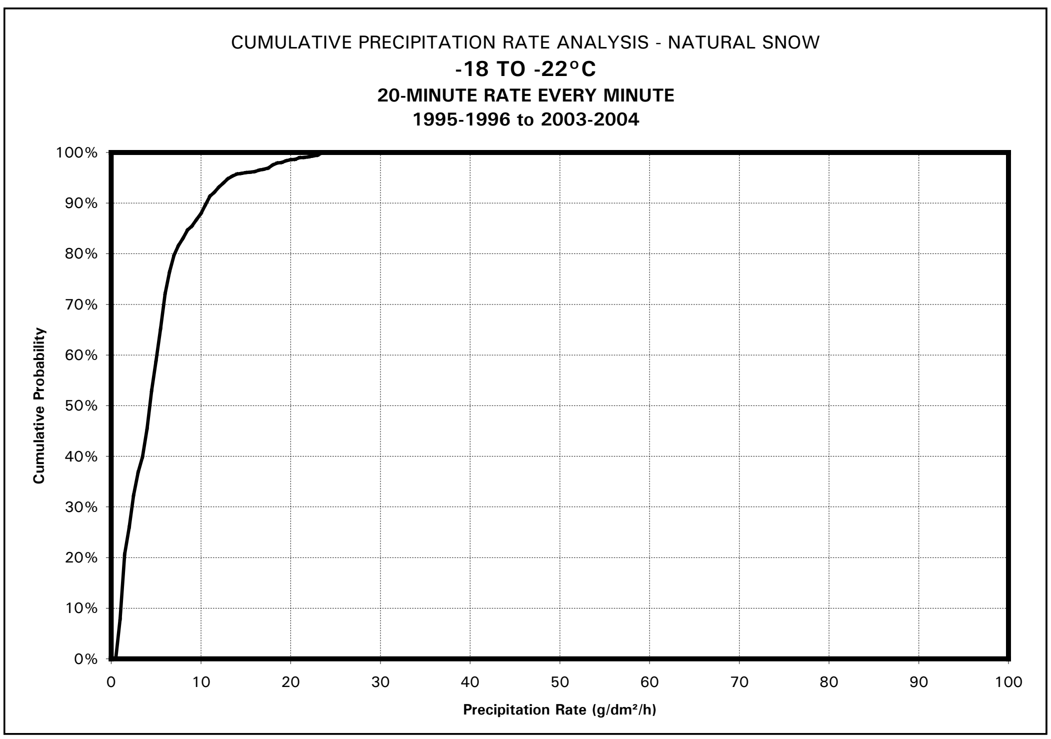

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

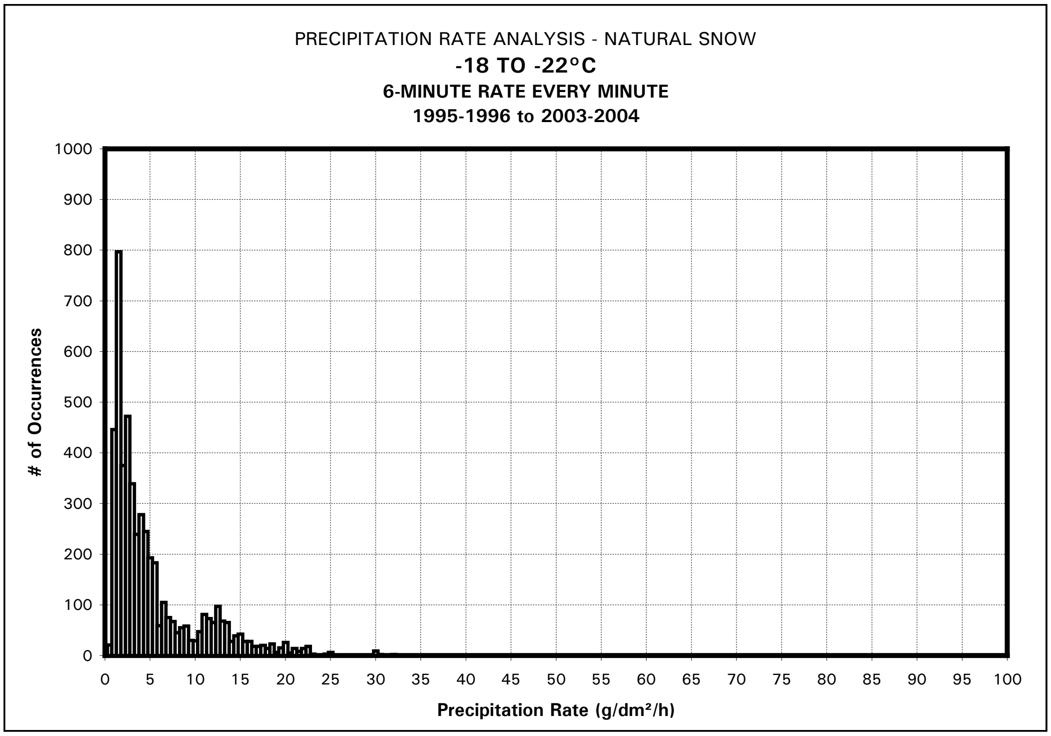

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-14 TO -18°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

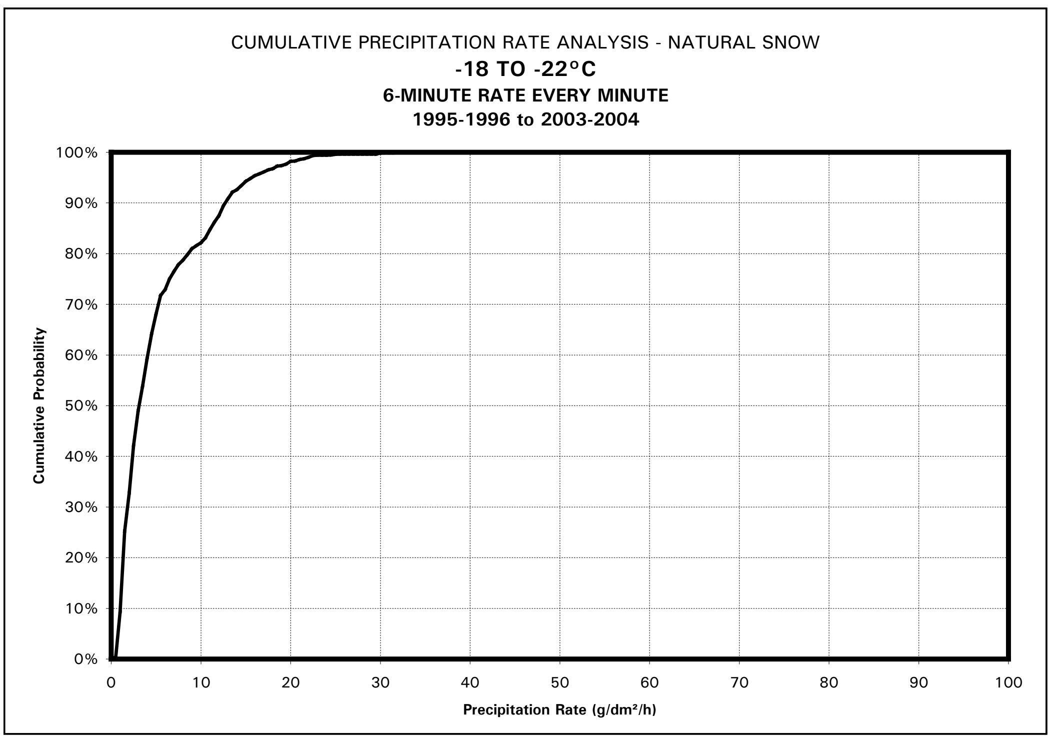

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

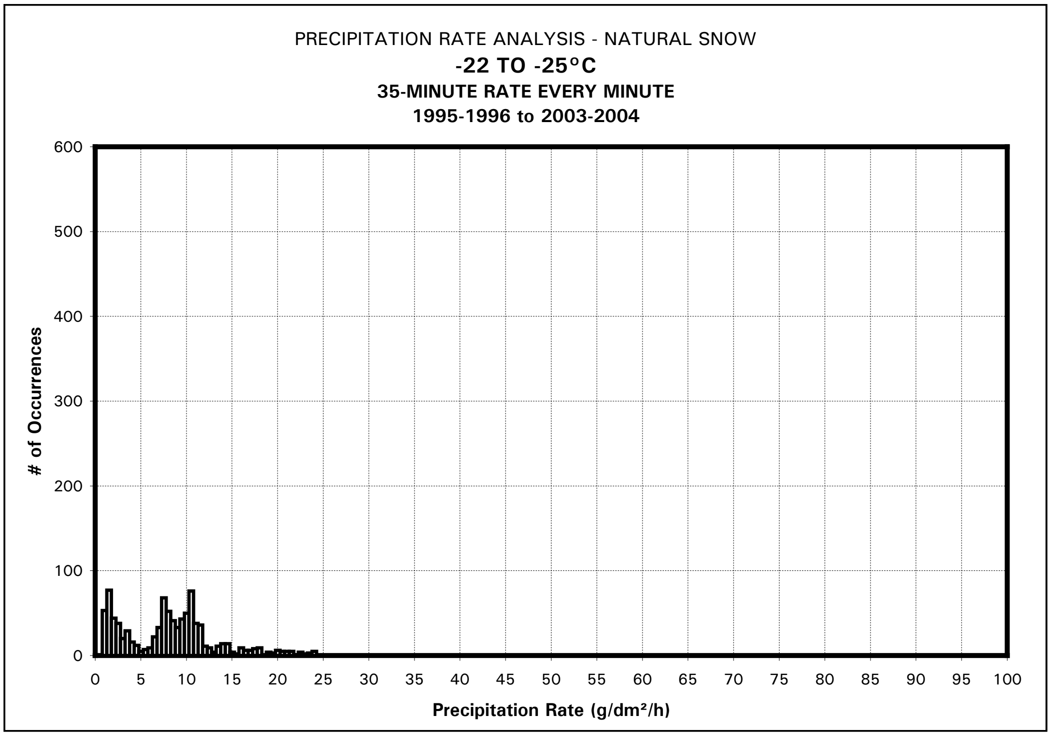

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

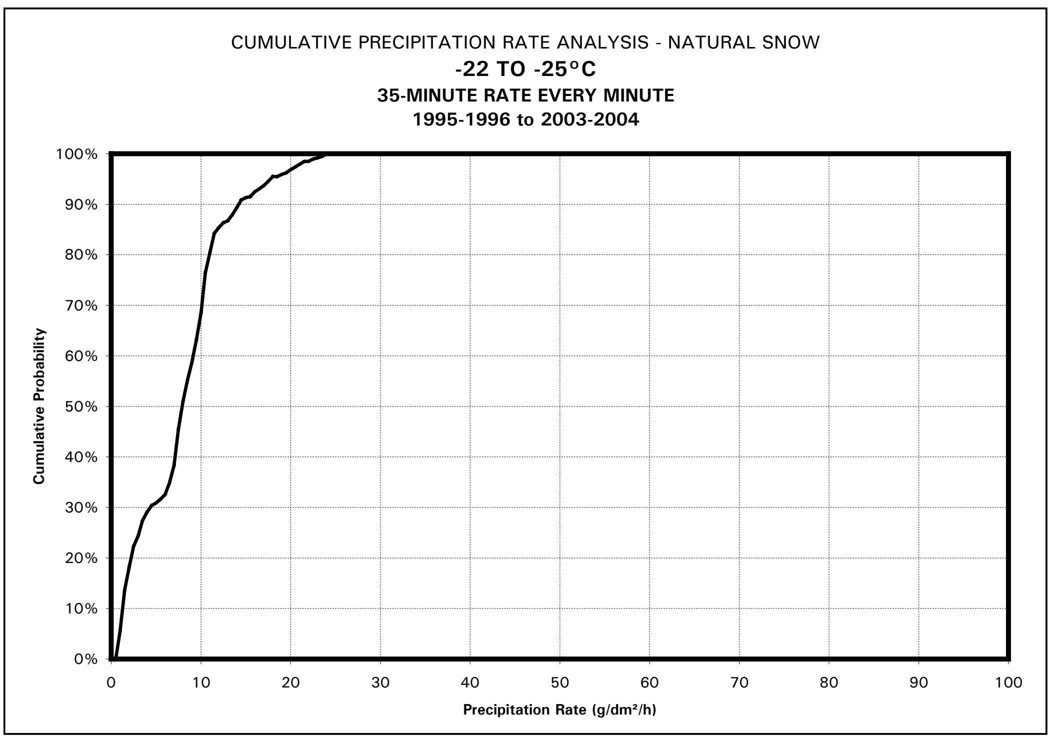

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
700
800
900
1000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)

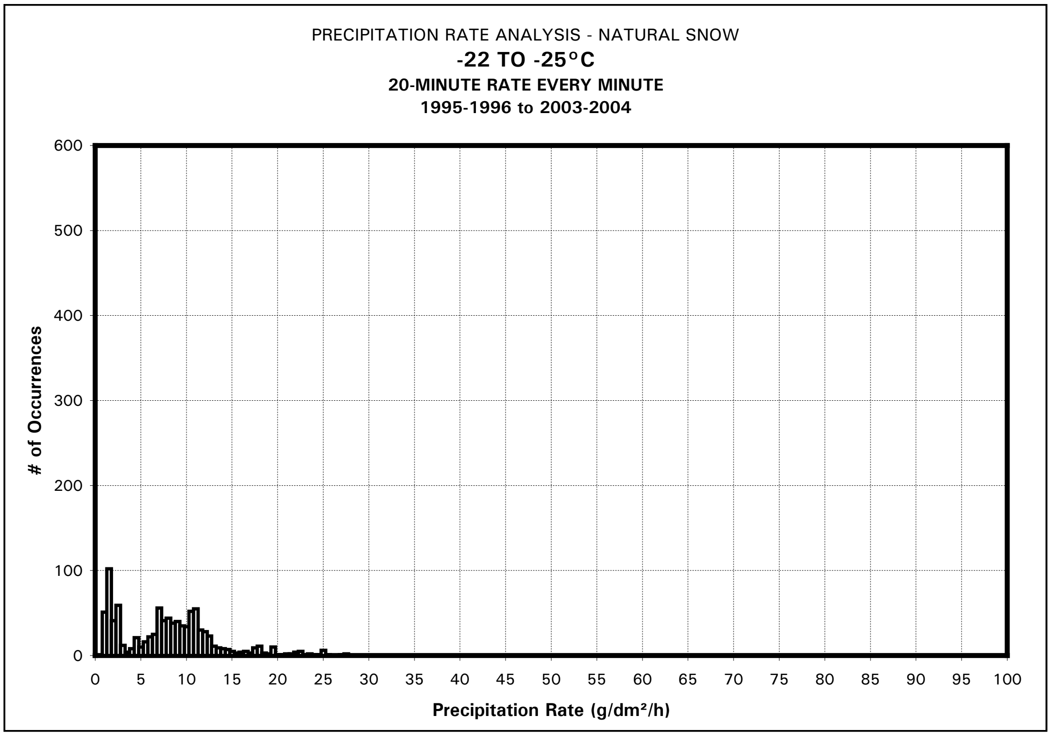

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

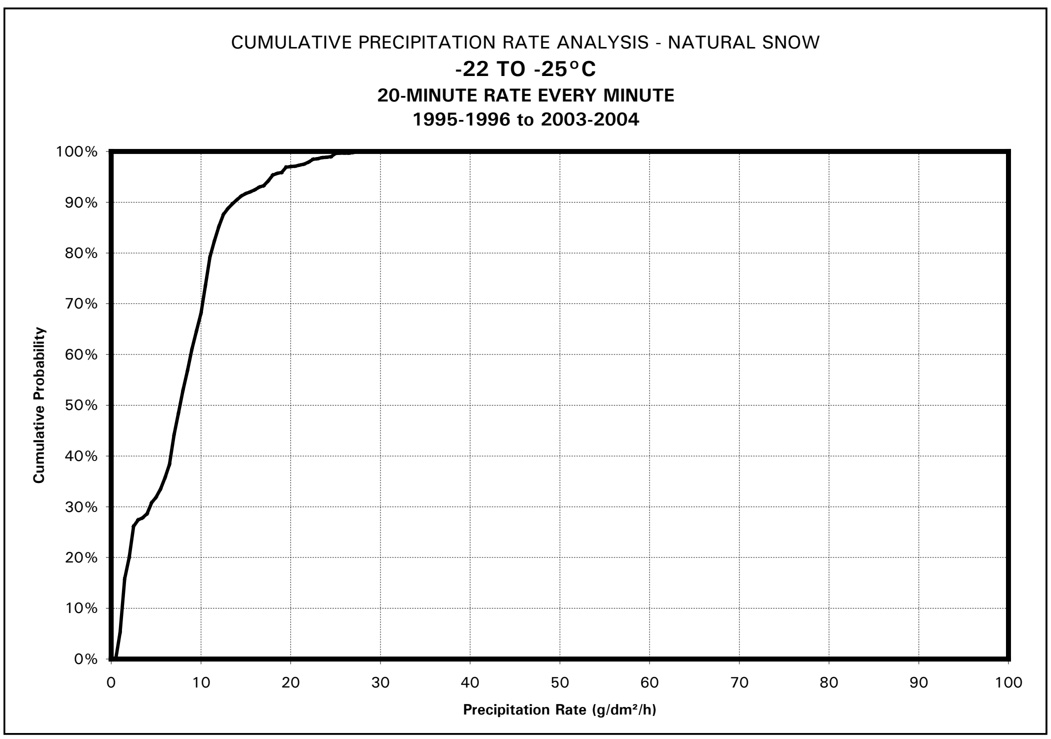

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)
0
100
200
300
400
500
600
700
800
900
1000
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

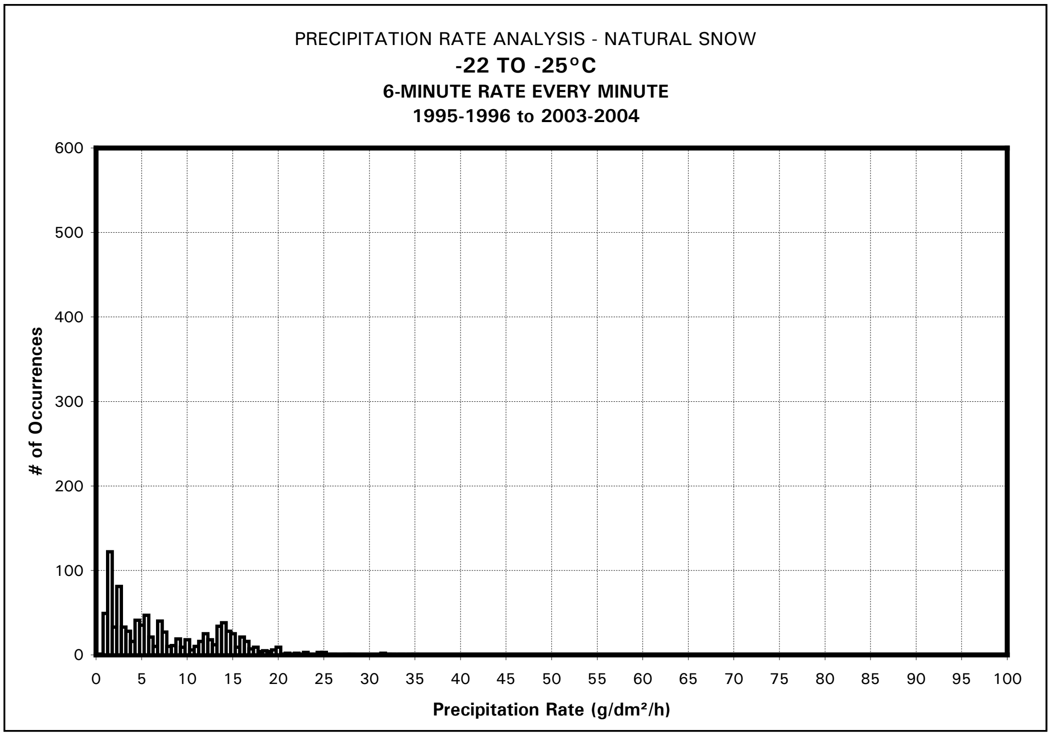

CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-18 TO -22°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
10
20
30
40
50
60
70
80
90
100

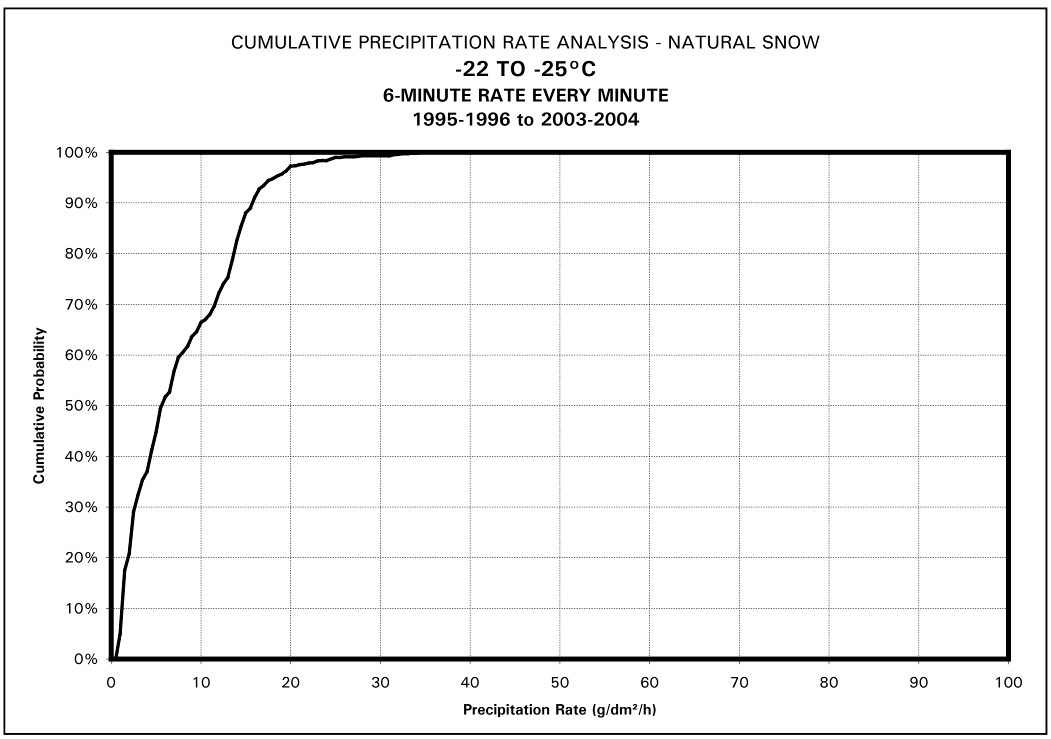

PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
Precipitation Rate (g/dm²/h)
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
35-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
Precipitation Rate (g/dm²/h)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
20-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)


PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
# of Occurrences
0
100
200
300
400
500
600
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Precipitation Rate (g/dm²/h)


CUMULATIVE PRECIPITATION RATE ANALYSIS - NATURAL SNOW
-22 TO -25°C
6-MINUTE RATE EVERY MINUTE
1995-1996 to 2003-2004
Cumulative Probability
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0 10 20 30 40 50 60 70 80 90 100
Precipitation Rate (g/dm²/h)

APPENDIX C

CR21X AUTOMATIC DATA ACQUISITION STATION

CR21X Automatic Data Acquisition Station

Source: Most of the info was researched and obtained from various web sites.

Observations of hourly precipitation amount are extremely useful tools for diagnostic and research purposes. In Canada, such observations are made at a number of sites, the most common being from Meteorological Service of Canada stations around the country.

The meteorological station at Dorval Airport (Photo 1) uses a Fisher/Porter (500 mm) precipitation gauge as a precipitation gauge and also a tipping bucket rain gauge.

Photo 1

The Fisher/Porter (F&P) precipitation gauge, developed by the Belfort instrument Company (Photo 2), is designed to work for many years in remote and harsh environments. The F&P gauge weighs the precipitation it collects in a large metal bucket. This bucket sits atop a mechanism that records the amount of precipitation (Photo 3). The recording & transmitting precipitation gauge converts the weight of collected precipitation into the equivalent depth of accumulated water in conventional units of inches or millimeters. An 8-inch (20.3 cm) diameter, knife-edge orifice collects all forms of precipitation. Rain travels through a funnel into the galvanized weighing bucket. The funnel is removed during the winter season to collect snow. When sub-freezing temperatures are expected, the bucket is partially filled with an antifreeze compound, which allows snow and ice to melt and be accurately measured. A weighing transducer provides instantaneous displacement values of the bucket in terms of millimeters of precipitation. This shaft displacement is transmitted every 5 seconds and averaged every minute in an attempt to eliminate spurious data caused by gusts of wind and temperature-induced contraction and expansion of the sensor. The readings are automatically logged with a CR21X data logger. The CR21X station has an accuracy of 0.1 mm (1 g/dm²).

Photo 2

Photo 3

Precipitation rates tend to fluctuate rapidly during snowstorms. The data from the CR21X station required less smoothing before it could be interpreted. The increased resolution of the CR21X weighing transducer allows better observation of short periods with heavy precipitation.

APPENDIX D

EXAMPLE OF MONTHLY METEOROLOGICAL SUMMARY
MONTREAL - DORVAL

ENVIRONNEMENT CANADA
SERVICE MÉTÉOROLOGIQUE DU CANADA

ENVIRONMENT CANADA
METEOROLOGICAL SERVICE OF CANADA

SOMMAIRE MÉTÉOROLOGIQUE MENSUEL
MONTHLY METEOROLOGICAL SUMMARY

Montreal - Dorval Int'l A

FEVRIER 2004
FEBRUARY 2004

LAT	: 45'28 N	ALTITUDE	: 35.7 MÈTRES (NMM)	HEURE NORMALE UTILISÉE	: DE L'EST
LONG	: 73'45 W	ÉLÉVATION	: 35.7 MÈTRES (ASL)	STANDARD TIME USED	: EASTERN

DATE	TEMPÉRATURE / TEMPERATURE: MAXIMALE / MAXIMUM °C	MINIMALE / MINIMUM °C	MOYENNE / MEAN °C	DEGRÉS-JOURS / DEGREE-DAYS: DE CHAUFFE / HEATING Base 18°C	DE CROISSANCE / GROWING Base 5°C	DE RÉFRIGÉRATION / COOLING Base 18°C	HUMIDITÉ REL / REL. HUMIDITY: MAXIMALE / MAXIMUM %	MINIMALE / MINIMUM %	ORAGE / THUNDERSTORM	PRÉCIPITATIONS / PRECIPITATION: PLUIE (HAUTEUR) / RAINFALL mm	NEIGE (HAUTEUR) / SNOWFALL cm	PRÉCIP TOTAL / TOTAL PRECIP mm	NEIGE AU SOL / SNOW ON GROUND cm	VENTS / WINDS: VITESSE MOYENNE / AVERAGE SPEED Km/h	DIRECTION DOMINANTE / PREVAILING DIRECTION	VITESSE MOYENNE MAX SUR 2 MIN ET DIRECTION / MAX 2 MIN MEAN SPEED AND DIRECTION Km/h		INSOLATION EFFECTIVE / BRIGHT SUNSHINE HEURES / HOURS
1	-6.1	-12.3	-9.2	27.2			84	63			TR	TR	7	20.6	WSW	WSW	28	6.6
2	-3.6	-12.3	-8.0	26.0			84	73					7	6.3	SW	NE	15	1.4
3	1.1	-12.2	-5.6	23.6			95	63		0.8	13.2	14.2	7	18.5	NNE	SE	26	2.1
4	0.0	-7.9	-4.0	22.0			96	49			3.0	2.4	25	32.4	W	WSW	54	4.5
5	-7.3	-13.7	-10.5	28.5			79	56			TR	TR	22	18.5	W	W	33	8.4
6	-6.6	-13.9	-10.3	28.3			92	62		0.4	12.0	12.4	22	23.7	NE	NE	35	
7	-5.6	-15.3	-10.5	28.5			92	64		0.2	2.2	2.4	19	19.8	WNW	WNW	35	
8	-4.9	-18.9	-11.9	29.9			73	55					21	27.1	WSW	WSW	41	8.2
9	2.4	-9.4	-3.5	21.5			81	54			TR	TR	21	21.0	SW	SW	43	3.4
10	1.8	-3.5	-0.9	18.9			88	58			0.2	0.2	15	27.3	SW	WSW	43	3.7
11	-2.3	-15.5	-8.9	26.9			80	51			TR	TR	15	27.7	W	W	41	9.1
12	-8.4	-17.6	-13.0	31.0			80	63			0.2	0.2	15	10.4	SSW	SW	20	5.5
13	0.0	-11.4	-5.7	23.7			86	60			0.2	0.2	15	35.8	SW*	WSW*	48	0.3
14	-1.7	-19.6	-10.7	28.7			81	36			0.4	0.4	14	26.0	WSW	WSW	43	3.3
15	-15.9	-24.0	-20.0	38.0			45	35					14	21.5	W	SW	37	10.1
16	-11.3	-19.9	-15.6	33.6			55	39					13	15.8	WSW*	W	28	10.0
17	-8.8	-19.7	-14.3	32.3			66	45					13	12.4	NNE	NNE	20	3.8
18	-1.9	-17.5	-9.7	27.7			75	48					13	4.2	SSW	SW	11	8.6
19	-1.8	-9.6	-5.7	23.7			83	60			0.8	0.8	13	7.4	SW	SW*	17	5.6
20	-0.2	-9.2	-4.7	22.7			81	56			0.2	0.2	13	12.8	NE	E	30	4.8
21	1.5	-1.3	0.1	17.9			88	69		1.4	3.8	5.2	14	16.6	SE	SSE	28	
22	-0.6	-6.5	-3.6	21.6			85	61			1.0	1.0	13	17.0	W	W	31	0.4
23	-2.9	-13.9	-8.4	26.4			77	49					12	11.8	WSW	W	24	10.1
24	-4.9	-17.0	-11.0	29.0			82	43					12	9.0	SW	SW*	22	8.2
25	0.1	-15.7	-7.8	25.8			70	44					12	11.7	SW*	SW*	20	10.0
26	-1.8	-12.9	-7.4	25.4			69	29					12	6.9	NNW	SW*	19	10.4
27	-1.1	-14.9	-8.0	26.0			73	36					12	8.5	SW	SW*	17	10.2
28	4.3	-9.1	-2.4	20.4			63	49					12	13.3	SW	W	26	8.3
29	5.5	-0.8	2.4	15.6			70	54					12	14.8	WSW	WSW*	28	0.3
	MOY -2.8 MEAN	MOY -12.9 MEAN	MOY -7.9 MEAN	TOTAL 750.8	TOTAL	TOTAL	MOY 78 MEAN	MOY 53 MEAN	TOTAL N/D	TOTAL 2.8	TOTAL 37.2	TOTAL 39.6		MOY 17.2 MEAN	DOMINANTE WSW PREVAILING	MAXIMALE WSW MAXIMUM	54	TOTAL 157.3
NORMALE / NORMAL	-4.3	-13.4	-8.9	758.2	0.9	0.0			0	18.4	43.8	59.7		15.0	WSW			123.9

SOMMAIRE DE DEGRÉS-JOURS
DEGREE-DAY SUMMARY

AU-DESSOUS DE 18 °C / BELOW 18°C	ANNÉE EN COURS / THIS YEAR	NORMALE / NORMAL	AU-DESSUS DE 5°C / ABOVE 5°C	ANNÉE EN COURS / THIS YEAR	NORMALE / NORMAL
TOTAL DU MOIS / TOTAL FOR MONTH	750.8	758.2	TOTAL DU MOIS / TOTAL FOR MONTH		0.9
ACCUMULÉS DEPUIS LE 1er JUILLET / ACCUMULATED SINCE JULY 1st	3306.1	3370.2	ACCUMULÉS DEPUIS LE 1er AVRIL / ACCUMULATED SINCE APRIL 1st	2273.3	2066.9

JOURS AVEC PRÉCIPITATIONS TOTALES / DAYS WITH TOTAL PRECIPITATION (mm)					JOURS AVEC CHÛTES DE NEIGE / DAYS WITH SNOWFALL (cm)				
0,5 ou plus / or more	1,0 ou plus / or more	2,0 ou plus / or more	10,0 ou plus / or more	50,0 ou plus / or more	0,2 ou plus / or more	1,0 ou plus / or more	2,0 ou plus / or more	10,0 ou plus / or more	50,0 ou plus / or more
7	6	5	2		12	6	5	2	

Canada

1. Normale/Normal 1971-2000
2. Journée climatologique/Climatological Day (01h00HNE à/to 01h00HNE)
3. (AUTO) : mesures d'une station automatique/data from automatic station
4. TR = Trace M = Manquant/Missing E = Estimé/Estimated C = Calme/Calm
5. Pas de valeur/No entry = Pas d'événement/No occurence
6. * = indique la première de plusieurs valeurs valides/indicates first of many valid values
7. c = correction

Données horaires non controlées
Hourly data not validated
Les précipitations ont un seuil mesurable de 1,0 mm
Measurable threshold of precipitation is 1,0 mm

RELEVÉS COMPARATIFS À : / COMPARATIVE RECORDS AT : **Montreal - Dorval Int'l A** — **FEVRIER 2004 / FEBRUARY 2004**

	UNITÉS / UNITS	CE MOIS-CI / THIS MONTH — RELEVÉ / VALUE	JOUR / DAY	ANNÉE PRÉCÉDENTE / PREVIOUS YEAR — RELEVÉ / VALUE	JOUR / DAY	NORMALE / NORMAL	RECORD POUR LE MOIS / RECORD FOR THE MONTH — MAXIMUM ABSOLU / HIGHEST EVER — RELEVÉ / VALUE	JOUR / DAY	ANNÉE / YEAR	MINIMUM ABSOLU / LOWEST EVER — RELEVÉ / VALUE	JOUR / DAY	ANNÉE / YEAR	DEPUIS / SINCE
TEMPÉRATURE MAXIMALE / HIGHEST TEMPERATURE (MAXIMUM)	°CELSIUS	5.5	29	4.1	21		15.0	22	1981				1941
TEMPÉRATURE MINIMALE / LOWEST TEMPERATURE (MINIMUM)	°CELSIUS	-24.0	15	-25.9	16					-33.9	15	1943	1941
TEMPÉRATURE MENSUELLE MOYENNE / MEAN MONTHLY TEMPERATURE	°CELSIUS	-7.9		-10.8		-8.9	-1.6		1981	-14.1		1993	1941
HAUTEUR TOTALE MENSUELLE DE PLUIE / TOTAL MONTHLY RAINFALL	mm	2.8		19.0		18.4	87.0		1981	0.0		1993	1941
HAUTEUR TOTALE MENSUELLE DE NEIGE / TOTAL MONTHLY SNOWFALL	cm	37.2		31.9		43.8	132.4		1960	11.4		1978	1941
PRÉCIPITATION TOTALE MENSUELLE / TOTAL MONTHLY PRECIPITATION	mm	39.6		62.8		59.7	174.5		1960	7.7		1978	1941
NOMBRE DE JOURS AVEC PRECIPITATION MESURABLE / NO OF DAYS WITH MEASURABLE PRECIPITATION		12		11		14	21		1960	2		1984	1941
HAUTEUR DE PLUIE MAXIMALE EN UNE JOURNÉE / GREATEST RAINFALL IN ONE DAY	mm	1.4	21	17.0	4		31.5	25	1961				1941
HAUTEUR DE NEIGE MAXIMALE EN UNE JOURNÉE / GREATEST SNOWFALL IN ONE DAY	cm	13.2	3	11.6	22		39.4	16	1954				1941
PRÉCIPITATION MAXIMALE EN UNE JOURNÉE / GREATEST PRECIPITATION IN ONE DAY	mm	14.2	3	21.6	23		39.4	16	1954				1941
HAUTEUR DE PLUIE ENREGISTRÉE EN : / MAXIMUM RAINFALL RECORDED IN :													
5 MINUTES	mm						1.0	24	1975				de/from
10 MINUTES	mm						1.3	9	1990				1943
15 MINUTES	mm						5.0	16	1983				à/to
30 MINUTES	mm						5.0	16	1983				1990
60 MINUTES	mm						5.3	22	1974				
24 HEURES CONSÉCUTIVE / CONSECUTIVE HOURS	mm												
VITESSE MOYENNE DU VENT / MEAN WIND SPEED	KM/H	17.2		19.4		15.0	22.2		1976	10.9		1987	1953
VITESSE MAXIMALE (MOYENNE SUR 2 MIN.) / MAXIMUM SPEED (2 MIN. MEAN)	KM/H	WSW 54	4	WSW 63	4		NNE 80	26	1961				1953
POINTE DE VENT MAXIMALE / MAXIMUM GUST SPEED	KM/H	WSW 69	4	SW 85	4		WSW 138	25	1956				1955
TOTAL DES HEURES INSOLATION / TOTAL HOURS OF SUNSHINE	HEURES	157.3		149.7		123.9	205.6		1987	73.7		1981	1969
PRESSION MOYENNE À LA STATION / MEAN STATION PRESSURE	kPa	101.59		101.19		101.27	101.91		1955	100.31		1958	1953
PRESSION MAXIMALE À LA STATION / GREATEST STATION PRESSURE	kPa	103.56	17	104.26	23		104.67	13	1981				1953
PRESSION MINIMALE À LA STATION / LEAST STATION PRESSURE	kPa	99.33	21	98.10	16					96.58	25	1956	1953

DONNÉES CLIMATOLOGIQUES CE MOIS-CI POUR LES 10 DERNIÈRES ANNÉES / CLIMATOLOGICAL DATA THIS MOUNTH FOR THE PAST 10 YEARS

ANNÉE / YEAR	TEMPÉRATURE MAXIMALE / MAXIMUM TEMP.	TEMPÉRATURE MINIMALE / MINIMUM TEMPERATURE	TEMPÉRATURE MOYENNE / MEAN TEMPERATURE	HAUTEUR DE PLUIE / RAINFALL	HAUTEUR DE NEIGE / SNOWFALL	PRÉCIPITATION TOTALE / TOTAL PRECIPITATION	VITESSE MOYENNE DES VENTS / MEAN WIND SPEED	VITESSE MAXIMALE DES VENTS / MAXIMUM WIND SPEED	HEURES D'ENSOLEILLEMENT / SUNSHINE HOURS	DEGRÉS-JOURS DE CHAUFFE / HEATING DEGREE-DAYS	DEGRÉS-JOURS DE CROISSANCE / GROWING DEGREE-DAYS	DEGRÉS-JOURS DE RÉFRIGÉRATION / COOLING DEGREE-DAYS	A.S.N / S.A.S
1995	5.0	-27.5	-9.8	2.6	55.6	58.0	18.6	SSE 48	142.3	778.2			158.9
1996	7.5	-23.6	-7.9	52.4	17.4	72.7	14.9	WNW 52	133.3	752.3			176.1
1997	8.2	-28.3	-7.9	35.9	70.5	96.4	14.2	SW 50	106.4	725.3			206.3
1998	5.9	-19.7	-3.8	16.5	27.2	63.8	12.5	W 39	137.5	610.7			190.4
1999	9.1	-19.0	-5.1	20.6	15.5	44.3	13.2	SSE 41	152.8	647.1			122.8
2000	10.9	-21.6	-7.0	8.2	67.1	73.0	18.0	SW 54	149.3	725.4	2.2		154.8
2001	8.8	-23.3	-8.7	30.1	44.0	74.2	18.0	W 76	114.5	747.0			188.6
2002	11.4	-18.8	-5.0	18.2	19.0	41.2	18.5	SW 67	105.3	643.3	1.0		94.8
2003	4.1	-25.9	-10.8	19.0	31.9	62.8	19.4	WSW 63	149.7	805.6			131.9
2004	5.5	-24.0	-7.9	2.8	37.2	39.6	17.2	WSW 54	157.3	750.8			137.0

Avis / Note :

* : Nouveau record / New record
# : Station manuelle / Manual station
A.S.N : Accumulation Saisonnière de Neige / S.A.S = Season Accumulation Snowfall

TEMPÉRATURE HORAIRE
HOURLY TEMPERATURE

Montreal - Dorval Int'l A

FEVRIER 2004
FEBRUARY 2004

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-112	-110	-111	-117	-115	-113	-114	-115	-121	-113	-102	-95	-88	-76	-69	-64	-61	-67	-70	-75	-80	-87	-90	-97
2	-101	-107	-111	-115	-122	-121	-116	-113	-111	-104	-91	-87	-74	-65	-58	-43	-46	-54	-58	-64	-64	-68	-67	-72
3	-77	-80	-81	-102	-108	-113	-118	-121	-116	-109	-87	-77	-61	-50	6	4	4	5	0	4	0	-5	-10	-13
4	-13	-12	-11	-8	-7	-6	-1	-3	-3	-3	-25	-35	-38	-43	-37	-38	-43	-52	-60	-64	-71	-70	-79	-69
5	-69	-76	-79	-89	-96	-105	-108	-117	-118	-112	-107	-96	-93	-87	-83	-76	-75	-81	-83	-88	-98	-105	-119	-130
6	-132	-134	-122	-96	-103	-97	-83	-86	-88	-93	-91	-93	-97	-94	-95	-90	-89	-83	-81	-77	-73	-68	-70	-67
7	-68	-68	-68	-67	-66	-65	-65	-65	-62	-59	-58	-57	-59	-64	-66	-68	-65	-67	-67	-67	-73	-87	-108	-126
8	-138	-152	-163	-167	-173	-175	-178	-186	-188	-181	-174	-163	-148	-134	-121	-116	-108	-104	-101	-94	-70	-54	-58	-50
9	-54	-50	-58	-71	-83	-84	-63	-63	-50	-64	-44	-27	-18	-16	5	10	1	18	16	13	17	15	12	17
10	22	18	13	4	2	0	4	1	-3	-2	0	0	3	10	14	13	5	-5	-10	-14	-11	-22	-24	-22
11	-33	-29	-25	-25	-30	-38	-42	-49	-70	-83	-92	-94	-93	-93	-89	-87	-87	-95	-105	-110	-113	-121	-112	-134
12	-135	-155	-166	-168	-160	-148	-146	-142	-132	-117	-109	-109	-100	-95	-88	-85	-88	-93	-101	-105	-109	-114	-119	-124
13	-111	-114	-107	-89	-83	-86	-85	-72	-61	-49	-41	-22	-12	-3	0	-4	-4	-4	-6	-10	-13	-16	-16	-17
14	-17	-17	-21	-21	-21	-25	-24	-25	-25	-21	-21	-28	-41	-51	-66	-78	-91	-113	-126	-140	-156	-156	-161	-187
15	-188	-193	-202	-223	-220	-225	-233	-239	-231	-218	-211	-200	-192	-184	-174	-169	-163	-161	-161	-162	-167	-159	-166	-172
16	-186	-183	-185	-187	-187	-187	-193	-196	-195	-181	-162	-146	-137	-128	-122	-116	-115	-121	-136	-153	-156	-134	-141	-148
17	-150	-153	-161	-163	-188	-193	-189	-178	-165	-156	-147	-128	-114	-106	-96	-88	-97	-97	-101	-120	-124	-123	-122	-125
18	-130	-128	-127	-137	-145	-159	-155	-155	-150	-125	-108	-85	-71	-57	-45	-40	-44	-52	-68	-69	-66	-76	-85	-91
19	-81	-97	-68	-67	-69	-81	-88	-91	-89	-84	-76	-56	-46	-36	-33	-21	-25	-25	-23	-29	-29	-28	-36	-32
20	-36	-25	-32	-45	-47	-75	-70	-76	-69	-47	-33	-27	-20	-18	-13	-15	-18	-19	-22	-20	-22	-35	-25	-17
21	-8	-2	1	-1	1	-3	-2	-3	-3	3	6	8	12	15	10	11	10	9	9	9	8	10	7	7
22	1	-12	-20	-23	-22	-26	-24	-24	-24	-24	-21	-17	-17	-14	-14	-8	-6	-8	-10	-14	-19	-24	-29	-44
23	-55	-63	-71	-78	-84	-99	-95	-115	-94	-84	-79	-72	-61	-52	-42	-35	-30	-31	-42	-46	-61	-72	-87	-106
24	-110	-131	-140	-143	-133	-147	-163	-169	-139	-124	-97	-85	-86	-79	-73	-62	-54	-51	-57	-70	-73	-106	-108	-90
25	-103	-120	-132	-147	-152	-134	-152	-136	-139	-115	-90	-76	-58	-44	-31	-17	-9	-3	-10	-22	-35	-45	-51	-54
26	-63	-65	-78	-84	-100	-123	-110	-107	-108	-81	-67	-61	-50	-35	-26	-35	-39	-39	-42	-65	-56	-66	-92	-110
27	-114	-113	-101	-127	-126	-134	-146	-122	-136	-96	-65	-50	-46	-31	-14	-13	-14	-17	-28	-33	-34	-69	-77	-75
28	-64	-89	-71	-60	-53	-50	-47	-50	-43	-34	-22	-7	7	18	29	36	41	39	30	27	32	22	14	6
29	4	1	-3	-3	1	-1	-3	-3	-3	6	11	17	30	43	48	51	51	46	38	33	33	31	27	25
30																								
31																								

Avis / Note : Unités / Units: 0.1 °C M = Manquant / Missing

Lire / Read -123 = -12.3 °C -1 = -0.1 °C 0 = 0.0 °C 12 = +1.2 °C 123 = 12.3 °C

Heure normale locale : Est
Local standard time: Eastern

Si vous avez des questions, commentaires ou désirez recevoir de l'information sur les produits offerts pas Environnement Canada :
If you have questions, comments or wish information on products offered by Environment Canada:

Écrivez-nous à : *Write to us at :*

ENVIRONNEMENT CANADA / ENVIRONMENT CANADA
Services climatologiques et de qualité de l'air / Climate and Air Quality Services
100 Alexis Nihon, 3e
Ville St-Laurent, QC - H4M 2N8 Télécopieur / Fax : (514) 283-2264
Courrier éléctronique / Email : *Climat.Quebec@ec.gc.ca*
Renseignements climatologiques / Climate Information : 1-900-565-1111 (2,99 $ / minute)

VENTS / WINDS

VENTS HORAIRES (KM/H) / HOURLY WINDS (KM/H) : Montreal - Dorval Int'l A — FEVRIER 2004 / FEBRUARY 2004

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	RAFALE MAX / PEAK GUST	Heure / Time	Jour / Day
1	WSW 24	WSW 22	WSW 22	WSW 20	WSW 20	WSW 19	WSW 22	WSW 26	SW 17	SW 20	WSW 19	WSW 26	SW 17	WSW 26	SW 26	SW 22	WSW 22	WSW 28	WSW 22	WSW 26	WSW 20	WSW 22	WSW 13	WSW 15	WSW 41	18	1
2	WSW 13	SW 11	SW 13	WSW 7	SW 6	WSW 6	SW 6	SW 7	WSW 6	C 0	W 4	SW 6	C 0	C 0	C 0	NE 7	E 7	ESE 7	ESE 7	ESE 6	E 7	ENE 6	ENE 7	ENE 11			
3	NE 15	NE 11	NE 19	NNE 13	NNE 17	NNE 20	NNE 22	NNE 19	NE 22	NE 22	NE 20	NNE 15	NNE 19	NNE 19	ESE 19	ESE 17	SE 15	ESE 17	ESE 19	SE 20	SE 26	SE 24	ESE 15	E 9	SE 41	21	3
4	E 22	ESE 13	SE 13	S 4	SW 9	SW 13	WSW 28	W 28	W 39	W 43	W 46	W 46	WSW 54	WSW 50	W 41	W 41	W 52	W 37	W 30	W 31	W 28	W 20	WSW 31	W 30	WSW 69	14	4
5	W 33	W 31	W 33	WNW 28	W 26	WNW 13	WNW 26	WNW 24	W 22	W 19	W 30	W 24	W 31	W 31	W 28	W 19	WSW 19	W 15	WSW 13	WSW 19	WNW 11	SSW 4	SW 6	WSW 4	W 48	2	5
6	C 0	C 0	C 0	E 11	E 11	E 7	ENE 20	NE 24	NE 30	NE 24	NE 26	NE 31	NE 28	NE 33	NE 31	NE 30	NE 35	NE 31	NNE 31	NE 28	NE 28	NNE 24	NNE 22	NNE 22	NE 48	14	6
7	NNE 22	N 19	NNE 15	NNE 11	N 7	N 9	NW 7	NW 9	WSW 7	SW 11	W 20	WSW 20	WSW 28	W 28	W 30	W 26	WNW 22	WNW 24	WNW 20	WNW 19	W 28	W 24	WNW 26	WNW 26	WNW 48	0	7
8	WNW 35	WNW 24	WNW 26	WNW 28	W 26	WNW 20	W 28	WSW 28	W 31	WSW 41	WSW 30	WSW 35	WSW 39	W 37	W 30	WSW 35	WSW 24	WSW 26	WSW 13	SSW 13	SW 24	WSW 35	SW 22	WSW 26	W 50	4	8
9	WSW 17	SW 17	WSW 17	WSW 13	SSW 9	S 13	S 15	S 13	SW 13	SSE 13	SE 15	SSW 15	SE 9	SE 11	SSW 13	SSW 15	SSW 11	SW 28	SW 33	SW 37	SW 41	SW 43	SW 33	SW 30	SW 59	20	9
10	WSW 35	W 30	WSW 41	WSW 26	WSW 24	SW 19	WSW 28	WSW 30	W 33	WSW 31	WSW 43	WSW 33	W 31	WSW 28	SW 24	SW 30	SW 31	SW 30	SSW 24	SSW 19	SW 17	SW 24	SW 22	SW 26	WSW 56	10	10
11	SW 19	SW 22	SW 26	WSW 28	WSW 28	WSW 35	W 31	W 31	W 41	W 26	W 39	WNW 33	W 37	W 39	W 35	W 35	W 35	WSW 26	WSW 30	WSW 30	W 22	W 13	W 13	SW 11	W 54	8	11
12	SW 11	SSW 9	SSW 6	SSW 4	SW 7	SW 7	SW 4	WNW 6	W 6	W 6	W 9	SSW 11	SSW 13	SSW 11	SSW 15	SW 20	SSW 15	SSW 15	SSW 17	SSW 15	SSW 15	SW 11	SW 15	SW 9			
13	SSW 6	SSW 6	SW 24	WSW 28	WSW 31	SW 22	WSW 28	WSW 28	WSW 31	SW 31	WSW 37	WSW 33	WSW 46	WSW 48	WSW 43	SW 48	WSW 41	SW 33	SW 37	SW 41	SW 43	SW 43	SW 37	SW 43	SW 67	15	13
14	SW 30	WSW 33	N 31	WSW 31	SW 39	SW 41	WSW 33	WSW 28	WSW 35	WSW 43	WSW 41	W 26	NW 30	WNW 22	NW 28	WNW 28	W 26	WNW 30	NW 28	NNW 13	NNW 15	N 11	NNW 9	NW 9	WSW 57	10	14
15	WNW 11	WNW 17	NW 17	WNW 11	W 15	NW 19	WNW 17	W 15	WNW 15	W 19	W 24	W 28	W 22	SW 37	WSW 35	WSW 33	W 28	WSW 30	W 22	W 19	W 19	W 28	WSW 28	WSW 20	WSW 48	16	15
16	WSW 9	WSW 7	WSW 11	WSW 11	WSW 13	WSW 13	WSW 11	WSW 9	SW 9	WSW 11	WSW 15	W 24	W 26	W 26	W 26	W 28	W 20	W 9	W 11	WNW 7	NW 13	ENE 17	ENE 20	ENE 20	W 35	13	16
17	ENE 17	ENE 11	NE 9	NE 15	NNE 9	NNE 11	NNE 13	NNE 11	NE 9	E 13	E 11	E 11	E 13	ESE 15	E 13	NE 17	NNE 20	NNE 17	NE 15	N 17	NNE 15	N 11	N 9	NNE 4			
18	N 11	NNE 9	NNE 4	C 0	NNW 6	WNW 6	NW 4	C 0	C 0	C 0	C 0	C 0	SW 11	SSW 6	WSW 4	S 6	SSW 6	SSW 6	S 6	WSW 6	SSW 4	WSW 7	SE 6	SW 4			
19	SSE 4	W 4	E 6	C 0	NW 4	N 7	N 7	NNE 13	N 11	NNW 6	NNE 9	NNW 4	WSW 6	SW 9	SW 17	SW 11	SW 17	SW 11	SW 6	SW 6	W 9	WNW 7	NW 4	C 0			
20	WSW 4	N 4	NNW 6	N 7	N 6	N 4	N 4	C 0	C 0	NNE 13	NNE 11	NE 15	NE 13	NE 11	NNE 11	NE 13	NE 19	NE 19	ENE 17	NE 13	E 19	ENE 19	ENE 19	ENE 17	E 44	1	21
21	E 20	E 30	E 24	E 20	SE 20	ESE 22	E 20	E 19	ESE 22	SE 24	SSE 28	SSE 24	SSE 22	SSE 15	SSE 19	SE 15	SE 15	SE 13	ESE 15	SE 15	ESE 9	ENE 6	C 0	C 0	E 41	2	21
22	NE 15	NNE 17	NE 20	NNE 17	NNE 11	N 13	N 15	NNE 13	NNE 11	N 7	N 7	N 4	WNW 6	W 22	W 24	W 30	W 31	W 26	W 28	WNW 24	WNW 24	W 24	NW 19	NW 11	W 46	15	22
23	WNW 11	NW 9	WNW 11	WNW 13	WNW 13	WNW 7	SW 4	W 9	W 17	WSW 9	SSW 15	SSW 19	SW 15	SW 17	W 17	WSW 17	W 19	WSW 17	WSW 15	W 24	WSW 15	WSW 11	C 0	C 0			
24	C 0	C 0	W 4	N 4	NNW 6	C 0	SW 7	W 4	C 0	C 0	SW 4	SW 9	SSW 15	SW 15	SSW 20	SW 22	SW 22	N 15	SW 15	SW 11	WSW 11	WSW 7	WNW 9	WNW 6			
25	WNW 4	W 7	WSW 6	SW 4	C 0	C 0	SW 4	SW 9	SSW 7	SSW 9	SSW 6	SSW 15	SSW 19	SSW 19	SW 20	SW 20	SW 20	WSW 17	W 19	WNW 11	NW 11	NW 13	NNW 6	NNW 20			
26	NNW 13	NNE 13	N 11	N 9	NNW 6	WNW 9	NNW 9	N 11	NNW 9	NNW 7	NE 6	NE 7	NE 6	C 0	C 0	SW 19	SSW 19	SSW 15	SW 9	W 6	C 0	C 0	C 0	SW 4			
27	WSW 4	C 0	NNW 6	N 6	E 6	NNW 4	NW 4	N 4	W 4	W 4	SW 6	SW 11	SW 15	SW 11	SW 13	SW 17	SSW 17	SW 15	SSW 13	WSW 9	SW 9	SW 9	SSW 6	S 4			
28	SW 7	S 4	SW 11	SW 13	WSW 17	SW 15	WSW 20	SW 15	WSW 17	WSW 15	WSW 9	SW 6	SW 4	SW 6	SW 15	SW 20	SSW 13	SW 13	SSW 11	WSW 7	W 26	WSW 17	WSW 13	W 11	W 39	20	28
29	WSW 17	SW 7	SW 15	SSW 9	SW 17	WSW 20	WSW 22	WSW 28	WSW 19	WSW 22	WSW 22	SW 15	WSW 15	WSW 24	WSW 19	WSW 28	WSW 17	W 19	W 13	NW 6	W 6	WNW 7	NW 7	C 0	WSW 41	14	29
30																											
31																											

Avis / Note: C = Calme / Calm — M = Manquant / Missing

Heure normale locale : Est
Local standard time : Eastern

HUMIDITÉ / HUMIDITY

POINTS DE ROSÉE HORAIRES
HOURLY DEW POINTS

Montreal - Dorval Int'l A

FEVRIER 2004
FEBRUARY 2004

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-131	-130	-133	-141	-141	-143	-146	-146	-154	-151	-146	-139	-133	-128	-121	-118	-119	-121	-123	-125	-128	-135	-135	-138
2	-141	-144	-145	-146	-150	-147	-143	-140	-138	-132	-125	-119	-111	-101	-95	-84	-86	-87	-91	-91	-92	-91	-94	-98
3	-101	-103	-103	-121	-125	-131	-140	-141	-136	-135	-116	-108	-92	-84	-57	-57	-54	-42	-27	-19	-14	-16	-20	-20
4	-20	-19	-18	-16	-13	-13	-10	-14	-15	-22	-47	-65	-83	-87	-92	-94	-108	-122	-133	-153	-151	-150	-149	-132
5	-127	-131	-129	-149	-155	-165	-177	-183	-175	-173	-167	-159	-154	-152	-147	-147	-147	-147	-146	-150	-150	-153	-156	-165
6	-164	-162	-149	-126	-131	-138	-143	-143	-147	-143	-137	-127	-122	-116	-113	-111	-111	-104	-102	-97	-89	-82	-81	-78
7	-79	-79	-79	-78	-77	-76	-76	-76	-73	-70	-69	-68	-74	-85	-86	-87	-89	-92	-110	-114	-119	-126	-156	-176
8	-192	-203	-212	-215	-218	-221	-221	-223	-224	-219	-217	-211	-200	-198	-190	-187	-176	-171	-163	-150	-119	-101	-106	-102
9	-100	-99	-106	-111	-115	-110	-93	-94	-91	-99	-96	-87	-83	-82	-78	-68	-59	-59	-49	-40	-28	-22	-23	-26
10	-31	-24	-20	-14	-24	-23	-38	-48	-46	-52	-62	-48	-46	-58	-56	-60	-50	-41	-29	-34	-43	-55	-57	-54
11	-62	-52	-54	-60	-70	-80	-80	-84	-116	-136	-156	-163	-158	-162	-168	-169	-164	-167	-172	-178	-180	-181	-182	-188
12	-188	-195	-202	-198	-195	-185	-180	-176	-161	-147	-151	-148	-145	-152	-137	-143	-143	-145	-150	-151	-152	-155	-155	-152
13	-143	-142	-127	-114	-117	-126	-125	-113	-101	-85	-61	-67	-71	-70	-66	-58	-55	-54	-56	-55	-59	-60	-57	-58
14	-59	-64	-70	-73	-69	-75	-77	-75	-78	-72	-66	-56	-84	-100	-145	-159	-182	-218	-235	-257	-260	-259	-264	-273
15	-275	-296	-304	-310	-312	-320	-326	-328	-325	-313	-311	-310	-297	-296	-291	-280	-276	-277	-276	-275	-274	-276	-278	-277
16	-278	-272	-267	-264	-262	-262	-263	-263	-262	-253	-240	-228	-236	-233	-229	-226	-226	-225	-230	-237	-236	-235	-248	-249
17	-250	-245	-249	-246	-245	-254	-247	-231	-221	-220	-220	-208	-209	-194	-192	-183	-172	-180	-174	-172	-179	-176	-176	-175
18	-179	-186	-182	-185	-186	-196	-197	-197	-198	-195	-179	-165	-155	-144	-133	-125	-136	-124	-126	-126	-122	-129	-132	-130
19	-124	-133	-124	-115	-109	-106	-112	-119	-119	-115	-113	-101	-99	-96	-92	-87	-87	-83	-81	-79	-75	-72	-78	-74
20	-75	-72	-74	-85	-94	-112	-105	-103	-100	-95	-94	-92	-82	-89	-89	-87	-91	-91	-91	-89	-89	-68	-67	-62
21	-52	-49	-49	-48	-33	-27	-25	-28	-25	-18	-15	-10	-7	-7	-11	-10	-12	-12	-13	-13	-13	-12	-13	-13
22	-19	-31	-42	-48	-48	-51	-50	-54	-55	-54	-49	-51	-46	-38	-46	-59	-66	-71	-73	-77	-81	-85	-94	-106
23	-109	-116	-123	-133	-140	-147	-146	-158	-144	-139	-133	-128	-129	-126	-126	-121	-121	-121	-127	-130	-133	-139	-143	-153
24	-155	-163	-178	-167	-164	-178	-197	-195	-177	-164	-157	-152	-151	-154	-155	-157	-157	-155	-163	-164	-166	-171	-179	-176
25	-176	-177	-187	-189	-196	-185	-197	-186	-191	-179	-163	-147	-140	-135	-129	-117	-115	-105	-113	-120	-123	-127	-125	-127
26	-132	-137	-144	-149	-155	-172	-159	-161	-161	-152	-171	-187	-178	-182	-181	-169	-147	-148	-164	-157	-167	-160	-166	-155
27	-167	-169	-151	-165	-172	-176	-188	-177	-180	-163	-151	-159	-151	-143	-142	-144	-142	-143	-139	-147	-153	-150	-149	-151
28	-156	-158	-158	-150	-141	-131	-117	-114	-103	-95	-89	-84	-67	-62	-57	-47	-44	-42	-45	-49	-49	-52	-56	-60
29	-61	-65	-67	-71	-72	-73	-71	-62	-59	-55	-52	-50	-44	-41	-38	-35	-30	-29	-28	-27	-27	-24	-24	-24
30																								
31																								

Avis / Note: Unités / Units : 0,1 ˚C M = Manquant / Missing

HUMIDITÉS RELATIVES HORAIRES RELEVÉE À :
HOURLY RELATIVE HUMIDITIES AT :

DATE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	86	85	84	82	81	78	77	78	76	73	70	70	70	66	66	65	63	65	66	67	68	68	70	72
2	72	74	76	78	80	81	80	80	80	80	76	78	75	75	75	73	73	77	77	81	80	84	81	82
3	83	83	84	86	87	86	84	85	85	81	79	78	79	77	63	64	65	71	82	84	90	92	93	95
4	95	95	95	94	96	95	94	92	92	87	85	80	71	71	66	65	60	58	56	49	53	53	57	61
5	63	65	67	62	62	61	57	58	62	60	61	60	61	59	60	57	56	59	60	61	66	68	74	75
6	77	79	80	79	80	72	62	63	62	67	69	76	82	84	87	85	84	85	85	85	88	90	92	92
7	92	92	92	92	92	92	92	92	92	92	92	92	89	85	86	86	83	82	71	69	70	73	68	66
8	64	65	66	66	68	67	69	72	73	72	69	66	64	58	56	55	57	58	60	64	68	69	69	67
9	70	68	69	73	78	81	79	79	73	76	67	63	61	61	54	56	64	57	62	68	72	76	77	73
10	68	74	79	88	83	84	73	70	73	69	63	70	70	60	60	58	66	77	87	86	79	78	78	79
11	80	84	80	77	74	73	75	76	70	65	60	57	59	57	53	51	54	56	58	57	57	61	56	64
12	64	71	73	77	74	73	75	75	79	78	71	73	69	63	68	63	64	66	67	69	70	72	74	79
13	77	80	85	82	76	73	73	72	73	76	86	71	64	60	61	67	68	69	69	71	71	72	74	73
14	73	70	69	67	70	68	67	68	67	68	71	81	72	68	53	52	47	41	39	36	40	41	40	46
15	46	39	39	45	43	41	42	43	42	42	40	37	39	36	35	37	37	36	36	37	39	36	37	39
16	44	45	48	50	51	51	54	55	55	53	51	49	43	41	40	39	39	41	45	48	50	42	40	42
17	42	45	46	49	61	58	60	63	62	58	54	51	45	48	45	46	54	51	55	65	63	64	64	66
18	66	62	63	67	71	73	70	70	67	56	56	52	51	50	50	51	48	57	63	64	64	66	69	73
19	71	75	64	69	73	82	83	80	79	78	75	70	66	63	64	60	62	64	64	68	70	72	73	73
20	74	70	73	74	70	75	76	81	78	69	63	61	62	58	56	58	57	58	59	59	60	78	73	71
21	72	71	69	71	78	84	84	83	85	86	86	88	87	85	86	86	85	86	85	85	86	85	86	86
22	86	87	85	83	82	83	82	80	79	80	81	78	81	84	79	68	64	62	62	62	62	63	61	62
23	66	66	66	65	64	68	66	70	67	64	65	64	58	56	52	51	49	50	51	52	57	59	64	68
24	69	77	73	82	77	77	75	80	73	72	61	58	59	55	52	47	44	44	43	47	47	59	56	50
25	55	62	63	70	69	65	68	66	65	59	55	57	52	49	47	46	44	46	45	47	50	53	56	56
26	58	56	59	59	64	67	67	64	65	56	43	36	36	31	29	34	43	42	38	48	41	47	55	69
27	65	63	67	73	68	70	70	63	69	58	50	42	44	42	37	36	37	37	42	41	39	52	56	54
28	48	57	50	49	50	53	58	61	63	63	60	56	58	55	53	54	54	55	58	57	55	58	60	61
29	62	61	62	60	58	58	60	64	66	64	63	61	58	54	54	54	56	58	62	65	65	67	69	70
30																								
31																								

Avis / Note: Unités / Units : pourcent /percent (%) M = Manquant / Missing

- Résumé / Summary -

Sommaire quotidien de février 2004 Aéroport International de Montréal/Dorval		Daily summary for February 2004 Montreal/Dorval International Airport	
Date		Date	
1 -	Faible neige cessant la nuit. Généralement ensoleillé. Venteux.	1 -	Light snow ending at night. Mostly sunny. Windy.
2 -	Plutôt nuageux.	2 -	Mainly cloudy.
3 -	Faible pluie ou neige débutant en fin d'après-midi se changeant en neige en soirée, neige parfois forte. Doux.	3 -	Light rain or snow beginning by late afternoon changing to snow in the evening, snow heavy at times. Mild
4 -	Neige cessant vers midi. Doux. Très venteux.	4 -	Snow ending around noon. Mild. Very windy.
5 -	Flocons la nuit. Ensoleillé.	5 -	Overnight flurries. Sunny.
6 -	Neige débutant le matin se changeant en bruine verglaçante en soirée. Venteux.	6 -	Snow beginning in the morning changing to freezing drizzle in the evening. Windy.
7 -	Bruine verglaçante se changeant en faible neige le matin cessant en soirée. Venteux par moments.	7 -	Freezing drizzle changing to light snow in the morning ending in the evening. Windy at times.
8 -	Ensoleillé. Venteux.	8 -	Sunny. Windy.
9 -	Ennuagement graduel. Flocons vers minuit. Doux. Venteux.	9 -	Increasing cloudiness. Flurries around midnight. Mild. Windy.
10 -	Faible neige intermittente la nuit et en soirée. Très doux. Venteux.	10 -	Intermittent light snow at night and in the evening. Windy.
11 -	Flocons vers l'aube puis ensoleillé. Venteux.	11 -	Flurries near dawn then sunny. Windy.
12 -	Averses de neige surtout le matin.	12 -	Snowshowers mainly in the morning.
13 -	Très faible neige en avant-midi. Flocons en après-midi. Doux. Venteux.	13 -	Very light snow in the morning. Afternoon flurries. Mild. Windy.
14 -	Très faible neige en avant-midi. Venteux.	14 -	Very light snow in the morning. Windy.
15 -	Ensoleillé. Très froid. Venteux.	15 -	Sunny. Very cold. Windy.
16 -	Ensoleillé. Froid.	16 -	Sunny. Cold.
17 -	Plutôt nuageux. Froid.	17 -	Mainly cloudy. Windy.
18 -	Ensoleillé.	18 -	Sunny.
19 -	Très faible neige débutant la nuit et cessant le matin.	19 -	Very light snow beginning at night and ending in the morning.
20 -	Très faible neige en soirée. Doux.	20 -	Very light snow in the evening. Mild.
21 -	Faible neige débutant la nuit se changeant en pluie vers midi cessant en soirée. Très doux.	21 -	Light snow beginning at night changing to rain around noon ending in the evening. Very mild.
22 -	Faible neige débutant vers l'aube cessant en après-midi. Doux.	22 -	Light snow beginning near dawn ending in the afternoon. Mild.
23 -	Ensoleillé.	23 -	Sunny.
24 -	Ensoleillé. Froid.	24 -	Sunny. Windy.
25 -	Ensoleillé.	25 -	Sunny.
26 -	Ensoleillé.	26 -	Sunny.
27 -	Ensoleillé.	27 -	Sunny.
28 -	Ensoleillé. Doux.	28 -	Sunny. Mild.
29 -	Nuageux. Très doux.	29 -	Cloudy. Very mild.

APPENDIX E

WINTER OPERATIONS SURVEY QUESTIONNAIRE AND RESPONSES OF WORLDWIDE AIRLINES

Transports Canada

Centre de développement des transports

800, bd René-Lévesque O.
6e étage
Montréal (Québec)
H3B 1X9
Tél. : (514) 283-0000
Télécopieur : (514) 283-7158
Site Web :
Www.tc.gc.ca/tdc/index_f.htm

Transport Canada

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6th Floor
Montreal, Quebec
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Tel.: (514) 283-0000
Fax: (514) 283-7158
Web Site:
www.tc.gc.ca/tdc/index.htm

Votre référence *Your file*

Notre référence *Our file*

SUBJECT: Winter Operations Survey

Dear Sir or Madam:

Transport Canada is attempting to collect additional data on actual deicing operations at several worldwide stations. During the last two years, similar studies of fifteen stations from Montreal, Pittsburgh, Sapporo, Chicago, Denver, Toronto, Paris (Orly and CDG), Newark, Helsinki, Louisville, Munich, Frankfurt, London, and Amsterdam have been conducted. The data set from these studies has been analyzed and it was found that approximately 52% of de/anti-icing operations occur in snow, 38% occur in frost, and 10% occur in freezing fog, light freezing rain, freezing drizzle, and rain on a cold-soaked wing combined. Data from another winter, as well as from other regions such as Calgary, Detroit, Boston, New York, Moscow, Vienna and Anchorage would provide a compelling data set for a representation of worldwide deicing operations. If you do not have precise data, we encourage you to provide us with estimates made using your best judgment.

The importance of this survey is to better evaluate and determine where to place funding and resources for de/anti-icing research. Presently, we are seeking this information in support of a review of the Holdover time table temperature and weather condition breakdowns. With the results obtained from this survey, we can ensure that our research and development is aimed at conditions where an important number of operations occur worldwide. This survey will also assist in identifying where improvements can be made to the format of the Holdover time tables. Your input and data will ensure that your operational conditions are included in the review process. We shall provide you with feedback of our findings from this survey.

Attached is one Microsoft Excel file containing four sheets ("tabs"). The first two tabs are the tables for you to complete: Table 1 for Type I operations and Table 2 for Type II and/or Type IV operations. Enter your data directly into these tables. If your data are in the form of percentages, please provide the total number of deicing operations as a numerical value as well. If you cannot separate out Type I operations, please provide the information for all fluids on Table 2 and check the appropriate box. The last two tabs – Tables 3 and 4 - serve as examples; these tables show the totaled results from the last two years (2000-2002) of information on deicing operations gathered from the fifteen international airports.

The following are our general guidelines for completing the tables:

1. First identify one deicing station for which you have data, or are willing to estimate operations, and provide information for this station. If possible, it should be the busiest winter station in your country. If you cannot isolate one station in your data, provide the names of the stations included. If you have large operations at many stations, data from these other stations would be appreciated. Please make copies of Tables 1 or 2 for this additional data.
2. Establish your level of operations by stating the number of deicing operations performed last winter at the station you have identified.
3. Assess how many or what proportion of your operations were for frost and how many were for snow at the bottom of the table.
4. Assess how many or what proportion of your operations were for freezing rain, freezing drizzle or freezing fog.
5. Assess how many or what proportion of your operations were for rain on a cold soaked wing.
6. State (or estimate) how many of the operations were in each temperature range in the table and do this for each weather class if possible in the body of the table.
7. Identify or estimate the distribution of operations by temperature on the right of the table.

When providing estimates, please identify that the figure is an estimate with the letter "E" alongside the value. If all entries are estimates, you need only indicate this in the space labeled “All values are estimates.”

If you need assistance in processing your data into a format for the forms provided, please feel free to call John D’Avirro of APS Aviation at 514-878-4388.

Please fill out the tables as completely as you can and return them to my attention by August 22, 2003.

Yours Sincerely,

Barry Myers

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: ______________________

Enter # of Deicing Operations: ______________________ **Specify if values are estimates (YES or NO):** ________

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27										0
-3 to -6	27 to 21										0
-6 to -10	21 to 14										0
below -10	below 14										0
	Total	0	0	0	0	0	0	0	0	0	0

COMMENTS:

____

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: ____________ **Specify if Type I is included (YES or NO):** ________

Enter # of Deicing Operations: ____________ **Specify if values are estimates (YES or NO):** ________

State fluid dilution used (100 or 75/25 or 50/50 or all): ____________

OAT °C	OAT °F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0°	above 32								0
0 to -3	32 to 27								0
-3 to -14	27 to 7								0
-14 to -25	7 to -13								0
below -25	below -13								0
	Total	0	0	0	0	0	0	0	0

COMMENTS:

____

TABLE 3 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

SUMMARY OF ALL AIRPORTS (2000 - 2002)

Total # of Deicing Operations: 62891 All values are estimates:

OAT °C	OAT °F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER RIME ICE	Total	
above 0°	above 32°	6538	62	6442	272	502	363	110	14289	23.0%
0 to -10	32 to 14	13568	77	25886	894	1860		1858	44143	70.0%
below -10	below 14	3218	0	1200				41	4459	7.0%
Total		23324	139	33528	1166	2362	363	2009		
		37.2%	0.2%	53.4%	1.8%	3.7%	0.6%	3.2%		

62891 of Operations

TABLE 4 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

SUMMARY OF ALL AIRPORTS (2000 - 2002)

Total # of Deicing Operations: 53710 Type I included NO All values are estimates:

OAT °C	OAT °F	Type IV Fluid Concentration Neat-Fluid/Water (% by volume)	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER RIME ICE	Total	
above 0°	above 32°	100/0 75/25 50/50	4787	415	7506	458	560	414	53	14193	26.0%
0 to -3	32 to 27	100/0 75/25 50/50	11806	610	12558	562	594		85	26215	49.0%
below -3 to -14	below 27 to 7	100/0 75/25	3990	487	7468	578	426		12	12961	24.0%
below -14 to -25	below 7 to -13	100/0	97	2	242				0	341	1.0%
below -25	below -13	100/0	0	0	0				0	0	0.0%
Total			20680	1514	27774	1598	1580	414	150		
			38.4%	2.8%	51.7%	3.0%	2.9%	0.8%	0.2%		

53710 of Operations

RESPONSES

Table 1 (for Type I Fluid) – Distribution of Deicing Operations in the Following Station (s)

Table 2 (for Type IV Fluid) – Distribution of Deicing Operations in the Following Station (s)

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TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: *Chicago AE (02-03)*

Enter # of Deicing Operations: *2048*

Specify if values are estimates (YES or NO): YES

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	350									350
-3 to -6	27 to 21			175	800	0	80				1055
-6 to -10	21 to 14					643					643
below -10	below 14										0
Total		350	0	175	800	643	80	0	0	0	2048

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: Chicago UA (02-03)

Enter # of Deicing Operations: 4871

Specify if values are estimates (YES or NO): YES

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	654	32	191	626	204	25				1732
-3 to -6	27 to 21	805		387	237	163		31			1623
-6 to -10	21 to 14	363		414	143	168					1088
below -10	below 14	324		104							428
	Total	2146	32	1096	1006	535	25	31	0	0	4871

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: Frankfurt (02-03)

Enter # of Deicing Operations: 0

Specify if values are estimates (YES or NO): ________

OAT		FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF										
above -3	above 27										0
-3 to -6	27 to 21										0
-6 to -10	21 to 14										0
below -10	below 14										0

Total	0	0	0	0	0	0	0	0	0	0

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: Helsinki (02-03)

Enter # of Deicing Operations: 12644

Specify if values are estimates (YES or NO): YES

OAT ºC	OAT ºF	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	800	100	1750				200	250		3100
-3 to -6	27 to 21	1300		1990	1150	850	200				5490
-6 to -10	21 to 14	350		985	1250	750					3335
below -10	below 14	250		469							719
	Total	2700	100	5194	2400	1600	200	200	250	0	12644

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: Dorval Airport (02-03)

Enter # of Deicing Operations: 6111

Specify if values are estimates (YES or NO): NO

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	863			814	131	76	71	110	63	2128
-3 to -6	27 to 21	437			674	56		37		50	1254
-6 to -10	21 to 14	488			697	1	1				1187
below -10	below 14	1228			314						1542
Total		3016	0	0	2499	188	77	108	110	113	6111

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: *Munich (02-03)*

Enter # of Deicing Operations: *2973*

Specify if values are estimates (YES or NO): NO

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	1114	7	0	26	12	0	0	0	0	1159
-3 to -6	27 to 21	693	4	0	19	0	0	0	0	0	716
-6 to -10	21 to 14	669	4	0	15	0	0	0	0	0	688
below -10	below 14	410	0	0	0	0	0	0	0	0	410

Total	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER	Total
Total	2886	15	0	60	12	0	0	0	0	2973

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: *Pittsburgh (02-03)*

Enter # of Deicing Operations: *5644*

Specify if values are estimates (YES or NO): YES

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	103	0	195	1325	900	25	200	0		2748
-3 to -6	27 to 21	117	0	180	975	985	90	130			2477
-6 to -10	21 to 14	17	0	75	190	85	21	11			399
below -10	below 14	0	0	5	10	5					20
	Total	237	0	455	2500	1975	136	341	0	0	5644

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: TORONTO-CDF

Enter # of Deicing Operations: 13491

Specify if values are estimates (YES or NO): NO

OAT		FROST	FREEZING FOG	Very Light Snow	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:Ice/Layover Ice/RimeIce	Total
ºC	ºF										
above -3	above 27	1129			1587	648	484		1	1564	5413
-3 to -6	27 to 21	432			847	477	216			935	2907
-6 to -10	21 to 14	769			1025	416				676	2886
below -10	below 14	1328			666	1				290	2285
	Total	3658	0	0	4125	1542	700	0	1	3465	13491

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: Zurich (02-03)

Enter # of Deicing Operations: 1862

Specify if values are estimates (YES or NO): YES

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	285		196	71	91				71	714
-3 to -6	27 to 21	183		119	57	59				46	464
-6 to -10	21 to 14	159		113	40	45				40	397
below -10	below 14	118		88	20	32				29	287
	Total	745	0	516	188	227	0	0	0	186	1862

TABLE 1 (FOR TYPE I FLUID)
DISTRIBUTION OF DEICING OPERATIONS

Enter Station's Name: ***Total Results***

Enter # of Deicing Operations: *49644*

Specify if values are estimates (YES or NO): ________

OAT °C	OAT °F	FROST	FREEZING FOG	VERY LIGHT SNOW	LIGHT SNOW	MODERTE SNOW	FREEZING DRIZZLE	LIGHT FRZ. RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above -3	above 27	10.7%	0.3%	4.7%	9.0%	4.0%	1.2%	0.9%	0.7%	3.4%	34.9%
-3 to -6	27 to 21	8.0%	0.0%	5.7%	9.6%	5.2%	1.2%	0.4%	0.0%	2.1%	32.2%
-6 to -10	21 to 14	5.7%	0.0%	3.2%	6.8%	4.2%	0.1%	0.1%	0.0%	1.4%	21.5%
below -10	below 14	7.4%	0.0%	1.3%	2.0%	0.1%	0.0%	0.0%	0.0%	0.6%	11.4%
	Total	31.8%	0.3%	14.9%	27.4%	13.5%	2.5%	1.4%	0.7%	7.5%	100.0%

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: Chicago AE (02-03)

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: 1835

Specify if values are estimates (YES or NO): YES

State fluid dilution used (100 or 75/25 or 50/50 or all): 100

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32								0
0 to -3	32 to 27			685	80				765
-3 to -14	27 to 7			1070					1070
-14 to -25	7 to -13								0
below -25	below -13								0
Total		0	0	1755	80	0	0	0	1835

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: Chicago UA (02-03)

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: 3159

Specify if values are estimates (YES or NO): YES

State fluid dilution used (100 or 75/25 or 50/50 or all): 100 % type IV

OAT °C	OAT °F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0°	above 32	1		666					667
0 to -3	32 to 27			610					610
-3 to -14	27 to 7	30		1625		227			1882
-14 to -25	7 to -13								0
below -25	below -13								0
	Total	31	0	2901	0	227	0	0	3159

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: *Frankfurt (02-03)*

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: *4371*

Specify if values are estimates (YES or NO): NO

State fluid dilution used (100 or 75/25 or 50/50 or all): 50/50 nad 100

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	373		610		23			1006
0 to -3	32 to 27	1089		956		16			2061
-3 to -14	27 to 7	641		663					1304
-14 to -25	7 to -13								0
below -25	below -13								0
Total		2103	0	2229	0	39	0	0	4371

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: ***Helsinki (02-03)*** **Specify if Type I is included (YES or NO):** Yes (as de-icing)

Enter # of Deicing Operations: ***7500*** **Specify if values are estimates (YES or NO):** YES

State fluid dilution used (100 or 75/25 or 50/50 or all): 100

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	800	50	800		200	250		2100
0 to -3	32 to 27	600	50	1750	200				2600
-3 to -14	27 to 7	250		1500					1750
-14 to -25	7 to -13	250		800					1050
below -25	below -13	0							0

Total	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER	Total
Total	1900	100	4850	200	200	250	0	7500

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: *Dorval Airport (02-03)*

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: *1917*

Specify if values are estimates (YES or NO): NO

State fluid dilution used (100 or 75/25 or 50/50 or all): ____________

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	3		60	8	4	72		147
0 to -3	32 to 27	32		444	58	47		43	624
-3 to -14	27 to 7	21		1019	1	34		49	1124
-14 to -25	7 to -13	1		21					22
below -25	below -13								0
	Total	57	0	1544	67	85	72	92	1917

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: Munich (02-03)   Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: 3115   Specify if values are estimates (YES or NO): NO

State fluid dilution used (100 or 75/25 or 50/50 or all): 100

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	22	13	567	3	9	109	0	723
0 to -3	32 to 27	22	115	959	3	3	0	0	1102
-3 to -14	27 to 7	44	374	860	0	0	0	0	1278
-14 to -25	7 to -13	9	0	3	0	0	0	0	12
below -25	below -13	0	0	0	0	0	0	0	0
	Total	97	502	2389	6	12	109	0	3115

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: *Pittsburgh (02-03)*

Specify if Type I is included (YES or NO): YES

Enter # of Deicing Operations: *1708*

Specify if values are estimates (YES or NO): YES

State fluid dilution used (100 or 75/25 or 50/50 or all): 100

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	0	0	40	0	0			40
0 to -3	32 to 27	0	0	880	125	180			1185
-3 to -14	27 to 7	0	0	300	65	40			405
-14 to -25	7 to -13	0	0	78					78
below -25	below -13	0	0	0					0

Total	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER	Grand total
Total	0	0	1298	190	220	0	0	1708

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: ***Schiphol (02-03)***

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: ***2849***

Specify if values are estimates (YES or NO): YES

State fluid dilution used (100 or 75/25 or 50/50 or all): all

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
ºC	ºF								
above 0º	above 32	0	0	0	0	0	0	0	0
0 to -3	32 to 27	855	142	570	142	57	0	0	1766
-3 to -14	27 to 7	855	0	228	0	0	0	0	1083
-14 to -25	7 to -13	0	0	0	0	0	0	0	0
below -25	below -13	0	0	0	0	0	0	0	0
Total		1710	142	798	142	57	0	0	2849

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: ***TORONTO-CDF***

Specify if Type I is included (YES or NO): **NO**

Enter # of Deicing Operations: ***4314***

Specify if values are estimates (YES or NO): **NO**

State fluid dilution used (100 or 75/25 or 50/50 or all): ***TYPE I XL54 & TYPE IV ULTRA 100%***

OAT		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:Ice/Layover Ice/Rime Ice	Total
ºC	ºF								
above 0º	above 32			188	21			134	343
0 to -3	32 to 27			1027	389			338	1754
-3 to -14	27 to 7	8		1267	189			664	2128
-14 to -25	7 to -13			89					89
below -25	below -13								0
Total		8	0	2571	599	0	0	1136	4314

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: Zurich (02-03)

Specify if Type I is included (YES or NO): NO

Enter # of Deicing Operations: 2375

Specify if values are estimates (YES or NO): YES

State fluid dilution used (100 or 75/25 or 50/50 or all): ____________

OAT ºC	OAT ºF	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0º	above 32	102		127				25	254
0 to -3	32 to 27	260		326				65	651
-3 to -14	27 to 7	537		672				134	1343
-14 to -25	7 to -13	51		63				13	127
below -25	below -13								0

Total	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER	
Total	950	0	1188	0	0	0	237	2375

TABLE 2 (FOR TYPE II & IV FLUID)
DISTRIBUTION OF DEICING OPERATIONS IN THE FOLLOWING STATION (S):

Enter Station's Name: ***Total Results***

Specify if Type I is included (YES or NO): ____________

Enter # of Deicing Operations: ***33143***

Specify if values are estimates (YES or NO): ____________

State fluid dilution used (100 or 75/25 or 50/50 or all): ____________________

OAT ºC	OAT ºF	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING	OTHER Specify:	Total
above 0º	above 32	3.9%	0.2%	9.2%	0.1%	0.7%	1.3%	0.5%	15.9%
0 to -3	32 to 27	8.6%	0.9%	24.8%	3.0%	0.9%	0.0%	1.3%	39.5%
-3 to -14	27 to 7	7.2%	1.1%	27.8%	0.8%	0.9%	0.0%	2.6%	40.4%
-14 to -25	7 to -13	1.0%	0.0%	3.2%	0.0%	0.0%	0.0%	0.0%	4.2%
below -25	below -13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	20.7%	2.2%	65.0%	3.9%	2.5%	1.3%	4.4%	100.0%

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